

# **25th ANNUAL NATIONAL CONFERENCE ON MANAGING ENVIRONMENTAL QUALITY SYSTEMS**

**APRIL 24-27, 2006**

**Marriott Renaissance, Austin, Texas**

## **Technical Papers**

### **Environmental Quality Systems Management: Best Practices and Case Studies**

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- T.Fitzpatrick, Automated Audit Software for the SFWMD - 11:00 AM
- A.Debebe, Spatial Modeling of Environmental Data - 11:30 AM

**TECHNICAL SESSION:  
Environmental Quality Systems Management:  
Best Practices and Case Studies**

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**Reengineering Data Flow Process for a Regional Environmental  
Monitoring Program**

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**Abstract**

*Many environmental organizations have quality systems and organizational processes that have evolved over time, often resulting in inefficient or duplicated procedures and/or loss of process. In 2005, the South Florida Water Management District reviewed its current quality system to optimize agency-wide processes and procedures with the ultimate goal of resource optimization and data and service quality improvement. The reengineering process involved understanding current processes (assessment phase); identifying redundancies, unnecessary work, disconnections in the process, and other roadblocks (analysis phase); benchmarking; and redesigning the process (optimization phase).*

*Mapping the sample and data flow process revealed redundancies and gaps at various stages during review, verification, and validation activities. It was also determined that the present system does not provide adequate communication links between the field, laboratory, and reporting functions. As a result, planning, sampling, and analytical requirements, as well as issues and resolutions during project implementation, have not always been effectively documented and communicated to the appropriate staff.*

*It was concluded that the most efficiency in the process is gained by modifying and defining the data flow process, unifying data validation procedures, and reorganizing staff roles and responsibilities. Specific review points, including clearly designated data gatekeepers, were established in the process. The list of data review elements was itemized for each level of responsibility.*

*To create technical linkages and promote better communication, project roles and responsibilities were redistributed. Due to the nature of data collection activities, the concept of formal project management was not suitable and often resulted in either multiple ownership for specific projects or no ownership and lack of accountability. The reengineered process now requires formal implementation of cross-functional project teams, as well as creation of a monitoring coordinator position, that serve as official communication links between the agency's divisions.*

## **Background**

The South Florida Water Management District (District) is an organization responsible for managing and protecting water resources within its regional boundaries. The District's Environmental Resource Assessment (ERA) Department is responsible for water quality monitoring in support of permits and other mandates as well as research and planning projects. ERA implements a rigid quality system to help ensure that the agency's monitoring activities comply with regulatory requirements and allow generation of data that are defensible and of acceptable quality to guide sound management decisions. The District utilizes the services of its internal sampling group and laboratory as well as a large number of contractors to fulfill its needs to monitor its vast network. Monitoring involves collection and testing for several analytes, including inorganic and organic compounds in surface water, groundwater, atmospheric deposition, soil, sediment, and biological tissues.

Continuous improvement can include both incremental or breakthrough improvement. The American Society for Quality (ASQ) defines reengineering as a breakthrough approach involving the restructuring of an entire organization and its processes. To continuously improve its processes, in 2005 ERA contracted Battelle Memorial Institute (Battelle) to reengineer its data flow process. Similar to other environmental organizations, the District's quality system and organizational processes have evolved over time. Over the years, key individuals and groups modified the existing system, which sometimes resulted in inefficient or duplicated procedures and/or loss of process. Over time, it became evident that piecemeal incremental improvements in the different steps were not sufficient to deliver the level of service that is demanded of this department. The ultimate goal of the reengineering effort was to optimize resource utilization and improve data and service quality.

The environmental monitoring process can be viewed as a chain of activities or tasks with each activity contributing to the end product. Just as with any other complicated process, some activities directly contribute value (value-added), while others may not (non-value-added). The scope of this reengineering project involved elimination of non-value-added steps and improving the efficiency of value-added steps. The reengineering process involved understanding the current processes (assessment phase); identifying redundancies, unnecessary work, disconnections in the process, and other roadblocks (analysis phase); benchmarking; and redesigning the process (optimization phase). It was critical to assess the present organizational structure, the culture within the organization, and past experiences. Similarly, during this reengineering process, it was important to consider the fact that breakthrough improvements must not interfere with agency strategic priorities and compliance goals.

Because the assessment and reengineering tasks were performed by an external group, the District was able to attain an independent outlook and minimize the impedance that would have been caused by internal staff being protective of their present processes.

## Assessment Phase

The first step in the assessment process was to interview managers and key technical representatives at different levels of the organization to thoroughly understand the current processes. This enabled Battelle to identify non-value added steps, the strengths and weakness of the actual process as well as the level of understanding among staff about what was occurring at different stages of the process. The results of the interviews were used to map the ten stages of the sample and data flow process from beginning (planning) to end (database):

- 1) Administration and management
- 2) Project planning
- 3) Field sampling and testing
- 4) Sample receipt
- 5) Laboratory analysis
- 6) Data verification by management
- 7) Data validation
- 8) Data loading to DBHYDRO
- 9) Final reasonableness checks
- 10) Data correction

The assessment also identified seven distinct data flow pathways that are based on which entity is collecting and analyzing the samples. Project management and data validation procedures vary, depending on data source. There were differences in field documentation requirements, thoroughness of the data reviews by contractors, completeness of the data package submission, compliance with District data deliverable requirements, and data verification and validation procedures.

The procedures implemented within critical process stages were compared to the District field and laboratory Quality Assurance (QA) Manuals and Standard Operating Procedures (SOPs) to determine if non-value-added steps were part of the system or had evolved by staff as “work-arounds” to known but uncorrected problems. For example:

- With data review processes in place, errors persisted. Individual data reviewers added items to routine checklists to address previously noted errors in review process.
- The validation group had evolved to encompass three distinct activities: data validation, laboratory contract management; and audits of laboratories. Staff responsibilities for these three activities varied according to the type of data which is one source of inconsistency.
- Outdated and/redundant data review SOPs resulted in different validation procedures for the same analysis performed by different laboratories; and validating data with insufficient supporting documentation.
- Lack of enforcement of the laboratory contracts resulted in validators correcting data errors in order to complete validation.

- Laboratory contracts were being managed by both field project managers and the validation group, with inconsistent procedures and requirements. Evaluation deliverables from field group-managed contracts were not as rigid and not validated as quickly as routine laboratory contracts.

Through the interview process, 68 distinct “roadblocks to quality” were identified and could be summarized under six general categories:

- Data flow inefficiencies
- Data validation dissimilarities
- Contractor (lack of) responsiveness
- Staff roles and responsibilities
- Communication gaps
- Corrective action ineffectiveness

The next step of the assessment phase was to identify corrective actions for each of the roadblocks and to identify which process flow area would have to implement the solution. The final step of the assessment phase was to benchmark other organizations in order to identify best practices that could be implemented.

### **Analysis Phase**

The analysis phase of the project involved integrating the ten process flow stages, the seven sample-data flow pathways, and the 68 roadblocks to quality (with proposed corrective actions) in order to optimize the process and streamline the data flow. Analysis of the data revealed that of the 68 roadblocks, approximately

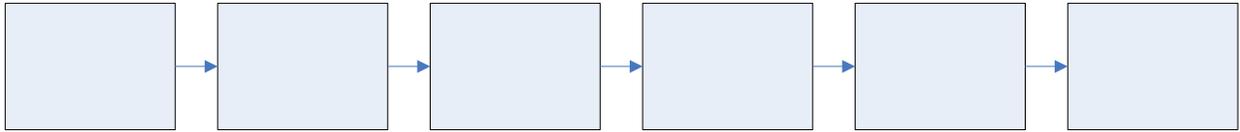
- 15 percent were contractor-related problems
- 27 percent could be addressed by enforcing existing requirements
- 30 percent were identified within the validation group

Ultimately, three of the roadblock categories drove the reengineering process: identifying an efficient data flow process; unifying data validation procedures; and redefining staff roles and responsibilities.

### **Optimization Phase**

As a starting point, the seven sample-data flow pathways were aligned to identify where the same process was being performed differently.

Using a simple, logical model, procedures were identified within each step that would address the gaps, redundancies, and inefficiencies identified in the process.



Regardless of the field collection or laboratory analysis organization, the data and documentation should be of equivalent quality if the same procedures are used. Internal staff and contractors should be trained in District-specified SOPs, maintain consistent documentation, and be responsible for the data quality and verification. Requirements for each step were identified, including preparation or updating of monitoring plans for each project and detailing all collection, analysis, and reporting requirements in the contractor statement of work.

### Development of a Defect Management Plan

## Project Planning

## Field Collection

The need for a defect management plan was highlighted by the number and type of roadblocks identified. Errors and defects that are noted during the sample-data flow process are often addressed in an informal process, without identifying the root causes. A Defect Management Plan was prepared to formalize the process and help in preventing defects. The plan establishes a process to systematically catch defects early in the data process flow, minimize the impact of defects, and prevent re-occurrence. The plan was designed to enable management to determine how to best to invest resources, based on an assessment of a defect’s risks and relevance.

These general principles of defect management were designed to be incorporated into the process flow through a six-step process:

- Step 1. Establish common definitions and criteria for defects
- Step 2. Identify and log defects
- Step 3. Describe defects, determine root cause and corrective options
- Step 4. Analyze risks of defects
- Step 5. Assign ownership and implement resolutions
- Step 6. Verify and evaluate implementation

### Improvement of data validation process

Based on the findings of the assessment phase, it is not surprising that the data validation process required the most modification. Basic reorganization was the first step. This included identifying the need for a dedicated data validation group; moving contract responsibilities to a laboratory client services group; and moving laboratory audit responsibilities to the QA office. Once the organization structure was defined, necessary procedural changes were then identified. These included:

- Requiring all laboratories to verify and qualify their own data
- Accepting laboratory data “as is” if submitted as a fully verified data package
- Validating only complete data packages

- Minimizing the number of different validation SOPs to maximize similar procedures and using the same validation SOP for each data type, regardless of the laboratory source (e.g., one SOP for each distinct analyte group)
- Requiring the use of the ADaPT software validation program for all laboratory data

The magnitude of changes needed within the validation group impacted both process flow and staff roles and responsibilities.

### **Realignment of Roles and Responsibilities**

Analysis of current responsibilities revealed that within the field division, field task managers were responsible for the full suite of activities associated with project planning, sample collection, laboratory contracting, and receipt of data deliverables. Laboratory contracting responsibilities were assigned differently within the laboratory contract and data validation group. The identification and logical reassignment of contracting, quality assurance, quality control, field, laboratory, data management, and reporting activities resulted in the creation of two positions: a central point of monitoring project control within the department and a Client Services Manager position within the laboratory. Reassignment of responsibilities included separating and dedicating data validation and contracts staff, assigning QC responsibilities to technical staff, and assigning all QA responsibilities to the QA staff. This enabled Battelle and the District to establish distinct processes whereby:

- All field work is managed by the field division
- All laboratory work is managed by the laboratory division
- All data validation is performed by the validation group
- Specific, detailed quality control checks were inserted throughout the data flow process and assigned to specific organizational roles so that errors are identified and corrected close to the source where the potential for redeeming the data is greatest and where ‘fixes’ are least expensive.

### **Implementation Phase**

To make sure that the outcome of this effort is maximized, the next phase of this project is to have an implementation plan. At this time, the reengineered process has incorporated in a Quality Management Plan. Although some of the reengineering plan components have already been implemented and others can be easily implemented or adopted, there are changes that would take time and resources to implement. District management is presently evaluating the remaining components. Implementation will be prioritized, based on resource and organizational limitations. Performance measures, including turnaround time, frequency of data defects, as well as customer and staff satisfaction have to be tracked. Further optimization of the processes might be necessary depending on performance measure outcomes.

## **Conclusion**

The SFWMD recognized the need for both incremental and breakthrough improvements in its quality system implementation to meet its ever increasing responsibility of producing reliable and timely data. The Battelle team, which led this effort, concluded that the most efficiency in the process is gained by modifying and defining the data flow process, unifying data validation procedures, and reorganizing staff roles and responsibilities. Specific review points, including clearly designated data gatekeepers and a list of data review elements was itemized for each level of responsibility, were established. Some changes have been implemented, but full implementation will take time, resources, and planning. Measures are in place to determine the success of this project.

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# **Automated Audit Software for Field Sampling Activities Standardizes and Streamlines Auditing Process for South Florida Water Management District**

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## **Abstract**

*As part of improving the process for performing on-site field sampling audits and maintaining and managing QA/QC documentation in a readily available electronic format, Laboratory Data Consultants, Inc. (LDC) under contract to the South Florida Water Management District (District) developed a Microsoft Access-based software program to streamline the audit preparation, on-site audit process, final reporting, and long-term documentation. The program has two primary components. The first is a master (Central) database, which contains information regarding contract and internal District sampling crews, field auditing checklists, statues and regulations and other applicable SOPs, contracts, monitoring plans and previous audits findings. The second is a “briefcase” database, which is downloaded from the master database prior to performing an on-site audit.*

*The “briefcase” database is taken to the on-site audit and contains the audit-specific checklist created in the Central database. All applicable standard references are embedded within the checklist using hyperlinks. The checklist can also be pre-populated with editable, canned findings and corrective actions which can be entered from a pull-down menu.*

*Completed audits are uploaded to the network-based Central database. Once uploaded, the custom query engine allows agency staff to query and save the results in Access or export the query results as an excel file to be used in quarterly reports or to track trends in deficiencies in order to focus training, process improvement and/or procedural documentation improvement. The audit software includes a report writing function that yields a printable report that is be submitted to the auditee.*

*SFWMD has been using the software to perform field audits since April 2004. This presentation will show how the use of this software has made the audit process more consistent, technically sound, and cost effective.*

## **Introduction**

Preparation for an audit has long been a time-consuming process involving the review of multiple documents such as field sampling method specific SOPs, agency Quality Assurance Manuals (QMs), internal quality assurance audit results, training records and more. Once the audit process begins, the auditor generates another stack of supporting documentation. There are standardized checklists and issue-specific questions/issues to investigate, lists of findings and related corrective actions/recommendations, response from the auditee to the auditor's findings, the auditor's response indicating acceptability of the lab's corrective action plan, etc. If more than a few audits are conducted annually, the auditors can find themselves spending much more time writing reports than performing audits.

The automated audit software developed by Laboratory Data Consultants, Inc. (LDC) under contract to the South Florida Water Management District (SFWMD) addresses the difficulties associated with the preparation for and execution of an on-site audit as well as the sometimes overwhelming task of organization, storage and retrieval of the massive amount of documentation associated with the audit process.

### **Audit Process and the Electronic Checklist**

The field audit process involves observation of sample and data collection processes and verifying these processes against written SOPs and agency or regulatory requirements. This process utilizes a checklist made of questions based on procedural requirements. Because the checklist is standardized it helps to ensure consistency between audits and auditors. Requiring a finding for each question ensures that each requirement is verified even if the procedure is not deficient.

The checklist is used in the field to keep track of what is to be assessed during the audit. Each entry on the checklist is a question answered with a compliance identifier. The auditor answers each question on the checklist with a "yes", "no" or "NA" for each question that is not a nonconformance with a requirement. Nonconformances are denoted with a "CA" for corrective action or "R" for recommendation. Corrective Actions are actions required to become compliant with a requirement or regulation. Recommendations are suggested improvements in protocol that may improve the overall quality of the data produced but are not required. Space is also provided for comments concerning each question. The completed checklist is used to produce the report.

Disadvantages of using a paper-based system of auditing and reporting are many. Bulky references are not readily accessible on site. Reports must still be written using templates and adjusted for each audit. Also, a significant amount of time is required to transfer the entries on paper into the electronic spreadsheet. Customized checklists have been developed for auditing SFWMD processes but the checklists for each audit were isolated

and the need for a database evolved out of attempts to assess overall audit program performance for periodic reporting.

The MS Access database audit tool developed by LDC provides the auditor with the ability to set up an audit that generates an electronic checklist for the specific methods audited that can be used on-site. The use of a tablet computer enables the auditor to have the checklist and references on site and eliminates the need for transferring the completed audit information from a paper checklist into electronic format. The report writing portion of the tool streamlines and standardizes this process and decreases the amount of time needed to prepare reports.

### **Conducting the Audit**

The auditor does all the preparation for the audit in the central database. The auditor is guided step-by-step through the preparation. The first step involves importing relevant documents (QMs, SOPs, previous audits, etc.) into the central database. These documents are supplied in electronic format by the auditee or scanned and converted to PDF files for electronic storage and retrieval. Once the database is populated with these documents, the auditor begins the process of building an electronic “briefcase folder” which will be exported to a tablet computer and taken to the on-site audit. The auditor tags the documents and references to be imported and can hyperlink these documents to questions in the checklist. The auditor can then open any of the references during the course of the audit by simply clicking on the embedded hyperlink. The auditor next selects the field processes to be audited from a list of the required field collection methods by SFWMD.

The standard checklist consists of questions based on SFWMD and FDEP requirements and regulations. The standard checklist can be easily appended by the auditor in several categories including previous audit results, field parameter instrument calibration and measurement, various sample collection methods and miscellaneous. Questions can be added either during the preparation in the central database or in the briefcase during the course of the audit. The program also contains a schedule and timeline tracker which is accessible from both the central and briefcase modules to keep track of critical dates in the audit process. The scheduler will send a reminder email to the auditor one month in advance of annual audits. A time log is also embedded in the product so that the auditor can keep track of the hours spent on preparation and execution of the audit.

After the auditor has selected the auditee agency, methods, reference documents and any additional questions, the entire audit package is then saved as a “briefcase” folder. The auditor next imports this folder into the briefcase module of the software which was designed to be used with a tablet computer. Printed copies of the checklist can also be used if a tablet or notebook pc is not available. The findings can then be entered into the program after conclusion of the field audit.

The auditor takes the audit-specific checklist to the on-site audit where it can be filled out directly using the electronic forms or from a printed hardcopy. Additional pertinent documents such as field calibration documentation, training records, raw data, etc. may also be added to the briefcase as PDF files during the course of the audit. A tabular summary of findings and an audit report are generated based on responses to questions in the audit checklist.

Reports are generated using a standardized template which merges answers to specific questions into the body of the template report. After merging the fields, the resulting report can then be modified by the user as required. Certain sections like conclusions will still need to be filled in freeform, but the majority of the report is prepared automatically.

The report is sent to the auditee in both hardcopy and electronic formats. The auditee's responses are imported into the summary table via excel spreadsheet and a letter of acceptance or further action required is generated from a template. This process is repeated as necessary until resolution of all issues is complete. Once completed, the briefcase database folder is exported to the central database for archiving, virtually eliminating the need for paper filing and storage.

### **Database Custom Query**

Since the software allows retention of audit findings and corrective actions, it facilitates performance tracking. The custom query function was designed to facilitate the tracking of audit performance over time. The comparison of periodic deficiency rates is beneficial for determining areas of process improvement for the agency, individual project or specific sampling group. These queries can also help assess the effectiveness of quality system documentation and past training as well as identifying where to focus future training resources.

### **Conclusion**

In summary, the SFWMD Automated Audit software is an extremely powerful tool in aiding the auditor to be better prepared and perform on-site audits in a cost effective, technically sound, and consistent manner. The software can be used to perform both internal and external audits.

## **Spatial Modeling of Environmental Data - An Integrated Approach**

*Aschalew Debebe, Ph.D., P.Eng., Lukas Calmbach, Ph.D, Sharon Wadley, M.Sc.*

The importance of quality data for a better understanding and safeguarding of the environment can not be over emphasized. This fact has, over the last decade or so, increased the demand for better environmental quality information systems. However, most existing systems with the exception of GIS, do not handle this challenge in a well integrated manner.

This paper presents the latest developments in integrated data management from Waterloo Hydrogeologic Inc., which covers the complete workflow for environmental quality information management (from data acquisition to reporting). The system allows for sample planning, scheduling, and tracking as well as comprehensive data analysis, visualization, spatial modeling and reporting of environmental data. It incorporates the state-of-the-art tools for data mining, statistical, geo-chemical analysis and GIS using a centralized and flexible environmental data management system.

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