

**Consolidated Online Data Management Strategy in Support of
Environmental Remediation Activities at the Dupont Chambers Works Formerly Utilized
Sites Remedial Action Program (Fusrap) Site**

K.A. Nelson
Cabrera Services, Inc.
103 E. Mount Royal Ave., Suite 2B, Baltimore, MD 21202, USA

N.B. Desai
Ten-Divide Consulting, Inc.
702 Broadway, Suite 102, Tacoma, WA 98402, USA

J.E. Samus
EA Engineering, Science and Technology, Inc.
15 Loveton Circle, Sparks, MD 21152, USA

G.O. Bock
U.S. Army Corps of Engineers, Philadelphia District
100 Penn Square East, Philadelphia, PA 19107, USA

ABSTRACT

The U.S. Army Corps of Engineers (USACE) has developed and implemented an innovative online data management application in support of site characterization and remediation activities at the DuPont Chambers Works Formerly Utilized Sites Remedial Action Program (FUSRAP) Site. The password-protected, web-based application was implemented to centralize project data, facilitate project communications, and provide a large and diverse group of project team members with access to the data and analytical tools they need to efficiently and effectively manage the ongoing characterization and remediation efforts. Centralizing resources using the online application and web-based strategy streamlines data access and communications, allowing the team to effectively keep the project on track while reducing the costs associated with data requests, data duplication, document review and retrieval, software requirements, and lapses in communication or data transfer.

INTRODUCTION

The success of any site characterization and remediation effort is fundamentally tied to the effective collection, analysis, and management of environmental data and tools that facilitate project management and communication. Large, complex efforts are typically planned, executed, and monitored by diverse teams of individuals from a variety of stakeholder organizations, consulting firms, and regulatory agencies. It is very common in such multi-stakeholder projects for data and analytical needs at each organization to differ significantly depending on individual project responsibilities. Effective team communication and data transfer also becomes more significant in the multi-stakeholder scenario. Though advances in information technology have resulted in a wide range of individual desktop applications to help meet data management and communication needs, no multifunctional, consolidated, efficient, and user-friendly solutions have been developed and implemented for such projects until very recently.

This paper presents one such innovative strategy and application developed and implemented by the U.S. Army Corps of Engineers (USACE), Philadelphia District to meet the complex data management, project management, and project communication challenges associated with multi-stakeholder environmental projects. The online application consolidates electronic file management, data storage, data querying, Geographic Information Systems (GIS) mapping, document review, events calendar, message board, and team directory functions into a single online application accessible by team members from any location. No software is required of users beyond standard internet browsers and internet connections, and the system is open-architecture, meaning it can be hosted, modified, and updated by anyone with the appropriate hosting infrastructure and required database and programming skills.

SITE BACKGROUND

The DuPont Chambers Works site is a 700-acre active chemical plant located in Pennsville and Carneys Point Townships on the southeastern shore of the Delaware River, north of the I-295 Delaware Memorial Bridge, and adjacent to the residential community of Deepwater, Salem County, N.J. USACE is conducting a remedial investigation at the DuPont Chambers Works site under the Formerly Utilized Sites Remedial Action Program (FUSRAP) to evaluate radioactive contamination resulting from activities in support of Manhattan Engineering District (MED) operations during World War II.

The Chambers Works plant first opened in the early 1900's, as a dye manufacturing plant. From 1942 to 1947, DuPont conducted research using uranium, converting uranium oxides to uranium tetrafluoride and uranium metal. More than half of the production at this facility came from the recovery process, where uranium-bearing dross and scrap were reacted with hydrogen peroxide to produce uranium peroxide dihydrate.

In 1948 and 1949, the Atomic Energy Commission (AEC) conducted initial radioactive surveys, decontamination of building surfaces and cleanup activities at the site using the criteria in existence at the time. The DOE (Department of Energy) conducted additional radiological surveys based on cleanup criteria in effect in 1977 and 1983. The areas investigated were those determined to be of interest through review of historical MED documents. Six separate areas in the former uranium handling areas have been identified and surveyed.

The Chambers Works has produced approximately 600 products, including petrochemicals, aromatics, fluorochemicals, polymers, and elastomers. Contaminants resulting from these other processes have also been detected within the boundaries of the FUSRAP investigation, including separate phase petrochemicals. The major FUSRAP contaminant in both water and soil, however, is uranium.

Responsibility for FUSRAP was transferred to the USACE in 1997. The site now falls within the Philadelphia District's boundaries, and the USACE initiated remedial investigation (RI) field activities in 2001. Cabrera Services, Inc., EA Engineering, Science and Technology, Inc., and Ten-Divide Consulting, Inc. are currently supporting the USACE with site characterization and remediation efforts.

OVERVIEW OF CONSOLIDATED ONLINE DATA MANAGEMENT APPLICATION

Personnel from six USACE Districts are currently supporting the characterization and environmental remediation activities at the DuPont Chambers Works site, along with a number of consultants, contractors, and regulatory agencies. As is common with most multi-stakeholder remediation projects, project team members are located in geographically separate locations and individual data needs among team members at each organization differ significantly based on their specific project responsibilities. As a result, a more advanced, robust, and flexible data management solution was developed and implemented by the USACE to help meet these project communication and information management challenges.

The online system, referred to as the Project Management Website (PMW), consolidates all historical and current analytical data into a central database that serves as the backbone of a password protected website from which users can create data queries, perform analyses, and export the specified data. The system effectively eliminates time associated with information requests and data transfer by giving each team member the ability to immediately access the information they need immediately from a web application regardless of their physical location. Users have the ability to specify the data fields they wish to include on their data results tables, query the data by any combination of fields and user-defined filter criteria, and export the returned data into user-specified formats for integration into other analytical tools. The system also includes an internet GIS module that allows users to generate and customize maps of the site and the associated data via a standard web browser. Users have the ability to view laboratory and field-generated analytical results associated with locations on a map, automatically add data labels to maps, measure distances and areas, automatically highlight map elements identified based on user-defined queries, and generate figures for reports and presentations. Again, no software is required of the users beyond standard internet browsers and internet connections.

The system also includes various communications functions such as an online file repository for all project documentation; a document review function to manage review comments and responses to comments; a project calendar to manage and communicate critical events; an online message board threaded by topics; and a full team directory including contact information. These system functions are presented in greater detail in the following sections.

ANALYTICAL DATA TOOLS

The PMW's analytical data tools allow Project Team members to access data collected from the site, including field measurements and onsite screening results, as well as data reported by the analytical laboratories via several functions, including standard data reports, custom data reports, and an internet mapping function. Selected users with the appropriate system permissions may enter data using the Data Maintenance function.

Data Maintenance Function

The PMW database was developed to accept output files from Automated Data Review (ADR), a data review software application designed by Laboratory Data Consultants, Inc. for USACE. ADR was designed to perform a level III summary review of laboratory data packages, and use of this software tool has been mandated across USACE. Laboratory Electronic Data

Deliverables (EDDs) are input into ADR, and following an automated data review process, five output files are created by the application. These five output files from ADR can then be directly uploaded to the PMW via a data upload page that prompts the user for each of the five ADR output files. After the files are uploaded to the PMW and verified, the data is then available for access through the site's various analytical data and mapping tools. Data files that have not been processed using ADR may still be uploaded, queried, plotted, and analyzed within the system.

Standard Data Reports

There are two types of reports that may be generated using the PMW's Data Reporting Function. The first type is the called the Standard Report, referring to formatted reports presenting predefined sets of information. The available Standard Reports and information contained in each are presented in Table I. The Standard Reports were designed to query the database and return particular data of common interest to the user without requiring any additional information from the user. The user simply clicks on the name of the Standard Report, and the system will dynamically create and display the formatted table with the associated data. Users can then page through the report table on-screen, navigate directly to a particular page of the report, search the report by keyword, print the report, and export the report table and data as an Adobe PDF file, Microsoft Excel File, or Microsoft Word file. The Standard Reports are dynamically generated each time the user clicks on the Report Name as listed on the Analytical Data Reports page. Therefore, every time the report is generated, the database is queried at that time ensuring that the most current data appears on the report.

Table I. Available Standard Reports and Associated Data Fields

Standard Report	Data Fields
Geochemical Parameters of Unfiltered Groundwater	<ul style="list-style-type: none"> • Boring • pH • Conductivity (mS / cm) • Temperature (° C) • ORP (mV) • Turbidity (NTU) • Dissolved Oxygen (mg/L)
Geotechnical Parameters of Soils	<ul style="list-style-type: none"> • Sample ID • Depth Interval (ft bgs) • Soil pH (SW 9045 C) • Specific Gravity (ASTM D 854) • Moisture Content (ASTM D 2216) • Liquid Limit (ASTM D 4318) • Plastic Limit (ASTM D 4318) • Atterburg Classification (ASTM D 4318) • Percent Silt & Clay (ASTM D 422)
Gross Alpha, Gross Beta & Radium in Groundwater	<ul style="list-style-type: none"> • Boring/Sample Number • Gross Alpha (Result, Flag, MDA, Error) • Gross Beta (Result, Flag, MDA, Error) • Radium-226 (Result, Flag, MDA, Error) • Radium 228 (Result, Flag, MDA, Error) • Filtered or Unfiltered
Major Ion Concentrations in Unfiltered Groundwater	<ul style="list-style-type: none"> • Location • Fe 2 + (mg/L, meg/L) • Alkalinity (mg/L, meg/L)

	<ul style="list-style-type: none"> • Cl- (mg/L, meg/L) • NO2- (mg/L, meg/L) • NO3- (mg/L, meg/L) • PO43- (mg/L, meg/L) • S2- (mg/L, meg/L) • SO4- (mg/L, meg/L)
Metal Concentrations in Unfiltered Groundwater	<ul style="list-style-type: none"> • Location • Metals Concentrations
Total Uranium Results from Soil Samples	<ul style="list-style-type: none"> • Field Sample ID • Top Depth • Bottom Depth • Gamma Spec – Onsite (Total Uranium, Flag, Error MDA) • Gamma Spec – Offsite (Total Uranium, Flag, Error MDA)

The Standard Reports were created based on the data thought to be of most common interest among team members in a format thought to be of greatest use. However, the diversity of the Project Team and wide range of true data needs and individual project responsibilities quickly made it evident that a more robust data reporting tool was required. As a result, the PMW Analytical Data section was expanded to include a Custom Report function, allowing users to define the data fields they wish to include in their data tables as well as the criteria by which they wish to query the data.

Custom Data Reports

The Custom Report function provides users with the ability to choose the data fields to be displayed in their report and more importantly, to filter the data based on their specified filter criteria. Users can also save the settings as a personal template they entered to create the report so the report can be quickly and easily regenerated dynamically, inclusive of any additional data added to the system.

After clicking on the “Custom HTML Report” link on the Data Reporting page of the PMW, users are presented with a list of saved custom report filters and a link to build a new custom report. After choosing to build a new custom report, the user is presented with a data entry screen on which to specify the data fields to include on the report as well as the criteria by which to filter the data. The page presents a list of the data fields available in the PMW database, and users simply click on a checkbox next to each desired field in the column labeled “Display”. The selected fields will appear as columns in the generated report table. Users can then use the checkboxes, pull-down menus, and text boxes in the “Filter Criteria” column to specify the criteria by which each data field will be queried. After the user completes their selections and clicks the “View Report” button, the database is then queried and the report dynamically generated. Fig. 1 illustrates the settings and results table for a custom report listing total uranium concentrations detected in soil in concentrations greater than 15 picoCuries per gram (pCi/g).

Users can sort the custom report table by clicking on individual column headings, create printer-friendly versions of the report in HTML and PDF formats, or export the report data into a comma- or tab-delimited text file or XML file. Users also have the ability to name and save their custom report settings and specify other Team Members and/or groups of Team Members to be provided access to the saved custom report settings. The saved custom report settings will

appear on the Saved Filter page of the PMW for the user and any Team Member specified. Users can then regenerate the custom report at any time by clicking on the view icon next to the name of each report on the Saved Filter page. As with the Standard Reports, the Custom Reports are dynamically generated each time the user clicks on the Report Name on the Saved Filter page.

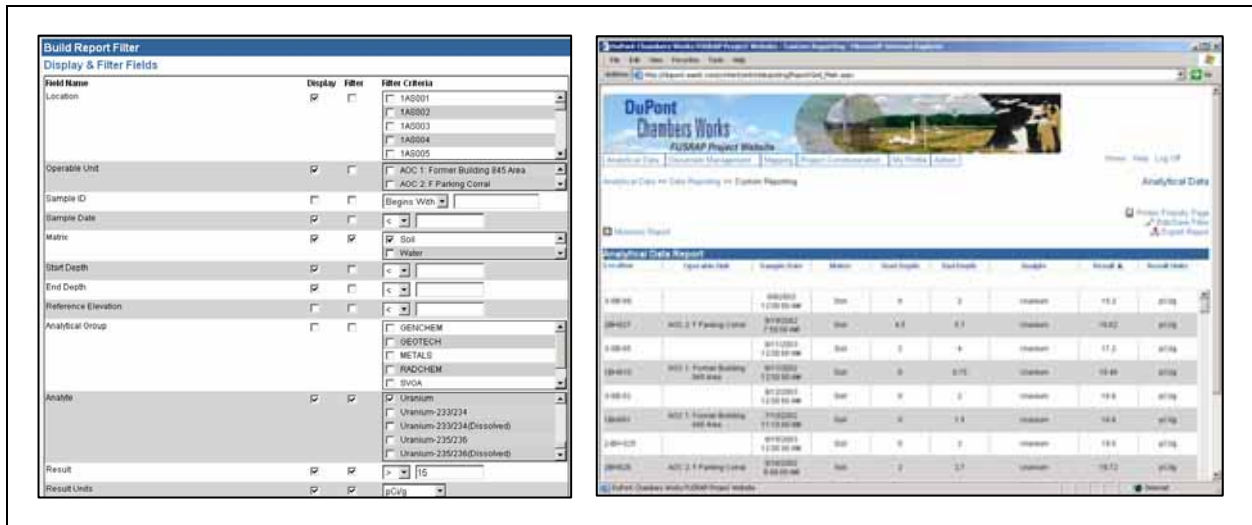


Fig. 1. Example Custom Report Filter Settings and Custom Report

Internet Mapping (GIS) Function

The PMW includes an internet mapping application that allows users to generate and customize maps of the site and the associated data via a standard web browser. Users have the ability to view data and automatically add data labels to maps, measure distances and areas, and automatically highlight map elements identified based on user-defined queries.

The applicability and power of GIS in support of environmental projects has been widely documented. However, the cost associated with GIS software and the associated training typically limits its availability for all individuals on a Project Team. The PMW minimizes these obstacles by utilizing the web-based format. All Team Members have access to the PMW GIS capabilities via standard web browsers and internet connections, and only very basic, if any, training is required to give users the ability to effectively utilize the mapping and analytical functions.

While the wide range of available GIS tools and capabilities can not be effectively explained within the guidelines of this paper, they can best be demonstrated by describing a specific hypothetical data analysis effort that may be performed using the internet mapping function of the PMW. For this example, we will revisit the data query discussed earlier in this paper in order to demonstrate the analytical power of the GIS mapping application.

The query tool of the internet mapping application could be used to query the database for total uranium results in soil samples greater than 15 pCi/g. A table of results will appear and the locations of the results will be highlighted automatically on the map. The user can then click on a checkbox next to any result in the table and have data labels post automatically on the map in a

user-defined format. The user could then use the measure tool to draw a polygon around the highlighted points on the map and the system will automatically calculate the area of the polygon. The depth of contamination could then be ascertained from the query results table, and the user could then easily estimate the volume of contaminated material. This information would be particularly useful in developing and evaluating various remediation or treatment alternatives. Users could then create custom labels on the map detailing the results of the calculations and evaluation. Finally, the user could create a figure including a title block, legend, and selected organization logos and either print the map or create a PDF directly through the PMW. The created map settings could then be named and saved and the user could specify other Team Members or groups of Team Members that should have access to the saved map settings. These steps could be completed in a matter of minutes and require no specific GIS or software training to perform. Fig. 2 presents screenshots of the internet mapping application.



Fig. 2. Screenshots of the Internet GIS Mapping Function

DOCUMENT MANAGEMENT TOOLS

The PMW's document management tools provide Project Team members with an online file repository to manage and organize electronic files and documents; an online document review function, which utilizes a split-screen approach for document review and capture of review comments and responses; and a document archive function providing access to historical documentation.

File Repository and Document Archive

Any project of this magnitude involves a large number of electronic project files and both text and graphic documents generated by the various organizations, agencies, and stakeholders involved. Effective management and organization of these files is crucial to ongoing project performance, as is providing efficient user access to the project files. File management for this project is handled primarily using the PMW's file repository function. The purpose of the repository is to manage, store, maintain, and provide user access to electronic project files, effectively serving as a virtual project "file room".

The PMW File Repository functions similarly to any standard computer operating system. Files are stored and maintained in hierarchical, appropriately-named folders that may be browsed or accessed in a basic tree structure. Users with the appropriate system permissions have the ability to upload files, create, edit or delete file information, create folders, and specify folder access rights in terms of other system users or groups of users. A user can only see and access folders for which they have been assigned appropriate access permissions. Users are also provided with the ability to search the file descriptions by keyword, file contents by keyword, and the files themselves by date uploaded and/or the Team Member who uploaded the file.

Historical project documentation, including aerial photographs, pictures, engineering reports from previous environmental actions, and other documents relative to MED and Chambers Works process activities, and an index of the Administrative Record are also resident on the PMW in a Document Archive section of the site. Users have the ability to search the Document Archive by keyword, and access any returned historical documentation stored in the archive. This combination of historical documentation and current project files in one online system provides users with a powerful method by which to access information they need when they need it. The system also reduces paper file storage, file or document duplication, and the need for accessing multiple sources for project information. Users have access to all project information immediately via a standard web browser and internet connection.

Document Review Function

Project Team review of draft and final documentation is a critical step in the site characterization and remediation process. Efficient document review, comment generation and management, and management of responses to comments is critical to ensure the quality of project deliverables and appropriate buy-in from the Project Team. The PMW facilitates this process using an online document review function.

Users with the appropriate system permissions can post an electronic document for review, set the review period, select reviewers, and assign responsibilities for responding to review comments. At the start of the document review period, all selected reviewers receive an auto-generated email notification from the system identifying the document to be reviewed, the review period, and the link to the document review section of the PMW. If a system user is not selected as a reviewer or responder, they will not see or have access to the document review information including comments and responses. This prevents unnecessary notification to all Team members, and allows for secure access and review by subsets of the Project Team, such as project managers or risk assessors.

The Document Review function operates in a split-screen format as illustrated in Fig 3. The document itself is visible in one window; comments, responses, and the comment and response forms are available in another; and a message board thread under the topic of the document to be reviewed is available in the third. Users have the ability to customize the location and format of the split-screen view and select the information that appears in each window.

During the review period, users can enter comments individually by entering the document section, page, and the comment itself on the online review form or by selecting the "No

Comment” box on the form. To provide additional flexibility for users that prefer to record all comments in one file, the online review form includes the ability to attach an electronic file of review comments. Selected responders can then post responses to comments, and a designated response administrator can release the responses to the system following review and approval. Users can also print and export all available comments and responses to comments for use in other applications.

Reminder emails are auto-generated by the system and sent to Team Members that have not posted review comments. In order to avoid the auto-generated email reminders, users must post a comment or at least select the “No Comment” box on the comment form. The system also provides document and system administrators with a list of reviewers, including whether they have reviewed the document and the number of comments posted.

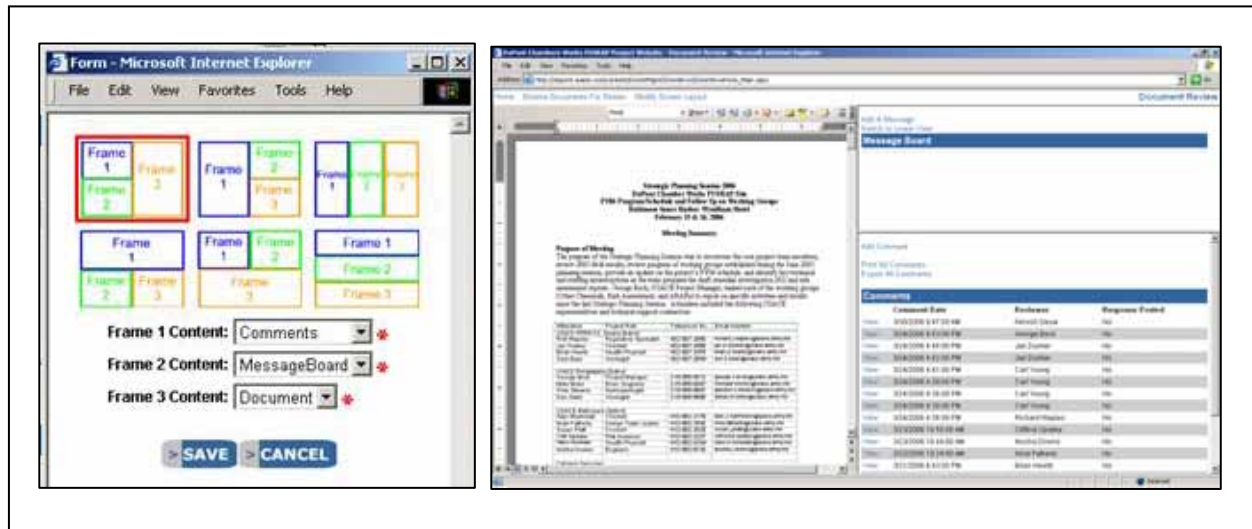


Fig 3. Split-Screen Format of Document Review Function

The application has been successfully utilized for the review of various project documents, and has increased the efficiency of the review process. The auto-generated email notifications help to keep the review process moving, and the application itself provides an ongoing historical record of all posted document review comments and responses.

PROJECT COMMUNICATION FUNCTIONS

As indicated throughout this paper, effective Project Team communication is essential to the success of large, complex, multi-stakeholder projects consisting of individuals and organizations in geographically separate locations. Inclusion of several system functions and features to facilitate team communication via the PMW has allowed the Team to consolidate the majority of pertinent site and project information into a single resource, thereby increasing the efficiency and effectiveness of communications as well as data access and transfer.

Message Board Function

The PMW includes a Message Board application that allows users to post and reply to messages from other users and review the flow of a discussion via a threaded list of messages under each topic. Users have the ability to create topics; select Team Members and groups of users who are permitted to view, post, and respond to messages under a given topic; post messages; reply to messages; and email messages. Users also have the ability to search messages by topic, message contents by keyword, and message posts by date and/or author. The PMW Message Board is directly linked to the Message Board section of the Document Review application; therefore messages posted under the document topic are accessible via either section of the site.

Events Calendar

The PMW Events Calendar function allows Team personnel with access to the website to post and view scheduled meetings, deadlines, and dates of other important project events. Users can post events and view events in a calendar format or in a chronological list. Information entered regarding each event includes the start and end dates and times, event title, location, and description. Users may also attach an electronic file to a posted event such as a meeting agenda, driving directions, or any associated documentation.

Team Directory

The PMW Team Directory function allows users to view, add, and edit contact information for individuals associated with the project. When a new user account is established by the System Administrator, the user's contact information automatically appears in the Team Directory. However, users can also post contact information for any individual that may be of interest to other Team Members. The Team Directory lists contacts alphabetically by name and includes their organization, email address, and phone number. Additional contact information is available by clicking on the name of each contact.

PMW Homepage and Automated Email Notifications

One of the most significant communication functions in terms of increased efficiency is the structure of the PMW homepage itself. After a user enters their username and password and logs onto the website, they are presented with the homepage which lists recent and important information regarding the project. Users are presented with a list of recently posted messages, events scheduled during the next 60 days, recently posted documents, notification of any new site data uploaded to the PMW, and a list of documents requiring their review. Each listed item also includes a direct link to the information, file, or pertinent PMW section. As such, the homepage provides users with a snapshot view of the most recent and pertinent project information immediately, at-a-glance, and reduces the time associated with navigation through the system.

This innovative notification strategy is extended through the use of automated email updates. The PMW allows users to schedule automated emails containing the homepage information. Users can have auto-generated email notifications sent to their email addresses daily, weekly, bi-weekly, or monthly. The emails contain the lists of recently posted messages, events scheduled during the next 60 days, recently posted documents, notification of any new site data uploaded to the PMW, and documents requiring their review as presented on the system homepage at that

time. The emails include direct links to the pertinent information, and are an excellent resource for Team Members to stay informed regarding project updates while requiring minimal effort in terms of accessing and navigating the site.

CONCLUSION

Advances in relational databases, programming technologies, data analysis, and visualization support applications have resulted in a wide range of desktop tools to help meet the complex data management and communication challenges associated with large environmental projects. However, in the case of large, diverse, geographically-separated project teams, use of numerous, local information technology applications with directed, specific utility in the areas of communication facilitation, data management, data analysis, mapping, document review, and file management often create new challenges, specifically in terms of software availability, licensing, versioning, training, data duplication, data transfer, and software integration. As a result, use of multiple applications by project teams often creates more inefficiency and increases associated costs to the point where they are no longer beneficial and their utility is ultimately limited.

In contrast, the consolidated, open-architecture system developed by the USACE and implemented in support of the DuPont Chambers Works FUSRAP site brings the wide range of communication, data management, data analysis, GIS mapping, and document management tools together into one application, available to all project team members regardless of their physical location, training, and available software. This consolidated data management strategy helps reduce the inefficiencies inherent in the team process and has allowed large, multi-stakeholder project teams to effectively keep diverse environmental projects on track while reducing the costs associated with data requests, data duplication, software requirements, and lapses in communication and data transfer.

The system can be modified and utilized for a wide range of environmental projects and continues to be expanded to provide Team Members with additional functionality. System upgrades and improvements currently under development include navigational upgrades, incorporation of data charting and graphing functions, inclusion of comparison criteria and automated highlighting of regulatory exceedances in the custom reporting and internet mapping query functions. Though the system was developed to perform specific functions as defined by the FUSRAP Project Team, the application continues to be expanded as needs evolve and in accordance with advances in technology. As today's environmental projects and the associated data management needs continue to become more and more complex, we will increasingly use consolidated online systems such as the PMW to meet our growing communication and data management challenges.