APPENDIX A
HYDROLOGY

Golder Associates	Subject:	Blackbird Creek Hydrology				
	Job No.:	9431595.009.1281	Made by:	JLE	Date:	5/27/2011
	Task:		Checked:	CRS		
			Reviewed:	MLB		

OBJECTIVE:

Develop annual maximum snowmelt flow series for Blackbird Creek
Estimate return period for annual peak snowmelt events of various magnitudes

METHOD OF ANALYSIS:

Develop annual maximum snowmelt flow series using data from BBSW01
Estimate flows in missing years using correlation with snowmelt at Morgan Creek Snotel Station
Conduct frequency analysis of annual maximum snowmelt flows

CALCULATIONS:

Calculate maximum 1-day decrease in snowpack snow water equivalent at Morgan Creek Snotel station for each year

Determine regression equation between annual maximum 1-day decrease in snowpack and annual peak runoff event in Blackbird Creek

Use regression equation to estimate Blackbird Creek peak flows for years missing data

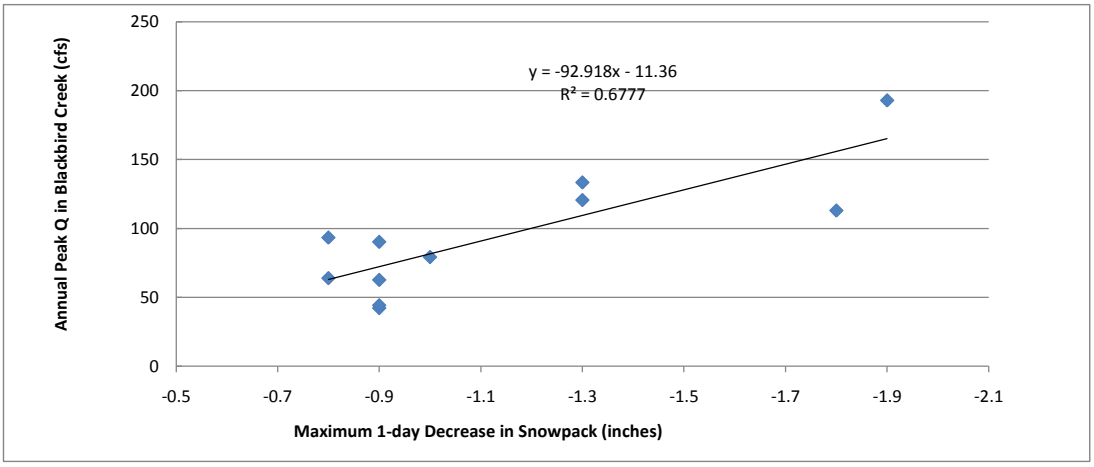
Conduct frequency analysis on annual peak flows in Blackbird Creek

Measured Flow at BBSW-01A

Date	Peak Daily Flow
	(cfs)
6/5/1996	133
5/16/1997	193
5/8/1998	42
5/29/1999	113
5/23/2000	44
5/9/2001	63
5/19/2002	90
2003	missing
5/22/2004	64
5/10/2005	93
5/1/2006	121
5/1/2007	79
2008	poor data
2009	poor data
2010	missing

From Morgan Creek Snotel Data

Year	Max 1-day Melt Depth
	(in)
1996	-1.3
1997	-1.9
1998	-0.9
1999	-1.8
2000	-0.9
2001	-0.9
2002	-0.9
2003	
2004	-0.8
2005	-0.8
2006	-1.3
2007	-1



Estimated peak flows using regression equation above

Year	Max 1-day Melt Depth	Estimated Peak Flow
	(in)	(cfs)
2003	-1.2	100
2008	-1.6	137
2009	-1.3	109
2010	-0.9	72
2011	-1.1	91

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Frequency Analysis:

P = m/n+1 T=1/P

where:

m = Rank
n = Number of years of record
P = Probability of exceedance
T = Return period

RESULTS:

Rank, m	y of Exceedan	Return Period, T	Peak Daily Flow
		(years)	(cfs)
1	0.063	16	193
2	0.125	8.0	137
3	0.188	5.3	133
4	0.250	4.0	121
5	0.313	3.2	113
6	0.375	2.7	109
7	0.438	2.3	100
8	0.500	2.0	93
9	0.563	1.8	90
10	0.625	1.6	79
11	0.688	1.5	72
12	0.750	1.3	64
13	0.813	1.2	63
14	0.875	1.1	44
15	0.938	1.1	42

APPENDIX B
HYDRAULICS

Golder Associates	Subject:	Hydraulics in Blackbird Creek Stabilization Areas				
	Job No.:	9431595.009	Made by:	JLE	Date:	5/27/2011
	Task:	1281	Checked:	CRS		
			Reviewed:	AQK		

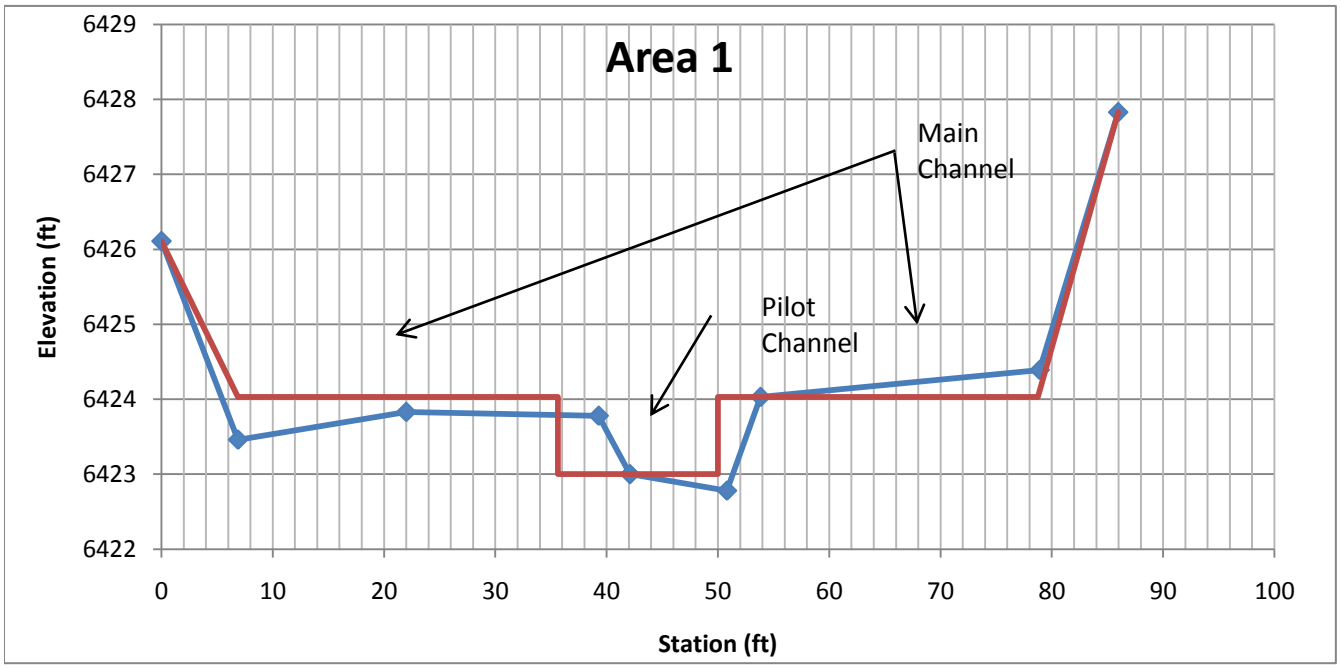
OBJECTIVE: Identify representative cross sections for all 8 instream stabilization areas
Develop idealized cross section based on avg. channel geometry for hydraulic calculations
Calculate depth and velocity for a range of flows at each representative cross section

METHOD OF ANALYSIS: Select representative cross section from as-built survey data
Use Flow Master to develop rating curves for each cross section

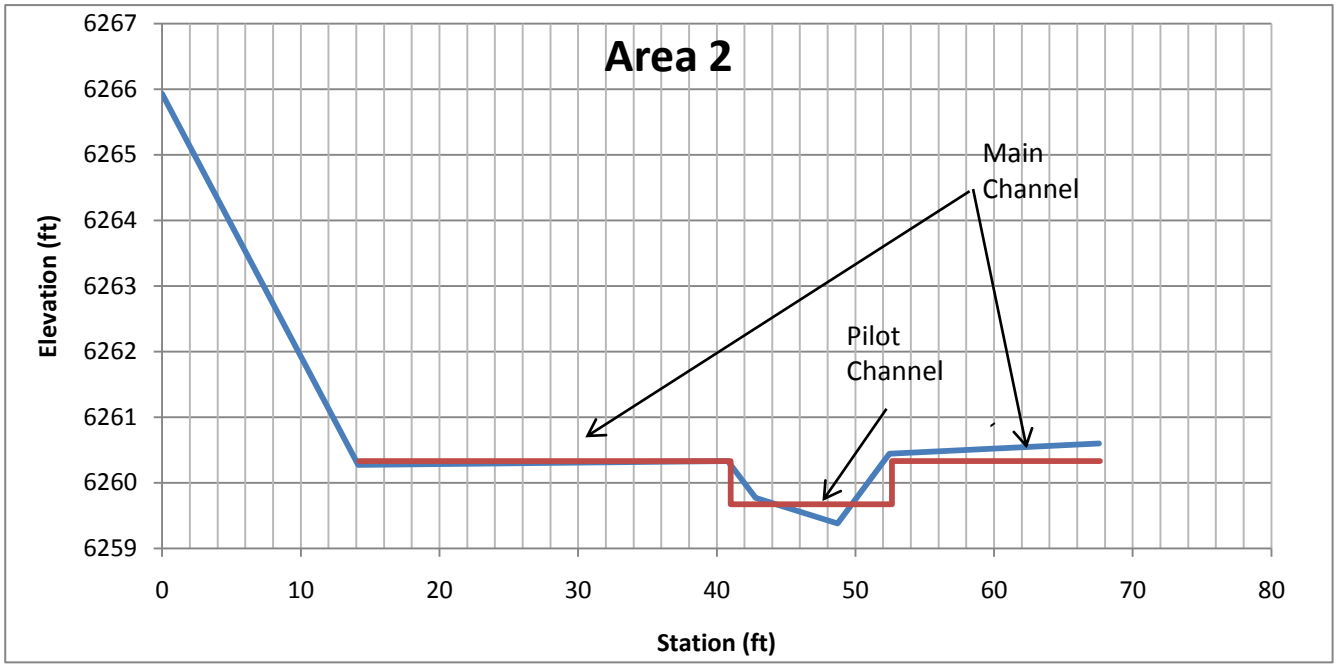
CALCULATIONS: The following cross sections were used for hydraulic and sediment transport calculations

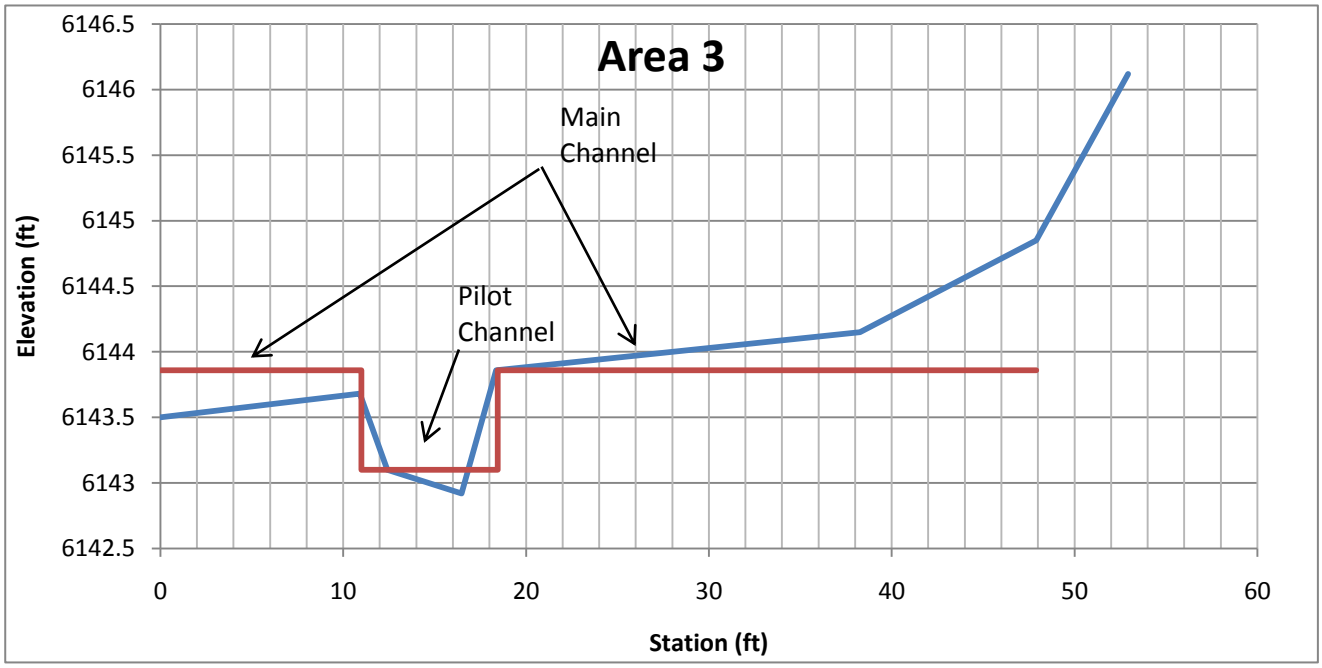
Cross section geometry was simplified as shown in the following plots with a rectangular pilot channel and main channel

Average channel dimensions were obtained from the simplified cross sections and used to develop rating curves.



Golder Associates	Subject:	Hydraulics in Blackbird Creek Stabilization Areas			
	Job No.:	9431595.009	Made by:	JLE	Date: 5/27/2011
	Task:	1281	Checked:	CRS	
			Reviewed:	AQK	





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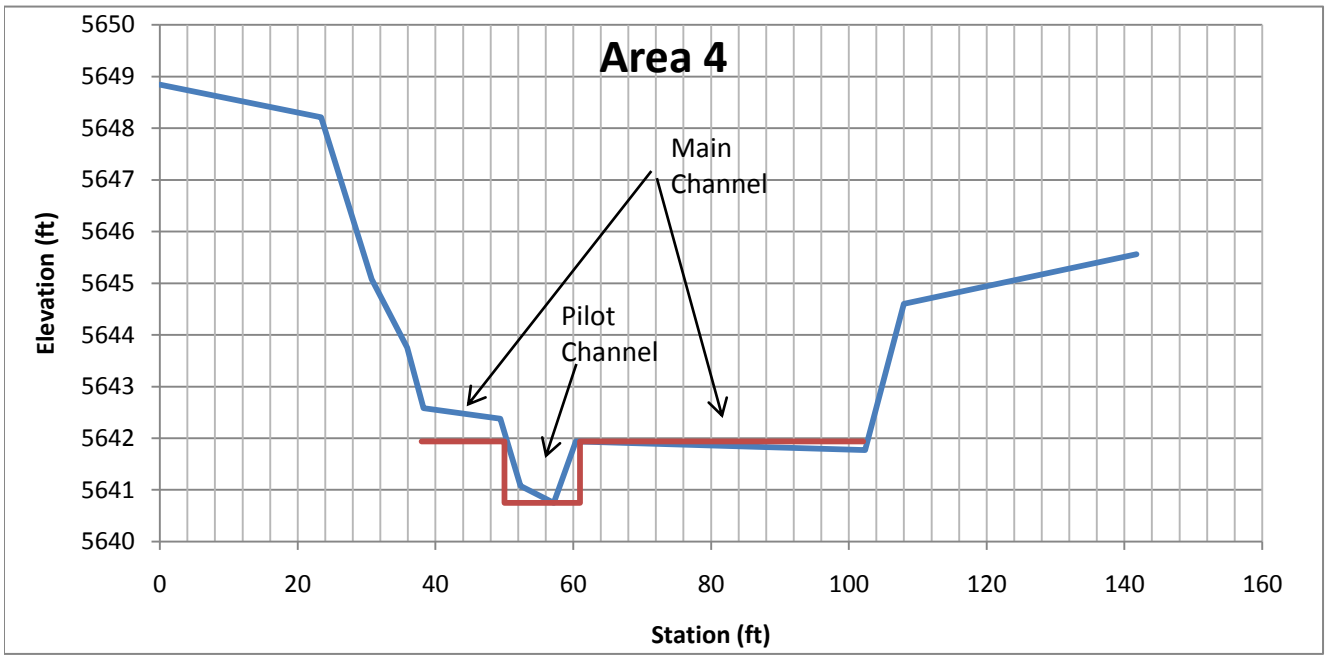

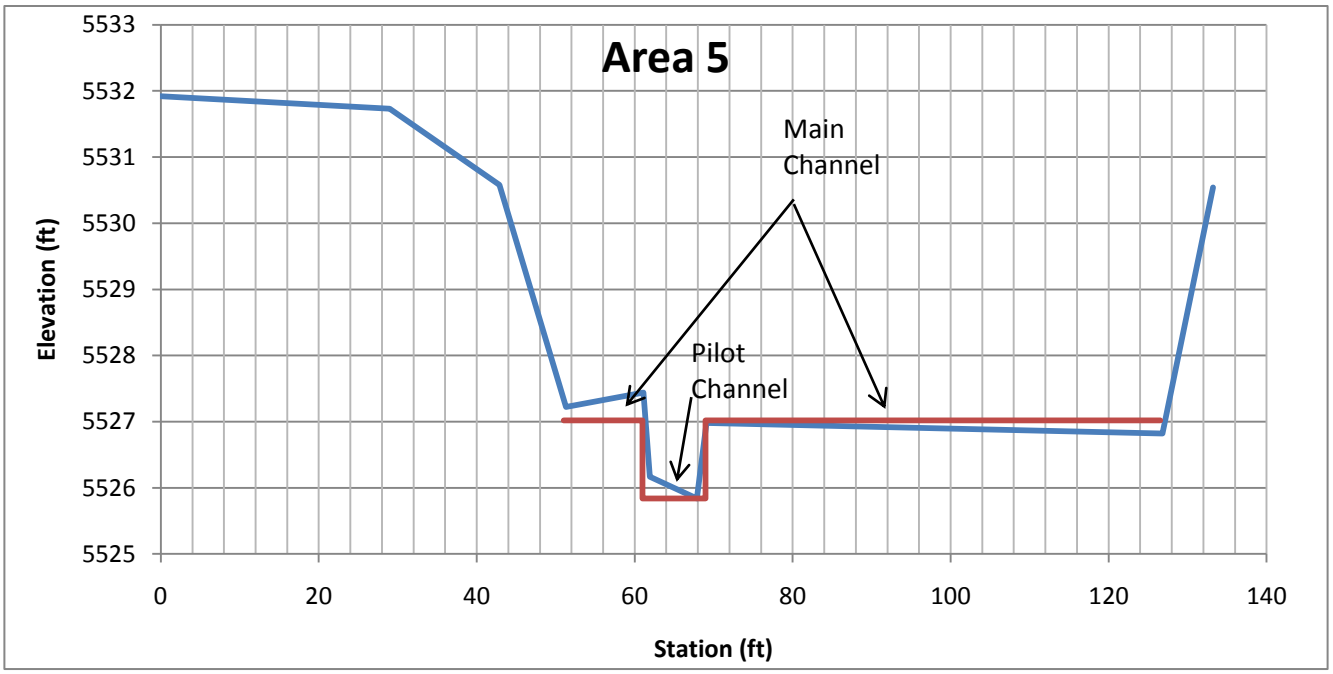

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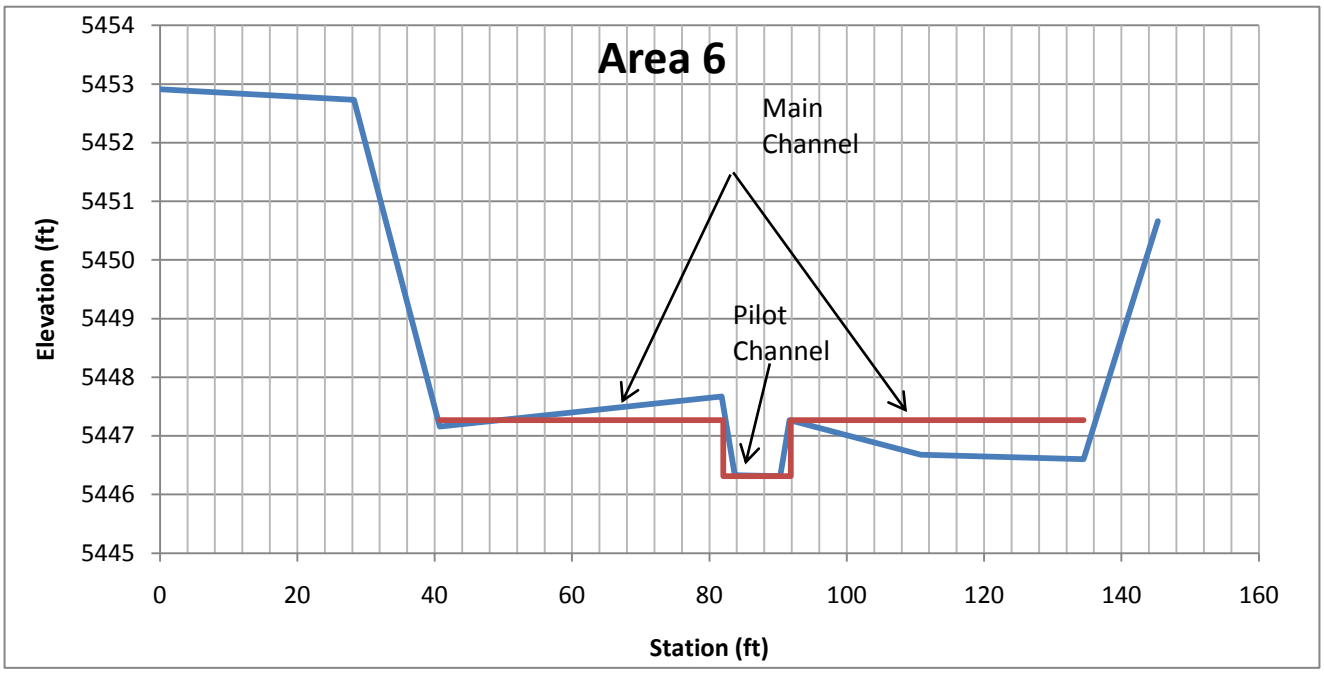

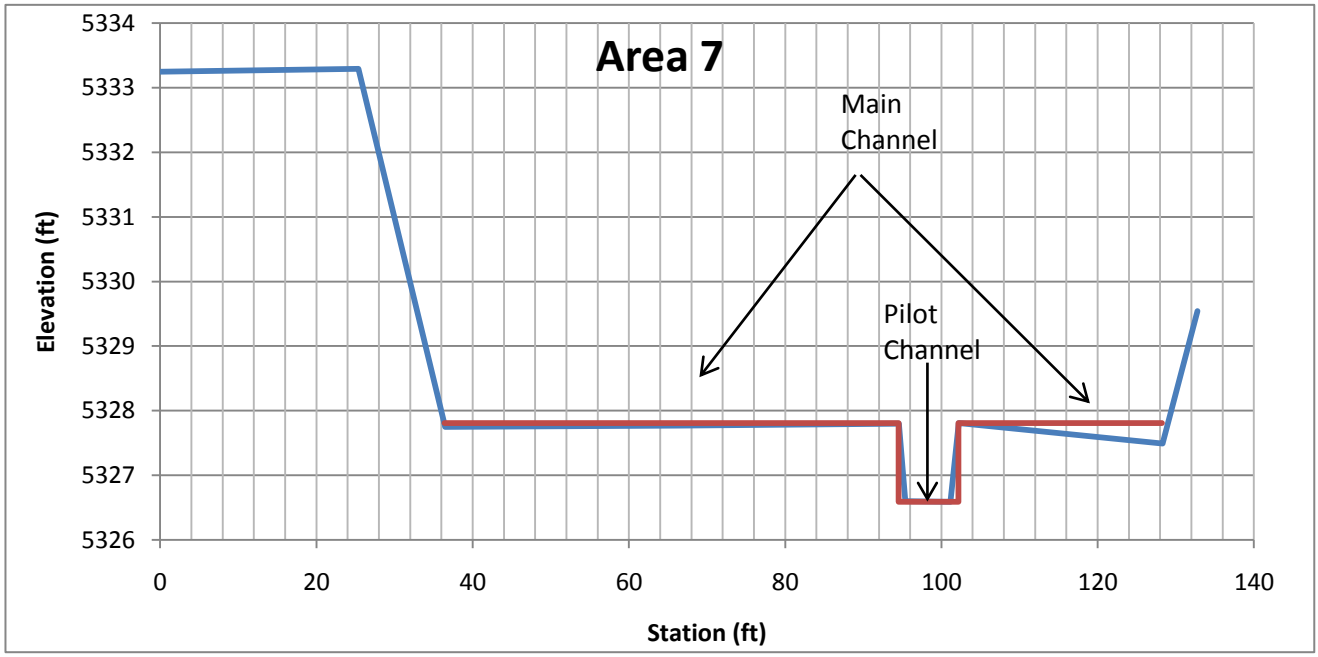

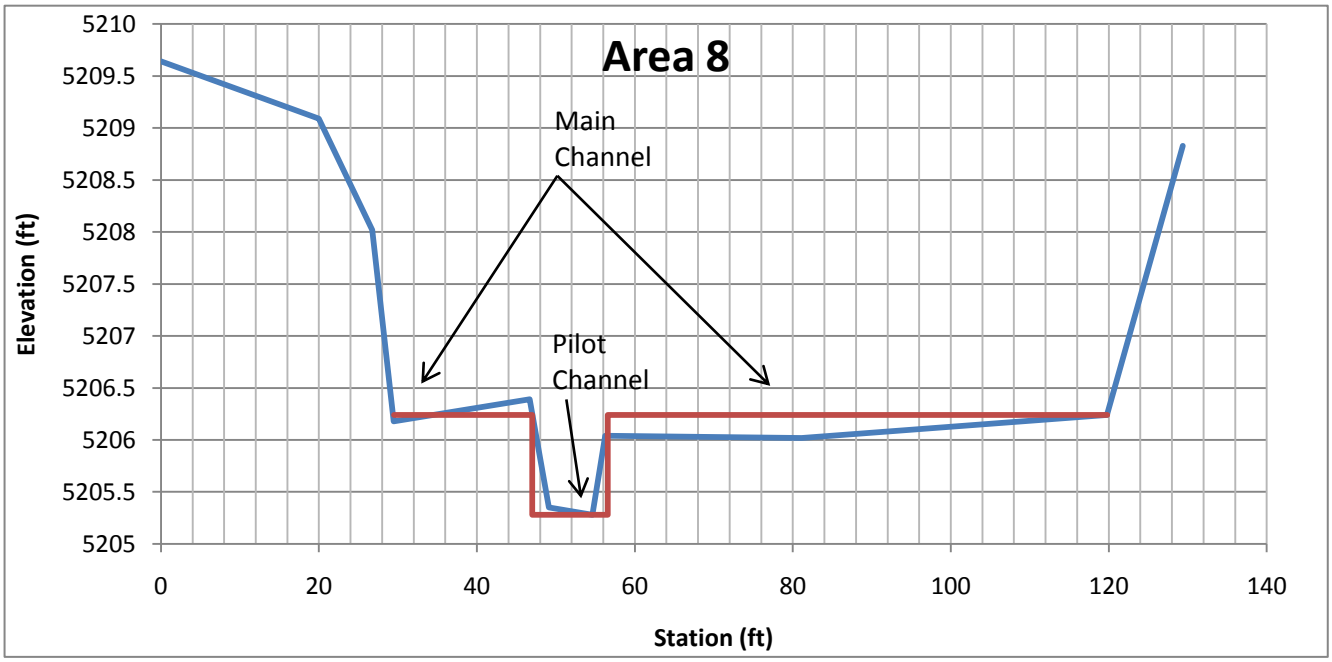

RESULTS:

Average channel geometry used for hydraulic and sediment transport calculations using FlowMaster and BAGS software respectively

ISS Area	Pilot Channel Width	Pilot Channel Depth	Main Channel Width	Average Channel Slope	Manning's n
	(ft)	(ft)	(ft)	(ft/ft)	
1	15	1.0	57	0.045	0.045
2	12	0.7	42	0.043	0.045
3	7	0.8	40	0.053	0.045
4	11	1.2	53	0.064	0.045
5	8	1.2	68	0.029	0.045
6	10	1.0	84	0.027	0.045
7	8	1.2	84	0.024	0.045
8	10	1.0	81	0.028	0.045

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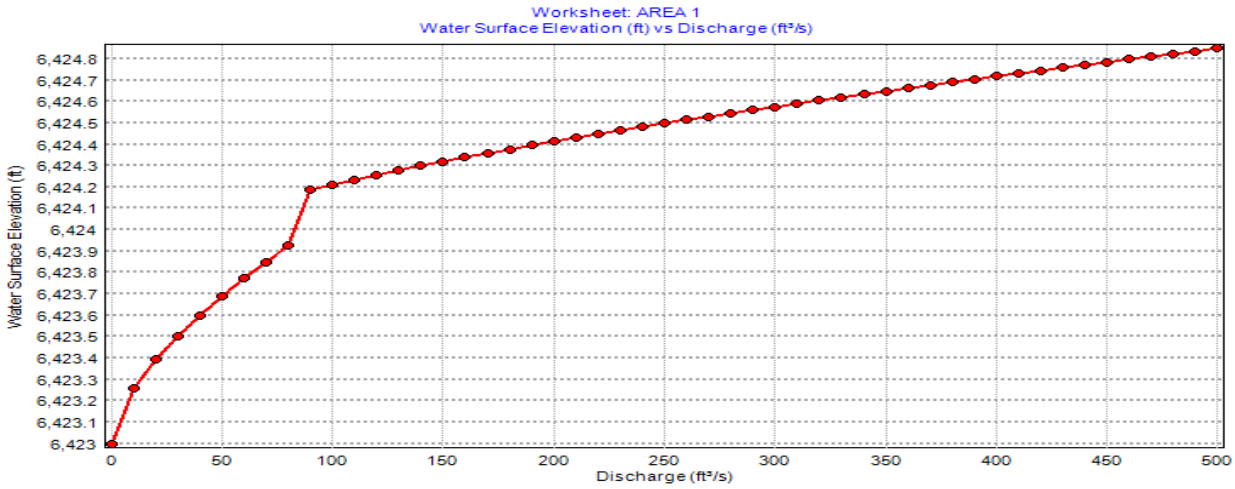

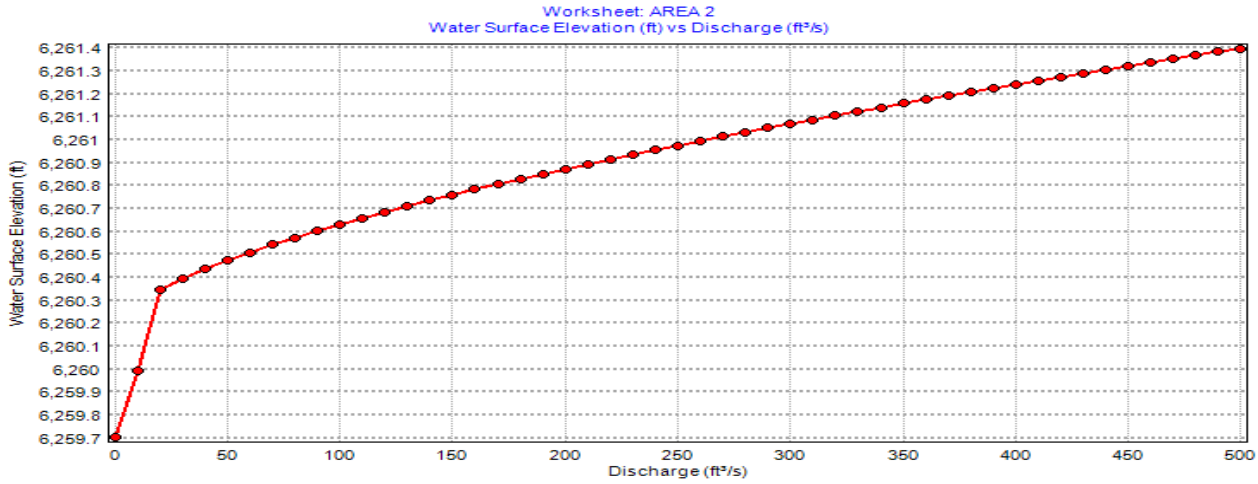

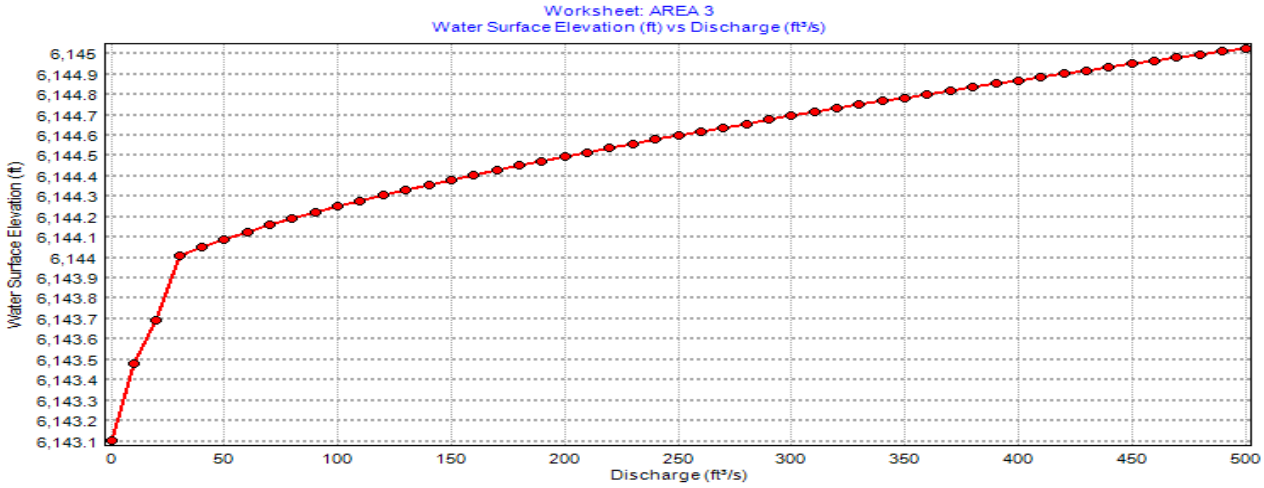

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	Job No.:	9431595.009	Made by:	JLE	Date: 5/27/2011
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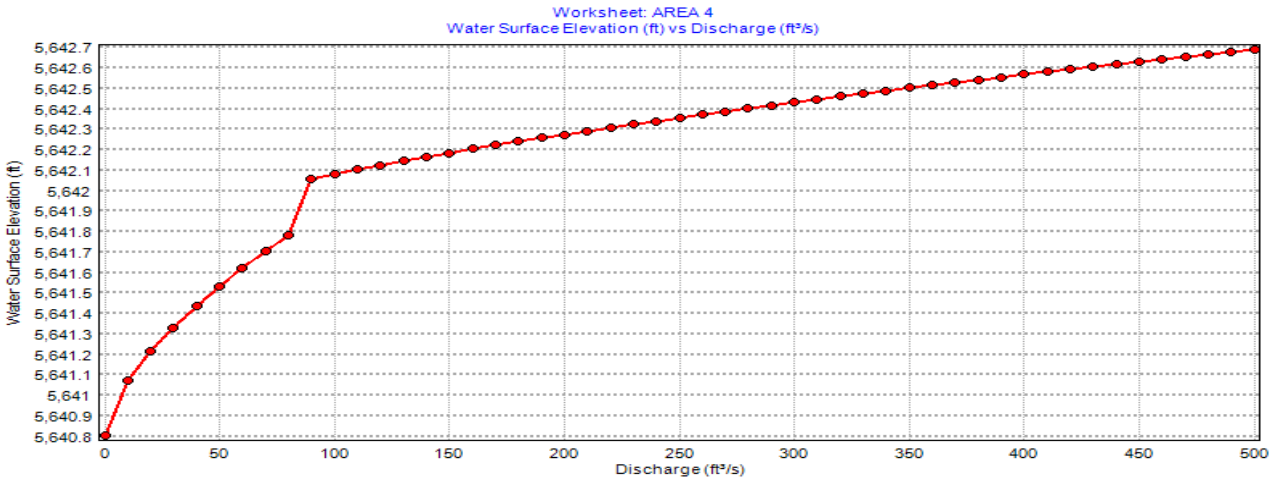

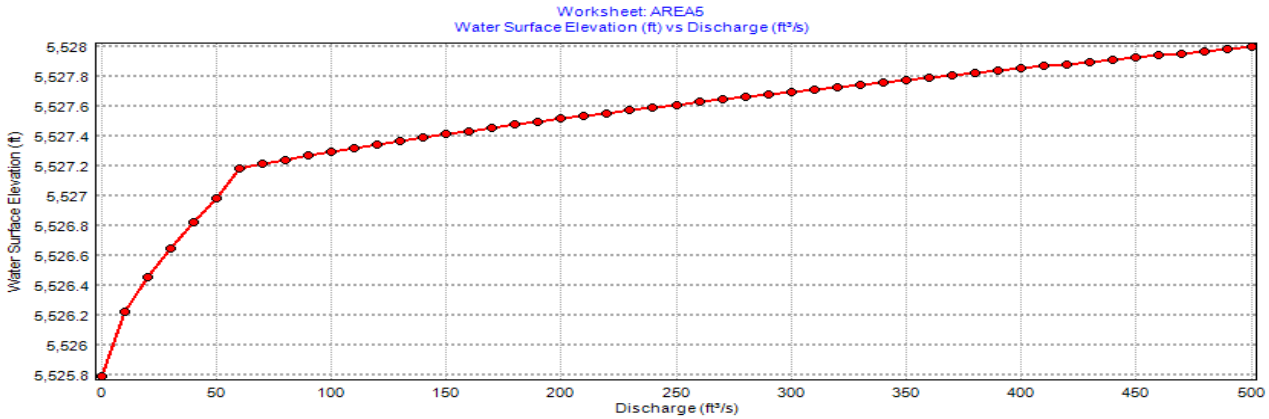

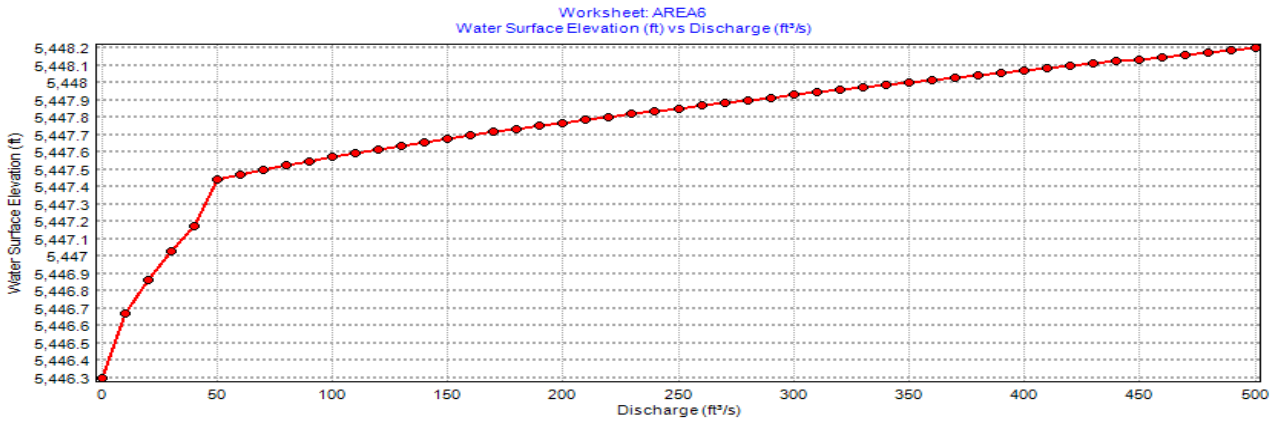

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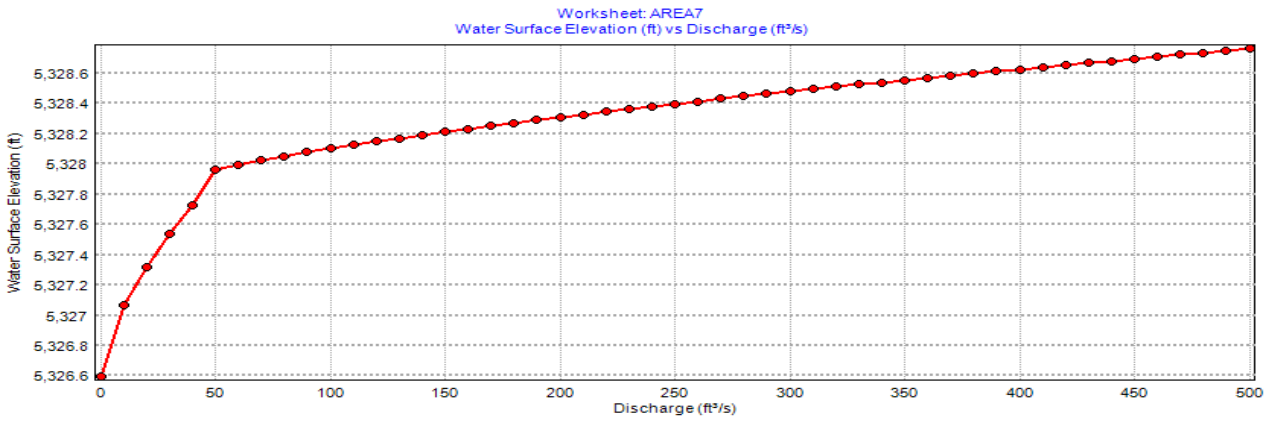
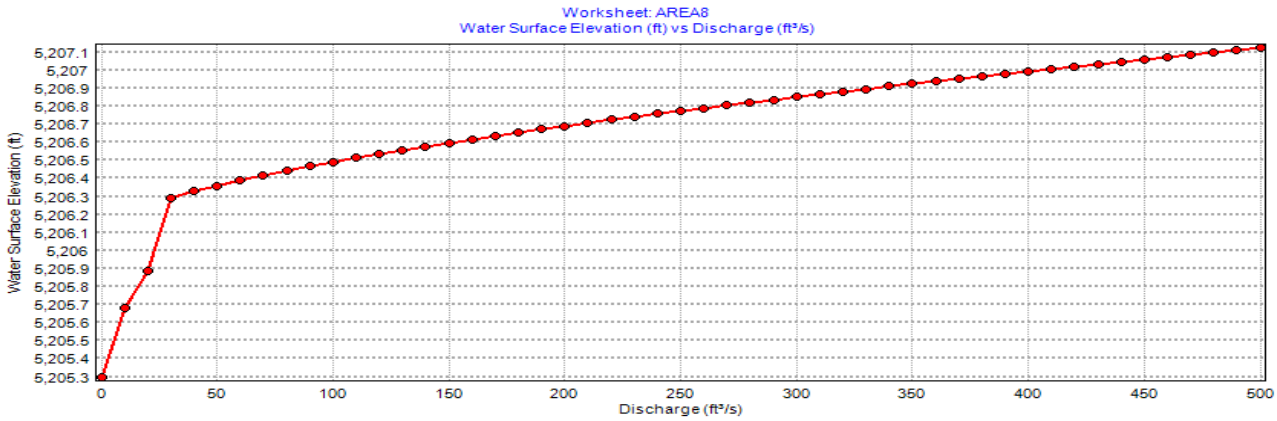
			Reviewed:	AQK	





APPENDIX C
GEOMORPHOLOGY AND SEDIMENT TRANSPORT

Appendix C-1: Geomorphology and Sediment Transport in Blackbird Creek Stabilization Areas

Appendix C-2: Alternative Effectiveness Evaluation during Rainfall Runoff Events

APPENDIX C-1
GEOMORPHOLOGY AND SEDIMENT TRANSPORT IN BLACKBIRD CREEK STABILIZATION AREAS

Golder Associates	Subject:	Geomorphology and Sediment Transport in Blackbird Creek Stabilization Areas				
	Job No.:	9431595.009.1281	Made by:	JLE	Date:	5/27/2011
	Task:		Checked:	AQK	Sheet:	of
			Reviewed:	MLB		

OBJECTIVE: Determine flows required to transport various fractions of the bed material in the Blackbird Creek stabilization areas

METHOD OF ANALYSIS: BAGS software

ASSUMPTIONS: Same bed material grain size distribution for all eight stabilization areas, (see figure below)

Minimum particle diameter in the stable armor layer will be 150 mm

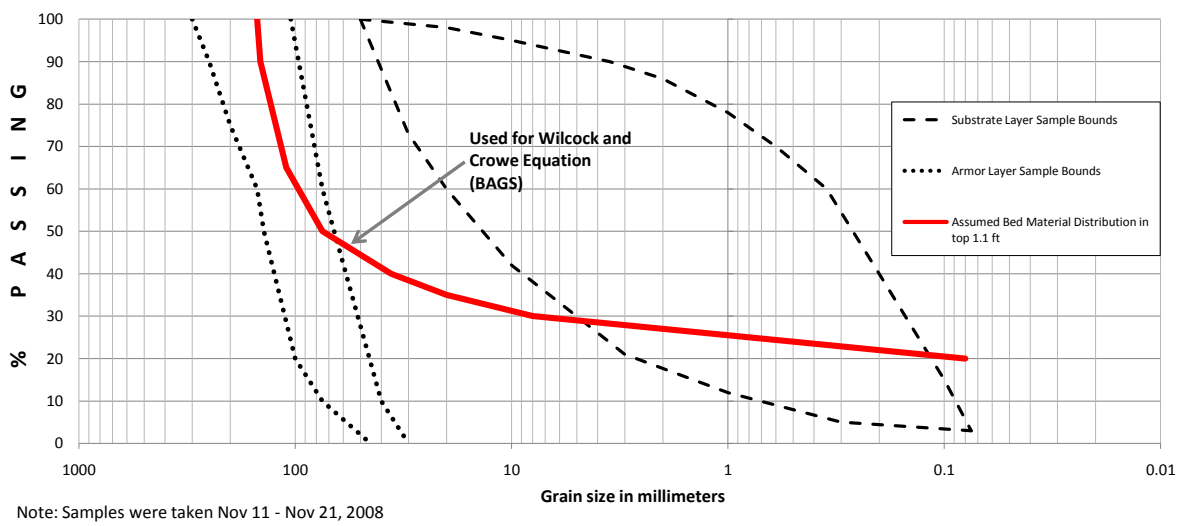
1.1 feet of bed material (finer than 150 mm) will be transported out of the stabilization areas during the armoring process

Contamination is contained in the fine fraction of the bed material (smaller than the #200 sieve)

The finer fraction of bed material is uniformly distributed throughout the bed, a portion of which is trapped by larger grain size fractions. The percentage of fines trapped by a given larger grain size fraction is directly proportional to fraction.

All fines in the top 1.1 feet will not be transported out of the stabilization areas until a flow capable of mobilizing 150 mm material in all portions of the channel occurs.

Flows capable of transporting 1 US ton or greater of a given grain size fraction per day were considered large enough to transport all of the fines trapped by that fraction out of Blackbird Creek within a day.



Note: Samples were taken Nov 11 - Nov 21, 2008

CALCULATIONS:

Determine flow depth required to transport various bed material fractions in the pilot channel and main channel in the 8 stabilization areas using BAGS software

Determine percent of bed material transported by various flows in each stabilization area in terms of flow at BBSW01 using the following drainage area relationship

Qa = Qb(DAa/DAb)^0.85

Fit functions for the % fines transported in each of the 8 stabilization areas for a given flow at BBSW01

Weight the individual transport functions according to the percentage of total contaminated sediment contained in each stabilization area and calculate overall contaminated sediment transport as a function of flow at BBSW01

Develop 15 different scenarios for peak flows that can be expected in the 15 years by reshuffling the 15 years of Blackbird Creek peak flows, starting the series on a different year for each scenario and looping the preceding years at the end of the series. The sequence of flows was kept the same to preserve interannual variability

The average percentage of total available contamination remaining after each year was then calculated

The average load (kg/year) of arsenic was then calculated for the next 15 years.

Golder Associates	Subject:	Geomorphology and Sediment Transport in Blackbird Creek Stabilization Areas				
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	DA (mi²)	% Total Remaining Arsenic
AREA 1	5.34	21%

	Grain Size	Fraction Total Depth	Cumulative Transport Depth	Width	% Total Width	Cumulative Transport	Q Area 1	Q BBSW01	% Total Contamination
			ft	ft		%	cfs	cfs	
Pilot Channel	0.08-8 mm	0.3	0.3	15	0.21	6%	5	15	1%
	8 - 36 mm	0.1	0.4	15	0.21	8%	5	15	2%
	36 - 75 mm	0.1	0.6	15	0.21	10%	7	23	2%
	75 - 95 mm	0.1	0.7	15	0.21	12%	12	39	3%
	95 - 115 mm	0.1	0.8	15	0.21	14%	15	48	3%
	115 - 132 mm	0.1	0.9	15	0.21	16%	19	61	3%
	132 - 145 mm	0.1	1.0	15	0.21	18%	25	80	4%
	145 - 150 mm	0.1	1.1	15	0.21	21%	25	80	4%
Main Channel	0.08-8 mm	0.3	0.3	58	0.79	44%	64	202	9%
	8 - 36 mm	0.1	0.4	58	0.79	52%	75	238	11%
	36 - 75 mm	0.1	0.6	58	0.79	60%	103	329	12%
	75 - 95 mm	0.1	0.7	58	0.79	68%	136	431	14%
	95 - 115 mm	0.1	0.8	58	0.79	76%	155	494	16%
	115 - 132 mm	0.1	0.9	58	0.79	84%	182	578	17%
	132 - 145 mm	0.1	1.0	58	0.79	92%	182	578	19%
	145 - 150 mm	0.1	1.1	58	0.79	100%	182	578	21%

	DA (mi²)	% Total Remaining Arsenic
AREA 2	5.62	9%

	Grain Size	Fraction Total Depth	Cumulative Transport Depth	Width	% Total Width	Cumulative Transport	Q Area 2	Q BBSW01	% Total Contamination
			ft	ft		%	cfs	cfs	
Channel	0.08-8 mm	0.3	0.3	12	0.22	7%			0.6%
	8 - 36 mm	0.1	0.4	12	0.22	9%			0.8%
	36 - 75 mm	0.1	0.6	12	0.22	11%	6	18	1.0%
	75 - 95 mm	0.1	0.7	12	0.22	13%	13	39	1.2%
	95 - 115 mm	0.1	0.8	12	0.22	16%	16	49	1.4%
	115 - 132 mm	0.1	0.9	12	0.22	18%	20	62	1.6%
	132 - 145 mm	0.1	1.0	12	0.22	20%	20	62	1.8%
	145 - 150 mm	0.1	1.1	12	0.22	22%	20	62	2.0%
Main Channel	0.08-8 mm	0.3	0.3	42	0.78	46%	44	133	4.1%
	8 - 36 mm	0.1	0.4	42	0.78	53%	55	166	4.8%
	36 - 75 mm	0.1	0.6	42	0.78	61%	79	240	5.5%
	75 - 95 mm	0.1	0.7	42	0.78	69%	103	313	6.3%
	95 - 115 mm	0.1	0.8	42	0.78	77%	118	358	7.0%
	115 - 132 mm	0.1	0.9	42	0.78	84%	137	418	7.7%
	132 - 145 mm	0.1	1.0	42	0.78	92%	137	418	8.4%
	145 - 150 mm	0.1	1.1	42	0.78	100%	162	494	9.1%

	DA (mi²)	% Total Remaining Arsenic
AREA 3	6.3	6%

	Grain Size	Fraction Total Depth	Cumulative Transport Depth	Width	% Total Width	Cumulative Transport	Q Area 3	Q BBSW01	% Total Contamination
			ft	ft		%	cfs	cfs	
Channel	0.08-8 mm	0.3	0.3	7	0.15	4%	4	12	0.3%
	8 - 36 mm	0.1	0.4	7	0.15	6%	4	12	0.4%
	36 - 75 mm	0.1	0.6	7	0.15	7%	4	12	0.4%
	75 - 95 mm	0.1	0.7	7	0.15	9%	6	16	0.5%
	95 - 115 mm	0.1	0.8	7	0.15	10%	7	20	0.6%
	115 - 132 mm	0.1	0.9	7	0.15	12%	9	25	0.7%
	132 - 145 mm	0.1	1.0	7	0.15	13%	12	33	0.8%
	145 - 150 mm	0.1	1.1	7	0.15	15%	12	33	0.9%
Main Channel	0.08-8 mm	0.3	0.3	40	0.85	40%	16	45	2.4%
	8 - 36 mm	0.1	0.4	40	0.85	49%	22	60	2.9%
	36 - 75 mm	0.1	0.6	40	0.85	57%	35	95	3.4%
	75 - 95 mm	0.1	0.7	40	0.85	66%	50	137	3.9%
	95 - 115 mm	0.1	0.8	40	0.85	74%	61	168	4.4%
	115 - 132 mm	0.1	0.9	40	0.85	83%	73	201	5.0%
	132 - 145 mm	0.1	1.0	40	0.85	91%	73	201	5.5%
	145 - 150 mm	0.1	1.1	40	0.85	100%	73	201	6.0%

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	DA (mi²)	% Total Remaining Arsenic
AREA 4	8.38	16%

	Grain Size	Fraction Total Depth	Cumulative Transport Depth	Width	% Total Width	Cumulative Transport	Q Area 4	Q BBSW01	% Total Contamination
			ft	ft		%	cfs	cfs	
Channel	0.08-8 mm	0.3	0.3	11	0.17	5%	4	9	0.8%
	8 - 36 mm	0.1	0.4	11	0.17	7%	4	9	1.1%
	36 - 75 mm	0.1	0.6	11	0.17	9%	4	9	1.4%
	75 - 95 mm	0.1	0.7	11	0.17	10%	8	17	1.7%
	95 - 115 mm	0.1	0.8	11	0.17	12%	10	22	2.0%
	115 - 132 mm	0.1	0.9	11	0.17	14%	10	22	2.2%
	132 - 145 mm	0.1	1.0	11	0.17	15%	13	27	2.5%
	145 - 150 mm	0.1	1.1	11	0.17	17%	13	27	2.8%
Main Channel	0.08-8 mm	0.3	0.3	53	0.83	42%	86	186	7%
	8 - 36 mm	0.1	0.4	53	0.83	50%	99	214	8%
	36 - 75 mm	0.1	0.6	53	0.83	59%	122	265	10%
	75 - 95 mm	0.1	0.7	53	0.83	67%	142	308	11%
	95 - 115 mm	0.1	0.8	53	0.83	75%	163	354	12%
	115 - 132 mm	0.1	0.9	53	0.83	83%	180	389	14%
	132 - 145 mm	0.1	1.0	53	0.83	92%	180	389	15%
	145 - 150 mm	0.1	1.1	53	0.83	100%	180	389	16%

	DA (mi²)	% Total Remaining Arsenic
AREA 5	18.74	3%

	Grain Size	Fraction Total Depth	Cumulative Transport Depth	Width	% Total Width	Cumulative Transport	Q Area 5	Q BBSW01	% Total Contamination
			ft	ft		%	cfs	cfs	
Channel	0.08-8 mm	0.3	0.3	8	0.11	3%	5	5	0.1%
	8 - 36 mm	0.1	0.4	8	0.11	4%	5	5	0.1%
	36 - 75 mm	0.1	0.6	8	0.11	5%	8	8	0.2%
	75 - 95 mm	0.1	0.7	8	0.11	6%	12	13	0.2%
	95 - 115 mm	0.1	0.8	8	0.11	7%	21	23	0.2%
	115 - 132 mm	0.1	0.9	8	0.11	8%	26	29	0.3%
	132 - 145 mm	0.1	1.0	8	0.11	9%	26	29	0.3%
	145 - 150 mm	0.1	1.1	8	0.11	11%	26	29	0.3%
Main Channel	0.08-8 mm	0.3	0.3	68	0.89	37%	38	41	1.1%
	8 - 36 mm	0.1	0.4	68	0.89	46%	52	57	1.4%
	36 - 75 mm	0.1	0.6	68	0.89	55%	82	89	1.7%
	75 - 95 mm	0.1	0.7	68	0.89	64%	147	161	2.0%
	95 - 115 mm	0.1	0.8	68	0.89	73%	180	197	2.2%
	115 - 132 mm	0.1	0.9	68	0.89	82%	180	197	2.5%
	132 - 145 mm	0.1	1.0	68	0.89	91%	216	236	2.8%
	145 - 150 mm	0.1	1.1	68	0.89	100%	216	236	3.1%

	DA (mi²)	% Total Remaining Arsenic
AREA 6	19.63	22%

	Grain Size	Fraction Total Depth	Cumulative Transport Depth	Width	% Total Width	Cumulative Transport	Q Area 6	Q BBSW01	% Total Contamination
			ft	ft		%	cfs	cfs	
Channel	0.08-8 mm	0.3	0.3	10	0.11	3%	5	6	0.7%
	8 - 36 mm	0.1	0.4	10	0.11	4%	5	6	0.9%
	36 - 75 mm	0.1	0.6	10	0.11	5%	11	11	1.2%
	75 - 95 mm	0.1	0.7	10	0.11	6%	23	24	1.4%
	95 - 115 mm	0.1	0.8	10	0.11	7%	28	30	1.7%
	115 - 132 mm	0.1	0.9	10	0.11	9%	36	38	1.9%
	132 - 145 mm	0.1	1.0	10	0.11	10%	36	38	2.1%
	145 - 150 mm	0.1	1.1	10	0.11	11%	36	38	2.4%
Main Channel	0.08-8 mm	0.3	0.3	84	0.89	37%	40	42	8%
	8 - 36 mm	0.1	0.4	84	0.89	46%	53	56	10%
	36 - 75 mm	0.1	0.6	84	0.89	55%	95	100	12%
	75 - 95 mm	0.1	0.7	84	0.89	64%	167	176	14%
	95 - 115 mm	0.1	0.8	84	0.89	73%	206	217	16%
	115 - 132 mm	0.1	0.9	84	0.89	82%	206	217	18%
	132 - 145 mm	0.1	1.0	84	0.89	91%	261	274	20%
	145 - 150 mm	0.1	1.1	84	0.89	100%	261	274	22%

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			Reviewed:	MLB		

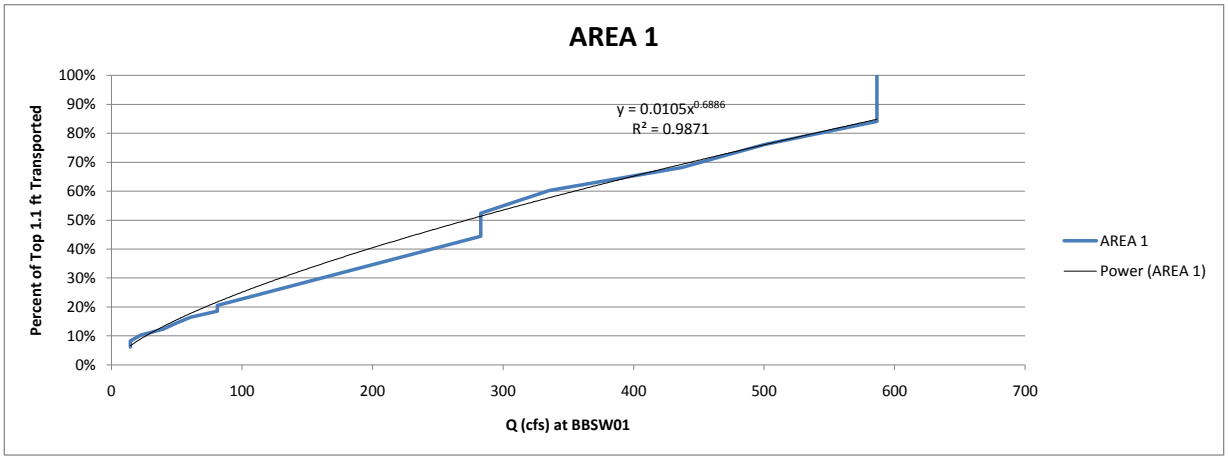
	DA (mi²)	% Total Remaining Arsenic
AREA 7	20.37	18%

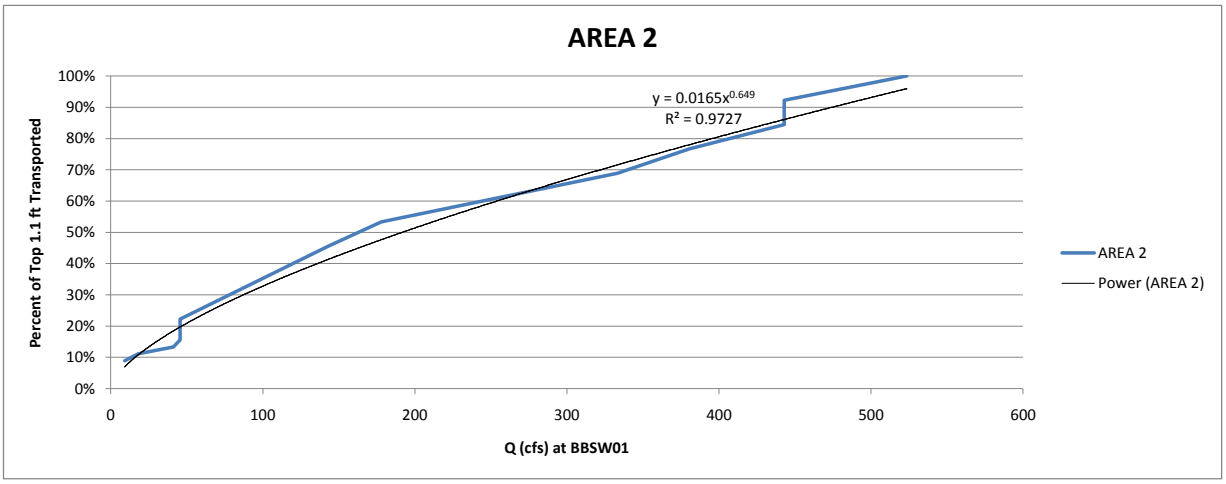
	Grain Size	Fraction Total Depth	Cumulative Transport Depth	Width	% Total Width	Cumulative Transport	Q Area 7	Q BBSW01	% Total Contamination
			ft	ft		%	cfs	cfs	
Channel	0.08-8 mm	0.3	0.3	8	0.09	3%	5	5	0.5%
	8 - 36 mm	0.1	0.4	8	0.09	3%	5	5	0.6%
	36 - 75 mm	0.1	0.6	8	0.09	4%	10	10	0.8%
	75 - 95 mm	0.1	0.7	8	0.09	5%	21	21	1.0%
	95 - 115 mm	0.1	0.8	8	0.09	6%	26	26	1.1%
	115 - 132 mm	0.1	0.9	8	0.09	7%	26	26	1.3%
	132 - 145 mm	0.1	1.0	8	0.09	8%	33	33	1.4%
	145 - 150 mm	0.1	1.1	8	0.09	9%	33	33	1.6%
Main Channel	0.08-8 mm	0.3	0.3	84	0.91	36%	58	59	7%
	8 - 36 mm	0.1	0.4	84	0.91	45%	76	77	8%
	36 - 75 mm	0.1	0.6	84	0.91	54%	125	128	10%
	75 - 95 mm	0.1	0.7	84	0.91	63%	184	188	12%
	95 - 115 mm	0.1	0.8	84	0.91	73%	223	227	13%
	115 - 132 mm	0.1	0.9	84	0.91	82%	276	281	15%
	132 - 145 mm	0.1	1.0	84	0.91	91%	276	281	17%
	145 - 150 mm	0.1	1.1	84	0.91	100%	334	340	18%

	DA (mi²)	% Total Remaining Arsenic
AREA 8	20.82	4%

	Grain Size	Fraction Total Depth	Cumulative Transport Depth	Width	% Total Width	Cumulative Transport	Q Area 8	Q BBSW01	% Total Contamination
			ft	ft		%	cfs	cfs	
Channel	0.08-8 mm	0.3	0.3	10	0.11	3%	5	5	0.1%
	8 - 36 mm	0.1	0.4	10	0.11	4%	5	5	0.2%
	36 - 75 mm	0.1	0.6	10	0.11	5%	10	10	0.2%
	75 - 95 mm	0.1	0.7	10	0.11	7%	15	15	0.3%
	95 - 115 mm	0.1	0.8	10	0.11	8%	26	26	0.3%
	115 - 132 mm	0.1	0.9	10	0.11	9%	26	26	0.4%
	132 - 145 mm	0.1	1.0	10	0.11	10%	33	33	0.4%
	145 - 150 mm	0.1	1.1	10	0.11	11%	33	33	0.5%
Main Channel	0.08-8 mm	0.3	0.3	81	0.89	38%	64	64	1.6%
	8 - 36 mm	0.1	0.4	81	0.89	47%	83	83	2.0%
	36 - 75 mm	0.1	0.6	81	0.89	55%	127	127	2.4%
	75 - 95 mm	0.1	0.7	81	0.89	64%	178	178	2.8%
	95 - 115 mm	0.1	0.8	81	0.89	73%	212	212	3.1%
	115 - 132 mm	0.1	0.9	81	0.89	82%	254	254	3.5%
	132 - 145 mm	0.1	1.0	81	0.89	91%	306	306	3.9%
	145 - 150 mm	0.1	1.1	81	0.89	100%	306	306	4.3%

The resulting transport functions for each of the 8 stabilization areas in terms of corresponding flow rate at BBSW01 are shown in the following 8 plots.





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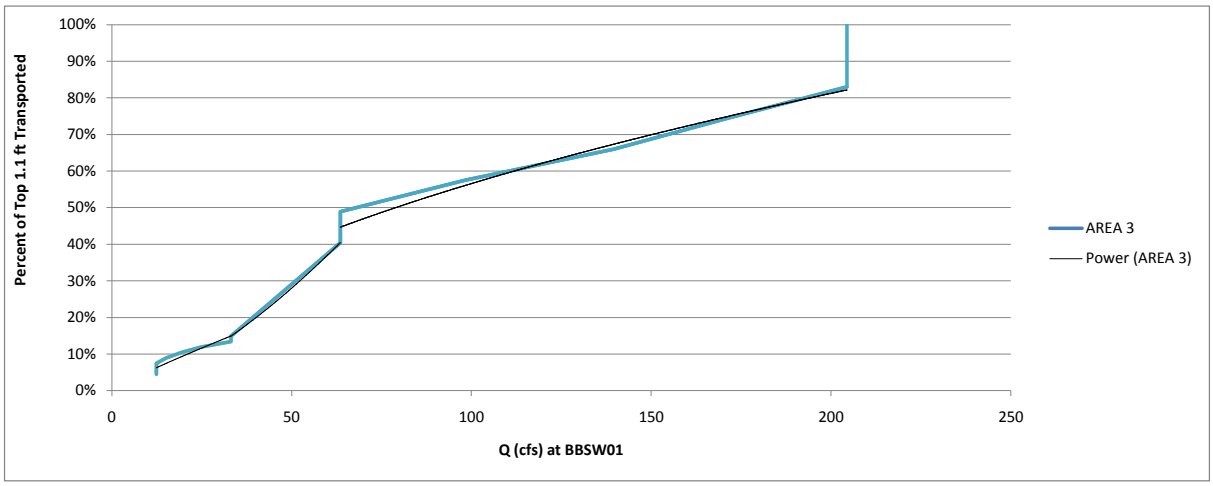
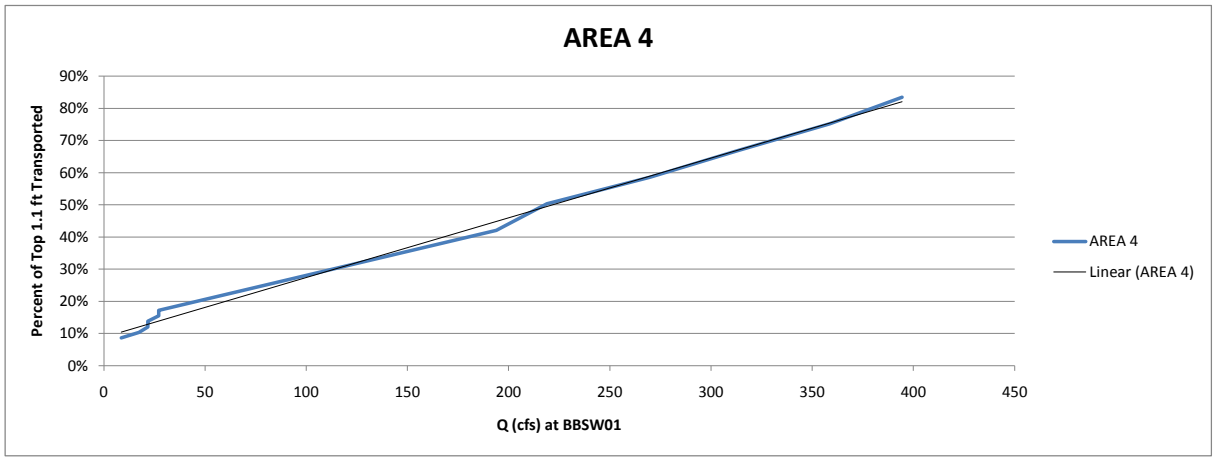
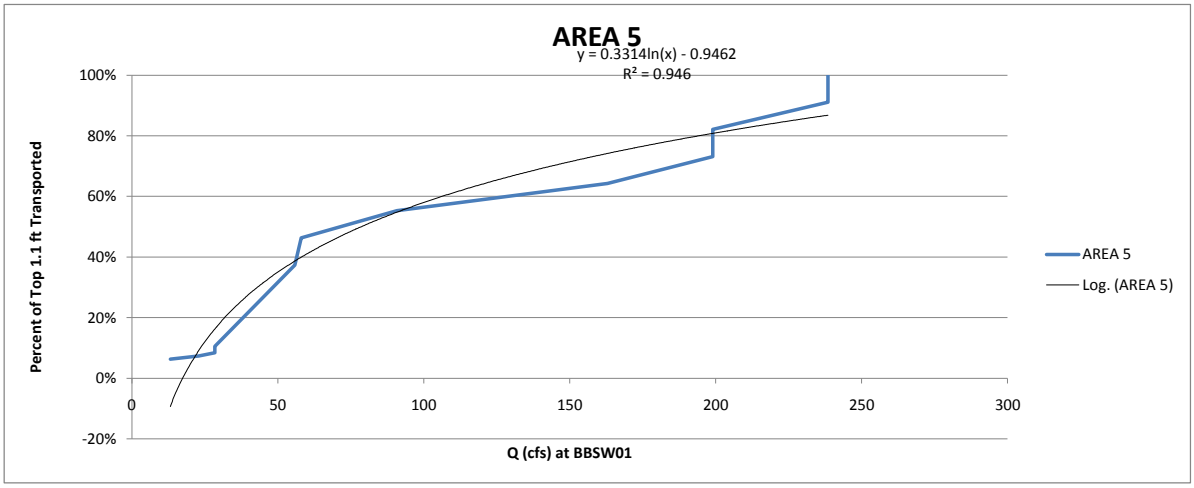
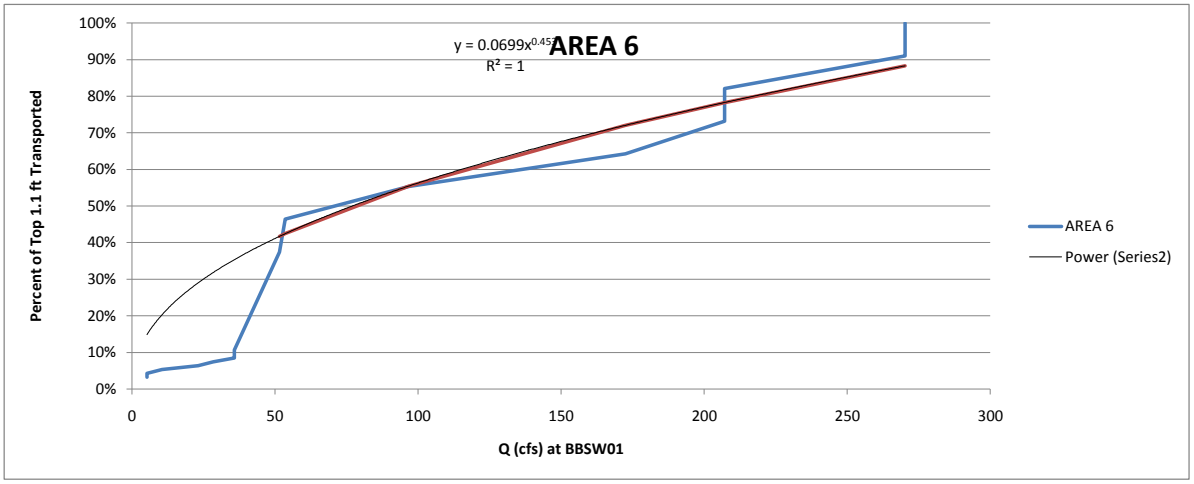
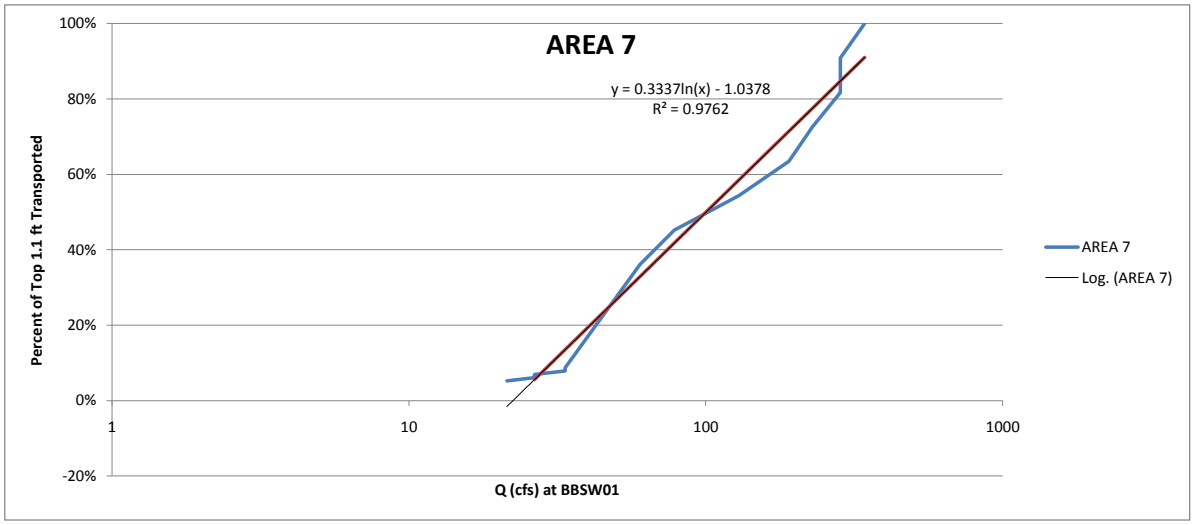


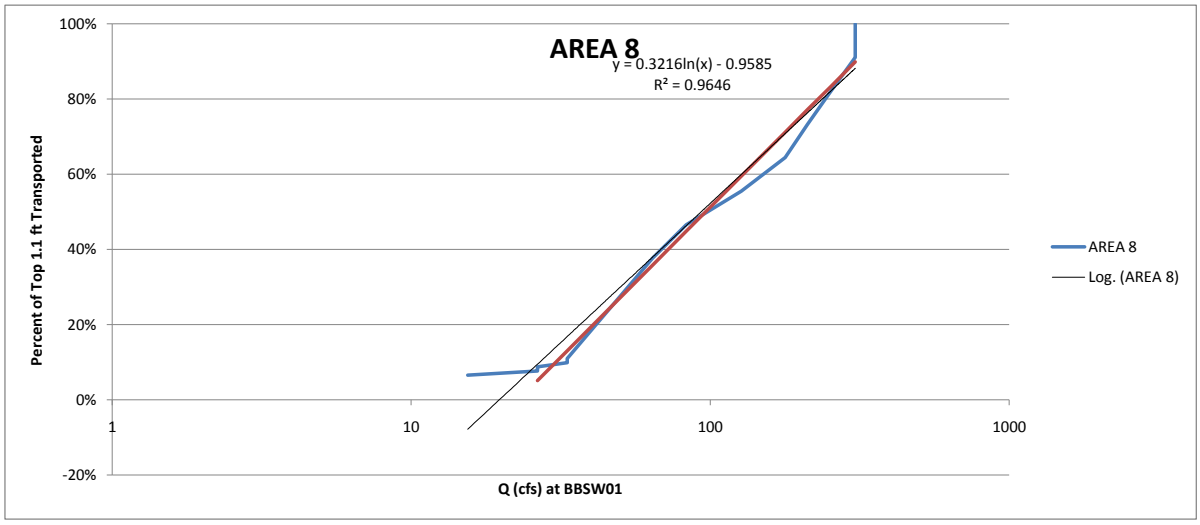




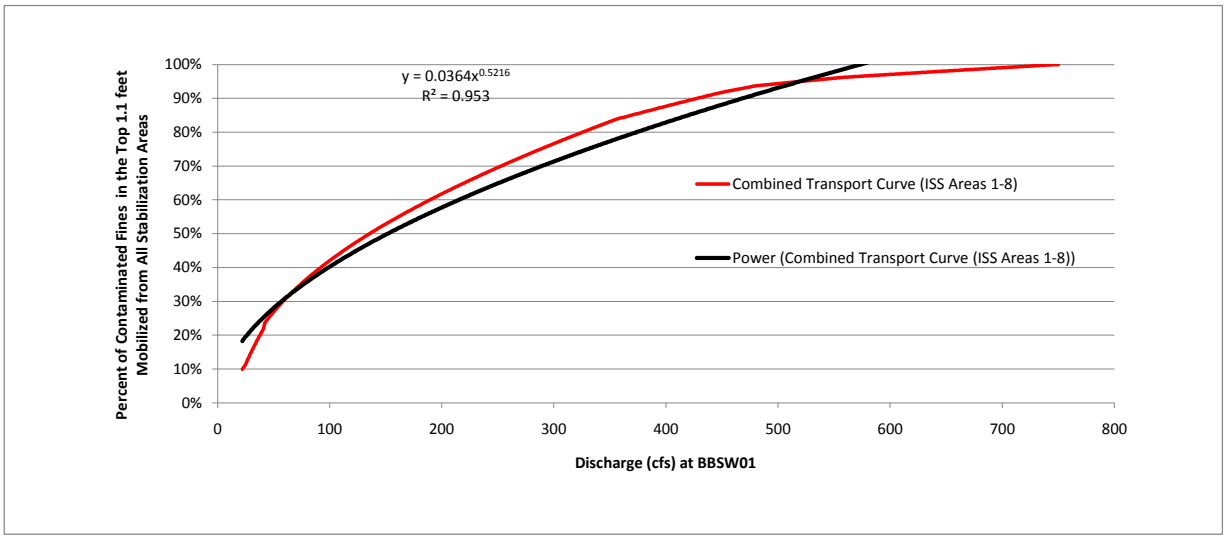
Golder Associates	Subject:	Geomorphology and Sediment Transport in Blackbird Creek Stabilization Areas				
	Job No.:	9431595.009.1281	Made by:	JLE	Date:	5/27/2011
	Task:		Checked:	AQK	Sheet:	of
			Reviewed:	MLB		





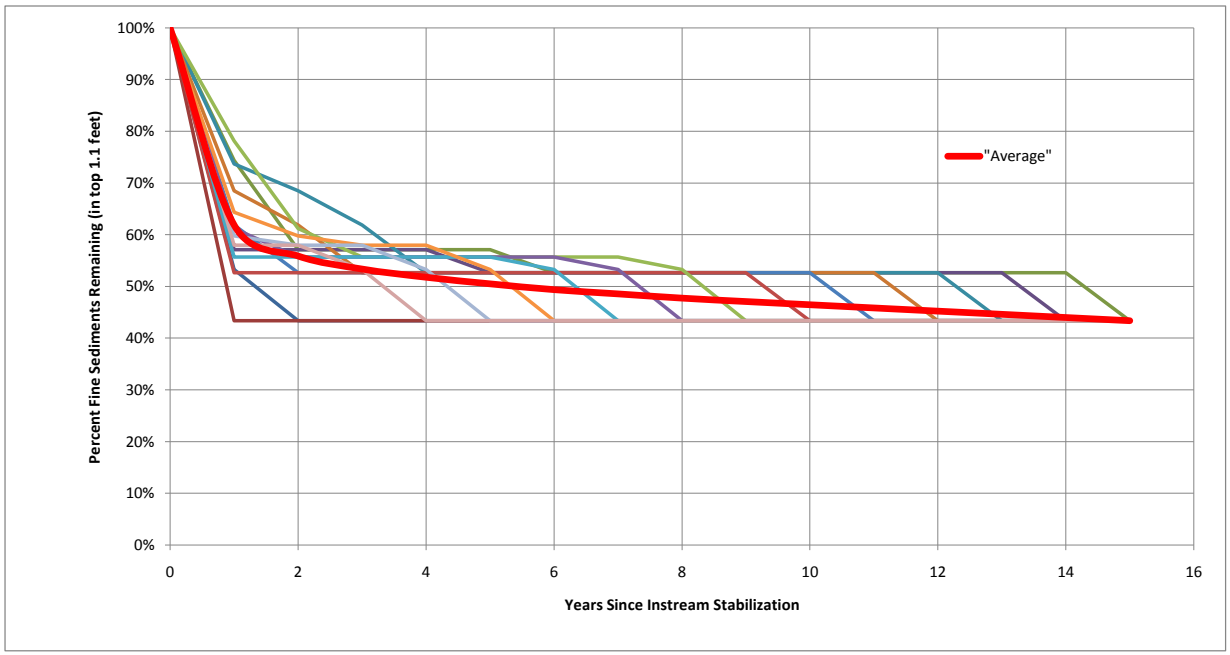


The transport functions for each individual stabilization area were then weighted according to the percent of total Arsenic estimated to be in the top 1.1 feet of each area. The sum of the weighted transport functions were used produce a combined transport function for the total remaining Arsenic in the top 1.1 feet of all 8 stabilization areas (see plot below).

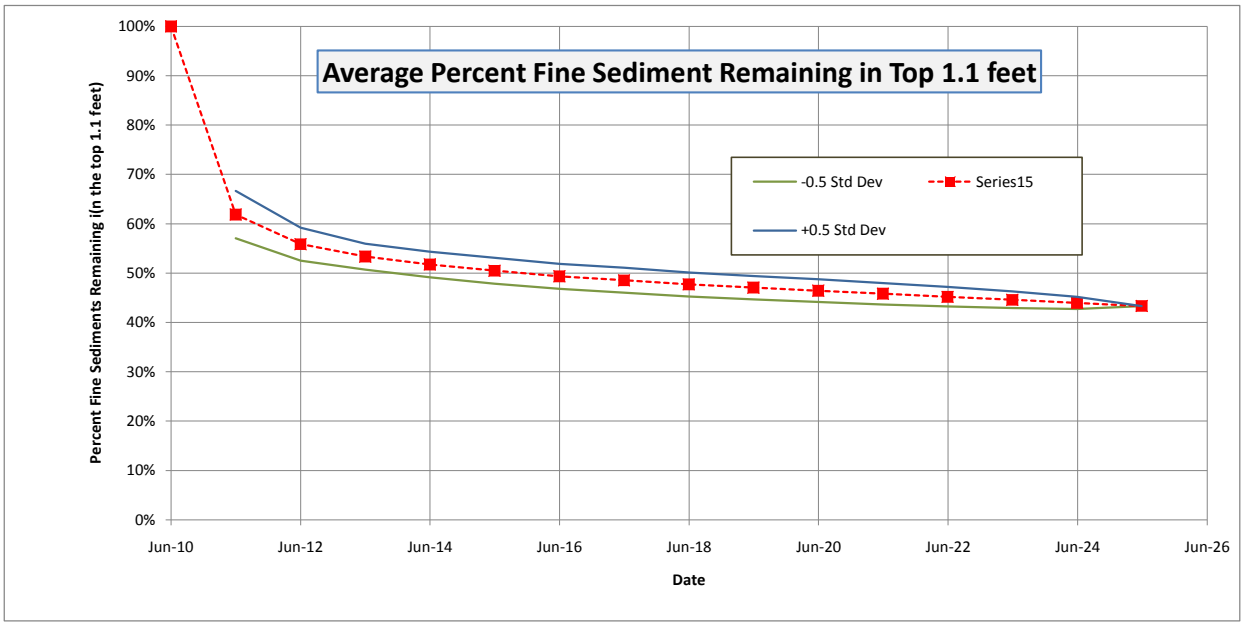


RESULTS:

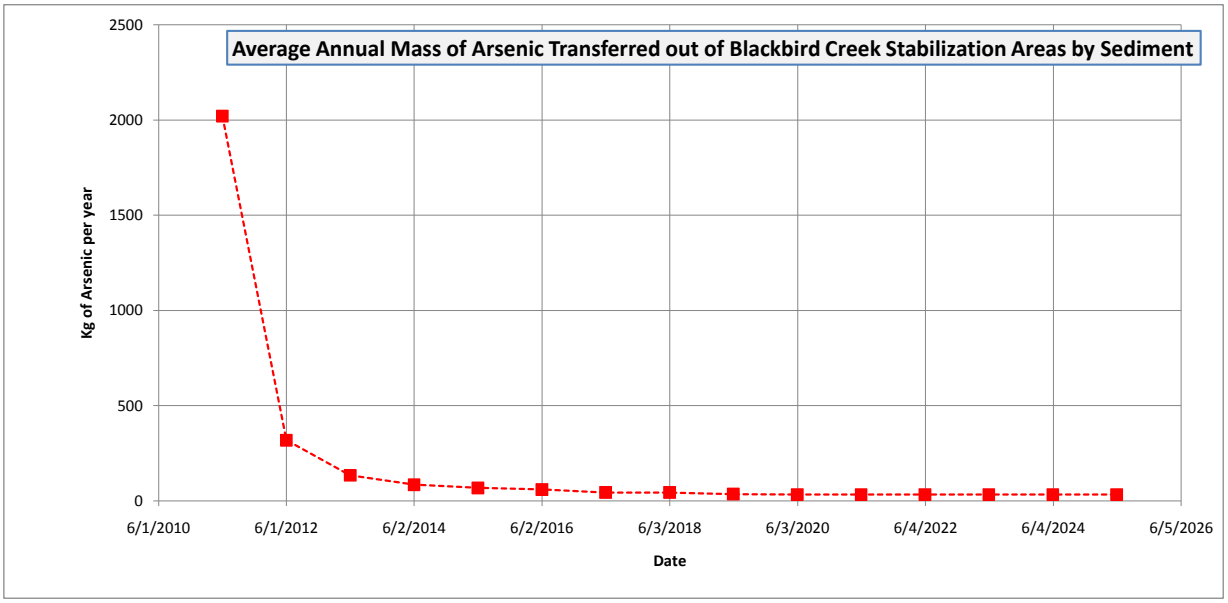
The combined transport function shown in the plot above was used to estimate how much of the total arsenic in the top 1.1 feet of the stabilization areas would be removed by various sequences of annual snowmelt events. The historical annual snowmelt flood series for BBSW01 was rearranged 15 different ways by shifting the start year each time and adding the preceding years to the end of the time series, otherwise maintaining the original sequence of annual floods to preserve interannual variability. The plot below shows the percent of contaminated fines remaining for the 15 different annual flood series. The thick red line is the average of all 15 annual flood series.



The average percent contaminated sediment remaining from the 15 different annual flood series is plotted below along with plus or minus 0.5 standard deviation.



The average annual mass of Arsenic transferred out of the stabilization areas as sediment was estimated by finding the slope of the above curve, (results shown in plot below).



APPENDIX C-2
ALTERNATIVE EFFECTIVENESS EVALUATION DURING RAINFALL RUNOFF EVENTS

Golder Associates	Subject:	Alternative effectiveness evaluation during rainfall runoff events		
	Job No.: 9431595.009	Made by: CRS	Date: 7/6/2011	
	Task: 1281	Checked: JLE		
		Modified: JLE		
		Reviewed: MLB		

OBJECTIVE: Estimate the effectiveness of the Blackbird Creek settling basins during a range of rainfall runoff events.

METHOD OF ANALYSIS:
Estimate the quantity of sediment available for transport and associated quantity of arsenic
Determine the % of fines mobilized during a range of rainfall runoff events
Estimate the % effectiveness of each alternative in controlling arsenic associated with sediment and floc

CASE 1 - Upper Bound

INPUT AND ASSUMPTIONS:

Approximate volume potentially contaminated sediments	650,000	cy	(Quantified in FS)
Arsenic in Sediment Available for transport	5,300	kg	(Quantified in Appendix D)
Total Arsenic Available for transport	5,760	kg	(sediment and yearly floc load)
Average concentration of Blackbird Cr. Seds	620	mg/kg	(Appendix D)
Soil density	100	lb/cf	
Assumed percent fines in sediments	20%		
Arsenic in potentially contaminated sediments	98,918	kg	Assumes all 650,000 cy has avg. As conc.
Percent effectiveness of in-stream stabilization	94.6%		Once all of top 1.1 ft is removed
Contribution of arsenic due to floc	16%		
	460	kg As/year	
Water treatment plant efficiency	95%	removal of contaminants	
WF Seepage Collection Efficiency	95%		
Combined Floc Treatment Efficiency	90%		

CALCULATIONS:

1) Based on the sediment transport evaluation, determine volume of sediment mobilized.

	Avg % Remaining	Avg % Mobilized in all prior years	Incremental % mobilized in interval	Incremental Arsenic mobilized in interval (kg)	Cumulative As Mass mobilized (kg)	Volume fines mobilized (cy)	Total volume mobilized (cy)	Cumulative volume mobilized (cy)	Volume available (cy)	Mass As in Sediment (kg)	Total Mass of As in system (kg)
Year 1	61%	39%	39%	2,246	2,246	2,982	14,910	14,910	635,090	2,246	96,672
Year 2	55%	45%	6%	346	2,592	459	2,294	17,204	632,796	346	96,326
Year 3	52%	48%	3%	173	2,765	229	1,147	18,351	631,649	173	96,153
Year 15	42%	58%	10%	576	3,341	765	3,823	22,174	627,826	576	95,577
Total Available		100%		5,300		7,036	35,179				

2) Using the projected Blackbird Creek flows for a range of return intervals, apply the sediment transport function developed in Appendix C-1 to determine the mass of fines that would mobilized from the top 1.1 feet of channel bed, along with the mass of arsenic.

	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
Blackbird Cr Flow (at the confluence, cfs)	16	73	122	203	393	588	1511
% of fines mobilized (% of total available in top 1.1 ft)	16%	35%	46%	60%	84%	100%	100%
Mass As mobilized (kg)	859	1870	2433	3159	4432	5300	5300
Mass As due to floc (kg)	460	460	460	460	460	460	460

3) Estimates effectiveness of alternatives in controlling quantity of arsenic available for transport

Alternative B Effectiveness - Evaluation completed in year 3 (3 years following construction of in-stream stabilization)

Year 3 As Available in sediment (kg) (in the top 1.1 ft)	2,535						
Year 3 Total As in system (kg)	96,153						
Year 3 As in floc (kg)	460	* assumes the floc flushes through Blackbird Creek each year					
Total As in system (kg)	96,613						
% of fines mobilized by flood (if available)	16%	35%	46%	60%	84%	100%	100%
Mass of As mobilized by flood (kg)	-	-	-	615	1,888	2,756	2,756
Mass of As in floc (kg)	460	460	460	460	460	460	460
Total As mobilized (kg)	460	460	460	1,075	2,348	3,216	3,216
Alt B % effectiveness	**99.5%**	**99.5%**	**99.5%**	**98.9%**	**97.6%**	**96.7%**	**96.7%**

Note there is no sediment transport for the 2 through 10 year events because the sediments that would have been mobilized by these flows have been assumed to have already flushed through the system by year 3.

Golder Associates	Subject:	Alternative effectiveness evaluation during rainfall runoff events		
	Job No.: 9431595.009	Made by: CRS	Date: 7/6/2011	
	Task: 1281	Checked: JLE		
		Modified: JLE		
		Reviewed: MLB		

Alternative C Effectiveness - Evaluation completed in year 3 (3 years following construction of in-stream stabilization)

Diversion System Capacity (cfs)	200						
Year 3 As Avail. in sediment (kg) (in top 1.1 ft)	2,535						
Year 3 Total As in system (kg)	96,153						
Year 3 As in floc (kg)	460	* assumes the floc flushes through Blackbird Creek each year					
Total As in system (kg)	96,613						
% of fines mobilized	16%	35%	46%	60%	84%	100%	100%
Mass of As mobilized by flood (kg)	-	-	-	615	1,888	2,756	2,756
Mass of As in floc (kg)	460	460	460	460	460	460	460
Total As mobilized (kg)	460	460	460	1,075	2,348	3,216	3,216

Pond effectiveness	2 year	5 year	10 year	25 year	50 year	100 year	500 year
(40% Efficiency)	40%	40%	40%	40%	40%	40%	40%
(70% Efficiency)	70%	70%	70%	70%	70%	70%	70%
(100% Efficiency)	100%	100%	100%	100%	100%	100%	100%

Arsenic mobilized into Panther Creek	2 year	5 year	10 year	25 year	50 year	100 year	500 year
(40% Efficiency)	276	276	276	651	1,870	2,778	3,046
(70% Efficiency)	138	138	138	334	1,512	2,450	2,918
(100% Efficiency)	-	-	-	16	1,153	2,122	2,790

The basins are zero percent effective in removing arsenic from the portion of the flow that exceeds 200 cfs.
Arsenic is assumed to be uniformly distributed throughout flow.

Alt C % Effectiveness	**2 year**	**5 year**	**10 year**	**25 year**	**50 year**	**100 year**	**500 year**
(40% Efficiency)	**99.7%**	**99.7%**	**99.7%**	**99.3%**	**98.1%**	**97.1%**	**96.8%**
(70% Efficiency)	**99.9%**	**99.9%**	**99.9%**	**99.7%**	**98.4%**	**97.5%**	**97.0%**
(100% Efficiency)	**100%**	**100%**	**100%**	**100%**	**98.8%**	**97.8%**	**97.1%**

Alternative F Effectiveness - Evaluation completed in year 3 (3 years following construction of in-stream stabilization)

Year 3 Sediment Total Sediment	631,649						
Year 3 As Total in sediments (kg)	96,153						
Year 3 As Available in sediment (kg) (in top 1.1 ft)	2,535						
Year 3 As in floc (kg)	460	* assumes the floc flushes through Blackbird Creek each year					
Total As available for transport (kg)	2,995						
Total As in system (kg)	96,613						
% of fines mobilized by flood (if available)	16%	35%	46%	60%	84%	97%	100%
Mass of As in sediment mobilized by flood (kg)	-	-	-	615	1,888	2,756	2,756
Mass of As in floc (kg)*(100%-Eff)	45	45	45	45	45	45	45
Total As mobilized to Panther Creek (kg)	45	45	45	660	1,933	2,801	2,801
Alt F % effectiveness	**100%**	**100%**	**100%**	**99.3%**	**98.0%**	**97.1%**	**97.1%**

Note there is no sediment transport for the 2 through 10 year events because the sediments that would have been mobilized by these flows have been assumed to have already flushed through the system by year 3.

RESULTS:

Alternative Effectiveness Comparison

	Flood Recurrence Interval						
Alternative	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
Alternative B	99.5%	99.5%	99.5%	98.9%	97.6%	96.7%	96.7%
Alt. C - 40% pond effec.	99.7%	99.7%	99.7%	99.3%	98.1%	97.1%	96.8%
Alt. C - 70% pond effec.	99.9%	99.9%	99.9%	99.7%	98.4%	97.5%	97.0%
Alt. C - 100% pond effec.	100%	100%	100%	100%	98.8%	97.8%	97.1%
Alternative F	100%	100%	100%	99.3%	98.0%	97.1%	97.1%

Golder Associates	Subject:	Alternative effectiveness evaluation during rainfall runoff events		
	Job No.: 9431595.009	Made by: CRS	Date: 7/6/2011	
	Task: 1281	Checked: JLE		
		Modified: JLE		
		Reviewed: MLB		

CASE 2 - Lower Bound

INPUT AND ASSUMPTIONS:

Approximate volume potentially contaminated sediments	650,000	cy	(Quantified in FS)
Arsenic in Sediment Available for transport	6,630	kg	(Quantified in Appendix D)
Total Arsenic Available for transport	7,090	kg	(sediment and yearly floc load)
Average concentration of Blackbird Cr. Seds	620	mg/kg	(Appendix D)
Soil density	100	lb/cf	
Assumed percent fines in stable sediments	10%		
Assumed percent fines in top 1.1 ft	25%		
Arsenic in potentially contaminated sediments	49,459	kg	Assumes all 650,000 cy has avg. As conc.
Percent effectiveness of in-stream stabilization	86.6%		Once all of top 1.1 ft is removed
Contribution of arsenic due to floc	16%		
	460	kg As/year	
Water treatment plant efficiency	95%	removal of contaminants	
WF Seepage Collection Efficiency	95%		
Combined Floc Treatment Efficiency	90%		

CALCULATIONS:

1) Based on the sediment transport evaluation, determine volume of sediment mobilized.

	Avg % Remaining	Avg % Mobilized in all prior years	Incremental % mobilized in interval	Incremental Arsenic mobilized in interval (kg)	Cumulative As Mass mobilized (kg)	Volume fines mobilized (cy)	Total volume mobilized (cy)	Cumulative volume mobilized (cy)	Volume available (cy)	Mass As in Sediment (kg)	Total Mass of As in system (kg)
Year 1	61%	39%	39%	2,765	2,765	3,671	14,910	14,910	635,090	2,765	46,694
Year 2	55%	45%	6%	425	3,191	565	2,294	17,204	632,796	425	46,269
Year 3	52%	48%	3%	213	3,403	282	1,147	18,351	631,649	213	46,056
Year 15	42%	58%	10%	709	4,112	941	3,823	22,174	627,826	709	45,347
Total Available		100%		6,630		8,801	35,179				

2) Using the projected Blackbird Creek flows for a range of return intervals, apply the sediment transport function developed in Appendix C-1 to determine the mass of fines that would mobilized from the top 1.1 feet of channel bed, along with the mass of arsenic.

	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
Blackbird Cr Flow (at the confluence, cfs)	16	73	122	203	393	588	1511
% of fines mobilized (% of total available in top 1.1 ft)	16%	35%	46%	60%	84%	100%	100%
Mass As mobilized (kg)	1074	2339	3043	3951	5544	6630	6630
Mass As due to floc (kg)	460	460	460	460	460	460	460

3) Estimates effectiveness of alternatives in controlling quantity of arsenic available for transport

Alternative B Effectiveness - Evaluation completed in year 3 (3 years following construction of in-stream stabilization)

Year 3 As Available in sediment (kg) (in the top 1.1 ft)	3,227						
Year 3 Total As in system (kg)	46,056						
Year 3 As in floc (kg)	460	* assumes the floc flushes through Blackbird Creek each year					
Total As in system (kg)	46,516						
% of fines mobilized by flood (if available)	16%	35%	46%	60%	84%	100%	100%
Mass of As mobilized by flood (kg)	-	-	-	769	2,362	3,448	3,448
Mass of As in floc (kg)	460	460	460	460	460	460	460
Total As mobilized (kg)	460	460	460	1,229	2,822	3,908	3,908
Alt B % effectiveness	**99.0%**	**99.0%**	**99.0%**	**97.3%**	**93.9%**	**91.5%**	**91.5%**

Note there is no sediment transport for the 2 through 10 year events because the sediments that would have been mobilized by these flows have been assumed to have already flushed through the system by year 3.

Alternative C Effectiveness - Evaluation completed in year 3 (3 years following construction of in-stream stabilization)

Diversion System Capacity (cfs)	200						
Year 3 As Avail. in sediment (kg) (in top 1.1 ft)	3,227						
Year 3 Total As in system (kg)	46,056						
Year 3 As in floc (kg)	460	* assumes the floc flushes through Blackbird Creek each year					
Total As in system (kg)	46,516						
% of fines mobilized	16%	35%	46%	60%	84%	100%	100%
Mass of As mobilized by flood (kg)	-	-	-	769	2,362	3,448	3,448
Mass of As in floc (kg)	460	460	460	460	460	460	460
Total As mobilized (kg)	460	460	460	1,229	2,822	3,908	3,908

Pond effectiveness	2 year	5 year	10 year	25 year	50 year	100 year	500 year
(40% Efficiency)	40%	40%	40%	40%	40%	40%	40%
(70% Efficiency)	70%	70%	70%	70%	70%	70%	70%
(100% Efficiency)	100%	100%	100%	100%	100%	100%	100%

Golder Associates	Subject:	Alternative effectiveness evaluation during rainfall runoff events		
	Job No.: 9431595.009	Made by: CRS	Date: 7/6/2011	
	Task: 1281	Checked: JLE		
		Modified: JLE		
		Reviewed: MLB		

Arsenic mobilized into Panther Creek	2 year	5 year	10 year	25 year	50 year	100 year	500 year
(40% Efficiency)	276	276	276	745	2,247	3,376	3,701
(70% Efficiency)	138	138	138	381	1,817	2,977	3,546
(100% Efficiency)	-	-	-	18	1,386	2,578	3,390

The basins are zero percent effective in removing arsenic from the portion of the flow that exceeds 200 cfs.
Arsenic is assumed to be uniformly distributed throughout flow.

Alt C % Effectiveness	**2 year**	**5 year**	**10 year**	**25 year**	**50 year**	**100 year**	**500 year**
(40% Efficiency)	**99.4%**	**99.4%**	**99.4%**	**98.4%**	**95.2%**	**92.7%**	**92.0%**
(70% Efficiency)	**99.7%**	**99.7%**	**99.7%**	**99.2%**	**96.1%**	**93.6%**	**92.4%**
(100% Efficiency)	**100%**	**100%**	**100%**	**100%**	**97.0%**	**94.5%**	**92.7%**

Alternative F Effectiveness - Evaluation completed in year 3 (3 years following construction of in-stream stabilization)

Year 3 Sediment Total Sediment	631,649						
Year 3 As Total in sediments (kg)	46,056						
Year 3 As Available in sediment (kg) (in top 1.1 ft)	3,227						
Year 3 As in floc (kg)	460	* assumes the floc flushes through Blackbird Creek each year					
Total As available for transport (kg)	3,687						
Total As in system (kg)	46,516						
% of fines mobilized by flood (if available)	16%	35%	46%	60%	84%	94%	100%
Mass of As in sediment mobilized by flood (kg)	-	-	-	769	2,362	3,448	3,448
Mass of As in floc (kg)*(100%-Eff)	45	45	45	45	45	45	45
Total As mobilized to Panther Creek (kg)	45	45	45	814	2,407	3,492	3,492
Alt F % effectiveness	**99.9%**	**99.9%**	**99.9%**	**98.3%**	**94.8%**	**92.5%**	**92.5%**

Note there is no sediment transport for the 2 through 10 year events because the sediments that would have been mobilized by these flows have been assumed to have already flushed through the system by year 3.

RESULTS:

Alternative Effectiveness Comparison

	Flood Recurrence Interval						
Alternative	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
Alternative B	99.0%	99.0%	99.0%	97.3%	93.9%	91.5%	91.5%
Alt. C - 40% pond effec.	99.4%	99.4%	99.4%	98.4%	95.2%	92.7%	92.0%
Alt. C - 70% pond effec.	99.7%	99.7%	99.7%	99.2%	96.1%	93.6%	92.4%
Alt. C - 100% pond effec.	100%	100%	100%	100%	97.0%	94.5%	92.7%
Alternative F	99.9%	99.9%	99.9%	98.3%	94.8%	92.5%	92.5%

APPENDIX D
CONTAMINATED SEDIMENT IN BLACKBIRD CREEK

Table D-1: Blackbird Creek - Remaining Arsenic and Cobalt Contaminated Sediment

Line	Blackbird Creek Reach: Station	Blackbird Creek Reach: Station	Blackbird Creek Coverage: (lineal ft)	Blackbird Creek Coverage: (%)	Area Description	Type of Reach	Location	Stabilized (V/Y/N)	Approximate Surface Area (sq. ft)	Approximate Depth (ft)	Approximate Volume (cy)	Approximate Volume (m^3)	Approximate Total Bedload Mass (kg)	Approximate Fine-grain Substrate Mass (kg) (20% of Bedload)	Approximate Fine-grain Substrate Mass (kg) (5% of Bedload)	XRF Testing Performed (Y/N): In-situ	XRF Testing Performed (Y/N): Field Lab	XRF Testing Performed (Y/N): Cert. Lab	Year(s)	Average [As] (mg/kg)	Average [Co] (mg/kg)	Remaining Arsenic Weight (kg)	Remaining Cobalt Weight (kg)
1	324.00	321.00	300	0.93	In-stream	Transport	Upper	N	2221.24	1.00	82.27	62.90	141521.66		7076.08	N	Y	Y	2010	994	377	7	3
2	321.00	319.50	150	0.46	In-stream		Upper	V	1168.08	1.00	43.26	33.08	74421.77		3721.09	Y	Y	Y	2010	534	311	2	1
3	319.50	313.50	600	1.85	In-stream		Upper	Y	4235.18	1.00	156.86	119.93	269835.64		13491.78	N	Y	Y	2010	919	231	12	3
4	313.50	313.25	25	0.08	In-stream		Upper	V	234.57	1.00	8.69	6.64	14945.14		747.26	N	Y	Y	2010	200	*281*	0	0
5	313.25	279.50	3375	10.42	In-stream		Upper	N	52343.22	1.00	1938.64	1482.19	3334938.46		166746.92	N	Y	Y	2010	1195	331	199	55
6	279.50	269.50	999	3.08	Stabilization Area #1	Depositional	Upper	Y	60706.07	1.10	2473.21	1890.91	4254536.30	850907.26		Y	Y	Y	2009/2010	1278	256	1088	218
7	269.50	257.00	1250	3.86	In-stream	Transport	Upper	N	15056.72	1.00	557.66	426.36	959307.51		47965.38	N	N	N	na	*1023*	*176*	49	*8*
8	257.00	251.25	575	1.77	Stabilization Area #2	Depositional	Upper	Y	44348.24	1.10	1806.78	1381.38	3108110.67	621622.13		Y	Y	Y	2003, 2009/2010	768	*176*	477	*109*
9	251.25	242.00	925	2.85	In-stream	Transport	Upper	N	9834.58	1.00	364.24	278.48	626589.92		31329.50	Y	Y	N	2009/2010	607	146	19	5
10	242.00	232.00	1000	3.09	Stabilization Area #3	Depositional	Upper	Y	45785.25	1.10	1865.32	1426.14	3208822.37	641764.47		Y	N	N	2010	490	*96*	314	*62*
11	232.00	223.00	900	2.78	In-stream	Transport	Upper	Y	9719.51	1.00	359.98	275.23	619257.97		30962.90	Y	Y	Y	2009/2010	1145	47	35	1
12	223.00	220.50	250	0.77	In-stream		Upper	N	3121.32	1.00	115.60	88.39	198868.18		9943.41	Y	Y	Y	2009	922	145	9	1
13	220.50	192.25	2825	8.72	In-stream	Transport	Upper	N	34437.65	1.00	1275.47	975.17	2194122.67		109706.13	Y	Y	N	2009	1969	106	216	12
14	192.25	179.75	1250	3.86	In-stream	Transport	Middle	N	16373.71	1.00	606.43	463.65	1043216.38		52160.82	Y	Y	N	2009/2010	859	*147*	45	*8*
15	179.75	156.75	2300	7.10	Stabilization Area #4	Depositional	Middle	Y	149802.86	1.10	6103.08	4666.14	10498813.34	2099762.67		Y	Y	N	2010	410	*147*	860	*309*
16	156.75	153.50	325	1.00	Upstream of WF Pond	Sediment Pond	Middle	Y	21658.27	1.10	882.37	674.62	1517902.51	303580.50		N	N	N	na	NA	NA		
17	153.50	152.50	100	0.31	Armored WF Pond Inflow		Middle	Y	3108.17	0.00	0.00	0.00	0.00	0.00		N	N	N	2010	NA	NA		
18	152.50	149.00	350	1.08	West Fork Sediment Pond		Middle	NA	30908.06	0.00	0.00	0.00	0.00	0.00		Y	Y	N	2010	NA	NA		
19	149.00	148.75	25	0.08	Armored WF Pond Outflow		Middle	Y	1402.03	0.00	0.00	0.00	0.00	0.00		N	N	N	2010	NA	NA		
20	148.75	142.75	600	1.85	Stabilization Area #5a	Depositional	Middle	Y	18900.90	0.00	0.00	0.00	0.00	0.00		Y	N	N	2010	929	*147*	0	*0*
21	142.75	140.75	200	0.62	In-stream	Transport	Middle	V	3794.10	1.00	140.52	107.44	241733.08		12086.65	N	Y	Y	2003	945	*147*	11	2
22	140.75	133.25	750	2.31	Stabilization Area #5b	Depositional	Middle	Y	42598.02	1.10	1735.48	1326.87	2985448.31	597089.66		Y	N	Y?	2009/2010?	271	187	162	112
23	133.25	122.50	1075	3.32	In-stream	Transport	Middle	V	16401.98	1.00	607.48	464.45	1045017.57		52250.88	N	Y	N	Pre-2003	468	*167*	24	9
24	122.50	120.00	250	0.77	In-stream		Middle	N	5630.58	1.00	208.54	159.44	358740.62		17937.03	Y	N	N	2010	426	*167*	8	3
25	120.00	101.75	1825	5.63	Stabilization Area #6	Depositional	Middle/Lower	Y	197451.07	1.10	8044.30	6150.31	13838200.31	2767640.06		Y	Y	Y	2003, 2010	438	146	1212	404
26	101.75	99.00	275	0.85	In-stream	Transport	Lower	V	5170.55	1.00	191.50	146.41	329430.61		16471.53	Y	Y	N	2003, 2010	308	*154*	5	*3*
27	99.00	90.00	900	2.78	In-stream		Lower	N	16142.02	1.00	597.85	457.09	1028455.06		51422.75	Y	Y	Y	Pre-2003, 2003, 2010	412	162	21	8
28	90.00	71.75	1825	5.63	In-stream		Lower	V	26835.80	1.00	993.92	759.91	1709786.76		85489.34	Y	Y	N	Pre-2003, 2010	549	*155*	47	13
29	71.75	55.00	1675	5.17	Stabilization Area #7	Depositional	Lower	Y	154275.47	1.10	6285.30	4805.45	10812272.56	2162454.51		Y	Y	N	Pre-2003/2003, 2010	445	147	962	318
30	55.00	54.00	100	0.31	In-stream	Transport	Lower	N	4639.33	1.00	171.83	131.37	295585.44		14779.27	Y	Y	N	Pre-2003/2003, 2010	343	*222*	5	3
31	54.00	52.75	125	0.39	In-stream		Lower	N	2358.45	1.00	87.35	66.78	150263.81		7513.19	Y	Y	Y	2003, 2010	343	*147*	3	1
32	52.75	39.00	1375	4.24	In-stream		Lower	V	18445.98	1.00	683.18	522.33	1175246.78		58762.34	Y	Y	N	2003, 2010	343	*147*	20	9
33	39.00	31.75	725	2.24	Stabilization Area #8	Depositional	Lower	Y	42452.53	1.10	1729.55	1322.33	2975251.67	595050.33		Y	Y	N	2003, 2010	380	*147*	226	*87*
34	31.75	26.75	500	1.54	Lower BB Crk Sed Ponds	Sediment Ponds	Lower	NA	18144.88	0.00	0.00	0.00	0.00	0.00		N	Y	Y	2009	257	71	0	0
35	26.75	26.50	25	0.08	Under Road Bridge	Transport	Lower	NA	857.22	1.00	31.75	24.27	54615.98		2730.80	N	N	N	NA	*280*	*85*	1	0
36	26.50	23.50	300	0.93	In-stream		Lower	N	7071.73	*1.00*	261.92	200.25	450560.49	90112.10		Y	Y	Y	2009	303	99	27	9
37	23.50	22.45	105	0.32	Confluence of BB/PA Crks		Lower	NA	5768.19	*0.00*	0.00	0.00	0.00	0.00		Y	Y	Y	2009	*261*	*95*	0	0
38	22.45	0.00	2245	6.93	Panther Creek - In-stream	NA	Lower	NA	27000.00	*0.00*	0.00	0.00	0.00	0.00		Y	Y	Y	2009	218	90	0	0
		Totals	32399	100																	**Estimated Total Weight (Kg)**	6068	1776
		Stabilized	**21374**	**66.0**																	Total Weight (Metric Tons)	6.1	1.8
		Partially Stabilized (vegetation/trees)	**5150**	**15.9**																			
		Not Stabilized	5000	15.4																			
		MISC Reaches (i.e. Sed Pond)	875	2.7																			

Assumptions :

Bedload Density =	2250	kg/m^3
Fine-grain concentration within volume (Stabilization Area) =	20	%
Fine-grain concentration within volume (In-stream) =	5	%
Depth of Potential Mobile Sediment (Stabilization Area)=	1.1	feet
Depth of Potential Mobile Sediment Based on 2-year flow Surface Area (In-stream)=	1	feet

Notes:

1) In-Stream indicates area within 2-year floodplain
2) Stabilization Area - area stabilized during 2009 and 2010 construction season
3) V = Stabilized by existing vegetation and/or trees
4) na = not available
5) NA = Not Applicable
6) Italicized values indicate that concentration values were obtained using in-situ XRF results (arsenic only) or estimated by using averages of concentrations from upstream and downstream areas of reach lacking data
7) Contaminant Concentrations are averages of in-situ, field lab XRF & certified lab XRF results for Arsenic and Cobalt in the particular Blackbird Creek reach

Average concentration of sediments in Blackbird Creek (mg/kg) **624** **166**

Total Quantity Available for Transport

	Arsenic (kg)	Cobalt (kg)
Upper Blackbird Creek	221	62
Stabilization Areas	5301	1619
Transport Areas	519	86
Below Bridge Area	27	9

Table D-2: Blackbird Creek - Remaining Arsenic and Cobalt Contaminated Sediment

Line	Blackbird Creek Reach		Blackbird Creek Coverage		Area Description	Type of Reach	Location	Stabilized (V/Y/N)	Approximate Surface Area (sq. ft)	Approximate Depth (ft)	Approximate Volume (cy)	Approximate Volume (m^3)	Approximate Total Bedload Mass (kg)	Approximate Fine-grain Substrate Mass (kg) (20% of Bedload)	Approximate Fine-grain Substrate Mass (kg) (5% of Bedload)	XRF Testing Performed (Y/N)			Year(s)	Average [As] (mg/kg)	Average [Co] (mg/kg)	Remaining Arsenic	Remaining Cobalt
	Station	Station	(lineal ft)	(%)												In-situ	Field Lab	Cert. Lab				Weight (kg)	Weight (kg)
1	324.00	321.00	300	0.93	In-stream		Upper	N	2221.24	1.00	82.27	62.90	141521.66		7076.08	N	Y	Y	2010	994	377	7	3
2	321.00	319.50	150	0.46	In-stream		Upper	V	1168.08	1.00	43.26	33.08	74421.77		3721.09	Y	Y	Y	2010	534	311	2	1
3	319.50	313.50	600	1.85	In-stream	Transport	Upper	Y	4235.18	1.00	156.86	119.93	269835.64		13491.78	N	Y	Y	2010	919	231	12	3
4	313.50	313.25	25	0.08	In-stream		Upper	V	234.57	1.00	8.69	6.64	14945.14		747.26	N	Y	Y	2010	200	*281*	0	0
5	313.25	279.50	3375	10.42	In-stream		Upper	N	52343.22	1.00	1938.64	1482.19	3334938.46		166746.92	N	Y	Y	2010	1195	331	199	55
6	279.50	269.50	999	3.08	Stabilization Area #1	Depositional	Upper	Y	60706.07	1.10	2473.21	1890.91	4254536.30	1063634.08		Y	Y	Y	2009/2010	1278	256	1360	272
7	269.50	257.00	1250	3.86	In-stream	Transport	Upper	N	15056.72	1.00	557.66	426.36	959307.51		47965.38	N	N	N	na	*1023*	*176*	49	*8*
8	257.00	251.25	575	1.77	Stabilization Area #2	Depositional	Upper	Y	44348.24	1.10	1806.78	1381.38	3108110.67	777027.67		Y	Y	Y	2003, 2009/2010	768	*176*	597	*137*
9	251.25	242.00	925	2.85	In-stream	Transport	Upper	N	9834.58	1.00	364.24	278.48	626589.92		31329.50	Y	Y	N	2009/2010	607	146	19	5
10	242.00	232.00	1000	3.09	Stabilization Area #3	Depositional	Upper	Y	45785.25	1.10	1865.32	1426.14	3208822.37	802205.59		Y	N	N	2010	490	*96*	393	*77*
11	232.00	223.00	900	2.78	In-stream	Transport	Upper	Y	9719.51	1.00	359.98	275.23	619257.97		30962.90	Y	Y	Y	2009/2010	1145	47	35	1
12	223.00	220.50	250	0.77	In-stream		Upper	N	3121.32	1.00	115.60	88.39	198868.18		9943.41	Y	Y	Y	2009	922	145	9	1
13	220.50	192.25	2825	8.72	In-stream	Transport	Upper	N	34437.65	1.00	1275.47	975.17	2194122.67		109706.13	Y	Y	N	2009	1969	106	216	12
14	192.25	179.75	1250	3.86	In-stream	Transport	Middle	N	16373.71	1.00	606.43	463.65	1043216.38		52160.82	Y	Y	N	2009/2010	859	*147*	45	*8*
15	179.75	156.75	2300	7.10	Stabilization Area #4	Depositional	Middle	Y	149802.86	1.10	6103.08	4666.14	10498813.34	2624703.33		Y	Y	N	2010	410	*147*	1075	*386*
16	156.75	153.50	325	1.00	Upstream of WF Pond		Middle	Y	21658.27	1.10	882.37	674.62	1517902.51	379475.63		N	N	N	na	NA	NA		
17	153.50	152.50	100	0.31	Armored WF Pond Inflow	Sediment Pond	Middle	Y	3108.17	0.00	0.00	0.00	0.00	0.00		N	N	N	2010	NA	NA		
18	152.50	149.00	350	1.08	West Fork Sediment Pond		Middle	NA	30908.06	0.00	0.00	0.00	0.00	0.00		Y	Y	N	2010	NA	NA		
19	149.00	148.75	25	0.08	Armored WF Pond Outflow		Middle	Y	1402.03	0.00	0.00	0.00	0.00	0.00		N	N	N	2010	NA	NA		
20	148.75	142.75	600	1.85	Stabilization Area #5a	Depositional	Middle	Y	18900.90	0.00	0.00	0.00	0.00	0.00		Y	N	N	2010	929	*147*	0	*0*
21	142.75	140.75	200	0.62	In-stream	Transport	Middle	V	3794.10	1.00	140.52	107.44	241733.08		12086.65	N	Y	Y	2003	945	*147*	11	2
22	140.75	133.25	750	2.31	Stabilization Area #5b	Depositional	Middle	Y	42598.02	1.10	1735.48	1326.87	2985448.31	746362.08		Y	N	Y?	2009/2010?	271	187	202	140
23	133.25	122.50	1075	3.32	In-stream	Transport	Middle	V	16401.98	1.00	607.48	464.45	1045017.57		52250.88	N	Y	N	Pre-2003	468	*167*	24	9
24	122.50	120.00	250	0.77	In-stream		Middle	N	5630.58	1.00	208.54	159.44	358740.62		17937.03	Y	N	N	2010	426	*167*	8	3
25	120.00	101.75	1825	5.63	Stabilization Area #6	Depositional	Middle/Lower	Y	197451.07	1.10	8044.30	6150.31	13838200.31	3459550.08		Y	Y	Y	2003, 2010	438	146	1515	505
26	101.75	99.00	275	0.85	In-stream		Lower	V	5170.55	1.00	191.50	146.41	329430.61		16471.53	Y	Y	N	2003, 2010	308	*154*	5	*3*
27	99.00	90.00	900	2.78	In-stream	Transport	Lower	N	16142.02	1.00	597.85	457.09	1028455.06		51422.75	Y	Y	Y	Pre-2003, 2003, 2010	412	162	21	8
28	90.00	71.75	1825	5.63	In-stream		Lower	V	26835.80	1.00	993.92	759.91	1709786.76		85489.34	Y	Y	N	Pre-2003, 2010	549	*155*	47	13
29	71.75	55.00	1675	5.17	Stabilization Area #7	Depositional	Lower	Y	154275.47	1.10	6285.30	4805.45	10812272.56	2703068.14		Y	Y	N	Pre-2003/2003, 2010	445	147	1203	397
30	55.00	54.00	100	0.31	In-stream		Lower	N	4639.33	1.00	171.83	131.37	295585.44		14779.27	Y	Y	N	Pre-2003/2003, 2010	343	222	5	3
31	54.00	52.75	125	0.39	In-stream	Transport	Lower	N	2358.45	1.00	87.35	66.78	150263.81		7513.19	Y	Y	Y	2003, 2010	343	*147*	3	1
32	52.75	39.00	1375	4.24	In-stream		Lower	V	18445.98	1.00	683.18	522.33	1175246.78		58762.34	Y	Y	N	2003, 2010	343	*147*	20	9
33	39.00	31.75	725	2.24	Stabilization Area #8	Depositional	Lower	Y	42452.53	1.10	1729.55	1322.33	2975251.67	743812.92		Y	Y	N	2003, 2010	380	*147*	282	*109*
34	31.75	26.75	500	1.54	Lower BB Crk Sed Ponds	Sediment Ponds	Lower	NA	18144.88	0.00	0.00	0.00	0.00	0.00		N	Y	Y	2009	257	71	0	0
35	26.75	26.50	25	0.08	Under Road Bridge		Lower	NA	857.22	1.00	31.75	24.27	54615.98		2730.80	N	N	N	NA	*280*	*85*	1	0
36	26.50	23.50	300	0.93	In-stream	Transport	Lower	N	7071.73	*1.00*	261.92	200.25	450560.49	112640.12		Y	Y	Y	2009	303	99	34	11
37	23.50	22.45	105	0.32	Confluence of BB/PA Crks		Lower	NA	5768.19	*0.00*	0.00	0.00	0.00	0.00		Y	Y	Y	2009	*261*	95	0	0
38	22.45	0.00	2245	6.93	Panther Creek - In-stream	NA	Lower	NA	27000.00	*0.00*	0.00	0.00	0.00	0.00		Y	Y	Y	2009	218	90	0	0
		Totals	32399	100																	**Estimated Total Weight (Kg)**	7400	2183
		Stabilized	**21374**	**66.0**																	Total Weight (Metric Tons)	7.4	2.2
		Partially Stabilized (vegetation/trees)	**5150**	**15.9**																			
		Not Stabilized	5000	15.4																			
		MISC Reaches (i.e. Sed Pond)	875	2.7																			

Assumptions :

Bedload Density =	2250	kg/m^3
Fine-grain concentration within volume (Stabilization Area) =	25	%
Fine-grain concentration within volume (In-stream) =	5	%
Depth of Potential Mobile Sediment (Stabilization Area)=	1.1	feet
Depth of Potential Mobile Sediment Based on 2-year flow Surface Area (In-stream)=	1	feet

Notes:
1) In-Stream indicates area within 2-year floodplain
2) Stabilization Area - area stabilized during 2009 and 2010 construction season
3) V = Stabilized by existing vegetation and/or trees
4) na = not available
5) NA = Not Applicable
6) Italicized values indicate that concentration values were obtained using in-situ XRF results (arsenic only) or estimated by using averages of concentrations
7) Contaminant Concentrations are averages of in-situ, field lab XRF & certified lab XRF results for Arsenic and Cobalt in the particular Blackbird Creek reach

Average concentration of sediments in Blackbird Creek (mg/kg) **624** **166**

Total Quantity Available for Transport

	Arsenic (kg)	Cobalt (kg)
Upper Blackbird Creek	221	62
Stabilization Areas	6627	2023
Transport Areas	519	86
Below Bridge Area	34	11

APPENDIX E
ALTERNATIVE COST INFORMATION

Table E-1: Alternative Comparison Cost Summary

Alternative	Alternative Costs			Total Cost
	Capital Cost	Annual O&M	NPC O&M[1]	Total NPC
B - In-Stream Stabilization and Removal	$4,682,000	$117,000	$2,140,800	$6,823,000
C - In-Stream Stabilization and Removal with Blackbird Ck. Diversion and Settling Basins	$8,523,000	$184,400	$2,782,000	$11,305,000
F - In-stream Stabilization with Water Treatment at West Fork	$8,379,000	$540,000	$8,177,000	$16,556,000

Table E-2: Alternative B Costs
Capital Cost Plus O&M Estimate - Blackbird Creek In-Stream Stabilization

Item	Quantity	Units	Unit Rate	Cost	Total
TOTAL CONSTRUCTION COST (ACTUAL):					$4,682,000
O&M Costs					
O&M Activities, per year	1	ls	$117,050		$117,050
Two Monitoring Activities	1	ls	$81,817		$81,817
Two Overbank Removals	1	ls	$327,267		$327,267
Present Value of O&M	12.41	PV Factor			$1,861,562
Contingency (15% applied to total O&M cost)	15%	percent			$279,200
O&M Total Cost					**$2,140,800**
TOTAL ALTERNATIVE COST					**$6,822,800**

Notes and Assumptions:

1. O&M assumed based on a percentage of total capital cost, occurring once every 2 years, converted to NPV.
2. Two overbank removal activities were assumed to occur, one in year 2 and another in year 4, both converted to NPV
3. Two monitoring activities were assumed to occur, one in year 2 and another in year 4, both converted to NPV

Table E-3: Alternative C Costs
Cost Estimate - In-Stream Stabilization and Blackbird Creek Diversion and Settling Basins

Item	Quantity	Units	Unit Rate	Cost	Total
Diversion Structure Construction					
Clearing and Grubbing (Diversion Structure Footprint)	830	cy	$15	$12,450	
Excavation (to be field fit, assume 3ft)	1,655	cy	$5	$8,273	
Spillway Grouted Riprap (D100 = 3ft)	640	cy	$310	$198,400	
Riprap on upstream face of spillway (D100 = 8-inches)	60	cy	$46	$2,760	
Sand Filter under around conduits	195	cy	$74	$14,522	
Sand Filter under grouted riprap (6" thick)	106	cy	$74	$7,894	
Conduit Concrete Encasement (inc. road crossings)	74	cy	$800	$59,520	
Concrete Spillway Cutoff Wall	7	cy	$800	$5,689	
General Fill Embankment (inc. bench & native u&d/s)	4,742	cy	$14	$64,116	
Embankment Compaction	4,742	cy	$1	$2,371	
Diversion Pipe and Low Level Inlet Concrete Structure	85	cy	$800	$67,754	
48-inch HDPE Low Level Outlet Pipe	80	lf	$95	$7,600	
48-inch HDPE Low Level Outlet Pipe, installation	80	lf	$11	$849	
Concrete Low Level Outlet - Outlet Structure	12	cy	$800	$9,651	
Low Level Outlet - 48" Sluice Gate	1	ls	$15,300	$15,300	
Low Level Outlet - Sluice Gate, Installation	1	ls	$1,530	$1,530	
Trash Rack	1	ls	$10,000	$10,000	
Diversion Pipe Entrance Structure Access Platform	1	ls	$3,000	$3,000	
Concrete transition from square to round section	1	ls	$10,000	$10,000	
54 inch HDPE diversion pipe, material cost	1,385	lf	$106	$146,949	
54 inch HDPE diversion pipe, Installation	1,685	lf	$11.00	$18,535	
54 inch Manhole Fitting, material costs	8	ea	$2,900	$23,200	
18" x 54" HDPE Tee Fitting , material cost	12	ea	$3,190	$38,280	
Field Fusion Weld of 48 inch	50	ea	$1,100	$55,000	
Winter Diversion 36" Entrance Gate	1	ls	$8,380	$8,380	
Winter Diversion Entrance Gate, Installation	1	ls	$840	$840	
Concrete Spillway Retaining Wall	70	cy	$800	$56,380	
Concrete Road Fill Retaining Wall	10	cy	$800	$7,733	
Instrumentation and Controls	1	ls	$50,000	$50,000	
Electric Power	1	ls	$50,000	$50,000	
Precast Concrete Electrical Control Vault	1	ls	$3,400	$3,400	
Precast Concrete Vault, Installation	1	ls	$340	$340	
Construction Diversion	1	ls	$20,000	$20,000	
SUBTOTAL					$1,034,794
Clearing and Grubbing (under road fill prism)	1,360	cy	$15	$20,403	
Fill for Access Road	7,760	cy	$10	$77,600	
Road Surfacing	330	cy	$13	$4,290	
SUBTOTAL					$102,293
Settling Basin Construction					
Clearing and Grubbing - basin bottoms	5,290	cy	$15	$79,350	
Clearing and Grubbing - under dike and pipe	5,740	cy	$15	$86,100	
Overexcavation under Dike	4,320	cy	$5	$21,600	
Basin Excavation	5,290	cy	$5	$26,450	
Outlet Pipe Trench Excavation	190	cy	$20	$3,800	
General Fill for Dike Construction	10,540	cy	$14	$142,501	
General Fill for Dike Construction, compaction	10,540	cy	$1	$5,270	
General Fill around Diversion Pipe	8,450	cy	$14	$114,244	
General Fill around Diversion Pipe, compaction	8,450	cy	$1	$4,225	
Diversion Pipe Sand Bedding	310	cy	$74	$23,086	
Diversion Pipe Gravel Filter	2,230	cy	$60	$133,800	
Dike Rip-Rap Armoring (Outer), inc. toe	7,500	cy	$46	$345,000	
Grouted Riprap at Basin Inlets	50	cy	$310	$15,500	
Grouted Riprap at Termination Structure	16	cy	$310	$4,960	
Road Surfacing on Dikes	480	cy	$13	$6,240	

Table E-3: Alternative C Costs
Cost Estimate - In-Stream Stabilization and Blackbird Creek Diversion and Settling Basins

Item	Quantity	Units	Unit Rate	Cost	Total
24 inch HDPE Pipe	400	lf	$21	$8,220	
24 inch HDPE pipe, Installation	400	lf	$2	$822	
Outlet Structures	10	ea	$3,700	$37,000	
Outlet Structure, Install	10	ea	$370	$3,700	
Geotextile (under riprap)	52,590	sf	$0.10	$5,259	
Sand Filter under dike riprap (6 in thick)	980	cy	$74	$72,981	
Concrete Diversion Pipe Termination Structure	9	cy	$800	$7,200	
18" Knife Gate Valves	12	ea	$4,013	$48,156	
18" Knife Gate Valve, Installation	12	ea	$401	$4,816	
Knife Gate Valve Delivery Fee	1	ls	$1,500	$1,500	
Concrete Valve Box	12	ea	$500	$6,000	
18-inch HDPE Pipe	145	lf	$21	$2,980	
18-inch HDPE Install	145	lf	$2	$298	
SUBTOTAL					$1,211,056
Settling Basin Access Fence					
Wood fence, ~4 ft high	1,610	lf	$25	$40,572	
Access Gates	4	ea	$2,000	$8,000	
Tie in to creek	1	ls	$3,556	$3,556	
SUBTOTAL					$52,128
Subtotal Construction Cost					$2,400,271
Mobilization at	10%			$240,000	
Subtotal				$2,640,271	
CQA	10%			$264,000	
Subtotal				$2,904,271	
Final Design Engineering	15%			$435,600	
Subtotal				$3,339,871	
Contingency at	15%			$501,000	
Total Diversion and Basin Construction Cost:					$3,841,000
Total In-stream Stabilization Cost (Actual)					$4,682,000
TOTAL CONSTRUCTION COST					**$8,523,000**
O&M Costs					
NPV One monitoring activity in year 2	1	ls	$43,672		$43,672
NPV One overbank removal activity in year 2	1	ls	$87,344		$87,344
O&M Activities (In-Stream Stabilization), per year	1	ls	$117,050		$117,050
O&M Activities (Diversion Structure), per year	1	ls	$6,000		$6,000
O&M Activities (Fence), per year	1	ls	$7,334		$7,334
O&M Activities (Settling Basins), per year	1	ls	$54,000		$54,000
Present Value of O&M	12.41	PV Factor			$2,419,042
Contingency (15% applied to total O&M cost)	15%	percent			$362,900
O&M Total Cost					**$2,781,900**
TOTAL ALTERNATIVE COST					**$11,304,900**

Notes and Assumptions:

1. O&M assumed based on a percentage of total capital cost, applied every 2 years, and converted to NPV
2. One monitoring activity was assumed to occur in year 2, converted to NPV
3. One overbank removal activity was assumed to occur in year 2, converted to NPV

Table E-4: Alternative F Costs
Cost Estimate - Blackbird Creek In-Stream Stabilization and Treatment (Hybrid Chemical Precipitation)

Item	Quantity	Units	Unit Rate	Cost	Total
Treament (Hybrid Precipitation)					
Clearing and Grubbing	1,613	cy	$15	$24,200	
Pond	1	ls	$50,000	$50,000	
Treatment Plant Building (800 sf) inc. tank, HVAC	1	ls	$175,000	$175,000	
Chemical Precip Components	1	ls	$100,000	$100,000	
Flow Baffles	1	ls	$50,000	$50,000	
Lime System	1	ls	$220,000	$220,000	
Mixer (blower)	1	ls	$15,000	$15,000	
Ancillary equipment	1	ls	$100,000	$100,000	
Backup generator	1	ls	$150,000	$150,000	
Electrical line (WTP to West Fork)	1	ls	$320,000	$320,000	
SUBTOTAL					$1,204,200
Relocate Blackbird Creek					
Excavation	1,956	cy	$5	$9,778	
Restoration and Permitting	1	ls	$30,000	$30,000	
SUBTOTAL					$39,778
Cutoff Wall					
Wall Construction	26,000	sf	$30	$780,000	
Collection and Conveyance	1	ls	$20,000	$20,000	
SUBTOTAL					$800,000
Subtotal Construction Cost:					**$2,043,978**
Mobilization at	10%			$204,400	
Subtotal				$2,248,378	
CQA	10%			$224,800	
Subtotal				$2,473,178	
Final Design Engineering	15%			$371,000	
Subtotal				$2,844,178	
Contingency at	30%			$853,300	
Total treatment cost					$3,697,000
Total In-stream stabilization cost (actual)					$4,682,000
TOTAL CAPITAL COST					**$8,379,000**
O&M Total Cost					
O&M In-Stream Stabilization					
O&M Activities, per year	1	ls	$117,050		$117,050
NPV Two Monitoring Activities	1	ls	$81,817		$81,817
NPV Two Overbank Removals	1	ls	$327,267		$327,267
Present Value of O&M	12.41	PV Factor			$1,861,562
Contingency (15% applied to total O&M cost)	15%	percent			$279,200
O&M Subtotal					$2,140,800
Chemcial Treatment Plant O&M, per year	1	ls	$423,000		
NPV Chemical Treatment Plant O&M	12.41	PV Factor			$5,249,024
Contingency (15% applied to total O&M cost)	15%	percent			$787,400
Treatment Subtotal					$6,036,424
O&M Total Cost					**$8,177,224**
TOTAL ALTERNATIVE COST					**$16,556,224**

Notes and Assumptions:

1. In-stream stabilization O&M assumed based on a percentage of total capital cost, applied every 2 years, and converted to NPV
2. Two overbank removal activities were assumed to occur, one in year 2 and another in year 4, both converted to NPV
3. Two monitoring activities were assumed to occur, one in year 2 and another in year 4, both converted to NPV
4. Treatment O&M summarized in attached O&M sheet.

Table E-5: Operations and Maintenance Costs

Item	Quantity	Units	Unit Rate	Cost
O&M Costs				
Present Value of O&M	12.41	PV Factor		
(I=7%, n=30 years - PV Factor =12.41)				
Contingency (15% applied to total O&M cost)	15%	percent		
costs for PV and Contingency are included in each alternative cost estimate				
ALT B: In-Stream Stabilization				
One monitoring activity at year 2 and year 4	1	ls	$50,000	
NPV= Cost*((1+.07)^-2 + (1+.07)^-4)				**$81,817**
Assume 5% of total capital cost, every 2-years.		2 yr	$234,100	
Total Annual O&M Cost ALT B, 1-yr increments:		1 yr		**$117,050**
one overbank removal activity at year 2 and year 4	1	ls	$200,000	
NPV= Cost*((1+.07)^-2 + (1+.07)^-4)				**$327,267**
ALT C: In-Stream Stabilization and Settling Basins				
Monitoring at year 2	1	ls	$50,000	
NPV= Cost*((1+.07)^-2				**$43,672**
One overbank removal, 2-yrs after construction	1	ls	$100,000	
NPV = Cost*(1+.07)^-2				**$87,344**
ALT C: In-Stream Stabilization O&M				
Assume 5% of total capital cost, every 2-years.		2 yr	$234,100	
Annual O&M (In-stream stabilization):		1 yr		**$117,050**
ALT C: Settling Basins O&M				
Assumed sediment cleanup = 4000 cy - 400 cy				
Annual Sediment Removal costs	3600	cy	$15	$54,000
Annual O&M (Settling Basins):				**$54,000**
ALT C: Diversion Structure O&M				
Assumed diversion structure sediment removal once per year	400	cy	$15	$6,000
Assume no additional cost for sluice gate operator				
Annual O&M (Diversion Structure)				**$6,000**
ALT C: Fence Maintenance				
Assume entire fence needs to be replaced every 10 yrs.				
Total Fence Construction Cost		ls	$67,000	
Every 10 year total replacement		per yr	$6,700	
Assume yearly maintenance (cleanup of debris).				
Assume 2 laborers, 1 day		ls	$634	
Annual O&M (Fence)				**$7,334**

Notes:

O&M Activity Assumptions

ALT B

Monitoring at 2 years and 4 years
Overbank removal activities at 2 years and 4 years after construction
Minor annual O&M of in-stream stabilization structures as a function of capital cost

ALT C

Monitoring at 2 years
One overbank removal activity 2 years after construction
Minor annual O&M of in-stream stabilization structures as a function of capital cost
Settling basin clean out once every 5 years
Diversion structure cleanout once per year
Replace fence every 10 years

Table E-6: Operations and Maintenance Costs (Treatment)

Estimated O&M Costs for Chem Precip Pond- 200 gpm, 200 mg/L Fe

Water Volumes		**Units**	**Qty**
Nominal flow rate		gpm	200
Annual treatment		gallons	105,120,000
Labor Cost	**Unit cost**	**Units**	**Qty**
Operators		FTE	1
OT/callouts		%	10%
Labor hours		hrs/yr	2,288
Operations labor cost	$ 45	$/hr	$ 103,000
Operations supervision		lump sum	$ 9,000
Compliance labor		lump sum	$ 15,000
Total Labor Cost		**$/yr**	**$ 127,000**
Utility Cost	**Unit cost**	**Units**	**Qty**
On line factor		%	90%
Connected load - pumps		HP	35
Additional loads		kw	15
Total power consumption		kwh/yr	325,000
Total power cost	**$ 0.06**	**$/yr**	**$ 20,000**
Chemicals	**Unit cost**	**Units**	**Qty**
Lime use		lb/year	350,554
Acid use		lb/year	0
Lime cost	$ 0.07	$/lb	$ 24,000
Acid cost	$ 0.50	$/lb	$ -
Total chemical cost		**$/yr**	**$ 24,000**
Miscellaneous Cost	**Unit cost**	**Units**	**Qty**
Sludge haul and disposal			
- contractor, 1X per year	ls/yr	ls/yr	$ 217,000
Sampling and analysis		lump sum	$ 25,000
Routine maintenance		lump sum	$ 10,000
Total miscellaneous cost			**$ 252,000**
Subtotal O&M Cost		**$/yr**	**$ 423,000**
Contingency	15%	$/yr	$ 64,000
Annual O&M Cost		**$/yr**	**$ 487,000**
Discount rate	7.00%		
Years	30		
Present worth factor	12.41		
Capital Cost			**$ 1,180,000**
PV O&M	**30**	**years**	**$ 6,044,000**

Notes:

(Removed Life Cycle Cost, which included capital cost - cc 2/26/09)

Changed O&M Contingency to 15% to match other costs.

Sludge haul and disposal includes contractor mobilization, pond sludge cleanout, operation of mobile filter press to dewater sludge, hauling and disposal. Mobilization is estimated at $100,000. Onsite processing is estimated at $43,000 ($163/dry ton), and disposal is estimated at $74,000 ($12.45/wet ton at 10 percent solids).

APPENDIX F
2011 RUNOFF PHOTOS

Project Title: Supplemental BCER

PHOTOGRAPH 1 Blackbird Creek below Haynes Stellite during initial high flow period in 2008 prior to construction of stabilization structures. Flows were concentrated in a narrow channel that was actively eroding its banks and had breached onto the road in some places.	
PHOTOGRAPH 2 Blackbird Creek below Haynes Stellite during initial high flow period on 5/14/2011 after construction of stabilization structures and road bank armoring. Flows are distributed evenly and banks are stable.	

PHOTOGRAPH 3 Blackbird Creek Stabilization Area 4 on 5/14/2011 during initial high flow period. Structures are effectively distributing flow across the entire channel.	
PHOTOGRAPH 4 Blackbird Creek Stabilization Area 4 on 6/7/2011. Turbidity has decreased and no significant changes to channel have occurred. Structures are continuing to distribute flows evenly across entire channel.	

PHOTOGRAPH 5 Blackbird Creek Stabilization Area 5 on 5/14/2011 during initial high flow period.	
PHOTOGRAPH 6 Blackbird Creek Stabilization Area 5 on 6/20/2011. Turbidity has decreased since initial high flow period and no significant changes to channel have occurred.	

PHOTOGRAPH 7 Lower Portion of Blackbird Creek Stabilization Area 6 on 5/14/2011 during initial high flow period.	
PHOTOGRAPH 8 Lower Portion of Blackbird Creek Stabilization Area 6 on 5/28/2011. Turbidity has decreased and no significant changes to channel have occurred.	

PHOTOGRAPH 9 Upper Portion of Blackbird Creek Stabilization Area 6 on 5/26/2011 during initial high flow period.	
PHOTOGRAPH 10 Upper Portion of Blackbird Creek Stabilization Area 6 on 6/7/2011. Turbidity has decreased and no significant changes to channel have occurred.	

PHOTOGRAPH 11 Looking Downstream from Blackbird Creek Bridge on 5/19/2009 during initial high flow period.	
PHOTOGRAPH 12 Looking Downstream from Blackbird Creek Bridge on 5/14/2011 during initial high flow period. Flows were less turbid than in 2009.	

PHOTOGRAPH 13 Looking Downstream from Blackbird Creek Bridge on 5/17/2011. Turbidity has decreased three days later.	
PHOTOGRAPH 14 Looking Upstream from Blackbird Creek Bridge on 5/19/2009 during initial high flow period.	

PHOTOGRAPH 15 Looking Upstream from Blackbird Creek Bridge on 5/14/2011 during initial high flow period. The flow is less turbid than in 2009.	
PHOTOGRAPH 16 Looking Upstream from Blackbird Creek Bridge on 5/17/2011. Turbidity has decreased three days later.	

PHOTOGRAPH 17 Looking Upstream from Blackbird Creek Bridge on 6/20/2011. Turbidity has significantly decreased since initial high flow period.	
PHOTOGRAPH 18 Blackbird Creek Sediment Pond on 5/19/2009 during initial high flow period.	

PHOTOGRAPH 19 Blackbird Creek Sediment Pond on 5/24/2011. Flow is less turbid than in 2009.	
PHOTOGRAPH 20 Confluence of Blackbird and Panther Creeks on 5/14/2011 during initial high flow period. Blackbird Creek had higher turbidity than Panther Creek.	

PHOTOGRAPH 21 Confluence of Blackbird and Panther Creeks on 5/17/2011. Turbidity similar in Blackbird Creek and Panther Creek.	
PHOTOGRAPH 22 Confluence of Blackbird and Panther Creeks on 6/14//2011. Less turbidity in Blackbird Creek than Panther Creek.	

PHOTOGRAPH 23 Turbid snowmelt runoff in Panther Creek at the PASW09 bridge in 2008.	
PHOTOGRAPH 24 Snowmelt runoff in Panther Creek at the PASW09 bridge on 6/8/2011.	