

ACID MINE DRAINAGE REMEDIATION WORKSHOP
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SAMPLING AND MONITORING

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Objective: is to provide a basic knowledge of sampling and monitoring plans and how they are used to predict and control the formation, sources, and mitigation of acid mine drainage

INTRODUCTION

What is a sampling and monitoring plan?

A sampling and monitoring program is the procedure implemented that answers specific questions and makes appropriate decisions by collecting samples of some media. Sampling and monitoring plans should be written documents that outline the procedures the program will use to ensure that the samples collected and analyzed, the data collected, and the interpretations are of high enough quality to meet the goals and objectives of the program. A sample is a representative portion of a population. Sampling strategies should be site specific and depend upon site characteristics, such as geology, uniformity of the sample media, size of sample media, access, etc. Many specific types of sampling and monitoring plans will be utilized during the life of a mine and it is important to maintain records of each plan so that data can be evaluated and used for other purposes than what it was initially intended. For example, modeling of ground-water flow may require water chemistry data that was obtained during the exploration stage, or chemical analyses of bench samples of blast holes during open-pit production may be utilized in characterizing the mine waste piles for reclamation.

Why are sampling and monitoring plans important?

Sampling and monitoring are important for numerous reasons. Establishing background/existing conditions/characterizing reference/ baseline data are obtained through effective sampling plans. Impacted (mine, human, logging, agriculture, other) areas verses pristine areas are identified and characterized. Potential use of water in the mining operation and the use of plants in reclamation are obtained through sampling and monitoring plans. Proper sampling plans are required to predict, model, and remediate MIW, AMD, and other environmental issues associated with mine sites. Sampling and monitoring programs best identify the risks that may occur, identify and quantify existing and potential sources, the pathways affected, and the potential receptors of

contamination. Sampling plans are required to establish remediation goals and evaluate and implement the results. Subsequent monitoring is required to determine if goals have been met. Sampling and monitoring are required to determine how well the predictive models work and how effective the remediation methods are. Sometimes a separate data collection may be needed with specific detection limits and confidence levels. Effective sampling and monitoring programs may result in prevention of contamination. Sampling and modeling programs are critical in understanding the long-term effects of metal mobility. And last, but certainly not least, specific sampling and monitoring programs are required to fulfill regulatory requirements, especially in remediation and operational compliance monitoring.

What can be sampled?

A variety of sampling media can be tested. It is very important to understand what data are required and how they are to be used and what sampling media will address the issue. For example, macro-invertebrates are indicators of the biodiversity and bioavailability of an ecosystem and ultimately represent the health of the ecosystem. We contend that all types of sampling media should be sampled at some point during the life of the mine, preferably in the initial stages to establish background/baseline conditions. These media can be broadly characterized as solid, liquid, air, biological, and other media (Table 1).

TABLE 1. Types of data and sampling media required in sampling and monitoring program

Physical data
Topography and altitude
Natural drainage vs man-made drainage
Wind direction and speed
Storm events and types
Slope aspects
Stream/river flow data
Geological data
Structural geology (faults, fractures, joints, lineaments)
Seismic data/earthquake prediction
Stratigraphy and lithology
Particle size analysis
Geomorphology
Deposit type
Mining methods
Aquifer characteristics
Permeability/porosity
Hydraulic conductivity
Ground water flow direction and rates
Climatological data
Temperature
Evapotranspiration
Rainfall/snowfall

Freeze-thaw
Growing season
Days of sunlight
Floods (10 yr, 100 yr, etc.)

Solid

Overburden
Country rock
Ore
Subore or low-grade material stockpiles
Waste (dumps, other)
Waste (dumps, other)
Tailings
Soils/top soil
Subsurface samples (drill core, cuttings, other)
Sediments (lake, stream, river, overbank)
Spent leach ore/material

Liquid

Leachate
Sludge
Ground water
Surface water
 Storm water (impacted and nonpacted)
 Stream/river
 Lakes and ponds
 Processed waste water
 Other waste water
 Surface runoff
 Pit lakes
 Seeps
 Springs
 Man-made discharge points (adits, tunnels, pit walls, etc.)
Rainwater/snow melt
Brine
Residuals from passive treatments
Process solutions

Air

Gases (oxygen flux)
Particulates
Aerosols

Biological

Humans
Animals
 Aquatic (macroinvertebrates, vertebrates)
 Terrestrial
Plants
 Aquatic (algae)

Terrestrial
Microorganisms (bacteria)
Aquatic
Terrestrial
Habitats

What are monitoring plans?

Monitoring means many things to different people and entities, but typically includes common key questions:

- What is the problem?
- What are the background conditions?
- What is the source of the problem?
- What are the pathways affected, and are people and/or the environment affected?
- What are the desired final results of remediation/reclamation and who will determine if the program was successful?
- Was the sampling and monitoring plan successful?
- Is the site in compliance with environmental laws?

What are the 12 components of sampling and monitoring plans?

1. Define questions and objectives (in other words, define the problem)
2. Develop site conceptual models
3. What are the costs and potential consequences of not sampling. This is also known as a cost and benefit risk analysis.
4. Identify types of data and information needed
5. Define confidence level and quantity of data required to answer questions
6. Design the sampling plan
7. Develop protocols
8. Conduct an orientation or pilot study (screening test or trying program out before implementation). Review questions and modify plan.
9. Conduct sampling plan (program implementation)
10. Analyze and manage data (information utilization, interpretation)
11. Make decisions (risk management)
12. Educate and inform the parties involved

DATA VERIFICATION

Accuracy and precision of data

“All analytical measurements are wrong: it’s just a question of how large the errors are, and whether they are acceptable” (Thompson, 1989). Everyone who is involved in measurement science must understand this fact. It also is the very reason why quality control and assurance (QA/QC) programs are so important.

DEFINITIONS

Precision—the degree of agreement among repeated measurements of the same characteristic. It may be determined by calculating the standard deviation, or relative percent difference, among samples taken from the same place at the same time.

Accuracy—measures how close your results are to a *true* or expected value and can be determined by comparing your analysis of a standard or reference sample to its actual value.

Completeness—the comparison between the amount of valid, or usable, data you originally planned to collect, versus how much you collected.

Comparability—the extent to which data can be compared between sample locations or periods of time within a project, or between projects.

As scientists we are taught that scientific measurements always have to be very accurate and precise, and that sophisticated instruments which generate more digits and more decimal places make scientific measurements even better. However, there are situations where representative data are more useful than precise data. For example, one might opt to do 8 inexpensive field tests with 25% error instead of 2 expensive laboratory analyses with 5% error. As a screening tool for prioritization of mine waste piles, one could use a monitoring system that gives discharges in a list relative to one another, whereas the actual concentrations in the discharge would not be accurate. It depends upon the decisions that need to be made based upon the data.

QC is referred to a program designed to detect and measure the error associated with a measurement process. QC is the program that ensures that the data are acceptable. QA is the program designed to verify the acceptability of the data using the data obtained from the QC program. QA provides the assurance that the data meets certain quality requirements with a specified level of confidence (Johnson, 1993).

Quality control/quality assurance

What is the purpose of your project?

What do you need the analyses for and how accurate should they be?

Where are the results going to be released or published?

What is the mineralogy?

What are appropriate certified standards (may need to develop lab standards)?

What are the detection limits (both upper and lower)?

Analytical errors vary from element to element, for different ranges of concentration, and different methods

Duplicate or more analyses of standards and unknowns verses duplicate runs of same sample

Analyze a separate set of standards rather than standards used for calibration

Send samples and standards to other laboratories

Establish written lab procedures

Are blanks and field blanks used and analyzed?

What are the custody procedures (collection date, preservation method, matrix, analytical procedures)?

Does the chemical analyses make geological sense? Is it consistent with the mineralogy and type of mineral deposit?

Sometimes there is more paper work than making sure the data is accurate

What do you do if there are problems with QA/QC?

Types of errors

Systematic versus bias (constant, unintentional)

Random errors (unpredicted but nonsystematic errors, imprecise practices)

Gross or illegitimate errors (procedural mistakes)

Deliberate errors

Measurement errors

Wrong sample

Wrong reading

Transposition or transcription errors

Wrong calibration

Peak overlap

Wrong method

Contamination

Losses

Inattention to details

Sampling problems

Instrument instability

Reagent control

Variability of blank

Operator skill

Sample variability