Quality Control in Mineral Exploration

Controlling the Quality of Information from Field to Data Base

Quality Control in Mineral Exploration

There many goals associated with a QA/QC program for the mineral industry:

- Prevent the entry of large errors into the geological Database.
- Demonstrate that sampling and analytical variances are small relative to geological variance.
- Provide assurance that the accuracy of the data can be confirmed.
- Save management time by automating sample names and performing automatic checks on sample names.
- Allow problems to be realized rapidly to minimize their effects.
- Keep an archive for a complete audit trail.
- Comply meticulously with government regulations and standards with a minimal amount of employee time and effort.

Quality Control in Mineral Exploration

Canadian Securities Regulation NI 43-101 dictates that every resource delineation project must come under the direction of a Qualified Person (QP)

A QP is a professional with at least 5 years experience and a member of a recognized professional organization that has an **enforced Code of Ethics**.

Quality Control in Mineral Exploration

World securities regulators and financial institutions have adopted the principles of NI 43-101 and now demand that full QC procedures are used for all resource delineation exploration programs

Quality Control in Mineral Exploration

Form 43-101 F1, Item 14 details the mandatory requirements for a technical report, including:

3. A summary of the nature and extent of all QC procedures employed and check assay and other check analytical and testing procedures utilized, including the results and **corrective** actions taken.

Quality Control in Mineral Exploration

Form 43-101 F1, Item 15 specifically details the data corroboration requirements including:

- the QC steps and data corroboration procedures which have been taken,
- whether the author has corroborated the data
- the nature of and limitations on such corroboration
- the reasons for any **failure** to corroborate the data

Quality Control Procedures are Necessary to Monitor

- Accuracy
- Precision
- Contamination

Accuracy

the degree to which an analysis or mean of a set of analyses approach a “true” concentration.

Note: the “true” concentration is never known; an “accepted value” together with error limits accompanies most standards.

Precision

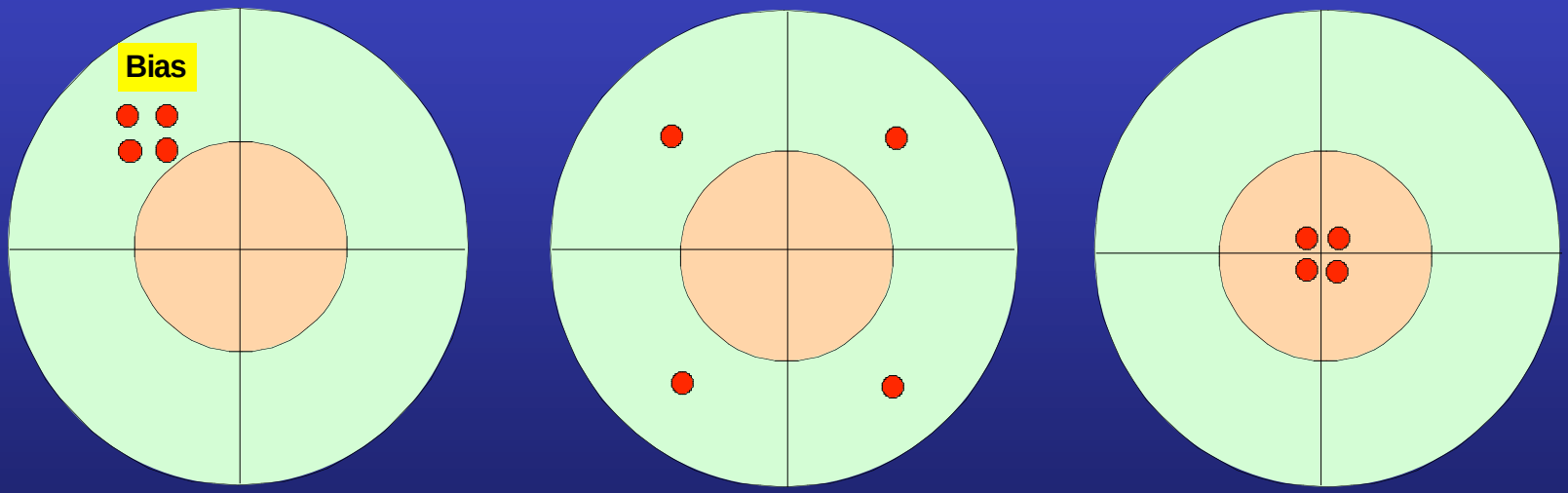
Is an estimate of the reproducibility of the sampling and analytical system. The percent precision is related to concentration by:

$$Pc = 2Sc/c \times 100$$

where Pc is the precision in percent at concentration c, and Sc is an estimate of the standard deviation at that concentration.

Quality Control

Comparison of Accuracy and Precision



Sampling and Analytical Bias

A systematic error inherent in a method or caused by some artifact or idiosyncrasy of the sampling system.

Contamination

The introduction of any substance to a geological sample that is not in the original *in situ* location of that sample.

Geological Blank

A sample of uncrushed rock or drill core that is known to contain a very low or non-detectable concentration of the element being sought.

The blank is used to monitor contamination.

Geological Standard

A composite of naturally occurring geological material for which an "**accepted mean**" and "**error**" on the mean has been defined.

The standard is used to monitor accuracy.

Round Robin

The analysis of a newly prepared geological standard, done in replicate by a number of labs, the purpose of which is to calculate the "accepted mean" and standard deviation. At least 60 analyses using a minimum of 5 labs are recommended.

Field Duplicate Sample

Splits of drill core, reverse circulation cuttings or outcrop from the same sampling interval. These splits are bagged separately with separate sample numbers so as to be blind to the sample preparation laboratory.

The Use of Field Duplicates

The field duplicate contains all levels of error: core or RC cuttings splitting, sample size reduction in the prep lab, and sub-sampling at the pulp, plus the analytical error. They are also a check on possible sample over selection.

The duplicates are used to calculate field, preparation and analytical precision.

Preparation Duplicate Sample

Splits of one sample taken after the coarse crush but before pulverizing (pulp). These should be done routinely by the sample preparation laboratory (usually 1 in 40 samples).

The preparation duplicate has the error of sample size reduction in the preparation lab and the error of analyses.

Pulp Duplicate Sample

Two separate weighings and analyses from one pulp. These are usually done routinely by all laboratories (between 1 in 5 to 1 in 20 samples).

The pulp duplicate has the error of analyses.

Sample Over Selection

Samplers have, either purposely or inadvertently sampled geological material, usually drill core, so as to preferentially place visible mineralization in the sample bag going for analysis.

The Use of Standards

Certified Reference Material (CRM's)

These may be purchased from a number of sources including:

- Canmet: www.nrcan.gc.ca/mms/canmet-mtb/ccrmp/
- CDN Labs: www.cdnlabs.com/
- NIST: ois.nist.gov/srmcatalog/
- USGS: minerals.cr.usgs.gov/geo_chem_stand/
- Rocklabs: www.rocklabs.com/
- Geostats: www.geostats.com.au
- African Minerals: www.amis.co.za

The Use of Standards

Certified Reference Material (CRM's)

New standard certificates include the Between Lab Standard Deviation, which is to be used in assessing accuracy of a single analysis.

First issued: November 2000

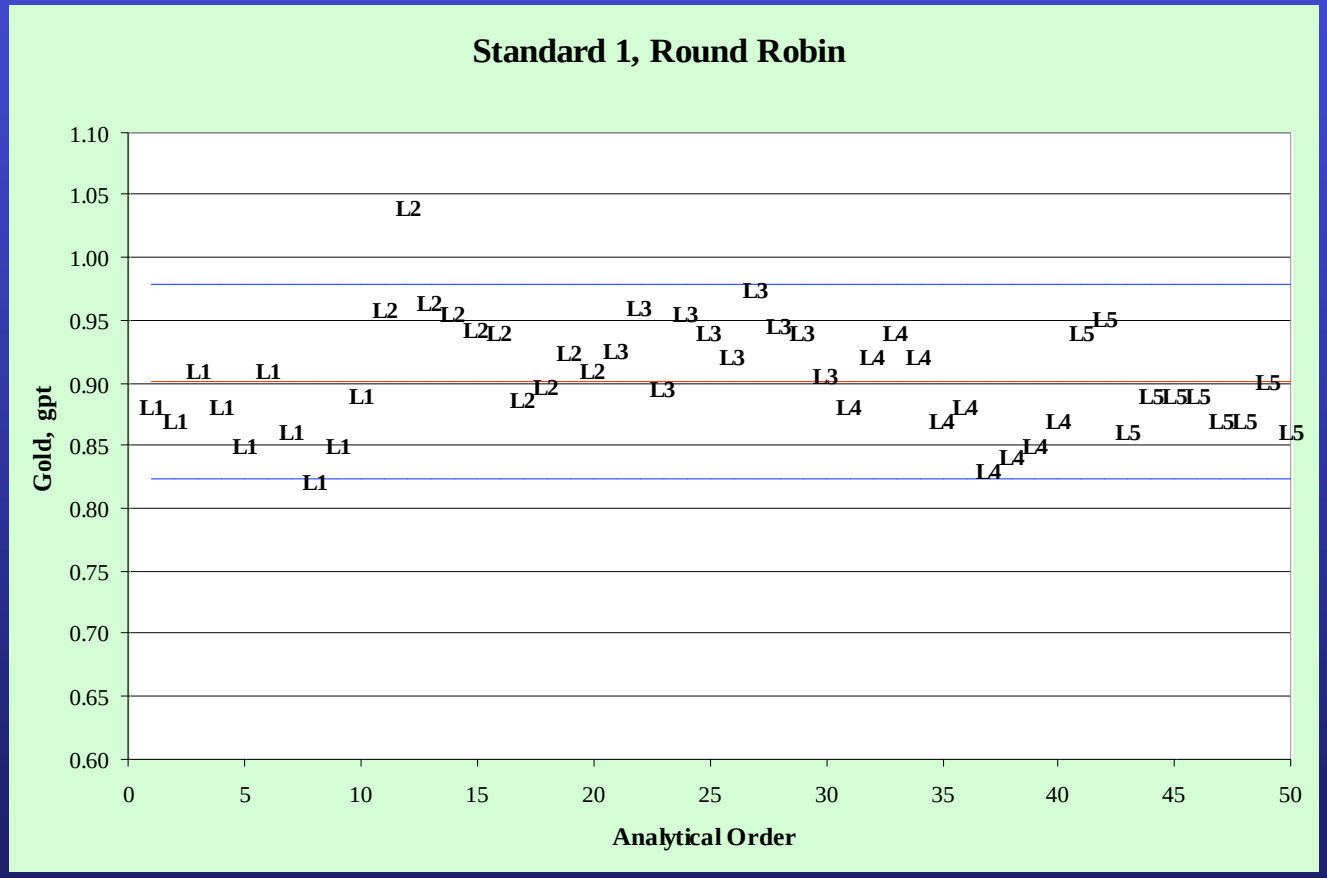
Table 1 - CCU-1c Certified Values

Element	Unit	Mean	Within-Lab Standard Deviation	Between- Lab Standard Deviation	95% confidence limit
Arsenic	µg/g	34	4	9	6
Cadmium	µg/g	136	5	12	6
Calcium Oxide	%	0.15	0.02	0.02	0.01
Carbon	%	0.09	0.01	0.02	0.01
Copper	%	25.62	0.07	0.12	0.05
Gold	µg/g	4.94	0.29	0.22	0.13
Iron	%	29.34	0.48	.68	0.28
Magnesium Oxide	%	1.02	0.04	0.06	0.04
Manganese	%	0.012	0.002	0.002	0.001
Molybdenum	µg/g	20	2	5	4
Selenium	µg/g	107	16	23	15
Silicon Dioxide	%	2.52	0.07	0.16	0.10
Silver	µg/g	129	2	5	2
Sulphur	%	33.3	0.2	0.5	0.3
Zinc	%	3.99	0.06	0.19	0.07

The Use of Standards

Property Specific Standards

Round Robin analysis and statistical calculations.

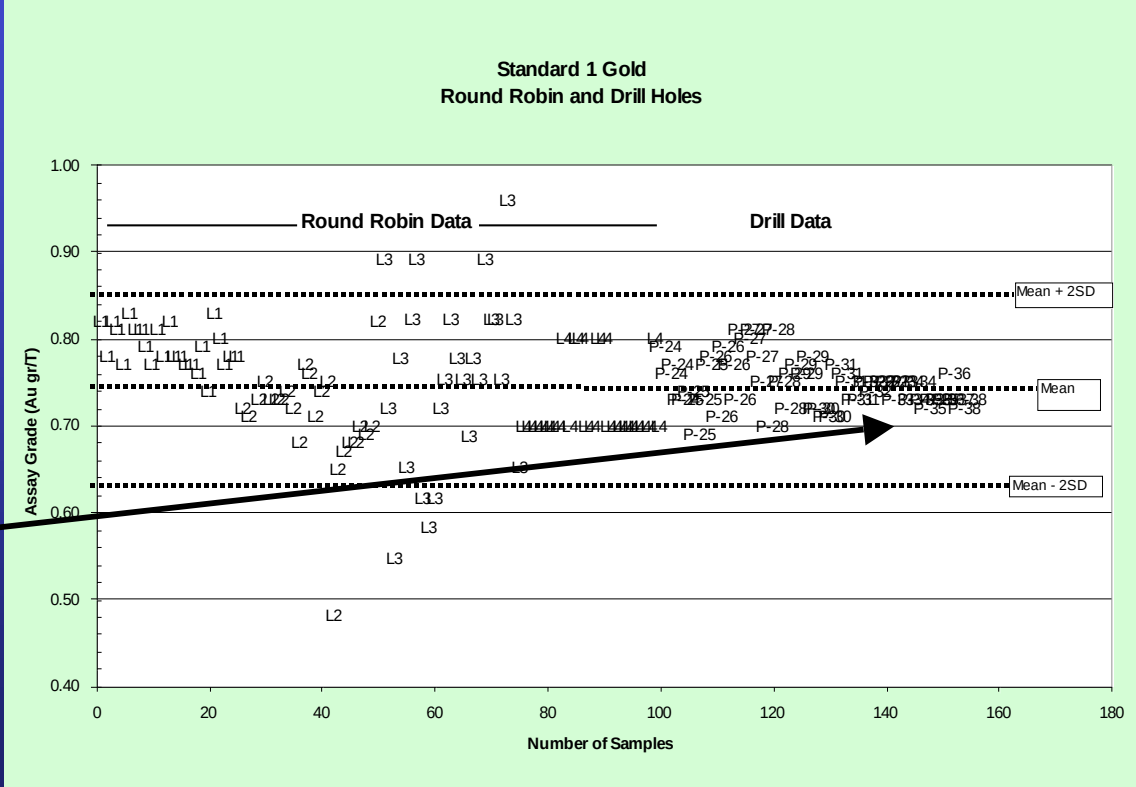


The Use of Standards

Property Specific Standards

Standard chart with standards from drill samples.

Note: lab does better as drill program proceeds.

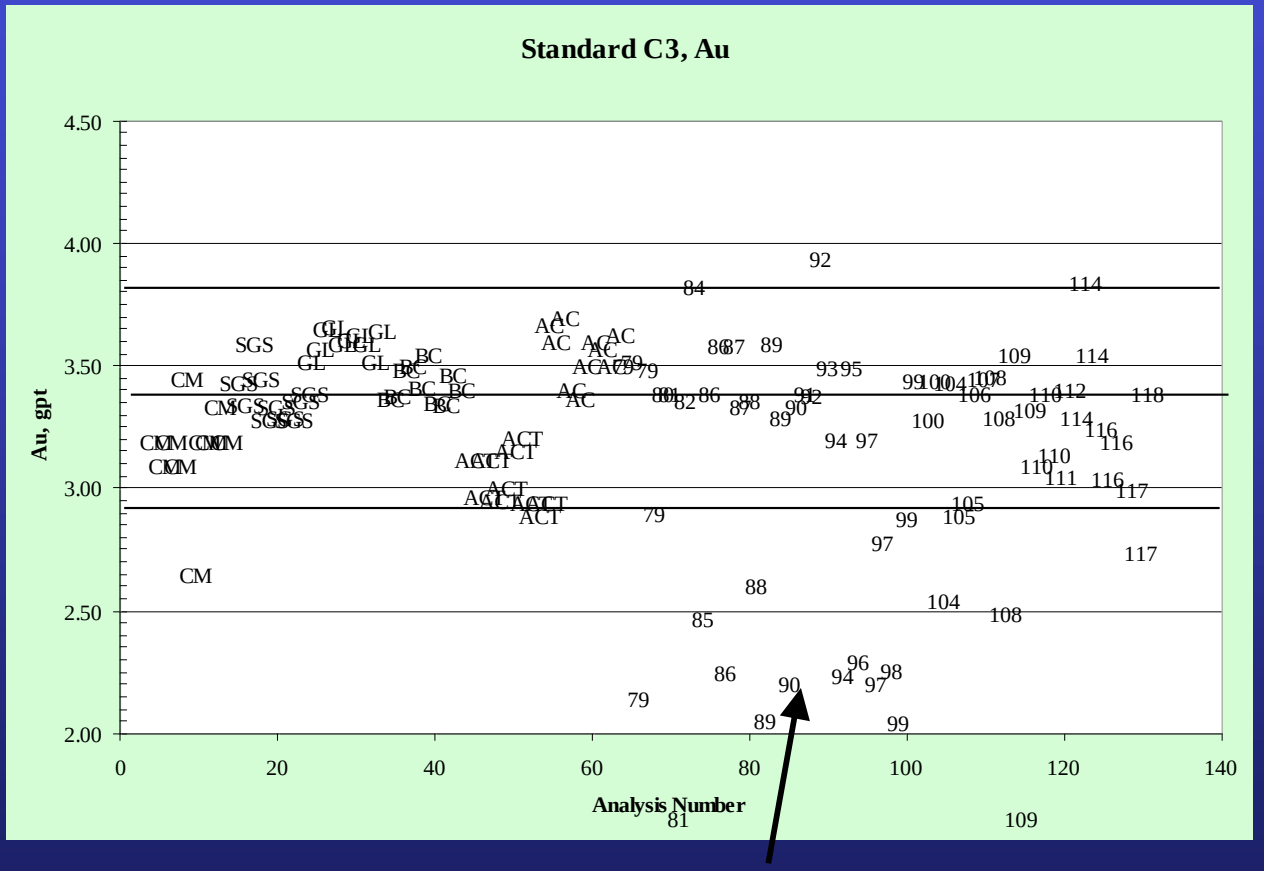


The Use of Standards

Property Specific Standards

Field Screw Ups

Failed standards caused by poor sample storage and contamination of standard in field.



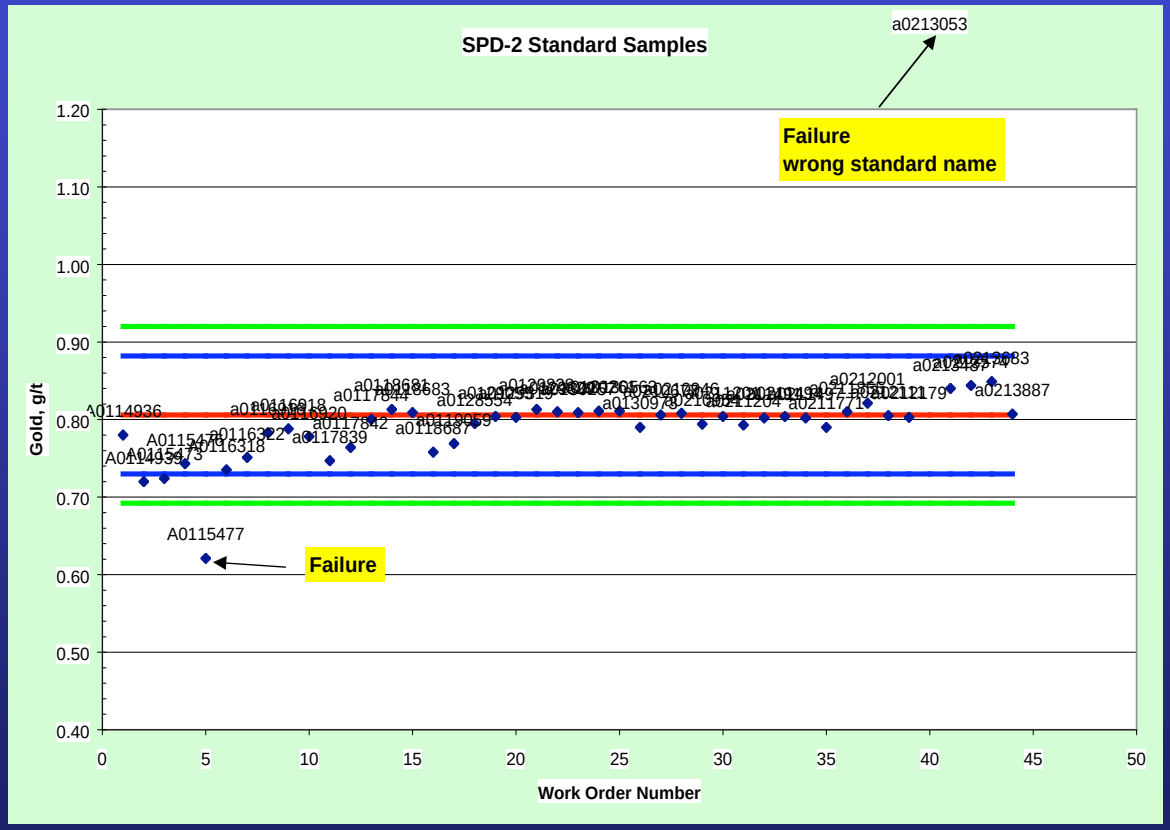
Standards in drill samples

The Use of Standards

Property Specific Standards

Inventing ways to screw up.

Give the standard a name in the data base. Wrong standard selected in the field.



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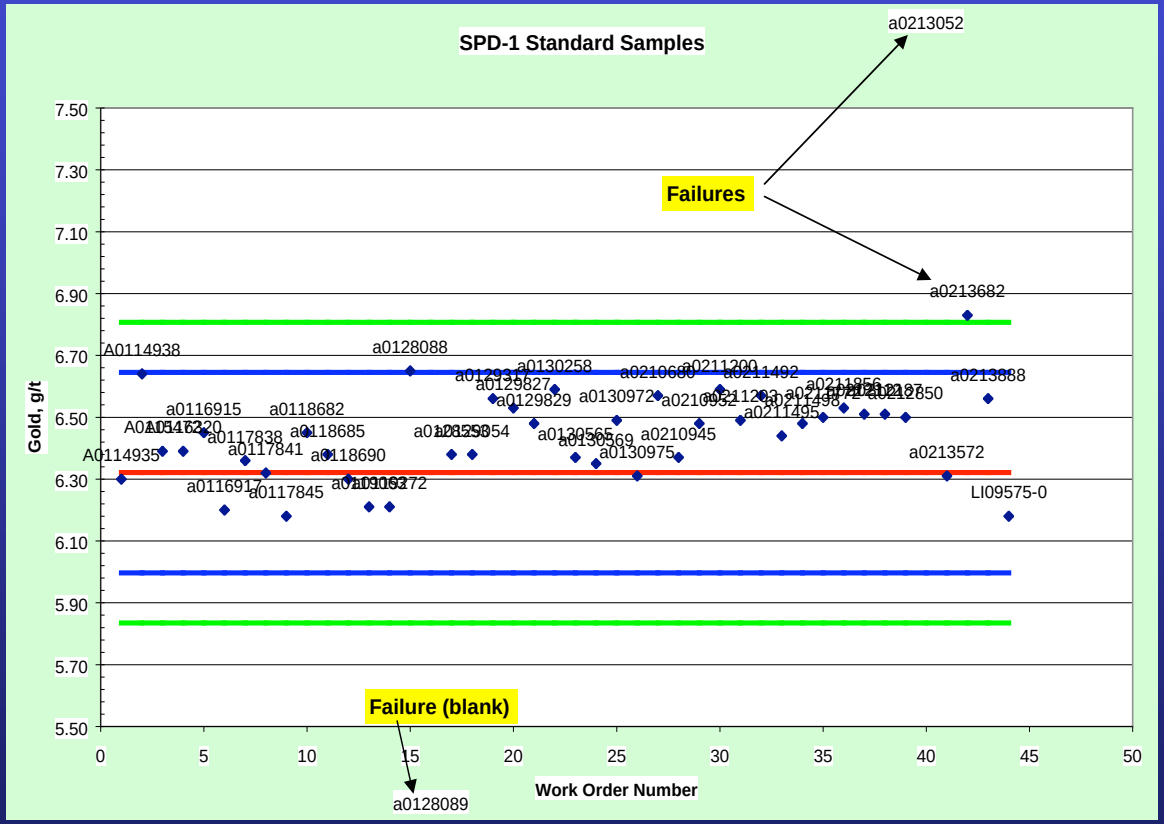
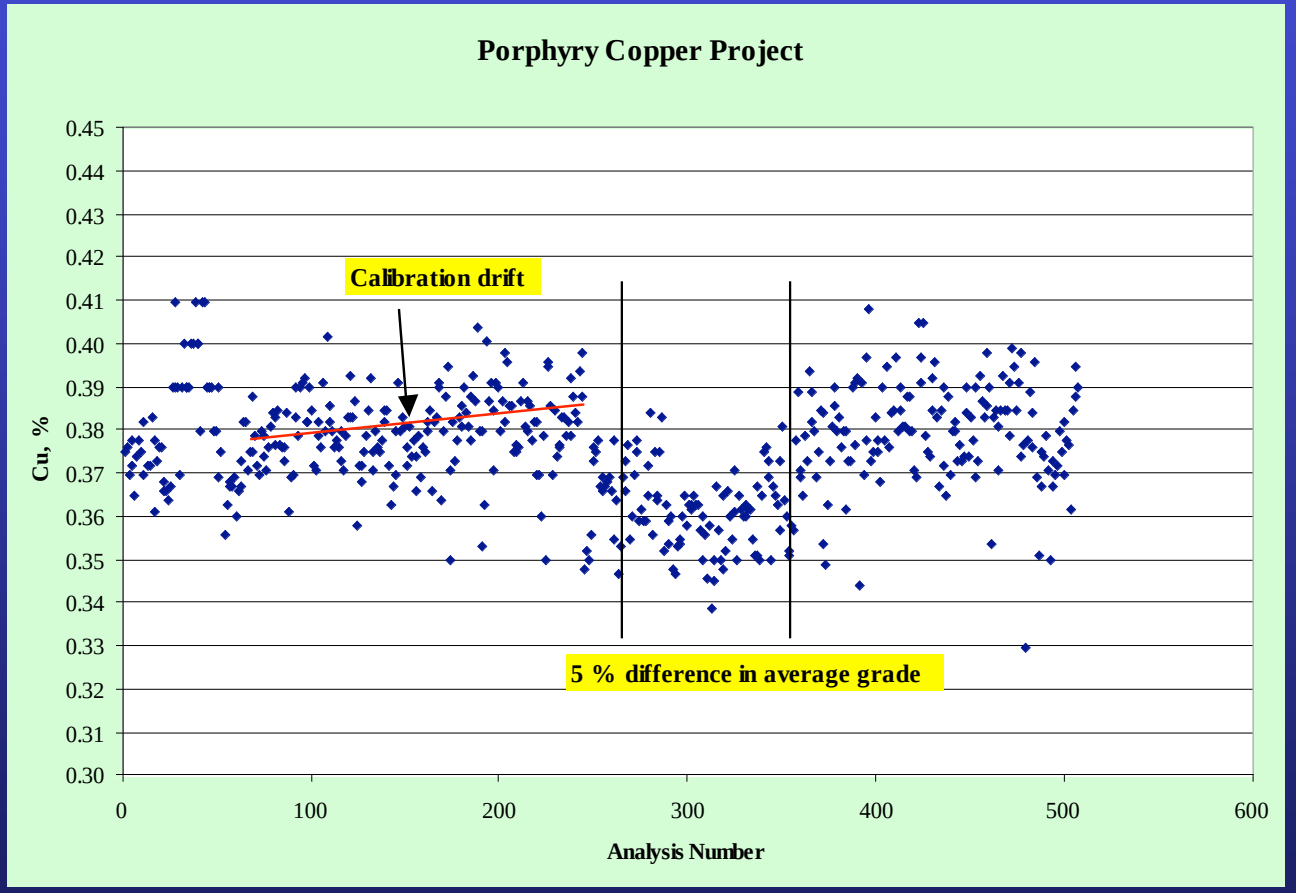


The Use of Standards

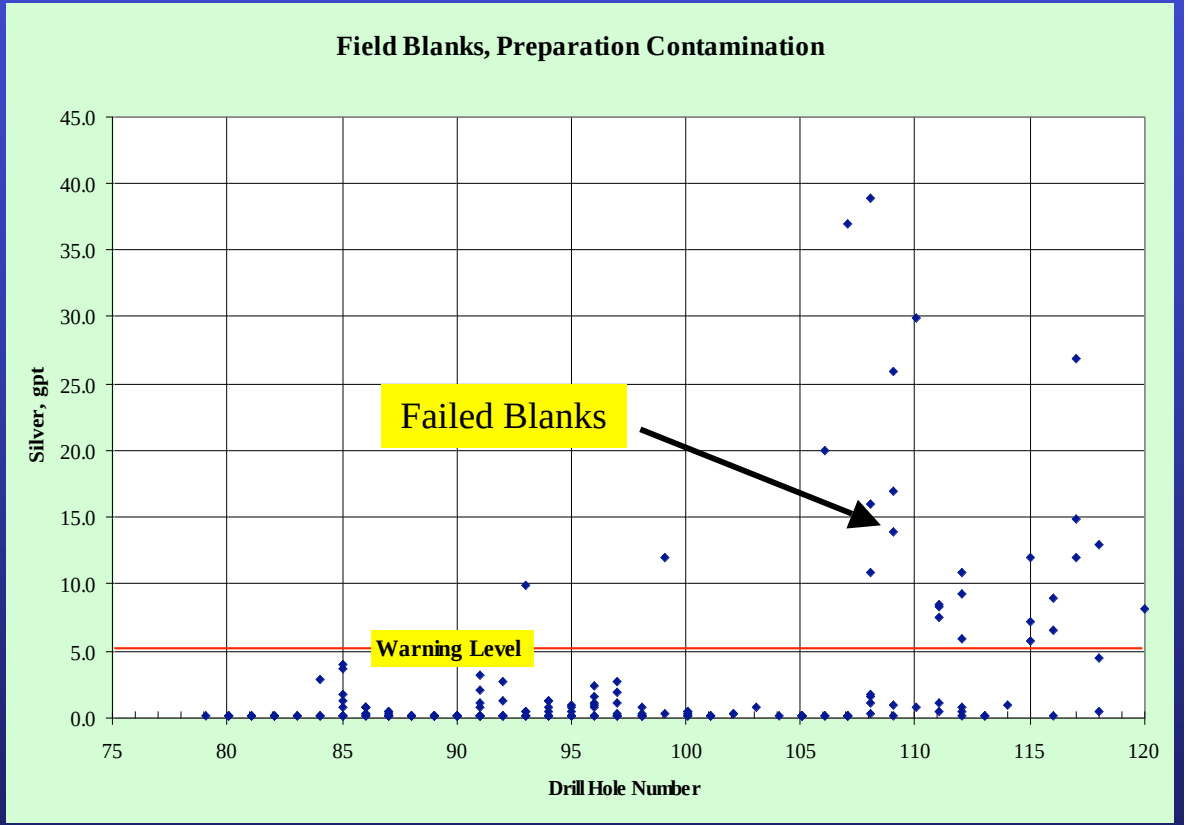
Property Specific Standards

Field standard showing both drift and change in instrument.



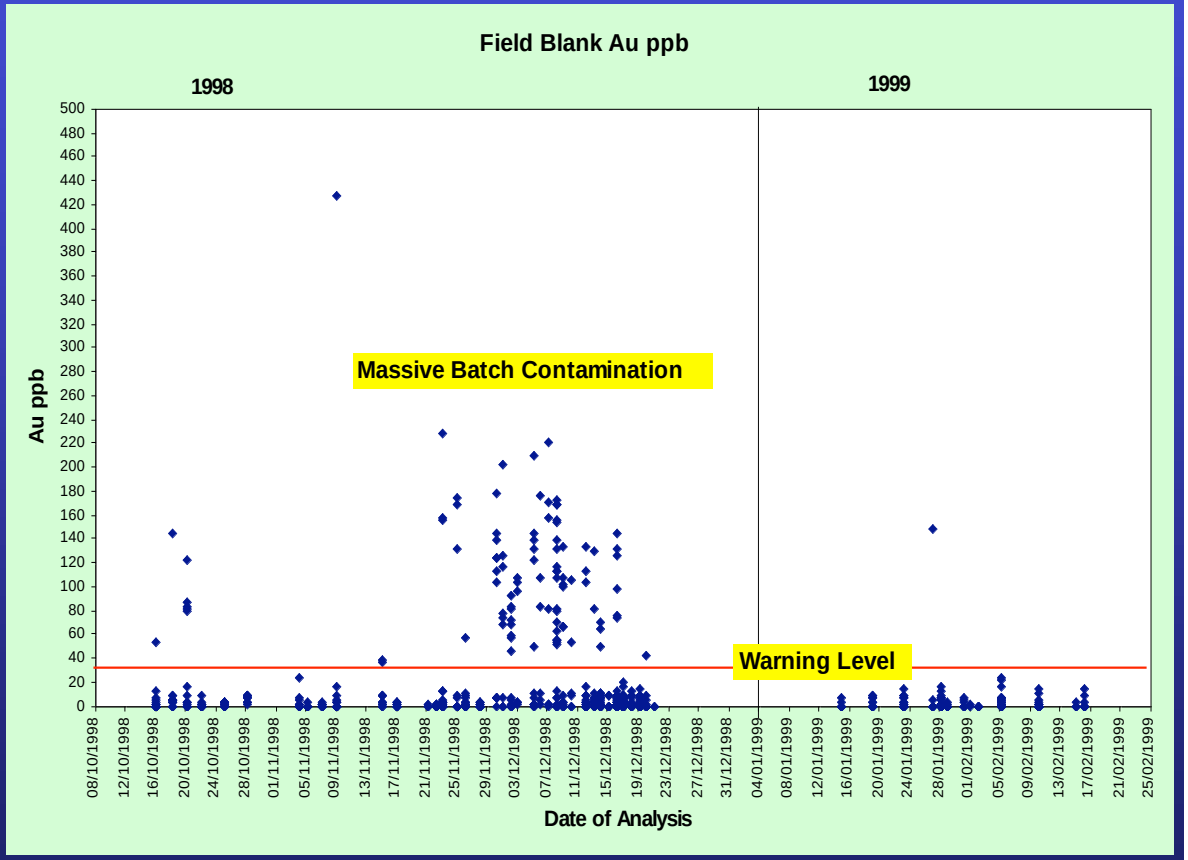
The Use of Field Blank

Most contamination occurs during sample preparation. Blanks must therefore be submitted from the field to the preparation laboratory.



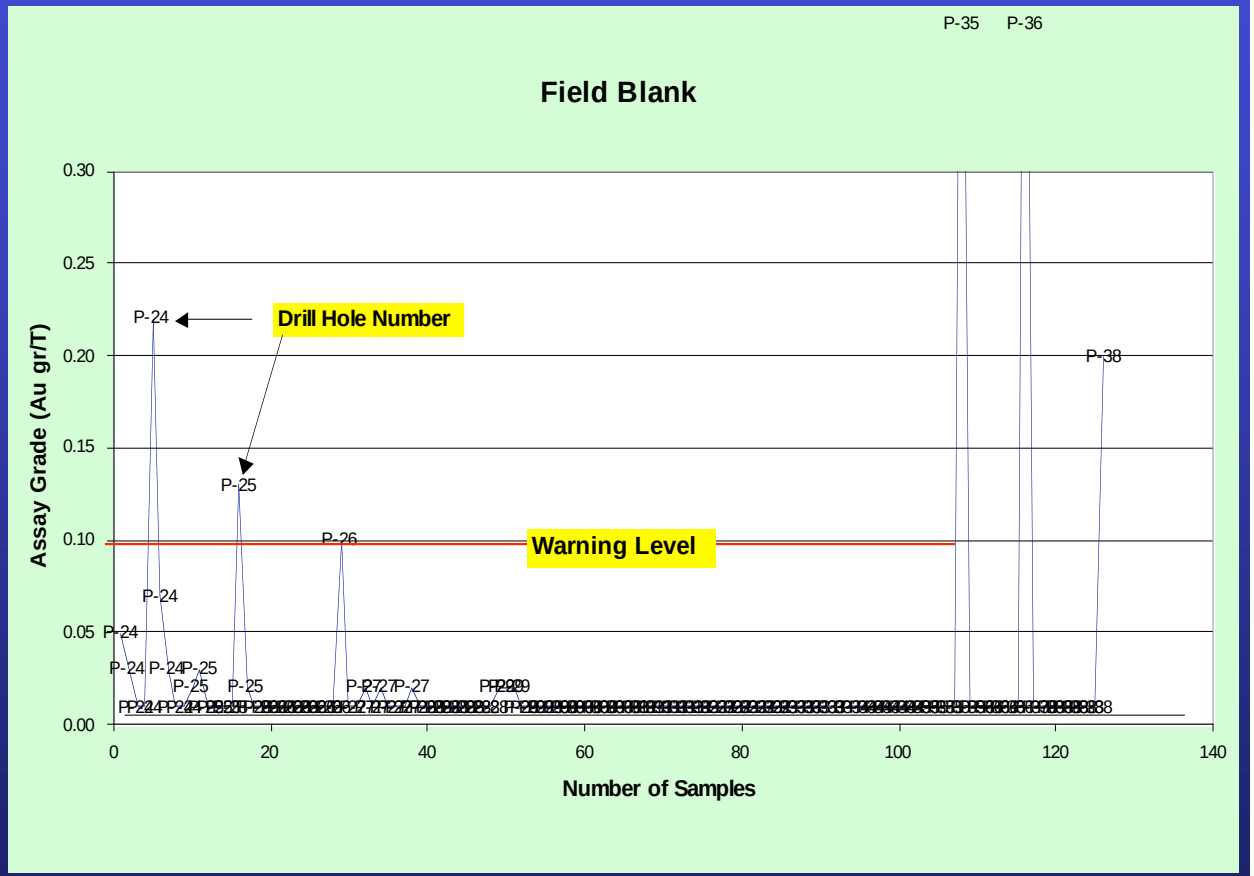
The Use of Field Blank

This contamination was found by the field blank only, not by the laboratory. It originated in the steel of the pulverizer, that contained 95 g/t Au.



The Use of Field Blank

The beginning of a drilling program usually has the most failures, as the laboratory becomes accustomed to the samples.

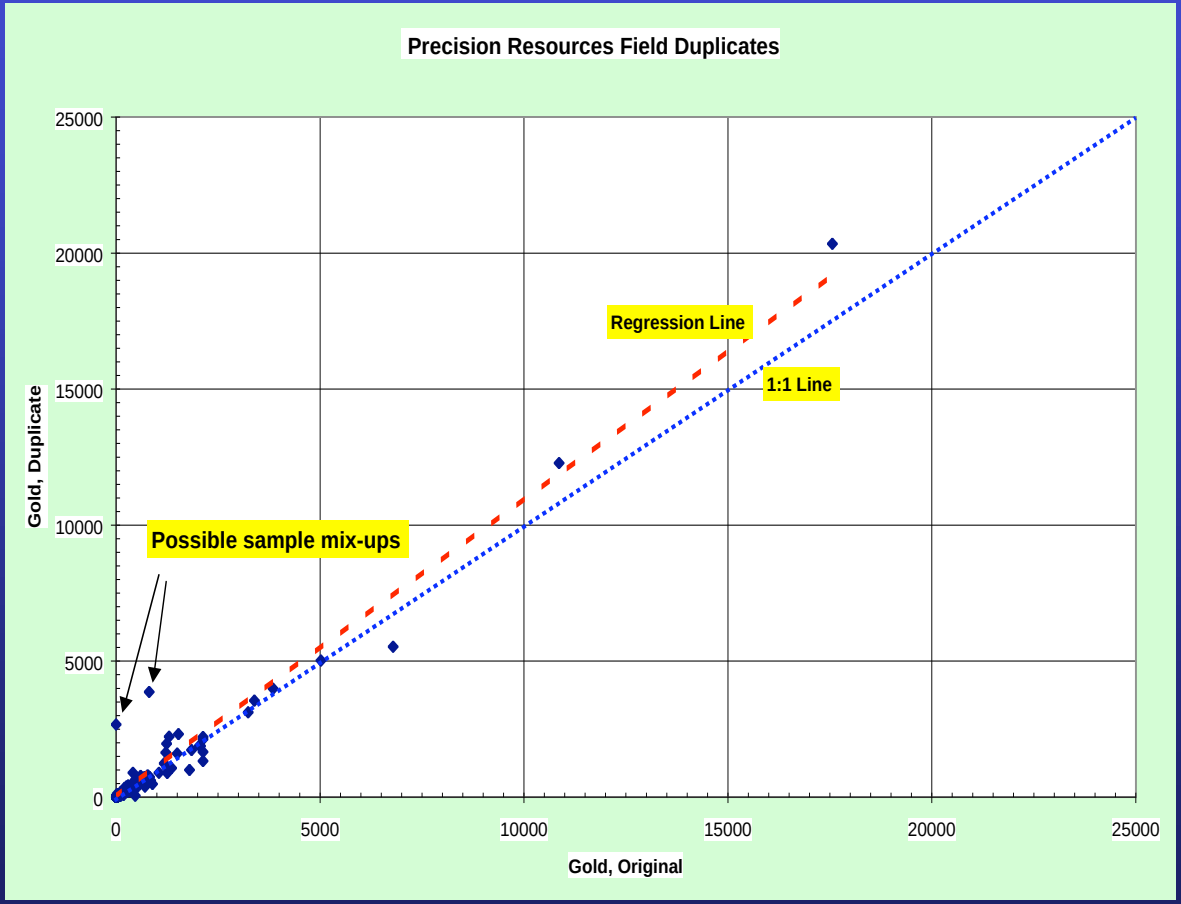


The Use of Field Blank

Example of field blank using unmineralized core.

The Use of Field Duplicates

1st step in handling duplicate data is to plot the original analysis vs the duplicate analysis. Look for “fliers” that may indicate sample mis-ordering or nugget effect.



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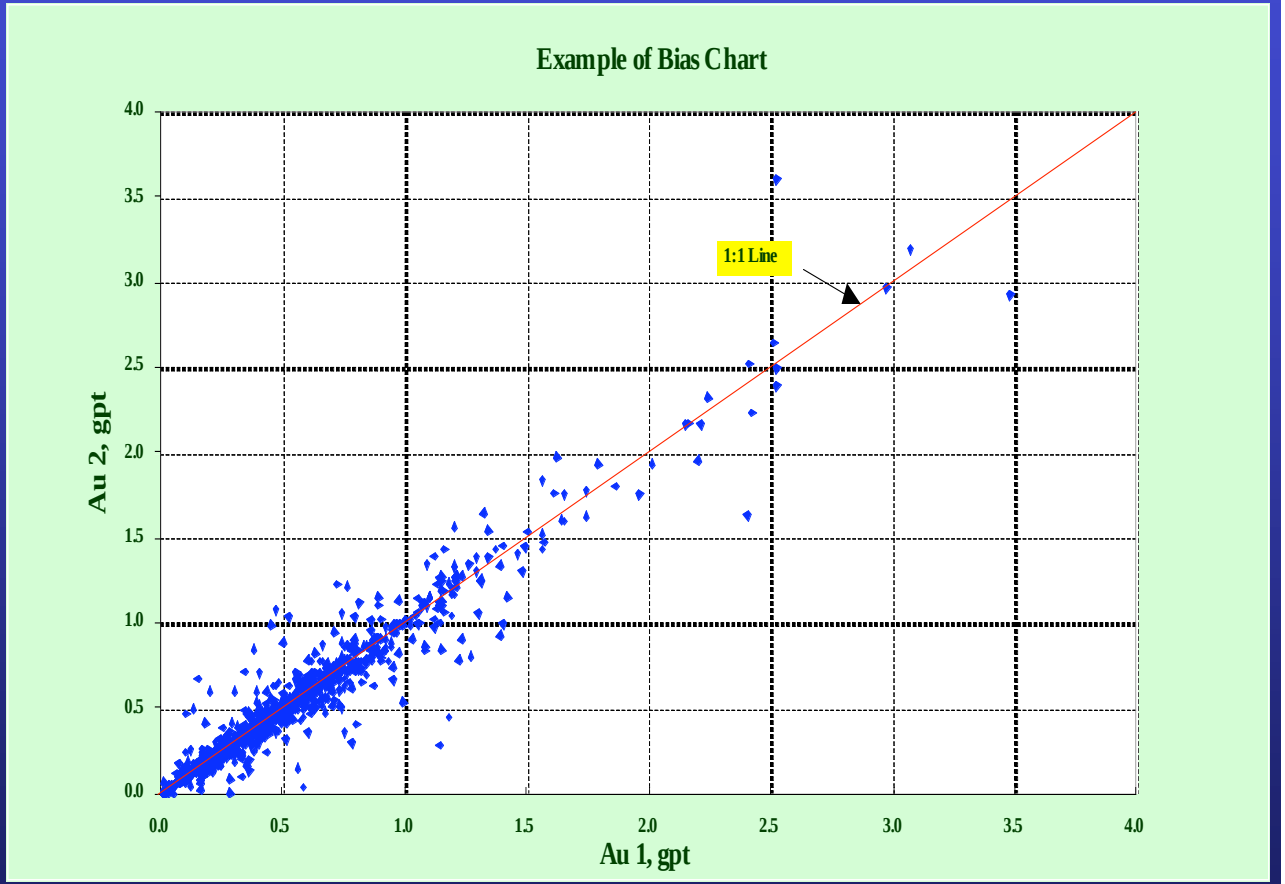
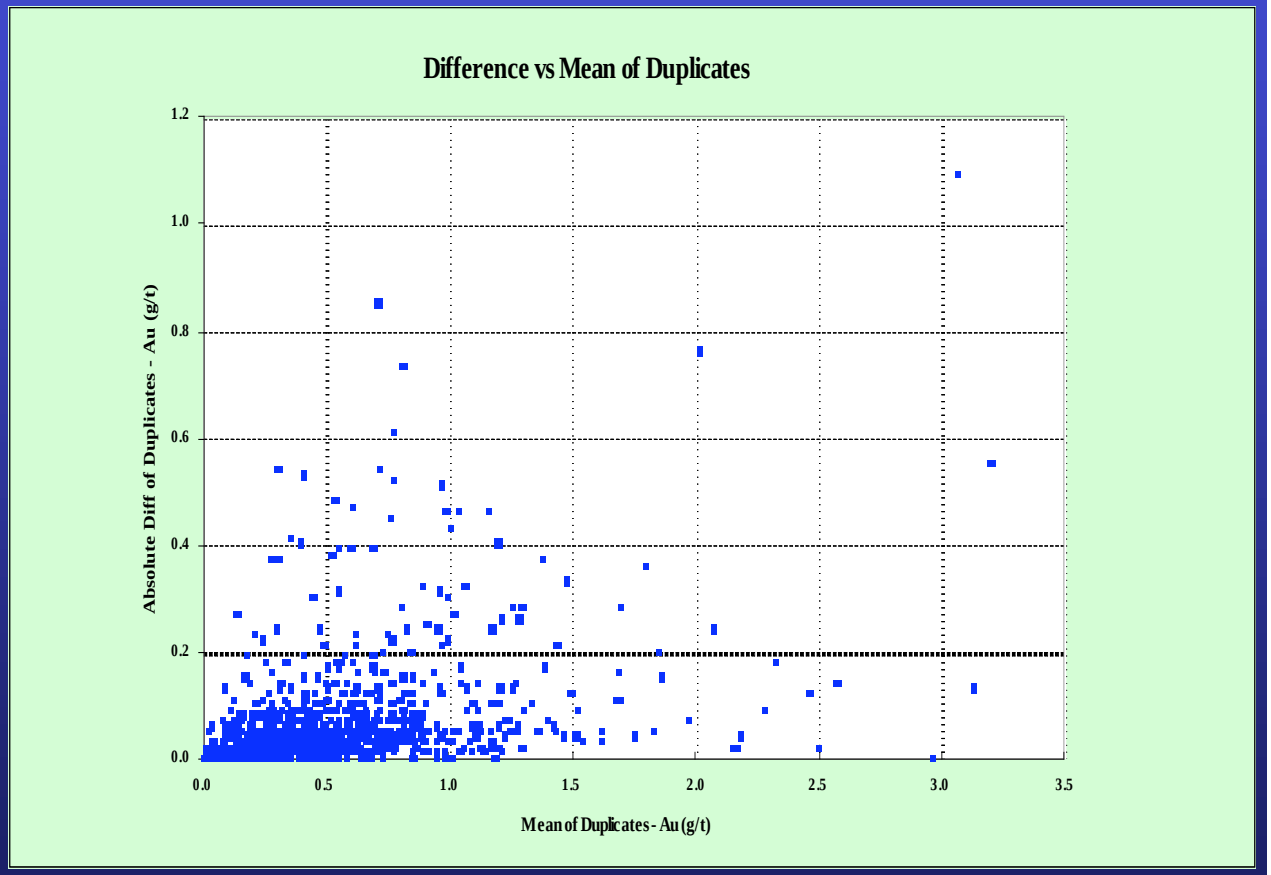


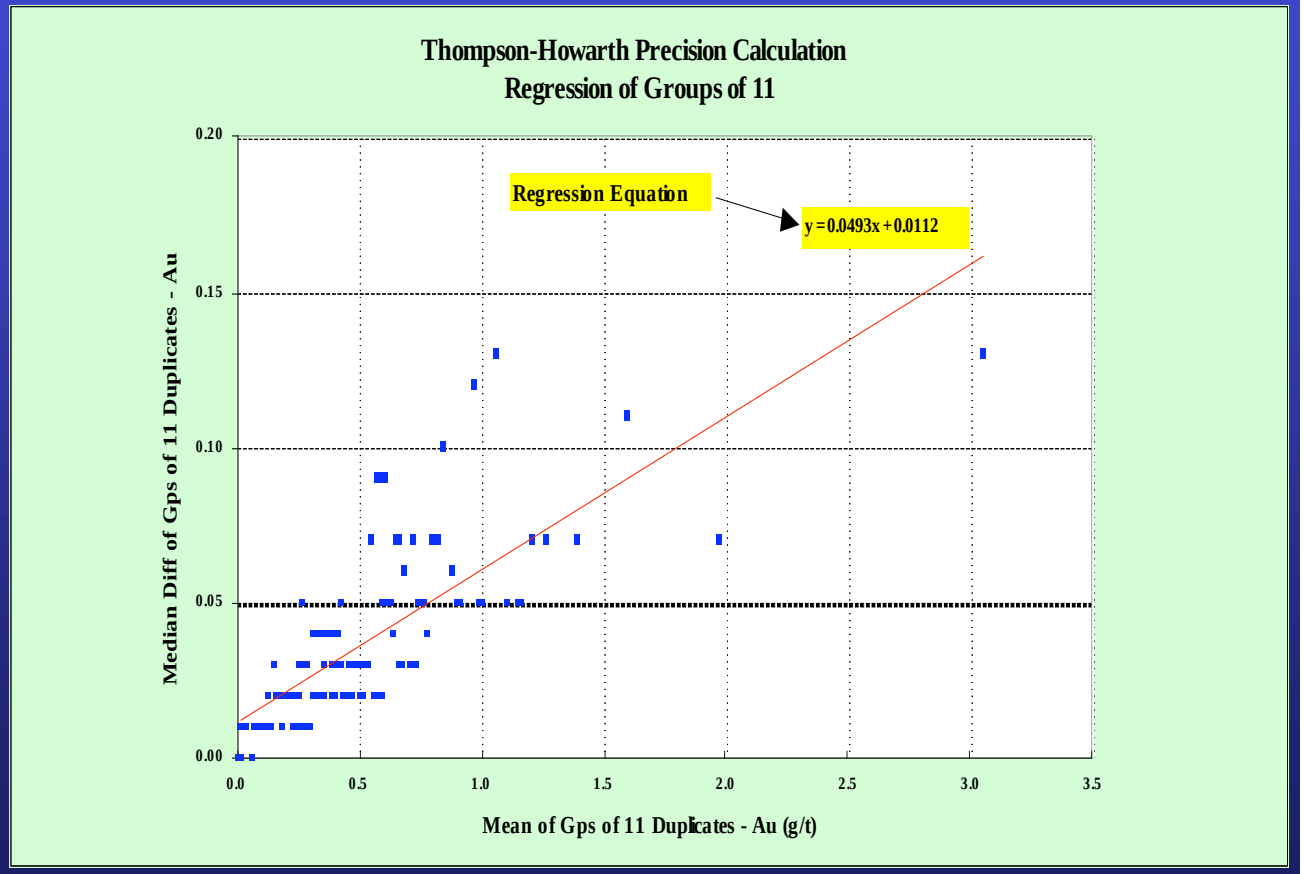
The Use of Field Duplicates

Calculate the mean of the duplicates and the absolute difference between the duplicates to look for the relationship between grade and precision.



The Use of Field Duplicates
Thompson-Howarth Estimate of Precision

Sort the mean and absolute differences by increasing mean. Then group the data in sets of 11 samples. Calculate the mean of each set of 11 and the median difference. Plot these.



The Use of Field Duplicates
Thompson-Howarth Estimate of Precision

Calculate the regression equation of the linear regression line.

Regression Coefficients

Intercept	**0.0112 = So**
X Variable	**0.0493 = K**

$$Pc = 2So/C + 2K$$

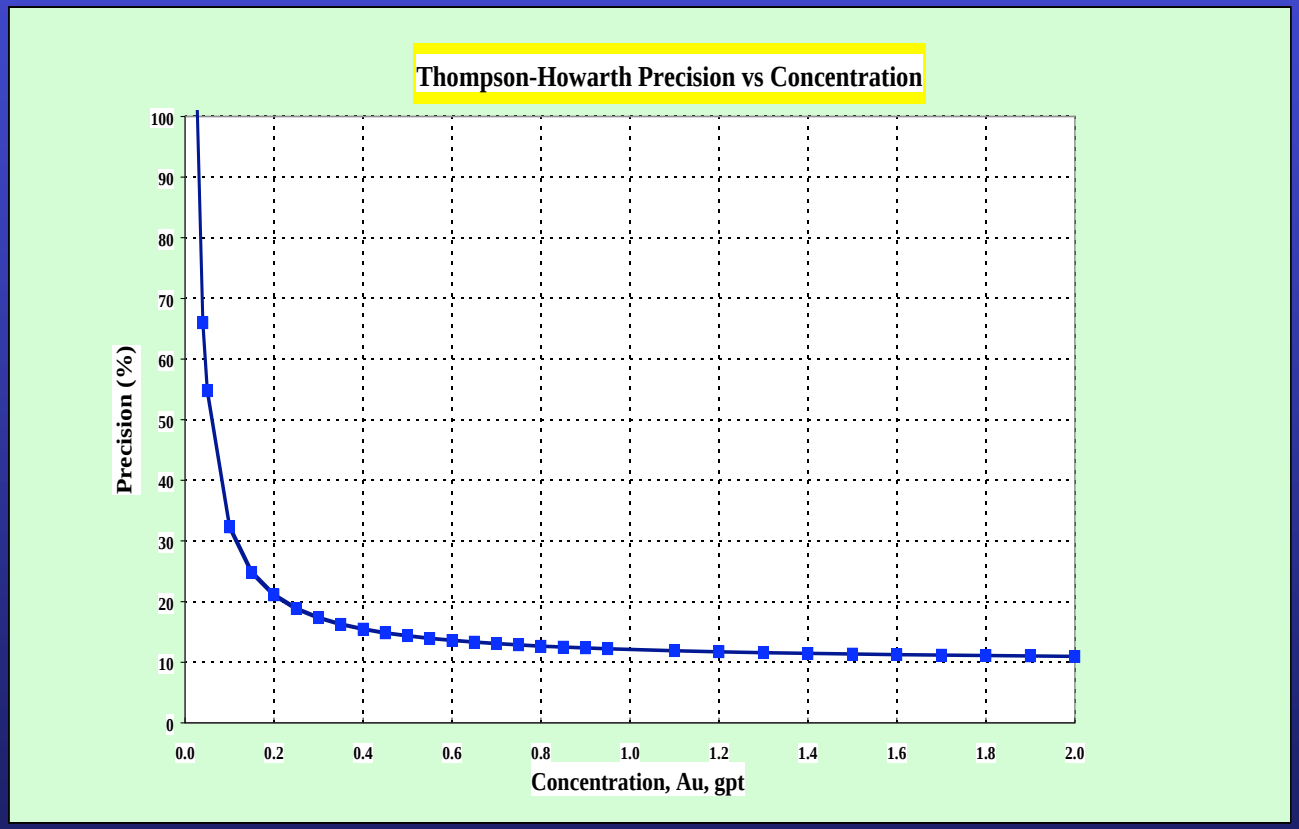
The Use of Field Duplicates
Thompson-Howarth Estimate of Precision

Use the formula to calculate the relationship between precision and concentration

C	Pc
0.01	234.36
0.02	122.11
0.04	65.98
0.05	54.76
0.10	32.31
0.15	24.82
0.20	21.08
0.25	18.83
0.30	17.34
0.35	16.27
0.40	15.47
0.45	14.84
0.50	14.34
0.55	13.94
0.60	13.60
0.65	13.31

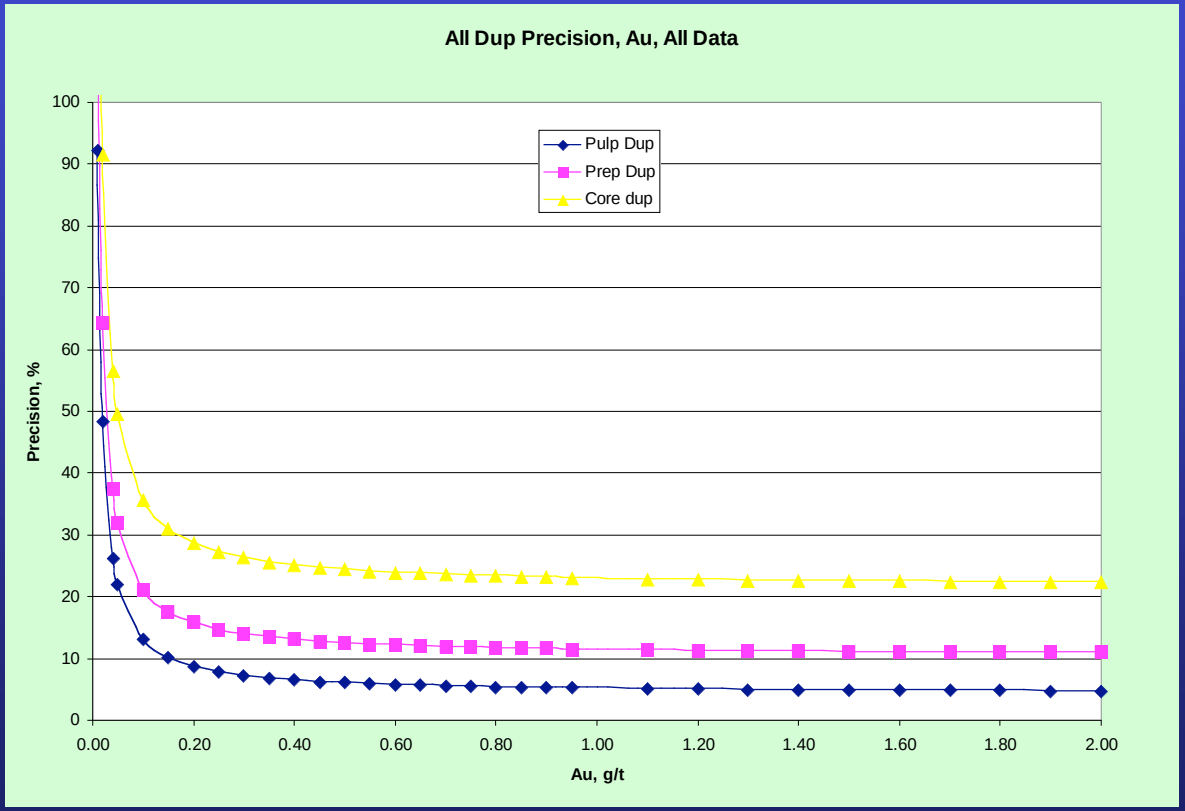
The Use of Field Duplicates
Thompson-Howarth Estimate of Precision

Plot this precision data on a chart.



The Use of Field Duplicates
Thompson-Howarth Estimate of Precision

Repeat this procedure for all three types of duplicates. This will show where the major error is in the sampling and analytical protocol.



Quality Control Logic

Decision logic is required for each project to decide if a QC sample is a failure, and a reason for the failure.

Quality Control Logic

Example of Logic for Gold Project

Table of Logic

Rule 1:	A standard greater than 3 SD's from the mean is a failure. (accuracy)
Rule 2:	Two adjacent standards that are greater than 2 SD's from the mean, on the same side of the mean, are failures. (bias)
Rule 3:	A blank sample that is greater than the Warning Limit is a failure.

Example of Table of Failures

Table of Failures

Work Order	Sample Number	Failure Type	Reason for Failure	Action Taken	Date New Data Received	Date Entered into Master Database

Comprehensive QC Program: