AGAT Laboratories

# Understanding Quality

## About AGAT Laboratories

AGAT Laboratories is a highly specialized Canadian company providing analytical solutions worldwide. As Canada's national privately-owned laboratory network, AGAT Laboratories is renowned for providing accurate, timely and defensible solutions to complex analytical requests with a constant focus on ensuring "Service Beyond Analysis" to its national and international clients since 1979. With coast-to-coast locations, AGAT Laboratories is comprised of 12 scientific divisions that service a wide spectrum of industries, namely, Environmental Chemistry, Mining Geochemistry, Petroleum Testing, Oil Sands Analysis, Rock Properties, Reservoir Characterization, Lubricant Testing, Air Quality Monitoring, Forensic Chemistry, Ultra-Trace and Toxicology, Food Testing, and Agricultural Analysis.

For more information, please visit **www.agatlabs.com**, follow us on **LinkedIn**, **Twitter** and **Instagram**, and subscribe to our **YouTube channel**.

AGAT Laboratories

# Understanding Quality


**AGAT Laboratories** employs quality assurance professionals whose mandate is the continuous improvement of our organization. Our Quality Assurance Division monitors the operations of the company and ensures compliance with the best-documented practices. This division employs a Quality Assurance System to ensure precision, accuracy and reliability in all of our services. These best practices are documented and consistent with industry-regulated standards. In addition, we conduct regular quality control checks on all instrumentation and our personnel regularly evaluate all methodologies and procedures for the continuous improvement of our services. Quality control data is delivered to our clients for review in the form of a Certificate of Analysis as well as a Quality Assurance Report.

We don't view analytical determinations from a factory perspective; we view *quality as the responsibility of the entire organization*.

**AGAT Laboratories is accredited or approved for specific analyses by the following:**

- The Canadian Association for Laboratory Accreditation (CALA)
- The Standards Council of Canada (SCC)
- Centre d'expertise en analyse environnementale du Québec (CEAEQ)
- The NELAC Institute (TNI)
- The British Standards Institution (BSI)

**AGAT Laboratories is accredited for specific tests as stated on the applicable scope of accreditation to the following:**

- ISO /IEC 17025:2017 - General Requirements for the Competence of Testing and Calibration Laboratories

**AGAT Laboratories is certified to the following:**

- ISO 9001:2015 - Quality Management System

AGAT Laboratories' Quality Assurance personnel operate as a team across Canada and are collectively responsible for ensuring the highest degree of data scrutiny possible. Our Quality Assurance Division operates separately from all of our other operations. They report directly to our Chief Executive Officer and have no compensation directly or indirectly tied to laboratory production, financial or otherwise. This allows the division to operate in an unbiased manner for the benefit and improvement of all operations.

## Quality Control: Accuracy vs. Precision

Understanding the difference between accuracy and precision is an important concept in quality control.

**Precision**: Is a measure of how well replicate measurements reproduce and can be calculated from laboratory duplicate samples.

*VS*

**Accuracy**: Is a measure of how near a result is to the true value (sometimes called the expected value) and is often expressed as percent recovery. Method accuracy is determined from the analysis of standards and spikes.

Method precision and accuracy are not the same factors. An analyst's data can be precise without being accurate, accurate without being precise, inaccurate and imprecise, or both accurate and precise.

The following bull's eye examples are often used when explaining the difference between accuracy and precision.

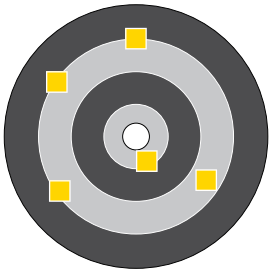

**Figure 1.**

**Figure 1 ▪ Inaccurate and Imprecise**

This is a random pattern, both inaccurate and imprecise. Results are not clustered together and are not near the bull's eye.

Analysis: The same sample was analyzed five times and the analyst did not achieve correct results (inaccurate) as no two results were the same (imprecise).

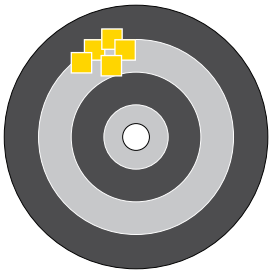

**Figure 2.**

**Figure 2 ▪ Precise but Inaccurate**

This is a precise pattern, but inaccurate. The results are clustered together but do not hit the intended mark (the expected result).

Analysis: A sample was analyzed five times. The analyst achieved results that were all close to each other (precise), however, they were not close to the actual result (inaccurate).

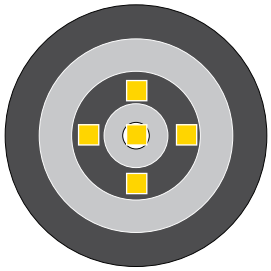

**Figure 3.**

**Figure 3 ▪ Accurate but Imprecise**

This is an accurate pattern, but imprecise. The results are not clustered but their "average" position is the centre of the bull's eye.

Analysis: For the sample analyzed five times, the average of the five results was the expected result (accurate) but the results are not close to one another (imprecise).

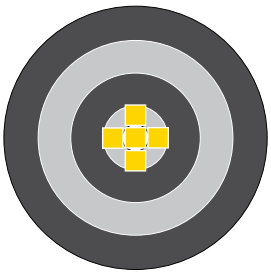

**Figure 4.**

**Figure 4 ▪ Precise and Accurate**

This pattern is both precise and accurate. The results are tightly clustered and their average position is the centre of the bull's eye.

Analysis: For a sample analyzed five times, the analyst consistently achieved the expected value.

Generally speaking, quality control samples that are analyzed in the laboratory alongside client samples are designed to measure precision and accuracy with the ultimate goal of developing each analytical process to the point where "Figure 4: Precise and Accurate" becomes the norm.

AGAT Laboratories

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# Quality Assurance
# Soil Analysis

CLIENT NAME: CLIENT ABC
PROJECT: ABC
SAMPLING SITE: FIELD 1

AGAT WORK ORDER: 22R123456
ATTENTION TO: CLIENT
SAMPLED BY: J. SAMPLER

| RPT Date | | | Duplicate | | | Method Blank | Reference Material | | | Method Blank Spike | | | Matrix Spike | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Measured Value | Acceptable Limits | | Recovery | Acceptable Limits | | Recovery | Acceptable Limits | |
| Parameter | Batch | Sample ID | Dup #1 | Dup #2 | RPD | | | Lower | Upper | | Lower | Upper | | Lower | Upper |
| **Summit Reclamation Salinity-AB Tier 1 with pH Calcium Chloride (mg/kg)** | | | | | | | | | | | | | | | |
| pH (CaC12 Extraction) | 20 | 3347343 | 7.02 | 7.27 | 3.5% | N/A | 101% | 90% | 110% | | | | | | |
| Electrical Conductivity (Sat. Paste) | 21 | 3347343 | 0.43 | 0.42 | 2.3% | <0.05 | 90% | 80% | 120% | | | | | | |
| Saturation Percentage | 21 | 3347343 | 48 | 48 | 2.1% | <1 | 98% | 80% | 120% | | | | | | |
| Chloride, Soluble | 21 | 3347343 | 21 | 21 | NA | <5 | 104% | 70% | 130% | 105% | 80% | 120% | 104% | 70% | 130% |
| Calcium, Soluble | 21 | 3347343 | 35 | 35 | 9.0% | 1 | 91% | 70% | 130% | 102% | 80% | 120% | 106% | 70% | 130% |
| Magnesium, Soluble | 21 | 3347343 | 15 | 15 | 1.8% | <1 | 106% | 70% | 130% | 110% | 80% | 120% | 106% | 70% | 130% |
| Potassium, Soluble | 21 | 3347343 | 7 | 7 | NA | <2 | 88% | 70% | 130% | 100% | 80% | 120% | 94% | 70% | 130% |
| Sodium, Soluble | 21 | 3347343 | 15 | 15 | 5.7% | <2 | 95% | 70% | 130% | 106% | 80% | 120% | 100% | 70% | 130% |
| Sulfate, Soluble | 21 | 3347343 | 47 | 47 | 1.8% | <2 | 96% | 70% | 130% | 89% | 80% | 120% | 84% | 70% | 130% |
| **CCME /Tier 1 Metals + Boron (Sat Paste)** | | | | | | | | | | | | | | | |
| Antimony | 21 | 3435102 | <0.5 | <0.5 | NA | <0.5 | 95% | 70% | 130% | 89% | 80% | 120% | 117% | 70% | 130% |
| Arsenic | 21 | 3435102 | 6.3 | 7.0 | 10.1% | <0.5 | 83% | 70% | 120% | 93% | 80% | 120% | 98% | 80% | 120% |
| Barium | 21 | 3435102 | 254 | 253 | 0.3% | <0.5 | 98% | 80% | 130% | 86% | 80% | 120% | 124% | 70% | 130% |
| Beryllium | 21 | 3435102 | <0.5 | <0.5 | NA | <0.5 | 119% | 70% | 130% | 107% | 80% | 120% | 120% | 70% | 130% |
| Boron (Saturated Paste) | 3347343 | 3435102 | <0.5 | <0.5 | NA | <0.5 | 102% | 70% | 120% | NA | | 1 | 101% | 80% | 120% |
| Cadmium | 21 | 3435102 | <0.5 | <0.5 | NA | <0.5 | 104% | 70% | 130% | 95% | 80% | 120% | 120% | 70% | 130% |
| Chromium | 21 | 3435102 | 18.4 | 18.6 | 0.9% | <0.5 | 99% | 70% | 130% | 118% | 80% | 120% | 104% | 70% | 130% |
| Cobalt | 21 | 3435102 | 7.0 | 7.0 | 0.0% | <0.5 | 100% | 70% | 130% | 112% | 80% | 120% | 106% | 70% | 130% |
| Copper | 21 | 3435102 | 13.5 | 13.3 | 1.5% | <0.5 | 97% | 70% | 130% | 113% | 80% | 120% | 97% | 70% | 130% |
| Lead | 21 | 3435102 | 8.0 | 7.9 | 2.0% | <0.5 | 106% | 70% | 130% | 96% | 80% | 120% | 125% | 70% | 130% |
| Molybdenum | 21 | 3435102 | 0.7 | 0.7 | NA | <0.5 | 103% | 70% | 130% | 94% | 80% | 120% | 128% | 70% | 130% |
| Nickel | 21 | 3435102 | 19.8 | 19.7 | 0.8% | <0.5 | 107% | 70% | 130% | 120% | 80% | 120% | 101% | 70% | 130% |
| Selenium | 21 | 3435102 | 0.6 | 06 | NA | <0.5 | 101% | 70% | 130% | 93% | 80% | 120% | 124% | 70% | 130% |
| Silver | 21 | 3435102 | <0.5 | <0.5 | NA | <0.5 | 101% | 70% | 130% | 95% | 80% | 120% | 116% | 70% | 130% |
| Thallium | 21 | 3435102 | <0.5 | <0.5 | NA | <0.5 | 99% | 70% | 130% | 94% | 80% | 120% | 125% | 70% | 130% |
| Tin | 21 | 3435102 | 1.4 | 0.6 | NA | <0.5 | 109% | 70% | 130% | 96% | 80% | 120% | 105% | 70% | 130% |
| Uranium | 21 | 3435102 | 0.7 | 0.7 | NA | <0.5 | 101% | 70% | 130% | 96% | 80% | 120% | 112% | 70% | 130% |
| Vanadium | 21 | 3435102 | 28.1 | 25.3 | 10.5% | <0.5 | 103% | 70% | 130% | 118% | 80% | 120% | 108% | 70% | 130% |
| Zinc | 21 | 3435102 | 51 | 46 | 10.4% | <1 | 98% | 70% | 130% | 97% | 80% | 120% | 94% | 70% | 130% |

*Comments: If the RPD value is NA, the results ofthe duplicates are under 5X the RDL and will not be calculated.*
*If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.*

AGAT Laboratories **QUALITY ASSURANCE REPORT (V1)**

AGAT Laboratories is accredited to ISO/IEC 17025 by the Canadian Association for Laboratory Accreditation Inc. (CALA) and/or Standards Council of Canada (SCC) for specific tests listed on the scope of accreditation. AGAT Laboratoires (Mississauga) is also accredited by the Canadian Association for Laboratory Accreditation Inc. (CALA) for specific drinking water tests. Accreditations are location and parameter specific. A complete listing of parameters for each location is available from www.cala.ca and/or www.scc.ca. The tests in this report may not necessarily be included in the scope of accreditation. RPDs calculated using raw data. The RPD may not be reflective of duplicate values shown, due to rounding of final results.

*Results relate only to the items tested. Results apply to samples as received.*

**Figure 5.**
*AGAT Laboratories' Quality Assurance Report.*

## Quality Control Samples

Accuracy and precision are estimated in an analytical process through the use of quality control samples. Quality control samples come from both the laboratory and the field. Laboratory quality control sample results are reported in the AGAT Laboratories' Quality Assurance Reports, which are delivered alongside the Certificate of Analysis. The following is an explanation of each of these laboratory samples, their origin and purpose

## Duplicates

Under the Duplicates heading in the AGAT Laboratories' Quality Assurance Report, there exists three columns, Duplicate 1, Duplicate 2 and RPD (Relative Percent Difference). Duplicates are a measurement of analytical precision and can mean more than one thing. It is important to understand the difference between the versions of these samples.

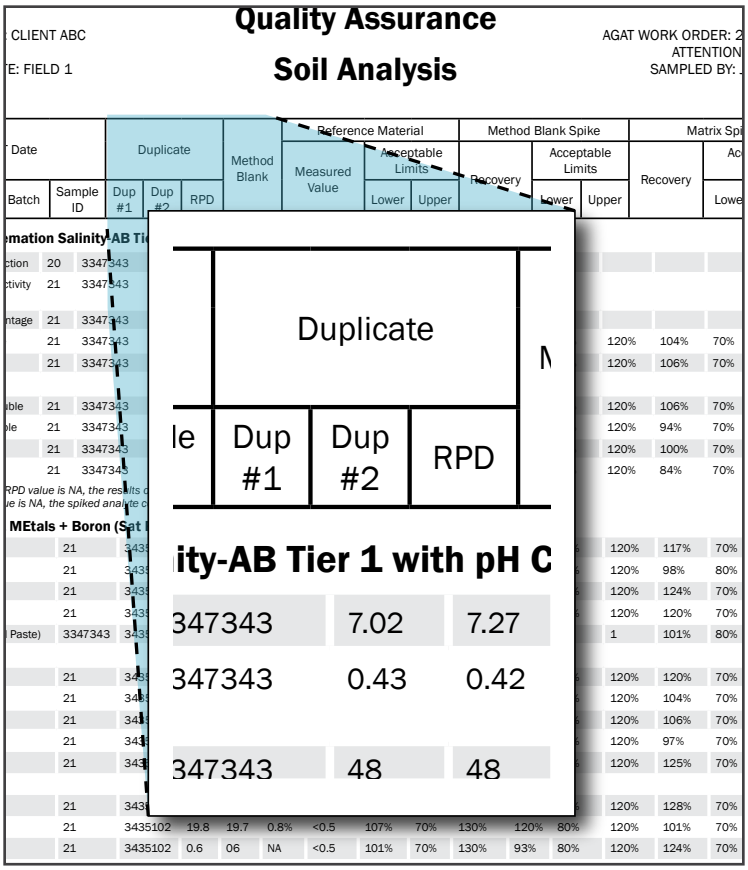



**Figure 6.**
*Duplicate data on Quality Assurance Report.*

Laboratory duplicates are two aliquots taken from the same sample container and then processed through the entire analytical procedure separately. Measured results are used to compare the analytical precision of the entire analytical process including sample preparation, digestion, extraction and instrumental measurement.

### Matrix Spike Duplicates

These are used to determine method precision. These samples involve taking two aliquots from a client sample and adding known amounts of the contaminants of interest to both aliquots, then processing them through the entire analytical procedure separately. Although similar to laboratory duplicates, in this method, precision can be measured on analytes even in situations where the sample itself might have been a "non-detect" for the compounds of interest.

### Instrument Duplicates

Where two aliquots are taken from the same extract or digest and then analyzed by the same instrument at the same time. Results from these duplicates indicate instrumental precision, however, they do not provide information relative to the entire analytical process. In all analytical procedures, we measure and report laboratory matrix spike duplicates, but never instrumental duplicates. This allows us a true and accurate picture of the entire analytical process, not just of the instrumental precision.

### Split Sample

A sample which has been thoroughly blended and split between two containers. These samples can then be sent to one laboratory, or sometimes to two separate labs. Split samples are intended to measure the precision of sampling and analytical procedures, however the thoroughness of the blending process can often be the determining factor in the precision of the two data points.

### Co-located Samples

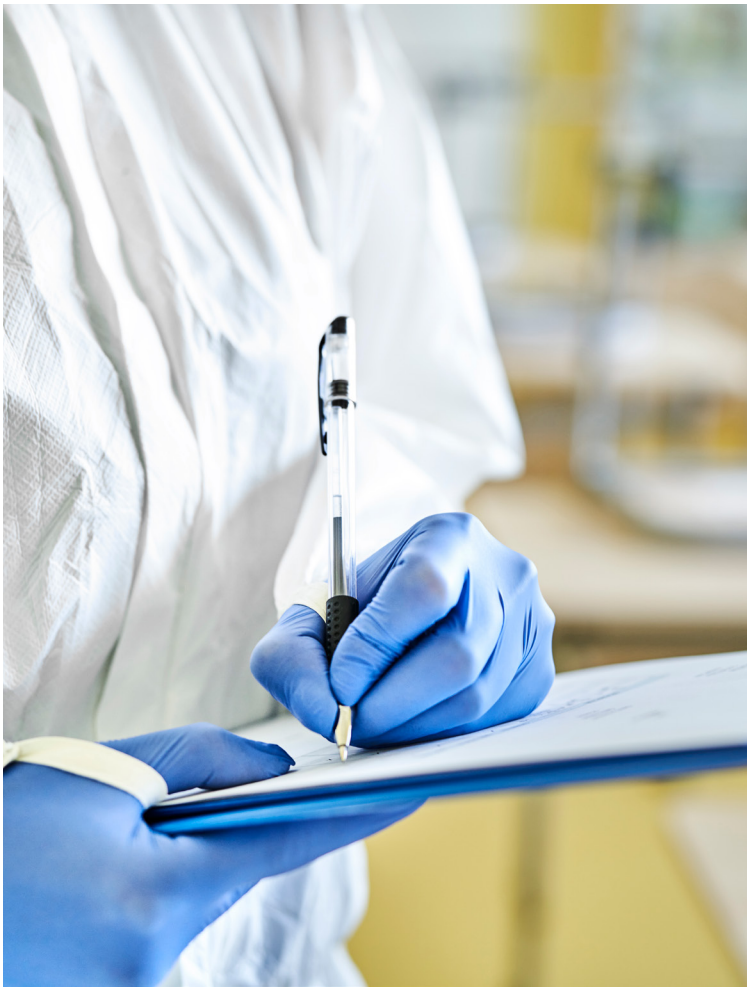
Samples taken in the same location but not blended. Due to the extreme variability of environmental samples over short spatial differences, especially soils, it is difficult to use co-located soil samples to assess laboratory precision. They can however be useful in measuring sample precision or the variability of the matrix.

### The Relative Percent Difference (RPD)

The numerical value of comparing duplicate values to one another. This is calculated by taking the difference of the two measurements, dividing it by the average of both measurements, and then multiplying it by 100 per cent. RPD is a direct indicator of quality control when comparing repeated measurements that are expected to have similar values.

## Certified Reference Material

Certified Reference Material (CRM) is purchased material that contains predetermined concentrations of the analyte or analytes of interest. CRMs are manufactured by companies accredited to the current version of the ISO 17034 standard. They are typically samples of either water or soil where the “right answer” for analysis is known to demonstrate the accuracy of a specific method. CRM can be used to calibrate instruments by preparing a calibration standard from dilutions of the sample. Reference standards are similar to calibration standards, but are purchased from a different supplier, not accredited to ISO 17034. They are used to ensure that the calibration standard is correct and that it is measured before and after a batch of client samples. On our Quality Assurance Report, the “measured value” for the CRM is expressed as a percentage recovery of the reference standard after the client samples have been measured.



## Spikes

There are two types of spikes that are routinely analyzed by AGAT Laboratories - Matrix Spikes and Method Blank Spikes. Both are used to measure the accuracy of the analytical method, and the effect a particular sample matrix has on the accuracy of that measurement.

### Matrix Spike

Is prepared by adding a known amount of the target analyte(s) to a volumetric aliquot of the client sample. By spiking the sample matrix, our laboratory analysts can demonstrate whether a chosen method is fit for purpose to measure the adjacent samples, that are of a similar matrix. The percentage recovery of the matrix spike will indicate the accuracy of the analytical method and provide a measure of any potential matrix interferences or heterogeneity issues.

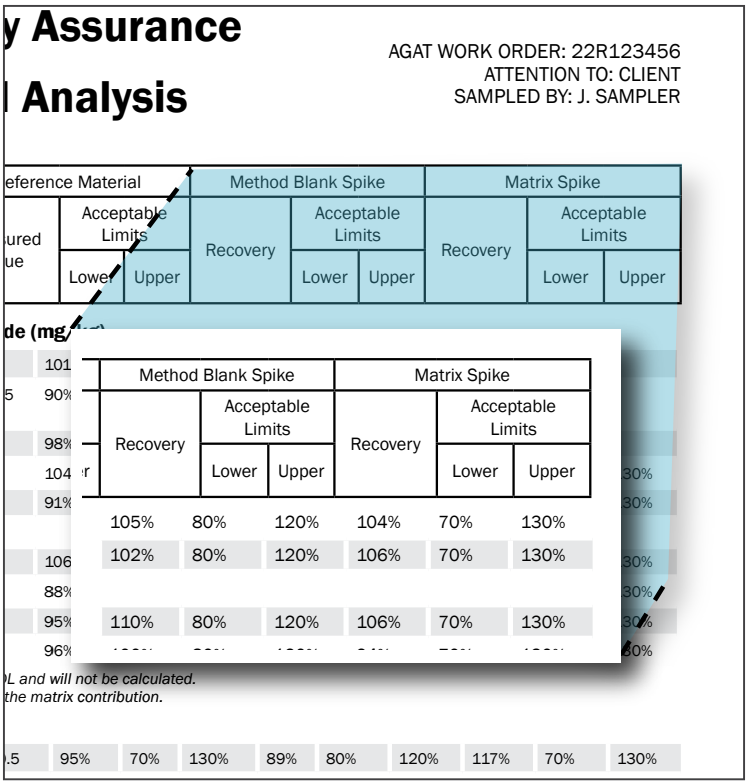



**Figure 8.**
*Spike data on Quality Assurance Report.*

### Method Blank Spike

Is constructed by simply adding a known quantity of the analyte of interest to an aliquot of reagent water or clean soil free of analytes being tested for. The method blank spike acts as a measure of the accuracy of the equipment and analyst technique, as well as a check on the preparation of the matrix spike.

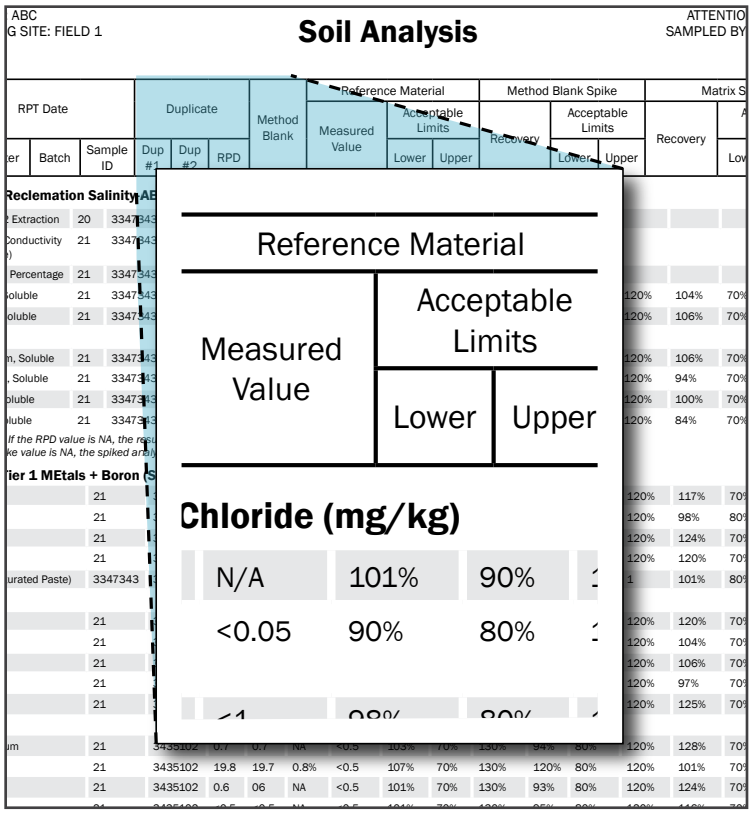



**Figure 7.**
*Reference material data on Quality Assurance Report.*

## Surrogate Samples

The Environmental Protection Agency defines a Surrogate Spike as: “A pure substance with properties that mimic the analyte of interest. It is unlikely to be found in environmental samples and is added to them to establish that the analytical method has been performed properly.”

Surrogate spikes are very important when analyzing organic environmental analytes. In particular, in determining how completely the analyte of interest was partitioned from the original water or soil sample. In the case of extractable compounds, this is into the solvent phase, and for the case of Volatile Organic Compounds, it is into the vapour phase.

In many cases, these compounds could be deuterated versions of the target compounds. These surrogates are identical to the parent compound; however, the hydrogen atoms on the original compound are replaced with deuterium atoms. In this way, the surrogate such as Toluene-d8 behaves in the same manner as the parent compound, yet is distinguishable from the parent by the analytical instrumentation.

## Putting It All Together

Focus and importance are usually centred on individual components of quality control procedures that are followed in the laboratory. Of equal importance however, is reviewing how all of these procedures fit together. To understand this fact, one must first understand how a laboratory defines a “batch” of samples.

How many client samples are analyzed before, between and after quality assurance samples are utilized to verify the validity of the produced data?

A typical scenario is depicted in Table 1 below. Note: there are numerous analytical parameters that each have their own quality control requirements. Table 1 is a summary of the typical batch criteria.

**Table 1.**

| Sample Type | Order | Sample Type | Order |
|---|---|---|---|
| Calibration Standard 1 | 1 | Client Sample 3 | 12 |
| Calibration 2 | 2 | Client Sample 4 | 13 |
| Calibration 3 | 3 | Client Sample 5 | 14 |
| Calibration 4 | 4 | Client Sample 6 | 15 |
| Method Blank | 5 | Client Sample 7 | 16 |
| Reference Material | 6 | Client Sample 8 | 17 |
| Method Blank Spike | 7 | Client Sample 9 | 18 |
| Client Sample 1 | 8 | Client Sample 10 | 19 |
| Client Sample 1 Duplicate | 9 | Client Sample 10 Duplicate | 20 |
| Client Sample 1 Matrix Spike | 10 | Client Sample 10 Spike | 21 |
| Client Sample 2 | 11 | Reference Material | 22 |

** As illustrated in the table, the analysis of ten client samples actually involves the measurement of up to 22 samples.*

If the first quality control samples adhere to the criteria, then the client samples undergo analysis. If the last quality control samples do not pass the specified criteria, client sample results are deemed “non-conforming” and the process starts again from the beginning, after the cause of the original failure has been determined.

Before client sample results are released to the client, both sets of quality control samples must pass all relevant tests and adhere to the criteria.

The quality control results that appear on your Quality Assurance Certificate are the results of the quality control samples analyzed after your samples. Any indication of irregularities will halt the laboratory analysis until such time that corrective measures can be taken and samples can be re-analyzed.

## As Stated in AGAT Laboratories’ Quality Policy:

*“We, AGAT Laboratories, strive to meet our clients’ turn-around time and service requirements while upholding the principle that the quality of the data is paramount.”*

AGAT Laboratories will not compromise the quality of data simply to meet an internal turnaround time target. Our employees are free from the possibility of disciplinary actions resulting from any slowdown in production as related to a quality issue. AGAT Laboratories’ employees are encouraged to raise any quality-related issues that they may identify without concern of reprisal or slowed production. All AGAT Laboratory staff sign off annually on AGAT’s Ethics and Compliance Policy and Data Integrity and Impartiality Compliance Policy.

## Quality Control Reference Guide

The following table represents typical acceptable ranges for the quality control samples previously described.

**Please note:** These ranges are guidelines and may not represent specific jurisdictional requirements. Please contact AGAT Laboratories' Quality Assurance Division for more information.

AGAT Laboratories has provided this overview to assist you in your interpretation of the quality control data that is provided in your reports.

If you are interested in our in-house quality seminar, please **visit our website** for more information or contact us at **info@agatlabs.com**.

**Table 2.**

| Quality Control Sample | Frequency of Use | Purpose | Acceptable Result |
|---|---|---|---|
| Calibration Blank | At the beginning of the day and after a spike or continuing calibration standard. | Used to determine instrument background. | <RDL |
| Method Blank | Every 10 client samples, minimum. | Contamination | <RDL |
| Calibration Standard | At the beginning and sometimes at the end of a batch of samples. | Accuracy | >0.990 correlation (or better) depending on the analysis. |
| Reference Standard | Run immediately after calibration. Analyzed after every 10 client samples if used as the Reference for the batch. | Accuracy | +/-30% recover (or better) depending on the analysis. |
| Method Blank Spike | Every 10 client samples, minimum. | Accuracy, check on prep equipment. | 60-140% recovery (or better) depending on the analysis. |
| Matrix Spike | Every 10 client samples, minimum. | Accuracy, matrix interferences and sample heterogeneity. | 60-140% recovery (or better) depending on the analysis. |
| Surrogate Spikes | Organics - every sample, blank and spike. | Accuracy of extraction and prep techniques. | 50-140% recovery (or better) depending on the analysis. |
| Replicates / Duplicates | Every 10 client samples, minimum. | Precision of the method. | +/-20% to +/-50% RPD depending on the sample matrix. |
| Matrix Spike Duplicates | Every 10 samples, for some methods. | Precision of the method. | +/-20% to +/-50% RPD depending on the sample matrix. |
| Instrument Duplicates | Every 10 samples, for some methods. | Precision of the instrumental determination. | +/-30% RPD (or better), depending on the analysis. |

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