Maintenance of Maywood Laboratory Operations Support During Contractor Transition and Replacement of the Project Databases - 16329

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ABSTRACT

In December 2013, Cabrera Services (Cabrera) executed transition of the FUSRAP Maywood Superfund Site remediation project operations, including an on-site accredited environmental lab, from a large business that had established technology infrastructure in place for over a decade which required updating to support the expected remediation scope and client needs. As of November 2015, Cabrera has shipped over 116,000 yd^3 of contaminated soil to disposal facilities.

During the transition, the USACE FUSRAP Maywood Laboratory (UFML) continued to support project operations, providing the expected timely and reliable results and maintaining their New Jersey Department of Environmental Protection certification for all parameters of concern, while having to cope with new challenges and additional tasks having the potential to disrupt the laboratory's ability to support project operations.

This case study examines the challenges with maintaining a certified radiochemistry laboratory and an aggressive remediation schedule during a period of prime contractor transition which included a complete IT infrastructure overhaul, and conversion of the existing Microsoft Access laboratory database and project Electronic Data Management System (EDMS) to a customized commercial solution.

Challenges

I. Procurement of a new database subcontractor and working closely with them to achieve the following:
   a. Migration of all environmental (including radiological, chemical, and quality control), health and safety, and spatial data as well as reports, queries, and analytical instrument software processes from a MS Access data management system to a SQL server system; and
   b. Verification that the functionality and data integrity of the databases remained intact.

II. The onsite laboratory was changed over to a new onsite network and the following tasks were completed with little or no interruption to site operations by January 10, 2014:
   i. Installation of new instrument personal computers (PCs) and making them fully operational;
   ii. Configuration of the lab domain and server to host the LIMS (replaced all servers/domain/workstations with Windows 7 and Server 2012 machines).

iii. Networking of the laboratory building into the rest of the project site via fiber optic cabling across the site.
iv. Upgrade of the wide area network (WAN) data connection to high-speed Fiber Optic service
v. Upgrade of the telephones into voice over internet protocol (VOIP) phones.
vi. Splitting of the database into front ends and a centralized back-end hosted on the new server to allow simultaneous access for fixes and improvements.

III. Phone service interruption; phone systems were operational by January 10, 2014

Additional Tasks

I. Revision of the USACE FUSRAP Maywood Laboratory (UFML) Quality Systems Manual Rev. 1 Submitted 01/16/14
II. Writing of the Uniform Federal Policy Quality Assurance Project Plan Rev. 1(UFP-QAPP) submitted 1/21/14. This document replaced the prior project data quality plan, the Chemical Data Quality Management Plan.
III. Support of USACE communications to the New Jersey Department of Environmental Protection (NJDEP) on lab management and personnel transition to Cabrera.

This work was important since it ensured a smooth transition and shows how critical project records infrastructure such as databases, can be upgraded with minimal interruption of project support. Such work may provide benefit to other similar projects, especially long term projects where database infrastructure upgrades may be beneficial in terms of improved efficiencies in data recording and transfer, and improved security in data storage.

INTRODUCTION

The challenges involved in a contract transition for a remediation project vary depending upon the size and complexity of the project, how much infrastructure is transferrable or requires replacement, the degree to which and the number of work plans and procedures requiring revision, as well as new and anticipated client needs. Within six months of the official contract handover date, an additional task arose, that of procuring a new database subcontractor to effectively transfer all of the DOE historic and existing project data into a new database and replace the existing laboratory and project databases with new ones. The issues associated with this database task have been challenging. The USACE, Cabrera Services, Inc. and their Subcontractors have met these challenges as described in the sections below.

INITIAL TRANSITION

Initial Mobilization

During the initial mobilization, the first step was to write the various project work plans, including the Project Management Plan, Contract Management Procedures, Uniform Federal Policy Act Quality Assurance Project Plan (UFP-QAPP) and UFML Quality System

Manual , Master Final Status Survey Plan, Remedial Action Work Plan, Accident Prevention Plan (within which the Health and Safety Plan resides), Quality Control Plan, Construction Loadout, Transportation and Disposal Plan, Materials Handling/Transport and Disposal Plan, Water Management Plan, Community Relations Plan, and General Environmental Protection Plan.

Following the initial mobilization, there was a transition period during which site personnel were trained in how to properly execute project procedures, reviewed the approved work plans and conducted transfer of site permits and responsibilities. Remediation was supposed to commence with one day of mobilization and 3 days of site setup. Site setup consisted of delineation of the exclusion zone, placement of a remote field trailer and placement of soil erosion and control features as appropriate.

As part of the contract transition, the Maywood onsite laboratory's (UFML) Quality System Manual (QSM) was revised and a UFP-QAPP was written to replace the Chemical Data Quality Management Plan (CDQMP).
The QSM changes included the following:

- Modified the narrative in the Introduction section by removing text regarding "other wet chemistry methods" in list of UFML capabilities;
- Replaced all occurrences of CB&I Federal Services with Cabrera Services, Inc;
- Added references for the Gamma Vision manual, and MDA equation
- Added text and revised other text in sections describing QAO and CQCC tasks and responsibilities;
- Added section describing the types of radioactive calibration sources and tracers, their purpose and how they are employed, and
- Updated UFML Radiochemistry DQO's in Attachment A.6. Revised A.4 Ethics Agreement.

The UFP-QAPP for the Maywood project has a completely different format than its predecessor, the CDQMP. The UFP-QAPP is largely comprised of worksheets, which clearly spell out roles and responsibilities, provide task descriptions, prescribe the analytical methods and QA/QC requirements by task, and describe the data validation and deliverable requirements.

Phone / Internet Service Interruption

The existing on site phone server was a plain-old-telephone-service (POTS) style setup. To replace the antiquated system, Cabrera opted for a VOIP solution from MegaPath that would run over a dedicated fiber optic data line. By keeping the data and voice on separate lines and (gigabit) switches, we were able to avoid latency and other network issues. Also, because the distance between the lab and main trailers was long enough to exceed the maximum operating distance of Cat6 Ethernet cable, two fiber optic data lines were strung across a telephone pole in order to bring phone and data into the lab.
Cisco Gigabit Ethernet switches were used to give the site a modern infrastructure that would support staff needs and future upgrades. High Speed Wi-Fi access points were also set up in the main trailers and the lab to ensure that newer devices such as smartphones and ultra-books could access network resources without an Ethernet cord.

Verizon FiOS fiber optic service was chosen for this site because of its availability and value. The remote geographical location of the trailers proved to be an issue when trying to bring more conventional internet service methods to the Maywood site. The subject system replacement took about three to four weeks and occurred over the Christmas break; thus it had minimal impact on project operations.

REPLACEMENT OF THE EXISTING DATABASES

Database Background

The former FUSRAP Maywood Superfund Site Database (MSSDB) was originally created 15 years ago. The original MSSDB was a relational customized database application created in Microsoft Access 97. While it was designed to provide a number of functions, its primary purpose was to facilitate the compilation, sorting, storage, and reporting of project technical data. The database also provided readily accessible information on Maywood Site properties, project personnel training records, site access and other public information communications.

The MSSDB employed a Graphical User Interface (GUI) that allowed the user to enter data, query data, and obtain reports without having in-depth knowledge of computer database design or databases in general.

In 2003, the UFML database was created and was similar to the MSSDB in terms of its basic structure and functions. It primarily served the Maywood onsite laboratory, allowing the staff to perform the following functions:

- Entering and importing data;
- Creating custom control charts for instrument QC and batch QC tests;
- Applying laboratory qualifiers to the data;
- Creating and printing reports;
- Creating Electronic Data Deliverables (EDDs);
- Querying the database; and
- Updating reference data.

During the many years following the creation of the MSSDB and the UFML database, a number of changes were implemented, including the following:

- A better file transfer system (use of ftp site) to allow offsite laboratory and data validation subcontractors to submit deliverables;
- Creation of new qualification forms based upon MARLAP guidance and the Maywood project Radiological Data Evaluation Guidance.
- Creation of control charts for all instrument QC and batch QC parameters for evaluation of trends; and
- Additional functionality to reflect changes in onsite laboratory capabilities.

While creation of new qualification forms and control charts provided a definite improvement to the quality and understanding of the data, there were many issues encountered during the implementation phase that had to be corrected by the database task manager. For example, problems would occasionally be encountered with importation of data, and the database task manager would work with the Lab Manager and Quality Assurance Officer to ensure that these problems were addressed promptly. In

addition, although there were multiple users who accessed the database via a remote desktop, they could not work on the database simultaneously since the remote desktop was connected to a single managed PC, which was a limitation of Access97.

Ongoing MSSDB and UFML database maintenance tasks included:

- Regular updating of instrument QC and batch QC parameter control limits to reflect (typically) gradual changes in response over time;
- Troubleshooting problems with the functionality of qualification forms and report formats.

Procurement of a Database Subcontractor

At the beginning of the Cabrera prime contract, and prompted by the impending retirement of the Maywood Database Task Manager, there were discussions about whether to replace the existing databases or to continue using them. Due to the age of the existing databases and the custom nature of their inner structures, it was difficult to find an individual with the required skills to maintain them. Therefore, the option of procuring a new database subcontractor and having them oversee not only the database installation and data transfer but also to provide ongoing technical support, was considered the better alternative.

A technical scope of work was written for a new database subcontractor to develop a database with the following capabilities:

- Be the central repository for FMSS data as well as migrate/incorporate all data stored on existing UFML and MSS database systems
- Provide a consistent, stable, and controlled-accessible framework for data management, review, and validation;
- Serve as a common platform integrating onsite laboratory EDDs from various instruments (i.e., instrument data streaming and LIMS or pseudo-LIMS capabilities);
- Import and manipulate offsite lab and validator EDDs;
- Allow multiple remote users to work concurrently; and
- Facilitate enhanced reporting, sample chain-of-custody, and geospatial presentation, including:
  a) flexible data sorting, ranking, selection, manipulation, and presentation
  b) direct import of instrument-generated results
  c) the ability to define, structure, and manipulate instrument quality control parameters
  d) application of laboratory data qualifiers
  e) the ability to associate data linked via multiple common variables, such as specific analytical test result, associated uncertainty, sample collection time, reference to clean-up criterion (or similar parameter of interest), geospatial information, and mapping and tabular presentation using multi-media standards, such as ArcGIS.

The selected contractor would also be required to:

- Test and verify the data integrity and software functionality prior to implementation;

- Guarantee that the database be secure as well as routinely maintained and serviced;
- Provide a disaster recovery plan; and
- Support change traceability by automatically generating a QC log of changes made to the database.

Potential bidders were identified and Requests for Proposal were issued. The proposals were evaluated and Geotech Computer Systems, Inc. of Centennial, CO (Subcontractor) was awarded the subcontract to provide a system based on their Commercial Off-The-Shelf (COTS) Enviro Data software. The procurement process, from issuance of the RFP to award, took 28 days.

Transition to a New Database

The Subcontractor proposed a task breakdown for transition of the databases as follows. The percentage of time they actually spent on each task is shown in parentheses:

1. **Workflow analysis, UFML (6.0%)**
   Review the UFML Database SOP and identify key features and related Access objects (tables, queries, forms, reports, macros and modules). Discuss the existing functionality and any needed changes.
2. **Workflow analysis, MSS (4.8%)**
   Review the MSSDB SOP. Review Enviro Data functionality with project staff, and map MSS functions to Enviro Data functions.
3. **Data table analysis, UFML (4.0%)**
   Review existing objects and identify any necessary changes, along with related functionality changes.
4. **Data table analysis, MSS (5.2%)**
   Perform detailed mapping of MSS to Enviro Data.
5. **Data conversion design and execution, UFML (4.9%)**
   Convert Access tables to SQL tables and remedy any problems.
6. **Data conversion design and execution, MSS (15.8%)**
   Move data from MSS tables to comparable Enviro Data tables.
7. **Program changes, UFML (10.4%)**
   Based on communication with Maywood staff, make any necessary software changes. Add functionality to attach to the SQL database.
8. **Program changes, Enviro Data (11.0%)**
   Identify and prioritize additional needed features. Develop and document features.
9. **SQL installation setup and configuration (6.6%)**
   Purchase third party software. Assist with ArcGIS installation. Get list of users and roles. Run the SQL Setup. Duplicate installation at Subcontractor facility.
10. **Overall system documentation (1.8%)**
    Describe the system architecture. Prepare a SQL attachment procedure for client machines.
    Prepare a diagram that illustrates the data flow. Interface the UFML to Enviro Data.
11. **Revised UFML system documentation (4.6%)**
    Update and modify the existing SOP to address any changes and new features. Modify document interface to Enviro Data.
12. **Subcontractor testing prior to delivery (5.6%)**
    Stress test all software functions and remedy any problems.

This was to be done in conjunction with documentation.

13. Acceptance testing and support (12.1%)

Work with Maywood staff to validate system.

14. Project management and contingency (5.7%)

Administrative management.
Technical management.
Accommodate task overruns, if any.
Subscribe to and set up offsite backup.

15. One year of offsite database and software backup (0)

Provide off-site database backup and restore.

16. Two days of onsite training (1.4%)

Travel expenses and time
Training days

The task breakdown percentages indicate that over 40% of the effort was expended on data conversion design and execution for the UFML and MSS (20.7%) and program changes for the UFML and Enviro Data (21.4%). The original estimates for these tasks were 12.9% and 12.9%, respectively, and so were underestimated by an average of about 63% relative.

Conversion of the MSSDB and UFML Databases to Enviro Data

Conversion and/or transfer of historical databases may encounter unique challenges and this was certainly true for conversion of the UFML Database and the MSSDB to Enviro Data databases. The following sections discuss these conversions in some detail. A common theme when discussing the proper functioning of any database is referential integrity. Referential integrity is a property of data which requires every value of one attribute or column entry of a relation or table to exist as a value of another attribute in a different (or the same) relation or table.

MSSDB Conversion

The goals of the MSSDB conversion were as follows:

1. Convert from an Access to a SQL Server back-end.
2. Convert to an industry-standard, supported solution.
3. Integrate with the UFML system.
4. Streamline data gathering, including as container label creation.
5. Streamline data transfer for validated and unvalidated data.
6. Integrate with a GIS solution (ArcGIS and Enviro Spase) for better mapping.
7. Update the user SOP.
8. Test and train.
9. Stay within a reasonable budget.

Proper storage and retrieval of data relies upon allowable sets of entries for various attributes associated with data such as Sample Type, Analytical Method, Parameter Name, Sample Purpose, etc. Each attribute typically has a table associated with it and that table contains one or more related attributes. The MSSDB was unnecessarily complex as it contained many tables for each task. There were ten tasks with significant amounts of

data as well as a few smaller tasks. It was not unusual for each task to contain between 10 and 20 tables. Almost every task contained four results tables: validated radiological data, unvalidated radiological data, validated chemical data, and unvalidated chemical data. It would typically contain other tables such as Sample Numbers, Sample Types, Lab Replicates, Blanks, etc. Migration of each results table required a unique set of queries to prepare and move the data. Migration of data from 10 tasks with 10 tables each is equivalent to converting 100 unique databases. The complexity of the relationships among the various attributes within the various MSSDB tables is illustrated in Figure 1 below.

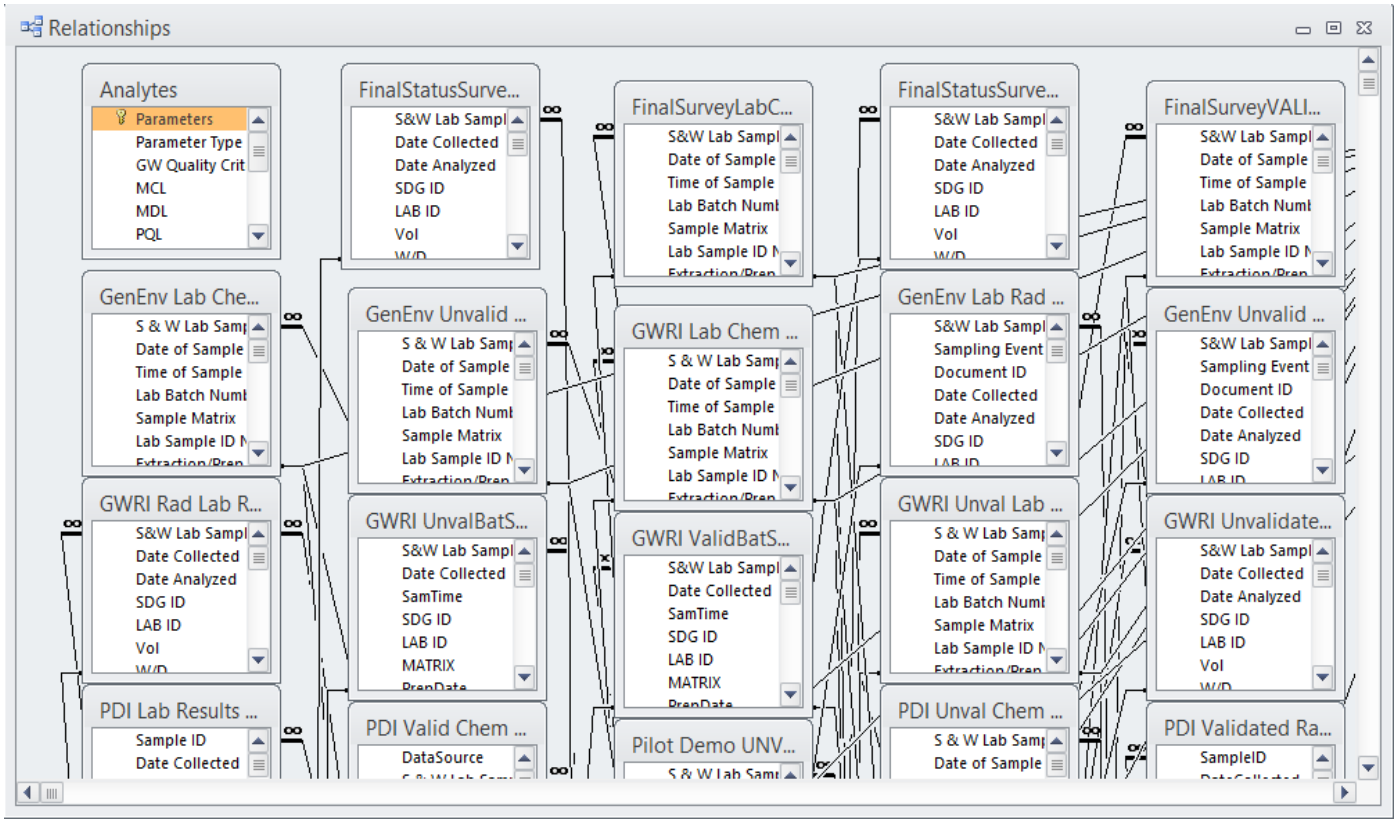

Figure 1. MSSDB Relationships between Table Attributes

Subcontractor's solution to this problem was to utilize the Enviro Data lookup tables to reduce the number of tables and thus simplify the maintenance of the database. The following steps were employed to achieve this goal.

A. Use **DataReview** lookup table and *DataReviewCode* to differentiate validated and unvalidated results.
B. Use **SamplePurpose** lookup table and *SamplePurposeCode* to differentiate tasks.
C. Use S**umCategory** lookup table and *SumCategoryCode* to differentiate radiological and chemical data.

The interrelationships between the tables is greatly simplified by these changes as shown in Figure 2.

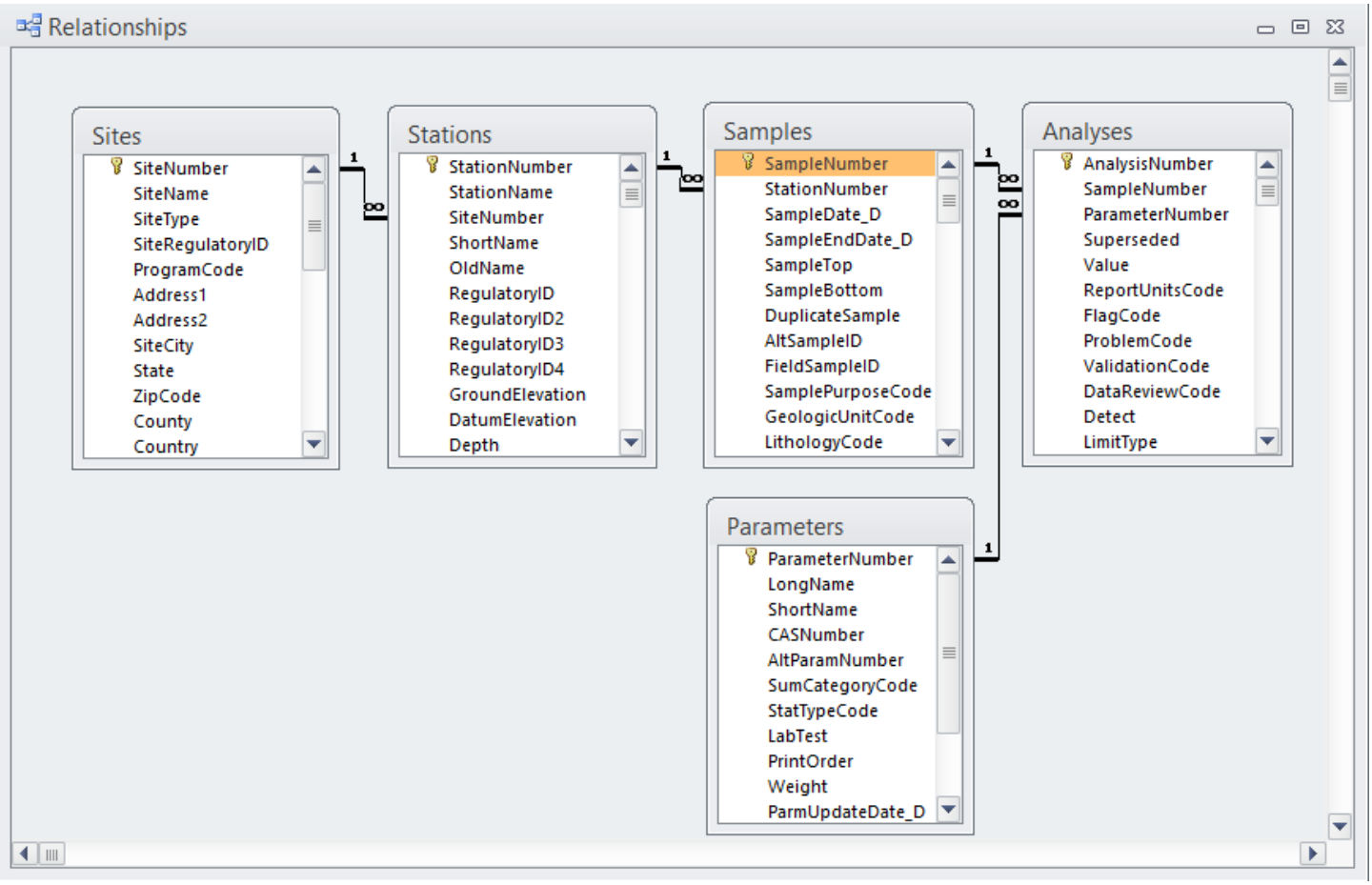

Figure 2. Enviro Data Relationships between Table Attributes

The following problems were also encountered during the MSSDB conversion process. The solution used to resolve each problem is provided in italics:

- No data dictionary on either database.
  "Data maps" were created in Excel for each table of to be migrated, matching MSS table and field names to Enviro Data table and field names
- Lack of unique indexes can lead to entry of duplicate results.
  Enviro Data does not permit duplicated or redundant data since that violates the unique index on tables. "Update queries" were used to assign higher values to the Samples "Duplicate" field and the "Analyses" Superseded field, where necessary.
- Lack of normalization and referential integrity on lookup tables permits incorrect information to be entered.
  The Subcontractor populated the Enviro Data lookup tables with values that they found in the MSS samples and results tables where possible. This resulted in subsequent issues, such as duplicate parameter names, in the Enviro Data database. After migrating the data, the Subcontractor ran update queries and used tools such as the Enviro Data "Remove Duplicate Parameter" tool to clean up the data.

"Update queries" were used to "fix" the data in the MSS database before migrating wherever possible. For example reporting units in the MSS database were entered as "mg/L" or "mg /L", plus other spellings, or in many cases were missing altogether. We corrected the data to use only the one correct spelling "mg/L" for this unit found in the Enviro Data "ReportingUnits" table.

In some cases the wrong type of data was entered. For example, reporting units were entered in a column that should contain the sample matrix. All of this had to be corrected before migrating the data.

- Multiple spellings for parameter names, matrices, etc.
  Same procedures as for the previous bullet.
- Duplicated fields in multiple tables
  1) Example: Sample date and depth information can be entered in both samples tables and results tables.
     a. *Used update queries to get all of the information into a single column that could be migrated.*
     b. *There were a lot of sample details including results where the information was missing from both samples and results tables. In these cases we used default values such as "Unknown" for fields that are required to be populated.*

  2) Which table contains the information? Need to check both tables and then make the data consistent.
     Same procedures as in #1.

- Missing information on sample dates, etc.
  1) *Used default values such as "Unknown" for fields that are required to be populated.*
  2) *Where the Enviro Data table structure doesn't require the field to be populated the field was left blank. For example, the new database contains samples from the old database that do not have a sample date, but the Enviro Data import process makes it impossible to import new data unless the sample date is present. Going forward blank dates will not be allowed.*

- Several fields in each sample and results table had to be corrected or populated in order to meet Enviro Data formatting rules.
  The Subcontractor ran update queries to accomplish this, and also corrected some records by hand-entering the required information. This process was tedious and time-consuming.

- "SampleType" vs. "Sample Type". Both fields are in result tables and contain different kinds of information.
  The Subcontractor migrated "SampleType" to the "QCSampleCode" in the Enviro Data "Samples" table, and migrated "Sample Type" to the "QCAnalysisCode" field in the Enviro Data "Analyses" table. This is an over-simplification, because for some results the information in the two fields was switched, and they had to correct the data first.

- Confusion over terminology (SDG, STF Number, etc).
  The Subcontractor was unfamiliar with some Maywood Site and UFML database jargon such that data from some tasks were migrated differently than others. The Subcontractor 's understanding was improved through discussions with the database task manager and the Project Chemist. After the migration was complete "update queries" were run to allow the errant information to be moved into the proper fields.

- Many "extra" tables and queries in the databases with unknown purpose.
  These tables were not included in the data mapping, and were ignored in the migration process.

- Lookup tables which contained more than one kind of information.
  Example: "Sample Types" table contained QC, sample method, and filtered information.
  We populated the corresponding Enviro Data lookups tables with the correct information. In the new database each lookup table contains only one kind of information.

Conversion of the UFML Database

The goals of the UFML database conversion were as follows:

- Convert from an Access to a SQL Server back-end.
- Update the user interface.
- Integrate the UFML database with the new Enviro Data data management system.
- Ensure that the system was auditable and easy for a third party to validate as needed.
- Fix minor problems.
- Streamline the business process as much as possible.
- Update the user SOP.
- Test and train.
- Keep within a reasonable budget.

The specific issues which made conversion of the UFML database more challenging are listed below:

1. The legacy system had grown over time by adding features as needed, so it was not well-integrated.
2. The original development was done with a focus on easy development techniques, rather than reliability and future support efficiency. For example, the widespread use of macros rather than code made debugging and testing very difficult.
3. Technical documentation was very limited, especially for internal processes.
4. Requirements, such as user access, had changed over time.
5. The system was large, with about 300 menu choices, but many were no longer used.
6. There was a lot of redundancy and very little consistency.

7. Some of the instrument interfaces required retrieving data from Access 97, which is no longer supported, so Subcontractor had to initially convert the data to Access 2010.
8. Testing was complicated because each output option required specific data selection choices, which further required project experience.
9. Users, developers, and IT staff were geographically diverse.

Some of the problems encountered during the database conversion process may be attributed to inadequate maintenance of the old database, such that queries had to be used to clean up the old database before conversion could be executed. Many table entries were either not needed or had not been used in many years.

In addition to simple persistence and hard work, a number of factors contributed to the Subcontractor's ability to meet the UFML database conversion challenge. First, they had performed many similar conversion projects. Second, the legacy database developer was still available, at least for a time, to provide assistance. Third, knowledgeable project staff, including Cabrera IT, were readily available to assist with questions, especially during testing.

In addition to the database conversions, Subcontractor provided users with two days of training. Subcontractor and Cabrera wrote Standard Operating Procedures for both the UFML Database and the Enviro Data (Project) Database.

Project Operations

During the conversion of the databases, many database users, including the onsite laboratory personnel, Project Chemist, FSS Task Manager, Backfill and Soil Disposal Engineer, Project Hydrogeologist and Radiation Safety Officer, met the challenge of learning a very different database system and incorporating the use of that system into their daily routines. Their tasks included sample planning (sample number, chain-of-custody and label generation), generation of data package reports and backfill conformance reports, and EDD generation. During this transition time as users learned how to utilize new databases, they continued to support multiple property remediation efforts, recertification of the UFML by the NJDEP, and a complete IT infrastructure swap-out by Cabrera. The importance of the scheduling and planning of project tasks, and the maintenance of their execution during this transition, cannot be overemphasized.

Database Maintenance and Other Tasks

Following conversion of the Maywood databases, the Subcontractor was retained for two one year periods to maintain the databases and provide ongoing user support, which including the following:

- Assisting with software change requests, changes in qualification methodology, and maintenance of lookup tables;
- Requested changes in the layout of forms, tables, and reports;
- User data entry issues and resulting errors;
- Problems with electronic deliverables and sample numbering, label generation and logging issues;

- Viewer query issues, including assistance with selection and reporting and possibly modifications to reports; and
- Assistance with mapping, as needed.

CONCLUSIONS

The FUSRAP Maywood project was successfully transitioned to a new prime contractor, Cabrera Services, Inc. in December 2013. In addition to infrastructure updates and improvements to the phone/internet service and computer systems, the Cabrera team converted the project database and onsite laboratory (UFML) database to a commercially-based database solution. The absence of data dictionary and unique indexes, as well as deficiencies in the referential integrity of lookup tables, made the database conversion very challenging. This paper provides the following lessons learned for other environmental remediation projects that may face similar conversions of historical data, especially for long-term projects.

1. Periodic database maintenance is recommended to avoid additional or even unnecessary future costs for updating or converting the database, as well as to ensure smoother and faster database functionality.
2. The level of effort required to transfer data and functionality from one database to another must be estimated carefully by employing personnel with the appropriate subject matter expertise, and conducting careful review of subcontractor proposed scopes of work.

REFERENCES

1. Cabrera Services, Inc., Project Database SOP, (2015).
2. Geotech Computer Systems, UFML SOP/Design Document, (2014).