9 Quality Assurance

Quality Assurance is an integral part of every activity at Brookhaven National Laboratory (BNL). A comprehensive Quality Assurance/Quality Control (QA/QC) Program is in place to ensure that all environmental monitoring samples are representative, and that data are reliable and defensible. Most analyses are performed by contract laboratories that are state certified and routinely participate in independent performance testing. Quality control at the analytical laboratories is maintained through daily instrument calibration, efficiency, background checks, and testing for precision and accuracy. Data are verified and validated, as required, by project-specific quality objectives before being used to support decision making. The multilayered components of QA monitored at BNL ensure that all analytical data reported for the 2022 Site Environmental Report are reliable and of acceptable quality.

9.1 QUALITY PROGRAM ELEMENTS

As required by Department of Energy (DOE) Order 458.1, Radiation Protection of the Public and Environment, and DOE Order 436.1, Departmental Sustainability, BNL has established a Quality Assurance/Quality Control Program to ensure that the accuracy, precision, and reliability of environmental monitoring data are consistent with the requirements of Title 10 of the Code of Federal Regulations, Part 830, Subpart A, Quality Assurance Requirements, and DOE Order 414.1D, Quality Assurance. The responsibility for quality at BNL starts with the Laboratory Director, who approves the policies and standards of performance governing work that extends throughout the entire organization. The purpose of the BNL QA Program is to implement QA methodology throughout the various Laboratory management systems and associated processes to do the following:

- Plan and perform operations in a reliable and effective manner to minimize any impact on the environment, safety, security, and health of the staff and public.
- Standardize processes and support continual improvement.
- Enable the delivery of products and services that meet customers' requirements and expectations.
- Support an environment that facilitates scientific and operational excellence.

For environmental monitoring, QA is deployed as an integrated system of management activities. These activities involve planning, implementation, control, reporting, assessment, and continual improvement. QC activities measure each process or service against the QA standards. QA/QC practices and procedures are documented in manuals, plans, and a comprehensive set of Standard Operating Procedures (SOPs) for environmental monitoring (EM-SOPs). Staff members who must follow these procedures are required to document that they have reviewed and understand them.

The goal of the environmental monitoring and analysis QA/QC program is to ensure that results are representative and defensible, and that data are of the type and quality needed to verify protection of the public, employees, and the environment. Figure 9-1 depicts the flow of the QA/QC elements of BNL's Environmental Monitoring Program and indicates the sections of this chapter that discuss each element in more detail.

Laboratory environmental personnel determine sampling requirements using the Environmental Protection Agency (EPA) Data Quality Objective (DQO) process (EPA 2006), or its equivalent.

During this process, the project manager for each environmental program determines the type, amount, and quality of data needed to support decision making, legal requirements, and

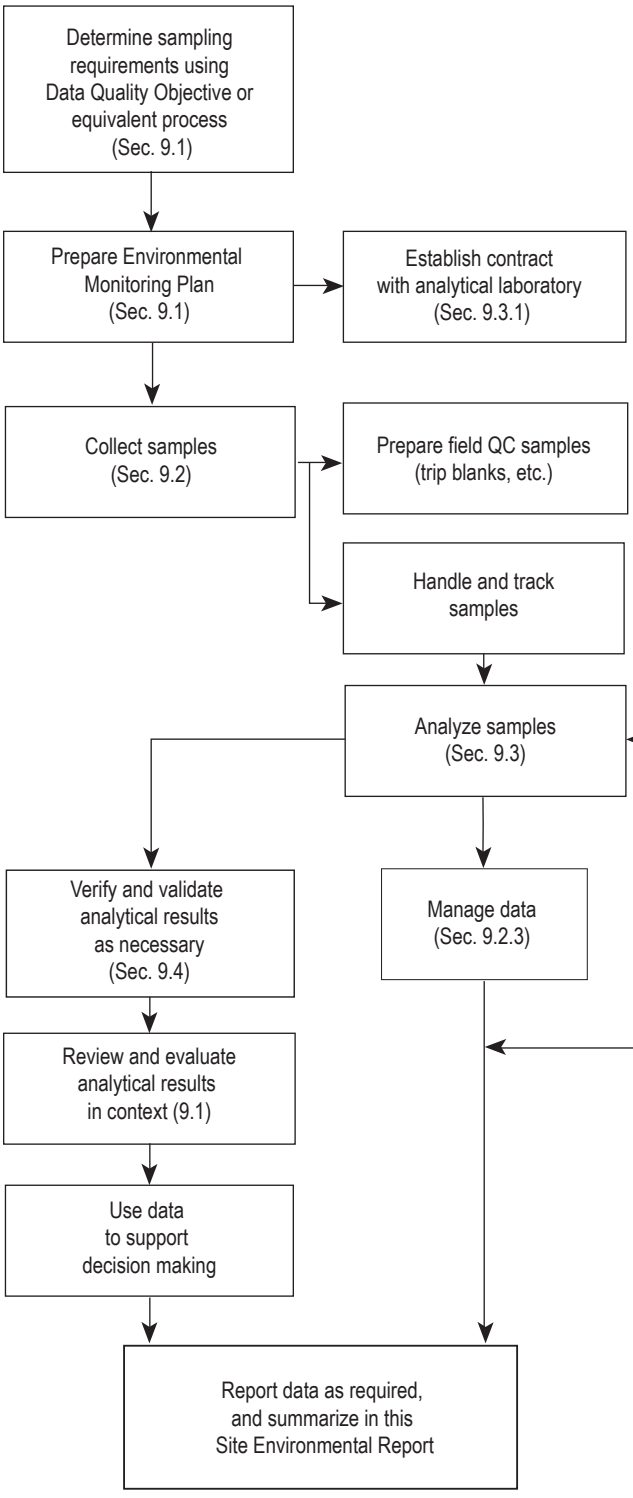


Figure 9-1. Flow of Environmental Monitoring QA/QC Program Elements.

stakeholder expectations. An environmental monitoring plan or project-specific sampling plan is then prepared, specifying the location, frequency, type of sample, analytical methods to be used, and a sampling schedule. These plans and the EM-SOPs also specify data acceptance criteria.

Contracts with off-site analytical laboratories are established for sample analysis. The EM-SOPs direct sampling technicians on proper sample collection, preservation, and handling requirements. Field QC samples are prepared as necessary and analyzed in the field or at a certified contract analytical laboratory. The results are then validated or verified in accordance with published procedures. Finally, the data are reviewed and evaluated by environmental professionals and management in the context of expected results, related monitoring results, historical data, and applicable regulatory requirements (e.g., drinking water standards, permit limits, etc.). The data are used to support decision making, reported as required, and summarized in this annual report.

9.2 SAMPLE COLLECTION AND HANDLING

In 2022, environmental monitoring samples were collected as specified in the 2022 BNL Environmental Monitoring Plan Update (BNL 2022) and project-specific work plans. BNL uses SOPs that are consistent with industry and regulatory standards for the collection of environmental samples, including groundwater, surface water, soil, sediment, air, flora, and fauna. These procedures contain detailed information on the sample collection process, including what types of equipment to use; equipment calibration; how to properly collect, handle, and preserve samples; sample handling and shipment; and how to manage any wastes generated during sampling. QC checks of sampling processes include the collection of field duplicates, matrix spike samples, field blanks, trip blanks, and equipment blanks.

9.2.1 Field Sample Handling

To ensure the integrity of samples, chain-of-custody (COC) was maintained and documented for all samples collected in 2022. A sample is considered to be in the custody of a person if any of the following rules of custody are met:

1. The person has physical possession of the sample,
2. The sample remains in view of the person after being in possession,
3. The sample is placed in a secure location by the custody holder, or
4. The sample is in a designated secure area.

These procedures are outlined in EM-SOP 109, "Chain-of-Custody, Storage, Packaging, and Shipment of Samples" (BNL 2020).

9.2.1.1 Custody and Documentation

Field sampling technicians are responsible for the care and custody of samples until they are transferred to a receiving group or contract analytical laboratory. Samples requiring refrigeration are placed immediately into a refrigerator or a cooler with cooling media and are kept under custody rules. The technician signs the COC form when relinquishing custody and contract analytical laboratory personnel sign the COC form when accepting custody.

As required by EM-SOP-201, "Documentation of Field Activities" (BNL 2019), field sampling technicians are also required to maintain bound, weatherproof field logbooks and electronic tablets, which are used to record sample ID numbers, collection times, descriptions, collection methods, and COC numbers. Daily weather conditions, field measurements, and other appropriate site-specific observations also are recorded in the logbooks.

9.2.1.2 Preservation and Shipment

Before sample collection, field sampling technicians prepare all bottle labels and affix them to the appropriate containers, as defined in the applicable EM-SOPs. Appropriate chemical preservatives are added to the containers before or immediately after collection, and samples are refrigerated as necessary. Sample preservation is maintained, as required, throughout the shipping of the samples to the analytical laboratory.

If samples are sent via commercial carrier, a bill-of-lading is used. COC seals are placed on the shipping containers and their intact status upon receipt indicates that custody was maintained during shipment.

Upon receipt of the samples, the contract laboratory verifies that proper preservation requirements have been met. BNL is notified as soon as practical if a sample arrives unpreserved, improperly preserved, or at the wrong temperature.

Sample preservations, including incorrect preservation, are noted on the sign-in documentation, and included with every data package. If the BNL Project Manager, with the help of a QC chemist and/or radiochemist, determines that an incorrect preservation issue would result in data that does not meet the data quality objectives of the project, the analysis would be cancelled, and new samples would be collected, as necessary.

9.2.2 Field Quality Control Samples

Field QC samples collected for the environmental monitoring program include equipment blanks, trip blanks, field blanks, field duplicate samples, and matrix spike/matrix spike duplicate samples. The rationale for selecting specific field QC samples, and minimum requirements for their use in the Environmental Monitoring Program, are provided in the BNL EM-SOP 200, "Collection and Frequency of Field Quality Control Samples" (2022). Field blanks and trip blanks were collected for all appropriate media in 2022.

An equipment blank is a volume of solution (in this case, laboratory-grade water) that is used to rinse a sampling tool after decontamination. Equipment blank samples are used to verify the effectiveness of the decontamination procedures on non-dedicated or reusable sampling equipment.

A trip blank is provided with each shipping container of samples to be analyzed for volatile organic compounds (VOC). The use of trip blanks provides a way to determine whether contamination of a sample container occurred during shipment from the manufacturer, while the container was in storage, during shipment to a contract analytical laboratory, or during analysis of a sample at a contract analytical laboratory. Trip blanks consist of an aliquot of laboratory-grade water

sealed in a sample bottle, usually prepared by the contract analytical laboratory or manufacturer prior to shipping the sample bottles to BNL. Trip blanks were included with all shipments of aqueous samples for VOC analysis in 2022.

Field blanks are collected to check for cross-contamination that may occur during sample collection. A field blank consists of an aliquot of laboratory-grade water that is poured into a sample container in the field. For the groundwater monitoring program, one field blank is collected for every 20 samples, or one per sampling round, whichever is more frequent. Field blanks are analyzed for the same parameters as groundwater samples. A Field Reagent Blank (FRB) is collected when analyzing for Per- and Polyfluoroalkyl Substances (PFAS) in groundwater or portable water analyzed using EPA Method 537.1. The FRB must use the same preservative as the samples, and is handled the same way as a Field Blank. For other programs, the frequency of field blank collection is based on their specific DQOs.

In 2022, the most common contaminant detected in the trip, field, and equipment blanks was trace to low levels of chloroform (Table 9-1). This commonly observed VOC is likely due to minor cross contamination of the samples at the analytical laboratory, and its detection does not indicate significant problems with the reliability of the analytical results.

Several other commonly observed compounds were also detected, such as methylene chloride and styrene at low levels. When these contaminants are detected, validation or verification procedures are used, where applicable, to qualify the associated data as "non-detects" (see Section 9.4). No contamination was detected in the FRBs during 2022. The results from blank samples collected during 2022 did not indicate any significant impact on the quality of the results.

Field duplicate samples are analyzed to check the reproducibility of sampling and analytical results, based on EPA Region II guidelines (EPA 2012, 2013). For example, in the groundwater monitoring program, duplicates are collected for five percent of the total number of samples collected for a project per sampling round.

During 2022, a total of 40 duplicate samples were collected for non-radiological analyses and 40 duplicates were collected for radiologic analyses. Not all parameters were analyzed in every duplicate. The parameters in each duplicate were consistent with those required for the specific program the duplicate was monitoring. Of the 1,677 non-radiologic parameters analyzed, 51 parameters (three percent) were above 50 percent Relative Percent Difference. For the radiologic parameters, 23 of the 202 parameters (11 percent) failed to meet criteria. These results are indicative of analytical method consistency within the laboratory, and that consistency within the sample collection process results in valid, reproducible data.

Matrix spike and matrix spike duplicates are used to determine whether the sample matrix (e.g., water, soil, air, vegetation, bone, or oil) adversely affected the sample analysis. A spike is a known amount of analyte added to a sample. Matrix spikes are performed at a rate specified by each environmental program's DQOs. The rate is typically one per 20 samples collected per project. No significant matrix effects were observed in 2022 for routine matrices such as water and soil. Non-routine matrices, such as oil, exhibited expected matrix issues.

9.2.3 Tracking and Data Management

Most environmental monitoring samples and analytical results were tracked in BNL's Environmental Information Management System (EIMS), a database system used to store, manage, verify, protect, retrieve, and archive BNL's environmental data. Tracking is initiated when a sample is recorded on a COC form. Copies of the COC forms and supplemental forms are provided to the data coordinator to be entered into the EIMS. Each contract analytical laboratory also maintains its own internal sample tracking system (also known as a Laboratory Information Management System).

Following sample analysis, the contract analytical laboratory sends the results to the BNL chemist and project manager for initial review. When required by project specific DQOs, the analytical data may also be sent to an independent contract chemist for full data validation. Once the results of the analyses are determined to be complete and of acceptable quality, the data are entered into the EIMS. Once entered into EIMS, reports can be generated using a web-based data query tool.

Table 9-1. Summary of Detections in Trip and Field Blank Samples.

Constituent	Number of Analyses	Number of Detects	Minimum	Maximum	Typical Reporting Limit	Units
Trip Blank Results						
Chloroform	74	14	0.27	0.61	0.5	µg/L
Methylene chloride	74	5	0.57	1.46	0.5	µg/L
Styrene	72	4	0.17	0.23	0.5	µg/L
Field Blank Results						
Organic Compounds						
Chloroform	35	8	0.38	0.57	0.5	µg/L
Styrene	33	2	0.19	0.2	0.5	µg/L
Methylene chloride	35	2	0.76	0.84	0.5	µg/L
Dichlorodifluoromethane	33	2	0.89	1.4	0.5	µg/L
Trichloroethylene	35	1	2.6	2.6	0.5	µg/L
cis-1,2-Dichloroethylene	33	1	0.16	0.16	0.5	µg/L
Bis(2-ethylhexyl)phthalate	1	1	2.4	2.4	9.9	µg/L
1,1-Dichloroethylene	35	1	0.61	0.61	0.5	µg/L
1,1-Dichloroethane	35	1	0.95	0.95	0.5	µg/L
Metals						
Calcium	2	1	1.14	1.14	1	µg/L
General Chemistry Parameters						
Sulfate	2	2	0.197	0.201	0.133	mg/L
Alkalinity (as CaCO3)	2	2	3.6	3.6	1.45	mg/L
Total Kjeldahl Nitrogen	2	1	0.0759	0.0759	0.033	mg/L
Nitrogen	2	1	0.0759	0.0759	0.033	mg/L
Nitrate (as N)	2	1	0.0684	0.0684	0.033	mg/L
Chloride	2	1	0.26	0.26	0.067	mg/L
Ammonia (as N)	2	1	0.0488	0.0488	0.017	mg/L

µg/L Micrograms per liter.
mg/L Milligrams per liter.

9.3 SAMPLE ANALYSIS

In 2022, environmental samples were analyzed by five contract analytical laboratories, whose selection is discussed in Section 9.3.1. All samples were analyzed according to EPA-approved methods or by standard industry methods where no EPA methods are available (e.g., for tolyltriazole). In addition, during sample collection field sampling technicians used calibrated field instrumentation for parameters such as conductivity, dissolved oxygen, pH, temperature, and turbidity.

9.3.1 Qualifications

BNL used the following five contract analytical laboratories for analysis of environmental samples in 2022:

1. Chemtex Lab in Port Arthur, Texas, for select non-radiological analytes
2. General Engineering Lab (GEL) in Charleston, South Carolina, for radiological and non-radiological analytes
3. PACE Lab in Melville, New York, for non-radiological analytes

4. Test America (TA), based in St. Louis, Missouri, for radiological and non-radiological analytes. BNL samples were also subcontracted out to TA Buffalo, TA Cedar Falls, TA Denver, TA Edison, TA Pittsburgh, and TA Sacramento.
5. Eberline Analytical in Oak Ridge, Tennessee, for radiological analytes

The process of selecting contract analytical laboratories involves the following factors:

- Maintaining required New York State Department of Health (NYSDOH) certifications for the specific analyses to be performed, as applicable;
- Their record on performance evaluation (PE) tests;
- Their contract with the DOE Integrated Contract Procurement Team;
- Pre-selection bidding; and;
- Adherence to their own QA/QC programs, which must be documented and provided to BNL.

Routine QC procedures that laboratories must follow, as discussed in Section 9.5, include daily instrument calibrations, efficiency and background checks, and standard tests for precision and accuracy. Four of the five contract laboratories used by BNL in 2022 were certified by the NYSDOH for the relevant analytes, where such certification existed. NYSDOH does not currently certify for the specific analytes tested by Chemtex Lab (e.g., tolyltriazole), which has Texas National Environmental Laboratory Accreditation Program (NELAP) accreditation. The laboratories also were subject to PE testing and DOE-sponsored audits (see Section 9.7).

9.4 VERIFICATION AND VALIDATION OF ANALYTICAL RESULTS

Environmental monitoring data are subject to data verification and, in certain cases, data validation when the data quality objectives of the project require this step.

The data verification process involves checking for common errors associated with analytical data. The following criteria can cause data to be rejected during the data verification process:

- *Holding time missed* – The analysis was not initiated, or the sample was not extracted, within the time frame required by EPA or by the contract.
- *Incorrect test method* – The analysis was not performed according to a method required by the contract.
- *Poor recovery* – The chemical compounds or radioisotopes added to the sample before laboratory processing were not recovered at the ratio required by the applicable analytical method/performance criteria.
- *Insufficient QA/QC data* – Supporting data received from the contract analytical laboratory were insufficient to allow for the verification or validation of results.
- *Incorrect minimum detection limit (MDL)* – The contract analytical laboratory reported extremely low levels of analytes as "less than minimum detectable," but the contractually required limit is not used.
- *Invalid chain-of-custody* – There was a failure to maintain proper custody of samples as documented on COC forms.
- *Instrument failure* – The analytical instrument did not perform correctly.
- *Preservation requirements not met* – The preservation requirements identified by the specific analytical method were not met or properly documented.
- *Contamination of samples from outside sources* – Possible sources include sampling equipment, personnel, and the contract analytical laboratory.
- *Matrix interference* – Analysis was affected by dissolved inorganic/organic materials in the matrix.

Data validation involves a more extensive process than data verification. Validation includes all the verification checks, as well as checks for common errors, including instrument calibration that was not conducted as required, internal standard errors, transcription errors, and calculation errors. The amount of data that are subjected to the validation process varies, depending on the environmental media and on the DQOs for each project. Data for some projects, such as long-term groundwater monitoring, may require only verification.

The results of the verification and/or validation process are entered into the EIMS. When analyses are determined to be outside of QC

parameters, a qualifier is applied to the result stored in the EIMS. Results that have been rejected are qualified with an "R." Rejected results are not used in the preparation of this report.

The most common QC issue encountered during 2022 was the detection of low-level contamination in the trip, field, and method blanks used in VOC analyses. Results for the trip and field blanks are summarized in Table 9-1. This issue resulted in minor qualification of sample results. Also, minor violations of laboratory control sample results were also common. In most cases, the violations do not result in qualified sample results.

9.4.1 Checking Results

Non-radiological data analyzed in 2022 were verified and/or validated when required by project DQOs, BNL EM-SOPs, and/or EPA contract laboratory program guidelines (EPA 2012, EPA 2013). Radiological packages were verified and/or validated using BNL and DOE guidance documents (BNL 2022). During 2022, the verifications were conducted using a combination of manually checking data packages and by the use of a computer program developed by BNL to verify the completeness of electronic data deliverables (EDDs) before the data are entered into BNL's EIMS.

9.5 CONTRACT ANALYTICAL LABORATORY QA/QC

In 2022, procedures for calibrating instruments, analyzing samples, and assessing QC were consistent with EPA methodology. QC checks performed included: analyzing blanks and instrument background; using Amersham Radiopharmaceutical Company or National Institute for Standards and Technology (NIST) traceable standards; and analyzing reference standards, spiked samples, and duplicate samples. Analytical laboratory contracts specify analytes, methods, required detection limits, and deliverables, which include standard batch QA/QC performance checks.

As part of the laboratory selection process, candidate laboratories are required to provide BNL with copies of their QA/QC manuals and QA program plans. Non-conformance reports are generated when discrepancies are found in field sampling designs, documented procedures, COC forms, data analyses, data processing systems, and QA software, or when failures in PE testing occur. Following investigation into the root causes, corrective actions are taken and tracked to closure.

9.6 PERFORMANCE OR PROFICIENCY EVALUATIONS

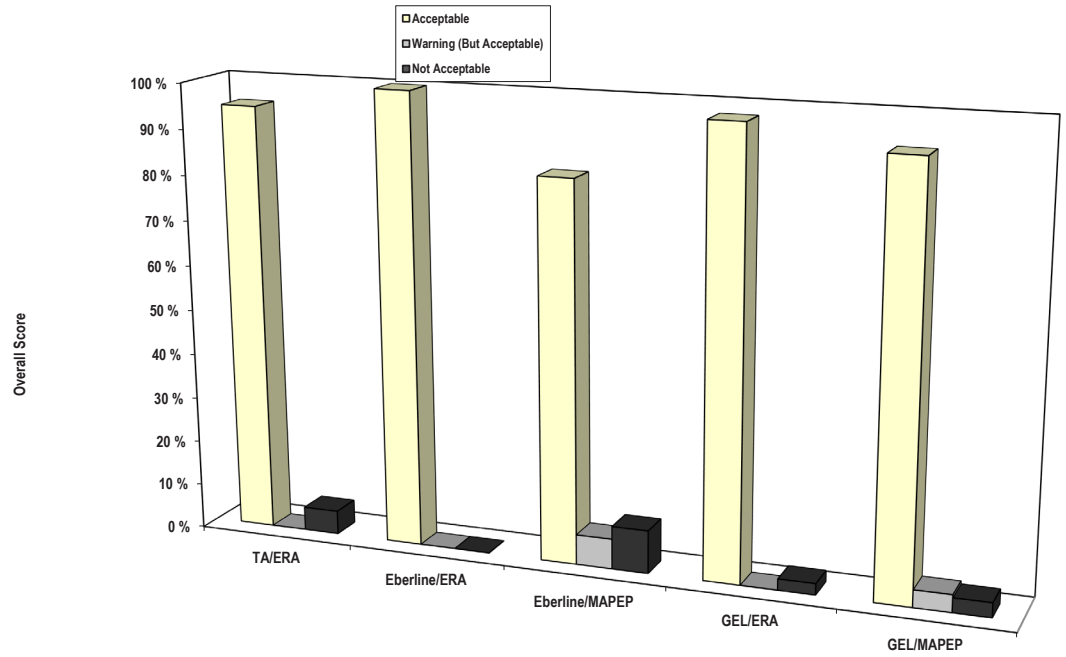
All of the contract analytical laboratories (Chemtex, Eberline, GEL, PACE, and TA) participated in several national and state Proficiency Evaluation (PE) testing programs in 2022. Chemtex Lab participated in PE testing for total phosphorus, which is used to determine one of the specific analytes Chemtex analyzed for BNL (specifically for tolyltriazole, polypropylene glycol monobutyl ether, and 1,1-hydroxyethylidene diphosphonic acid). Each of the participating laboratories took part in at least one testing program, and several laboratories participated in multiple programs.

Results of the tests provide information on the quality of a laboratory's analytical capabilities. The testing was conducted by Environmental Resource Associates (ERA), the DOE Mixed Analyte Performance Evaluation Program (MAPEP), Resource Technology Corporation, Phenova, and the NYSDOH Environmental Laboratory Accreditation Program (ELAP). The results from these tests are summarized in Section 9.6.1.

9.6.1 Summary of Test Results

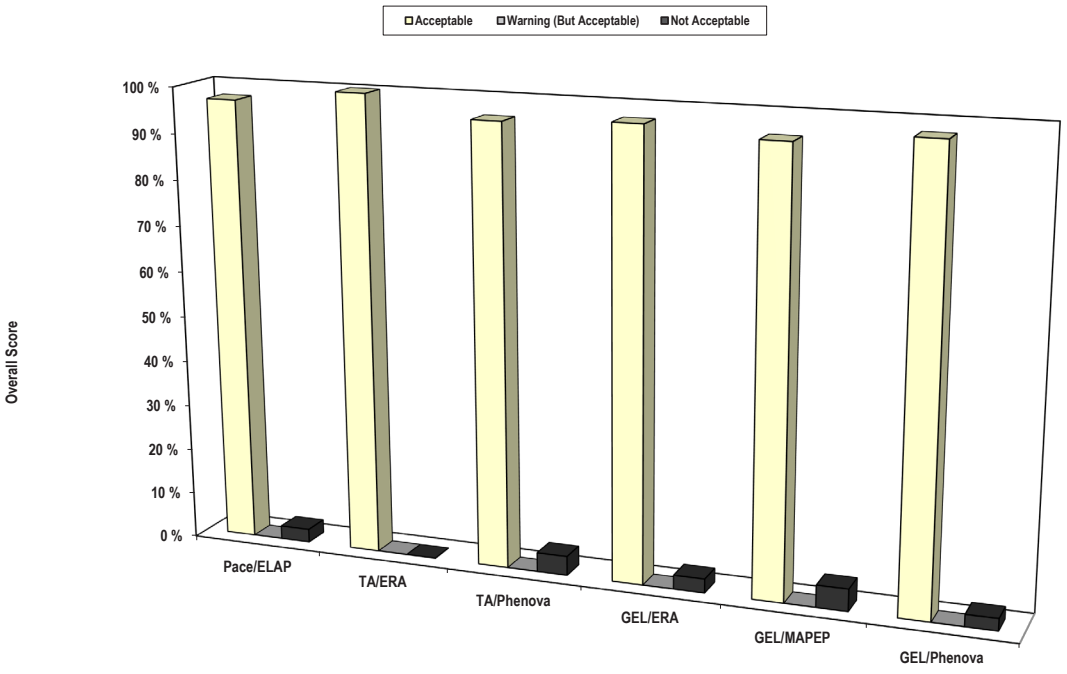
As shown by Figures 9-2 and 9-3, test results are plotted as percentage scores that were "Acceptable," "Warning (But Acceptable)," or "Not Acceptable." A Warning (But Acceptable) is considered by the testing organization to be "satisfactory." An "Average Overall Satisfactory" score is the sum of results rated as Acceptable and those rated as Warning (But Acceptable), divided by the total number of results reported. A Not Acceptable rating reflects a result that is greater than three standard deviations from the known value—a criterion set by the independent testing organizations.

Table 9-2 provides a summary of the DOE's Consolidated Audit Program (DOECAP) audit results. The TA labs had eight Priority II findings and two Priority I findings; Eberline had two Priority II findings. Chemtex, GEL, and PACE were not audited for 2022 for DOECAP. Priority II findings are deviations from a requirement. Priority I findings are



Note that the Acceptable scores and the Warning (But Acceptable) scores combined constitute the "overall satisfactory" category referred to in the text of this chapter.

Figure 9-2. Summary of Scores in the Radiological Proficiency Evaluation Programs.



Note that the Acceptable scores and the Warning (But Acceptable) scores combined constitute the "overall satisfactory" category referred to in the text of this chapter.

Figure 9-3. Summary of Scores in the Nonradiological Proficiency Evaluation Programs.

Table 9-2. Summary Results of 2022 DOECAP Audits

Laboratory	Finding Priority	Area of Concentration	Number of Findings
Test America, Earth City, Missouri			
	NA	Radiochemistry	NA
	I	Quality Assurance	2
	II	Quality Assurance	1
	NA	Organic Analyses	NA
	II	Inorganic Analyses and Wet Chemistry	1
	NA	Laboratory Information Management Systems	NA
	II	Materials Management	2
Test America, Sacramento, Califorina			
	NA	Radiochemistry	NA
	II	Quality Assurance	2
	NA	Organic Analyses	NA
	II	Inorganic Analyses and Wet Chemistry	2
	NA	Laboratory Information Management Systems	NA
	NA	Materials Management	NA
Eberline Analytical, Oak Ridge, Tennessee			
	NA	Radiochemistry	NA
	II	Quality Assurance	2
	NA	Organic Analyses	NA
	NA	Inorganic Analyses and Wet Chemistry	NA
	NA	Laboratory Information Management Systems	NA
	NA	Materials Management	NA

NA Not audited.

issues that present substantial risk if not resolved in an expedited manner. Resolution/impacts of these findings are discussed in Section 9.7.

9.6.1.1 Radiological Assessments

Figure 9-2 summarizes radiological performance scores in the ERA, ELAP, and MAPEP programs for 2022. Eberline, GEL and TA participated in the ERA radiological PE studies with Eberline having an average overall score of 100 percent. GEL had an average overall score of 98 percent. TA also had an overall score of 95 percent. GEL and Eberline scored 97 percent and 90 percent, respectively, in the MAPEP program. Chemtex and PACE did not analyze radiological samples for BNL. None of the analytical contract laboratories participated in any radiological ELAP proficiency testing.

9.6.1.2 Nonradiological Assessments

Figure 9-3 summarizes the non-radiological performance results of three participating laboratories (GEL, Pace, and TA) in the ERA, MAPEP, Phenova, and ELAP tests. During 2022, PACE participated in the NYSDOH ELAP evaluations of performance on tests of nonpotable water, potable water, and solid wastes. NYSDOH found 97 percent of PACE's nonradiological tests to be in the Acceptable range. GEL participated in the ERA, MAPEP, and Phenova programs for nonpotable water, potable water, and solid wastes and received scores of 97 percent, 95 percent, and 97 percent, respectively. TA participated in the ERA and Phenova programs for nonpotable water, potable water, and solid wastes with scores of 100 percent and 96 percent, respectively.

9.7 AUDITS

As part of DOECAP, TA-St. Louis was audited in December 2022 (ANAB 2022) by ANSI-ASQ National Accreditation Board (ANAB). During the audits, six nonconformities were cited. Two of these were Priority I findings. One of these findings was for no record of non-conformance or corrective action for a failing refrigerator temperature. The other Priority I finding was for no Certificate of Calibration for a hood flow meter. Both, Priority I findings were addressed by TA-St. Louis. These findings did not affect the quality of BNL's data.

TA-Sacramento was audited in April 2022 (ANAB 2022a) by ANSI-ASQ National Accreditation Board (ANAB). During the audits, four nonconformities were cited. These findings did not affect the quality of BNL's data.

Eberline was assessed by Perry Johnson Laboratory Accreditation (PJLA 2022) for their DOECAP-AP and approval was given on June 23, 2022. During this audit, two nonconformities were cited. These findings did not impact the quality of BNL's data.

GEL, Chemtex, and PACE were not assessed for DOECAP during the 2022 calendar year. Based on the audit and assessments, the analytical laboratories met the criteria of the audit programs for Acceptable status.

9.8 CONCLUSION

The data validations and data verifications conducted on analytical results are designed to eliminate data that fails to meet the DQOs of each project. The results of the independent PE assessments and assessments of contractor laboratories summarized in this report are also used to assess the quality of the results. As a result of these assessments, BNL has determined that the data used in this Site Environmental Report are of acceptable quality.

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