Pebble Project Environmental Baseline Studies
Analytical QA/QC Management

Agency Meeting
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Analytical QA/QC Objectives

Analytical QA/QC Management for Environmental Baseline Studies

Objectives are to ensure sample collection activities, laboratory analyses, management of chemical and field data are:

LEGALLY DEFENSIBLE

ACCEPTABLE TO FEDERAL AND STATE AGENCIES

USABLE FOR NEPA/EIS PERMITTING PURPOSES

Analytical QA/QC Management

Analytical QA/QC Management for Environmental Baseline Studies

- Define purpose of the chemistry data
- Establish data quality objectives based on regulatory criteria (federal and state) for all parameters in all media
- Criteria applied to Pebble Project are based largely on risk assessment requirements

Project Activities

Quality Assurance and Project Plans

Field Sample Management

Field Audits

Laboratory Management

Data Management

Validate Chemistry Data

Data Quality Assessment Reports

Environmental Baseline Document

Chemistry Consultation

Quality Assurance Project Plan (QAPP)

The QAPP provides the analytical quality assurance (QA) and quality control (QC) requirements for all sampling and analysis including:

Water Quality Studies

Trace Element Studies (fish, mussels, soil, sediment, vegetation)

Marine Studies (water, mussels)

Mammal Studies (tissues)

QAPP Critical to Project Success

Strict adherence to the QAPP ensures that the environmental samples and analytical results are defensible, valid, and adequately represent existing environmental conditions.

Field Sampling Plans – The Road Map

Provides detailed descriptions of field tasks.

Reviewed for consistency in field sampling protocols across all consultant teams to ensure field procedures meet program objectives.

Field Sample Management

For each sampling event Shaw receives samples from the field teams in Iliamna.

- Inspection
- Generate chain-of-custody
- Label and package all samples into coolers
- Ship coolers to laboratories

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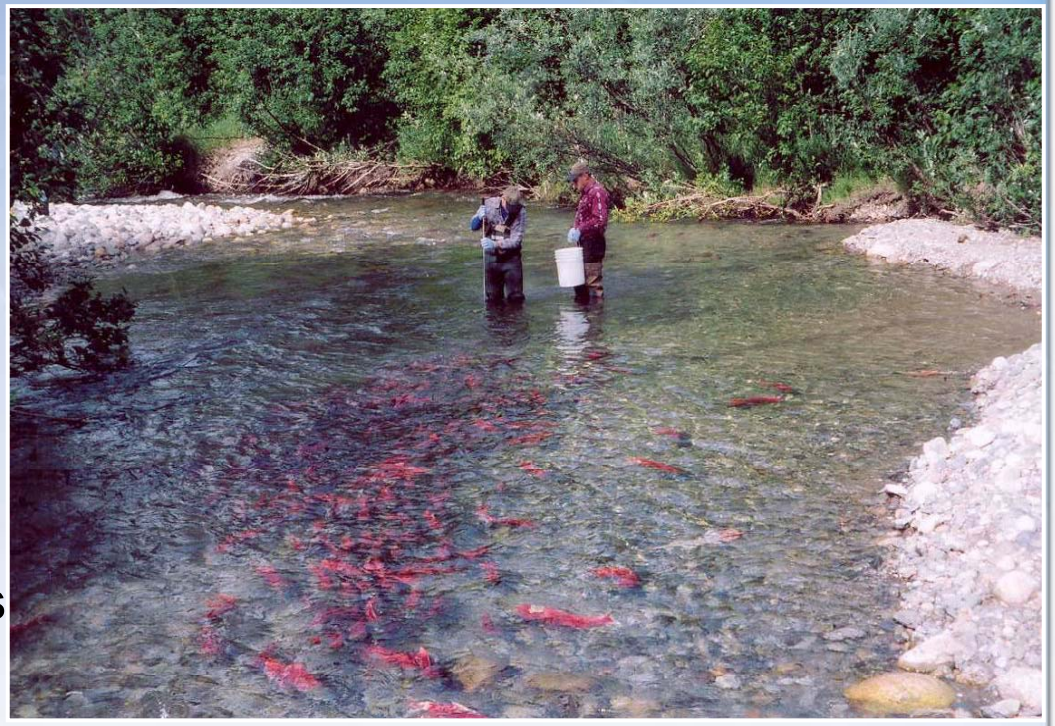
Field Sample Management

Sample Type	Samples Analyzed per Year				Total Samples Analyzed	Total Parameters Analyzed
	2004	2005	2006	2007 (est.)		
Western Deposit Surface Water Streams, Lake, and Pools	344	504	447	626	1,921	142,154
Western Deposit Surface Water Seeps	23	60	154	398	635	46,990
Western Deposit Soil	163	115	49	44	371	12,614
Western Deposit Sediment	85	77	105	44	311	10,574
Western Deposit Vegetation	302	250	264	44	860	24,080
Western Deposit Aquatic Vegetation	0	3	11	12	26	728
Western Deposit Groundwater	35	151	191	218	595	44,030
Western Deposit Fish Tissue	314	362	36	200	912	12,768
Western Deposit Lake Mussels	0	6	6	1	13	182
Transportation Corridor Surface Water	87	140	8	9	244	18,056
Transportation Corridor Groundwater	16	18	0	0	34	2,516
Transportation Corridor Sediment	51	63	14	4	132	4,488
Transportation Corridor Vegetation	100	0	63	18	181	5,068
Transportation Corridor Soil	41	0	9	0	50	1,700
Marine Water, sediment and tissues	96	23	0	0	119	3,526
Totals	1,657	1,772	1,357	1,618	6,404	329,474

Field Audits

Field sampling teams were audited winter and summer to ensure field procedures were executed according to approved field sampling plans.



Audit objective is to ensure quality of field measurements and consistency among sampling teams.

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Field Audits

On-Site Audit of Each Field Team

- Field Water Quality Measurements
- Stream Flow Measurements
- Field Forms and Log Books
- Sample Collection
- Cross Contamination
- Sampling equipment decontamination
- Instrument Calibration Logs
- Documentation

Post Audit Review with Field Teams

Field Audits – Water Quality

Study Area	Field Team	2004	2005		2006		2007	
		Summer	*Winter*	*Summer*	*Winter*	*Summer*	*Winter*	*Summer*
West Deposit	CH2M Hill – streams/seeps	X						
Transportation Corridor	BEESC – streams	X	X	X		X		
West Deposit	HDR - Streams		X	X	X		X	X
West Deposit	HDR - seeps			X	X	X	X	X
West Deposit	HDR – Lk Iliamna			X				X
West Deposit	SLR - groundwater			X	X		X	X

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Field Audits – Trace Elements

Study Area	Field Team	2004	2005		2006		2007	
		Summer	*Winter*	*Summer*	*Winter*	*Summer*	*Winter*	*Summer*
West Deposit	CH2M Hill – veg/soil/sediment	X						
Transportation Corridor	BEESC – veg/soil	X		X		X		X
West Deposit	SLR – veg/soil			X		X		X
West Deposit	HDR – fish tissues	X		X		X		X
West Deposit	HDR sediment			X		X		X
West Deposit	HDR Lk. Iliamna			X		X		

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Field Audits

On-Site Audit of Each Field Team and Discipline

✓**Field Water Quality Measurements**	✓**Cross Contamination**
✓**Stream Flow Measurements**	✓**Decontamination**
✓**Field Forms and Log Books**	✓**Instrument Calibration Logs**
✓**Sample Collection**	✓**Documentation**

Post Audit Review with Field Teams

Laboratory Management

Five laboratories selected for primary and QA analysis

- SGS Environmental Services, Inc. (SGS)
- ACZ Laboratories (ACZ)
- Columbia Analytical Services, Inc. (CAS)
- TestAmerica (TestAm)
- Severn Trent Laboratories (STL)

Media	Primary Laboratory	QA Laboratory
Streams and Lake Iliamna Surface Water and Ground Water	**SGS – Anchorage, AK**	**CAS – Kelso, WA**
Seeps Surface Water	**ACZ – Steamboat Springs, CO**	**CAS – Kelso, WA**
Surface Water and Ground Water (low-level mercury only)	**TestAm – Portland, OR**	**CAS – Kelso, WA**
Soil and sediment	**STL – Tacoma, WA**	**CAS – Kelso, WA**
Animal tissue (mammal, fish, mussels)	**CAS – Kelso, WA**	**STL – Tacoma, WA**
Vegetation	**CAS – Kelso, WA**	**STL – Tacoma, WA**

Data Management

- Designed and maintaining analytical database
- Designed and maintaining sample tracking database
- Conducting audits of consultants' internal field data management processes
- Developing field data management system

Validate Chemistry Data

- Compare data to QAPP QA/QC criteria & data quality objectives
- Evaluate accuracy and precision of data
- Qualify data based on compliance to the QAPP and EPA approved method requirements
- Generate final data quality assessment reports that are loaded to the project document repository
- Upload final qualified data to the Pebble database, which currently contains data from April 2004 to August 2007

Data Quality Assessment Reports (DQARs)

DQARs present technical review findings for each sampling event. The objective of DQAR is to

- Evaluate QA/QC procedures
- Determine if data quality objectives were met
- Discuss all data quality issues and impacts to results
- Qualify data with flags such as J for estimated results

Environmental Baseline Document

Analytical QA/QC Review

Spring 2004 – Spring 2006

Environmental Baseline Document

Parameter	Surface Water	Ground-water	Surface Soil	Sediment	Vegetation	Fish Tissue	Bivalve Tissue
Inorganics							
pH	X	X					
Specific Conductance	X	X					
Acidity	X	X					
Alkalinity	X	X					
Ammonia	X	X	X	X			
AVS – SEM (1)				X			
Chloride	X	X	X	X			
Cyanide	X	X	X	X	X		
Fluoride	X	X	X	X			
Nitrite and Nitrate	X	X					
Orthophosphate	X	X					
Phosphorus	X	X					
Sulfate	X	X	X	X			
Sulfur				X			
Thiocyanate	X	X					
Total Dissolved Solids	X	X					
Total Suspended Solids	X	X					

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Environmental Baseline Document

Parameter	Surface Water	Ground-water	Surface Soil	Sediment	Vegetation	Fish Tissue	Bivalve Tissue
Trace Elements							
Mercury	X	X	X	X	X	X	X
Metals (2)	X	X	X	X	X	X	X
Organics							
Total Organic Carbon			X				
Fuels			X				

Notes:

1 - AVS – SEM = acid volatile sulfides – simultaneously extracted metals (Cd, Cu, Pb, Hg, Ni, Zn)

2 - Al, Sb, As, Ba, Be, Bi, B, Ca, Cd, Co, Cr, Cu, Fe, Pb, Mg, Mn, Mo, Ni, K, Se, Si, Ag, Na, Tl, Sn, V, Zn.

Sb, As, Be, Cd, Cr, Cu, Pb, Hg, Mo, Ni, Se, Ag, Tl, and Zn analyzed in fish and bivalve tissue.

Environmental Baseline Document

Analytical QA/QC Review

Review evaluates data in terms of precision, accuracy, representativeness, comparability and completeness.

Precision – agreement between set of replicate measurements. Assessed from field and laboratory duplicates.

Accuracy – nearness of a result to the true value. Assessed by reference samples and QC sample percent recoveries.

Environmental Baseline Document

Analytical QA/QC Review

Representativeness - how closely the measured results reflect the actual concentration or distribution of the chemical parameters in the environment. Assessed from sample collection and handling.

Comparability - the level of confidence with which one data set can be compared with another. Assessed from methods employed among laboratories and over time.

Completeness - is a measure of the amount of data determined valid compared to the total number of data acquired. Reported as percent completeness as follows.

Environmental Baseline Document

Analytical QA/QC Review

Completeness - is a measure of the amount of data determined valid compared to the total number of data acquired reported as percent. Completeness goal is 90%.

$$\text{Percent Completeness} = \frac{\text{Number of valid results} * 100}{\text{Number of all results}}$$

Environmental Baseline Document – Analytical QA/QC

PRECISION

Laboratory precision goals are 20 – 40 % (matrix dependent). There are no precision goals for field duplicates.

RPD = relative percent difference

$$RPD = \frac{(C1 - C2)}{(C1 + C2) / 2} * 100$$

C1 = larger of the two observed values
C2 = smaller of the two observed values

Environmental Baseline Document – Analytical QA/QC

PRECISION

Relative Percent Difference

Example 1

C1 = 300
C2 = 100

$$RPD = \frac{(300 - 100) * 100}{200} = 100\%$$

Example 2

C1 = 100
C2 = 80

$$RPD = \frac{(100 - 80) * 100}{90} = 22\%$$

Environmental Baseline Document – Analytical QA/QC

Groundwater Field Precision				
Selected Parameters	**n-pairs**	**Mean Field Duplicate RPD**	**SD**	**RSD**
Aluminum	**39**	**41.8**	**52.0**	**124%**
Antimony	**42**	**25.3**	**29.5**	**117%**
Arsenic	**29**	**8.0**	**10.1**	**126%**
Barium	**56**	**7.6**	**8.2**	**108%**
Chromium	**49**	**32.3**	**37.4**	**116%**
Copper	**54**	**26.9**	**24.8**	**92.2%**
Iron	**31**	**33.5**	**37.3**	**111%**
Lead	**25**	**34.6**	**36.9**	**107%**
Magnesium	**60**	**4.7**	**3.5**	**74.5%**
Manganese	**50**	**18.0**	**27.1**	**151%**
Mercury	**2**	**3.5**	**-**	**-**
Molybdenum	**51**	**20.9**	**30.4**	**145%**
Nickel	**56**	**17.5**	**23.5**	**134%**
Silver	**6**	**30.3**	**16.5**	**54.5%**
Thallium	**6**	**53.7**	**70.0**	**130%**
Tin	**8**	**31.1**	**22.1**	**71.1%**
Vanadium	**40**	**15.2**	**22.9**	**151%**
Zinc	**36**	**21.3**	**24.8**	**116%**

Environmental Baseline Document – Analytical QA/QC

Groundwater Precision from Laboratory Duplicates

Analyte	n-pairs	Mean Lab Duplicate RPD	SD	RSD
Aluminum	52	7.3	12.1	166%
Antimony	52	3.7	4.4	119%
Arsenic	52	3.6	3.8	106%
Barium	51	3.6	3.1	86%
Chromium	52	3.3	3.1	94%
Copper	51	3.4	3.3	97%
Iron	50	4.5	4.1	91%
Lead	50	4.1	8.7	212%
Magnesium	52	5.2	16.2	312%
Manganese	51	3.8	4.2	111%
Mercury	54	2.9	3.5	121%
Molybdenum	52	3.5	3.8	109%
Nickel	51	6.6	22.7	344%
Silicon	24	9.8	21.9	223%
Silver	48	5.4	13.9	257%
Thallium	48	4.8	12.5	260%
Tin	47	3.9	4.2	108%
Vanadium	52	3.9	4.8	123%
Zinc	51	3.3	3.1	94%

Environmental Baseline Document – Analytical QA/QC

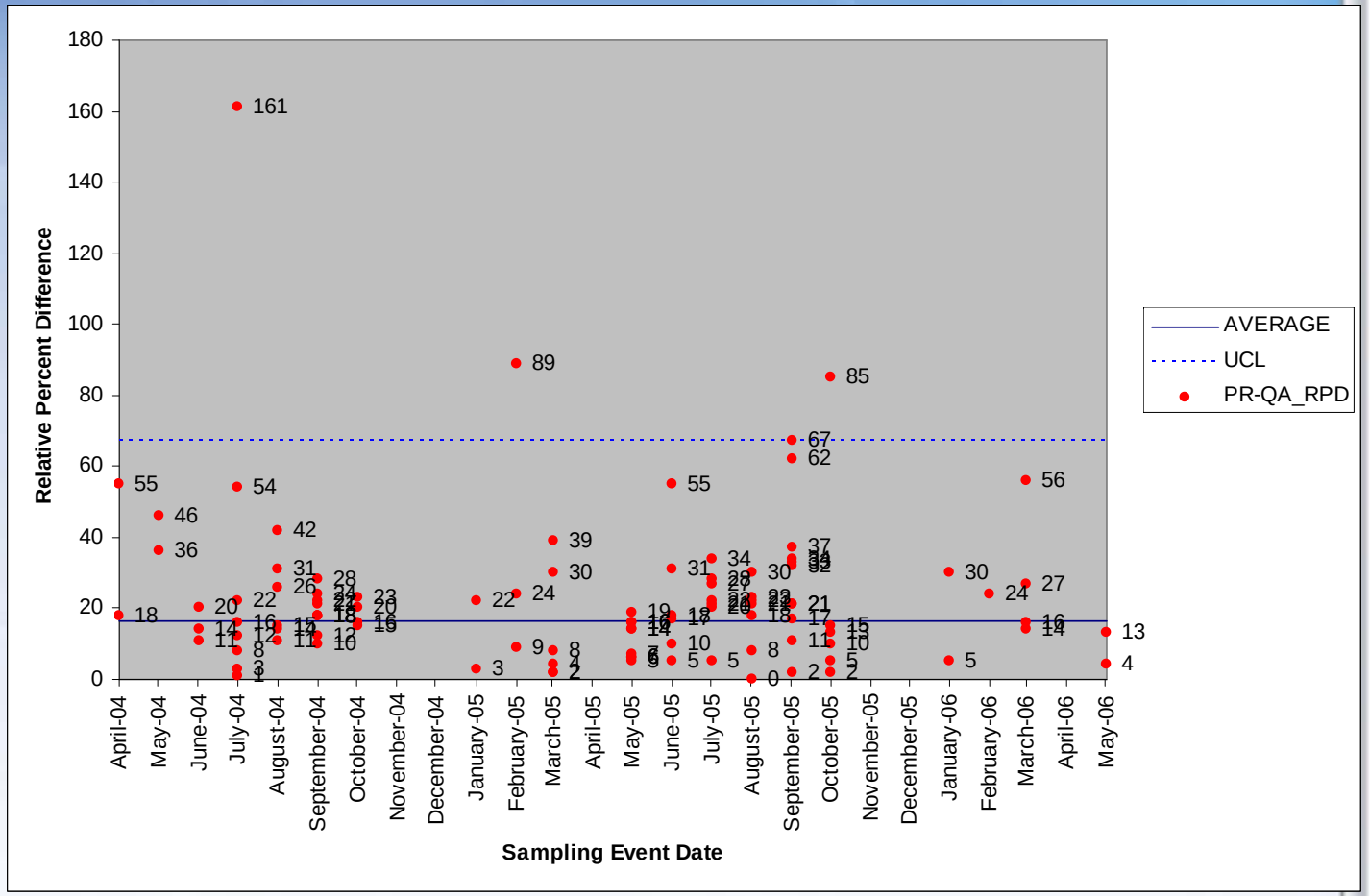
PRECISION AND CONTROL CHARTS

- **Plot of primary laboratory mean RPD and upper control limit (3*SD) over time**
- **Compares QA laboratory RPDs to primary laboratory RPDs**

Environmental Baseline Document – Analytical QA/QC

Arsenic in Surface Water

Control Chart



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Environmental Baseline Document – Analytical QA/QC

ACCURACY

$$\text{percent recovery} = \frac{\text{measured concentration}}{\text{true concentration}} * 100$$

Example - measured concentration of 85 and true concentration of 100 gives 85% recovery.

Environmental Baseline Document – Analytical QA/QC

Groundwater Laboratory Accuracy and Precision				
Analyte	**n**	**Mean LCS % Recovery**	**SD**	**RSD**
Aluminum	**525**	**101**	**6.4**	**6.4%**
Antimony	**512**	**97.6**	**5.8**	**5.9%**
Arsenic	**510**	**99.8**	**4.9**	**4.9%**
Barium	**509**	**100**	**5.3**	**5.3%**
Chromium	**509**	**99.1**	**5.9**	**6.0%**
Copper	**508**	**99.6**	**5.1**	**5.1%**
Iron	**513**	**103**	**6.3**	**6.1%**
Lead	**510**	**98.9**	**4.7**	**4.8%**
Magnesium	**523**	**101**	**6.4**	**6.3%**
Manganese	**503**	**101**	**5.0**	**5.0%**
Mercury	**534**	**96.6**	**22.7**	**23.5%**
Molybdenum	**509**	**98.5**	**5.5**	**5.6%**
Nickel	**511**	**101**	**5.4**	**5.4%**
Silicon	**302**	**102**	**5.5**	**5.4%**
Silver	**512**	**100**	**7.0**	**7.0%**
Thallium	**507**	**98.9**	**6.3**	**6.4%**
Tin	**501**	**96.2**	**7.3**	**7.6%**
Vanadium	**509**	**100**	**5.9**	**5.8%**
Zinc	**513**	**99.4**	**5.9**	**5.9%**

Chemistry Consultation

- Cyanide analysis, speciation and natural source evaluation
- On-site sample filtration for dissolved metals and dissolved organic carbon
- Guide field teams on sample collection, handling, reporting, and custody procedures

2008 Activities

- All QA/QC activities will proceed as in previous years
- Prepare QA/QC review for EBD for Summer 2006 – Winter 2007 analytical data
- Complete field data management audits
- Prepare field management plan
- Testing for cyanide producing bacteria in soil

Shaw Alaska, Inc.