Web Based GIS Tools for Accessing Hanford Site Environmental Data – 14447

T.E. Seiple, D.J. Watson, M.B. Triplett
Pacific Northwest National Laboratory

B.L. Charboneau, J.G. Morse
DOE Richland Operations

ABSTRACT

Data volume, complexity, and access issues pose severe challenges for analysts, regulators and stakeholders attempting to efficiently use legacy data to support decision making at the U.S. Department of Energy's (DOE) Hanford Site. DOE has partnered with the Pacific Northwest National Laboratory (PNNL) on the PHOENIX (PNNL-Hanford Online Environmental Information System) project, which seeks to address data access, transparency, and integration challenges at Hanford to provide effective decision support. PHOENIX is a family of spatially-enabled web applications providing quick access to decades of valuable scientific data and insight through intuitive query, visualization, and analysis tools. PHOENIX realizes broad, public accessibility by relying only on ubiquitous web-browsers, eliminating the need for specialized software. It accommodates a wide range of users with intuitive user interfaces that require little or no training to quickly obtain and visualize data. Currently, PHOENIX is actively hosting three applications focused on groundwater monitoring, groundwater clean-up performance reporting, and in-tank monitoring. PHOENIX-based applications are being used to streamline investigative and analytical processes at Hanford, saving time and money. But more importantly, by integrating previously isolated datasets and developing relevant visualization and analysis tools, PHOENIX applications are enabling DOE to discover new correlations hidden in legacy data, allowing them to more effectively address complex issues at Hanford.

INTRODUCTION

Vast amounts of environmental data, combined with isolated legacy databases and old software limit data transparency and utility, and make it difficult for DOE and its contractors to quickly report on and analyze environmental conditions at DOE's Hanford site. The Hanford site is a federal clean-up site occupying about 1,500 square kilometers in southeastern Washington State.

Contaminated groundwater plumes cover an area of more than 180 square kilometers at Hanford. Each year, thousands of samples are collected to monitor the groundwater, air, soil, vegetation, and biota resulting in hundreds of thousands of distinct analytical results distributed across a mosaic of surface and subsurface administrative boundaries. Scientific studies, field investigations, model simulations, remediation system performance assessments, and sensor networks also yield extensive volumes of data each year.

These activities are managed by several different programs within DOE, and are physically performed by multiple contractors. As a result, related data often reside in disparate database or file systems, with no convenient means to link and visualize relevant datasets. This fragmented data ecosystem creates technical and institutional barriers to accessing publicly-owned science

data. Existing data retrieval software is just as fragmented, with each tool tailored to a specific data source. Consequently, simple analyses can be labor-intensive, as analysts use several software tools to compile and format the necessary data.

Collectively, data volume and access issues pose severe challenges for analysts, regulators and stakeholders attempting to leverage these data in a timely manner to support decision making at the Federal, State, and local levels.

DESCRIPTION

DOE has partnered with the Pacific Northwest National Laboratory (PNNL) on the PHOENIX project, which seeks to facilitate decision support by addressing data access, transparency, and integration challenges at Hanford, enabling DOE to be more responsive to emerging data trends.

PHOENIX is a family of spatially-enabled web applications and related data services developed by PNNL to provide the Hanford community with easy access to decades of valuable scientific data through simple to use query, visualization, and analysis tools.

Broad public accessibility is realized by integrating disparate data sources using web services and by relying only on ubiquitous web-browsers, eliminating the need for specialized software. It accommodates a wide range of users with intuitive user interfaces that require little or no training to quickly obtain and visualize data.

PHOENIX is best regarded as a layer of decision support that sits between data providers and data consumers. It does not seek to replace or even replicate existing data access portals, which are generally the primary source for comprehensive information on a given data topic. The purpose of PHOENIX is to integrate across data providers, enhancing “data of interest” in a way that adds value for the data consumer.

In some cases, adding value means integrating various datasets into an intuitive map-based application, providing spatial context to the results and revealing previously undiscovered correlations. Other times it means using a dashboard to display key status indicators, automating performance reporting, or even hosting a web-based ecological risk model. Considerable value is also achieved by simply providing public access to publicly-funded data for the first time.

Therefore, PHOENIX decision support tools may manifest themselves as data services, web applications, performance reports, animations, or any other digital format, depending upon the intended use case, whether it is performing open ended investigations or answering specific management questions in order to accomplish key programmatic objectives.

PHOENIX applications consume web (data) services. Web services are a method for transferring data from a data source over the web. Essentially, a web service is a “middle man” that brokers the request-response transaction between the web client and the data source.

Using web services to connect and integrate disparate data sources is a cost effective integration strategy that avoids expensive legacy database upgrades and allows the respective data owners to

retain configuration management of their data assets, thereby preserving existing roles and responsibilities across the data ecosystem. They also make data transactions more secure, since the web user does not connect directly to the data source.

PHOENIX uses web services to host spatial and non-spatial data and to perform computational tasks such as geoprocessing or modeling. Generally, most of the data consumed by PHOENIX are stored in either PNNL or DOE managed databases. However, PHOENIX can also consume any web-accessible resource, including databases, data files, and third-party web services.

When PNNL is not the data owner, PHOENIX uses either pass-through "proxy" web services to relay data, or near-real-time data replication to move data from various data systems through PNNL managed web applications. These indirect methods become necessary as a result of corporate firewall structures, including PNNLs, which restrict outbound and cross-domain communication from external hosts that can also connect to internal resources.

PHOENIX currently hosts three map-based applications for DOE, which are customized to address different application areas at Hanford: 1) PHOENIX groundwater edition, focusing on groundwater monitoring, 2) PHOENIX Annual Groundwater Report Edition, reporting clean-up performance, and 3) PHOENIX tank farms edition, focusing on in-tank monitoring. Several new applications are under development.

PHOENIX Groundwater Edition

Providing public access to environmental data is the first step in improving transparency of environmental conditions and cleanup progress. Reducing the effort required to discover, browse, acquire, format, and manipulate data affords scientists more time to perform more robust analyses and deliver performance and summary analyses to the public.

PHOENIX Groundwater Edition [1] (figure 1) provides easy access to the entire inventory of Hanford groundwater monitoring results, and blends it with a rich set of complementary geospatial data and imagery that characterize historical and current conditions. This application was the first of its kind at Hanford, and offers previously unrealized data transparency and integration.

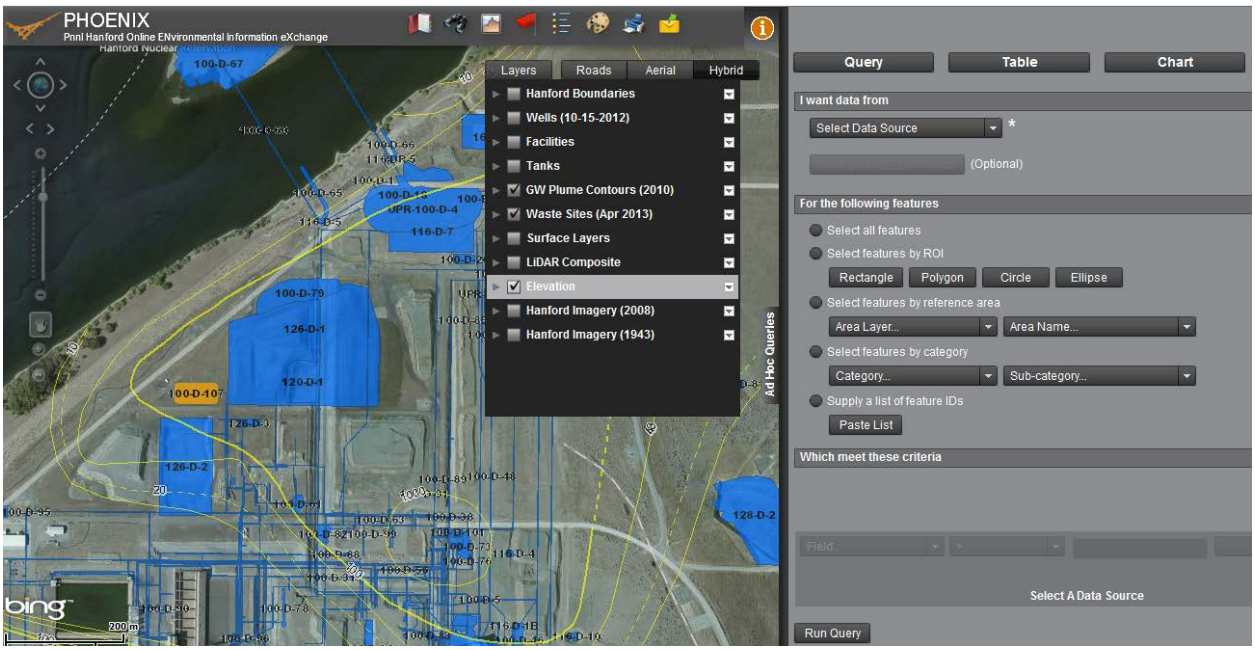

Figure 1. PHOENIX Groundwater Edition mapping and query interface.

Data can be easily obtained through the application's direct connection to the Hanford Environmental Information System (HEIS). The data access tools were carefully designed to balance a novice user's need for simple query construction with an advanced user's need to quickly configure the query in order to precisely acquire data of interest for download. A single query interface provides access to multiple types of data, reducing the learning curve for the user.

The groundwater application provides multi-directional synchronization between all views (i.e. map, table, chart), such that if a user activates a map feature, table record, or chart series, the other views are dynamically filtered. Dynamic chart rescaling and map navigation ensure the user can easily compare the spatial view to the data views.

PHOENIX Annual Groundwater Report Edition

Providing a web portal to communicate performance report content, with standardized formatting, rigid data structures and automation tools greatly reduces the time and money required to produce and issue an environmental report to the public.

PHOENIX Annual Groundwater Report Edition [2] (figure 2) replaces a very lengthy, more than 1,000 page, paper-based annual report with a web-based tool that delivers the same narratives, analysis and visualization, but also allows the user to explore the entire data package used to develop the report.

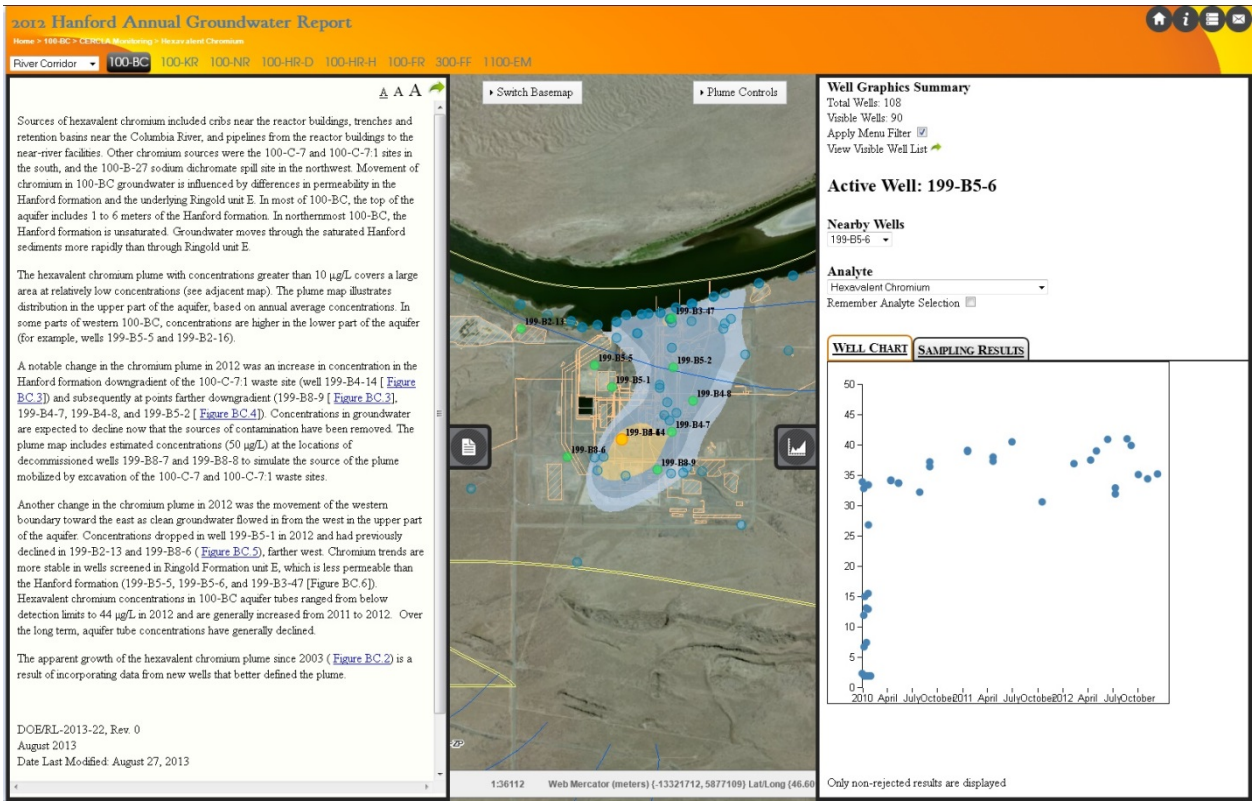

Figure 2. PHOENIX Annual Groundwater Report Edition mapping interface.

The interface is designed as a triptych, with a "presentation panel" containing interpretive text on the left, an interactive map in the middle, and a "data exploration panel" on the right. The left and right panels are collapsible.

The menu along the top (figure 3) mimics the table of contents of a traditional report, and is organized by groundwater interest area. Clicking a menu item causes the application to load a new narrative, preconfigured map, and clickable graphics.

Hovering over a top level menu item expands the full menu showing all of the content available for the active menu item. This reduces the work necessary to access a given sub menu, and also gives the user a quick overview of what each "chapter" contains.

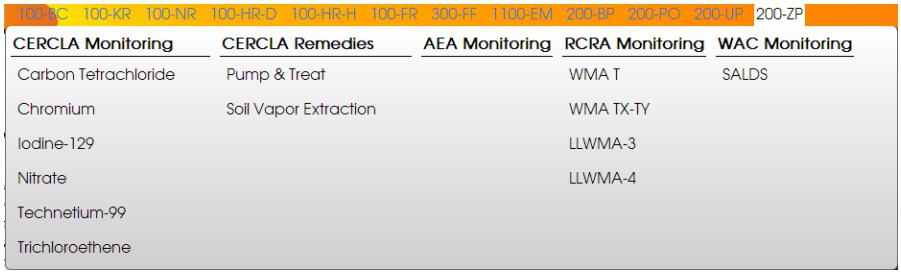

Figure 3. Expanded sub menus for menu item "200-ZP"

The application also provides a plume animation control that allows the user to step through or animate historical groundwater contaminate plumes.

PHOENIX Tank Farms Edition

In FY-13, collaboration with DOE's Office of River Protection (ORP) and PNNL was initiated to adapt PHOENIX tools and approaches to develop a prototype application that could improve the accessibility and transparency of in-tank measurements of surface levels, interstitial liquid levels, and temperature.

This effort was initiated due to concerns that some single-shell tanks were showing indications that leaks could be recurring. The *PHOENIX Tank Farms Edition* prototype is being enhanced in FY-14 to provide rapid access to tank summary information, as well as detailed tank inventory and in-tank monitoring data reported in Tank Waste Information Network System (TWINS) [3].

DISCUSSION

Several real-world outcomes illustrate the positive impact PHOENIX applications are having at Hanford.

Real-time Milestone Tracking (DOE-RL)

DOE wanted to have the ability to quickly evaluate progress toward Tri-Party Agreement (TPA) milestones for groundwater cleanup along the Columbia River corridor for hexavalent chromium, uranium and strontium-90 [4].

Prior to PHOENIX, it would take hours to days for a contractor to compile the necessary data and create associated maps, charts and tables. Furthermore, contractors could not provide a complete picture since they were limited to the number of wells they could report on. The vast number of groundwater wells in a groundwater operable unit (as many as 1300) precluded the manual creation of contaminant trend charts for every well. Nor could analysts readily create a map indicating which wells exceeded the drinking water standard for a given analyte.

PNNL addressed this need by developing the TPA Milestone tool, as part of the PHOENIX Groundwater Edition. This tool uses groundwater monitoring data stored in HEIS to automate TPA evaluations and dynamically generate the desired visual outputs in real-time.

Figure 4 depicts the results of running the TPA milestone tool for a milestone tracking uranium cleanup. The well symbols are green if the latest uranium groundwater concentration is below drinking water standards and red if it is above. The directionality of the symbol indicates whether the data are trending up, down, or no change. The right panel displays the sampling data for every well in the map. Clicking on a well graphic will filter the data in the chart.

DOE management is now able to independently obtain near real-time assessments of TPA milestone progress, and view groundwater concentrations from all TPA wells across the entire

Hanford site, all from the web.

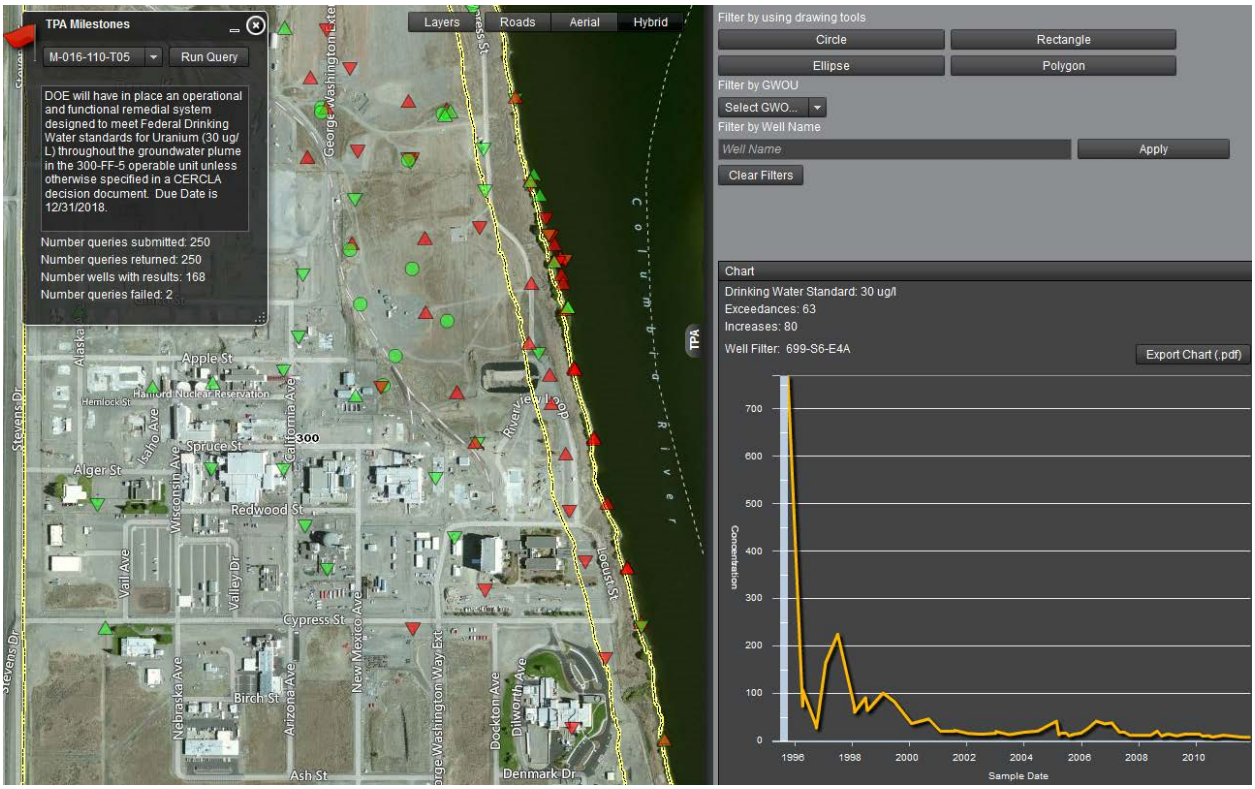

Figure 4. TPA Milestone tool automatically evaluates milestone progress

Effectively Communicating Groundwater Clean-up Progress

DOE wanted to reduce the cost and turnaround time for producing the Hanford annual groundwater monitoring report, while increasing its utility and accessibility. The DOE-Richland (RL) office is obligated to provide this annual report to regulators and the public. The report, which describes on-site groundwater contaminant conditions and remediation effectiveness, is the primary reporting mechanism for monitoring at Resource Conservation and Recovery Act (RCRA) treatment, storage, and disposal units, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) groundwater operable units and AEA-regulated sites.

Since it was first issued in 1996, the report has grown to more than 1,000 pages and includes several hundred tables and figures [5], making it cumbersome to use and very expensive and time consuming to produce. It was not uncommon for the annual report to take eight months to produce, rendering some of the content obsolete by the time the report was issued.

Recognizing the need to reduce the cost and turnaround time for producing the annual report, while increasing its utility and accessibility, DOE asked PNNL to create an on-line version of the annual groundwater report. The site groundwater remediation contractor responsible for

developing the annual report was instructed to transfer the content (narratives, data analyses, and conclusions) to PNNL for display in PHOENIX.

The PHOENIX Annual Report Edition (figure 2) transforms 1,000 pages of text and data into a single, easy to use web interface. It offers several major advantages over the traditional paper-based product. First, users can simultaneously view each narrative alongside the related map and data, never having to turn a page to make correlations between these common views.

Second, unlike a printed appendix, a web application is not limited on the volume of data that can be presented. The online annual report connects to a snapshot of HEIS [6] to give users access to the complete sampling history for Hanford, including millions of sample results that go back as far as the early 1950's.

Third, readers can explore groundwater concentration trends in wells for contaminants not covered by the report narratives, which is impossible to do in traditional paper-based reports.

Multi-agency DQO Meeting Facilitation

In 2012, the Tri-party agreement (TPA) was amended to include a new process-based operable unit containing approximately 5,000 acres of pre-Hanford orchard lands, in order to assess and mitigate potential environmental or human health impacts from persistent lead and arsenic resulting from application of lead arsenate as an insecticide in the early 1940's [7].

A series of multi-agency meetings between the DOE-Richland Operations Office, the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology, were held to 1) determine precisely which lands were historically used as orchards, and 2) assign background concentrations to pre-Hanford farming activities.

In order to facilitate the enumeration of operable unit work plan data quality objectives (DQO), a mosaic of black and white aerial photography of the Hanford site taken in 1943, and a feature layer representing preliminary operable unit boundaries were added to *PHOENIX Groundwater Edition.*

Using PHOENIX allowed the DQO meetings to take place anywhere an internet connection was available, and removed the need for specialized GIS software to overlay the operable unit boundaries over the historical imagery and other layers already available in PHOENIX (figure 5). Regulators and DOE could then collectively review the boundaries and identify areas where they failed to encompass historical orchards, or extended beyond the orchard lands. This capability made PHOENIX a critical component of the DQO process.

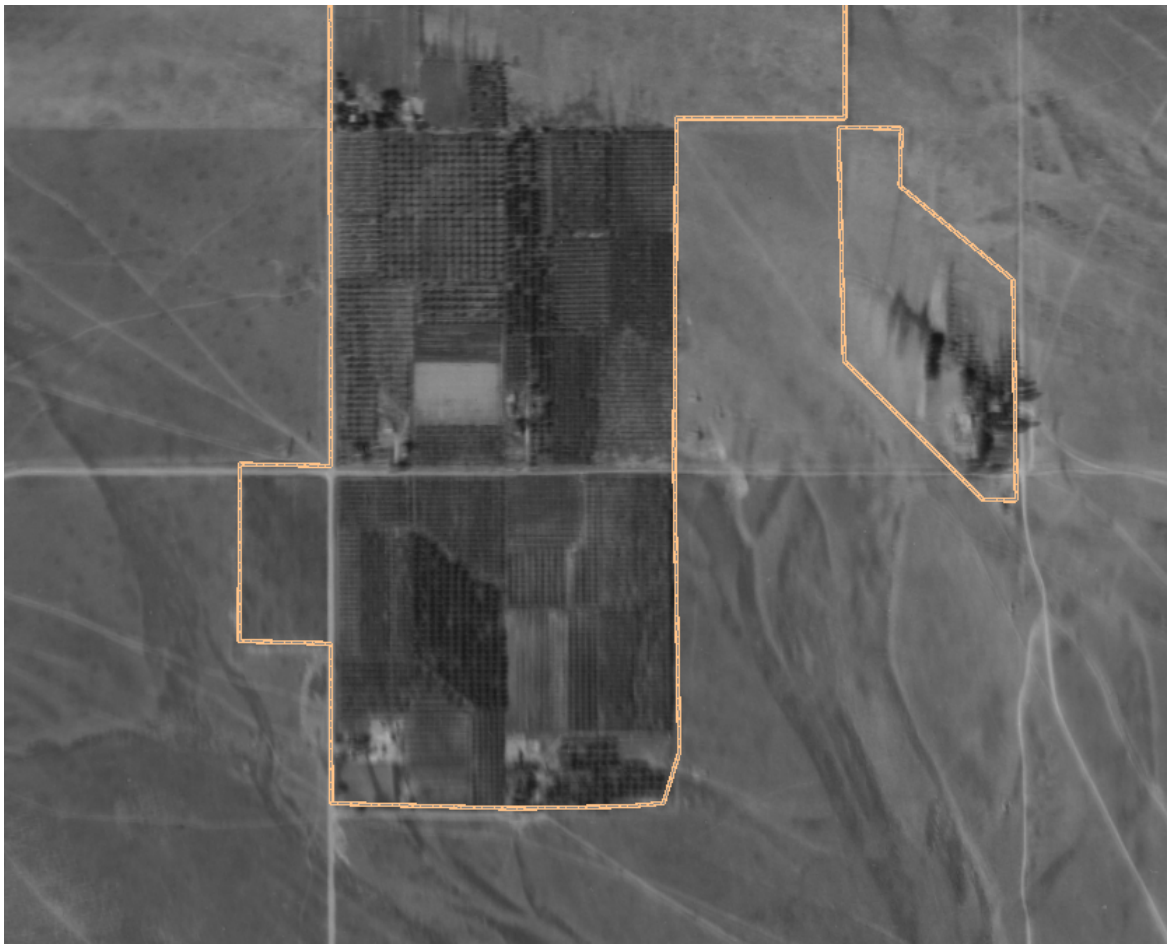

Figure 5. Historical orchard boundaries with 1943 USGS imagery.

CONCLUSION

PHOENIX-based applications are being used to streamline dozens of investigative and analytical processes at Hanford, substantially reducing costs and helping contractors to fulfill their obligations in the current environment of reduced staffing.

But more importantly, by integrating previously isolated datasets and providing relevant visualization and analysis tools, PHOENIX applications are creating new forms of decision support, which are enabling DOE to discover new correlations in legacy data and effectively address complex issues at Hanford.

Considerable demand by PHOENIX users has also caused DOE to release additional data sets for public use, which are now also accessible through PHOENIX, helping DOE to achieve data transparency with the public. PNNL science data is also being published through PHOENIX, increasing the access and utility of costly data assets. The PHEONIX approach for integrating legacy data can also serve as a model for other large federal sites that are experiencing similar data challenges.

REFERENCES

1. “PHOENIX: PNNL Hanford Online Environmental Information Exchange.” Pacific Northwest National Laboratory. Accessed November 2013 at http://phoenix.pnnl.gov/ (last updated November 1, 2013).
2. "2012 Hanford Annual Groundwater Report." Pacific Northwest National Laboratory. Accessed: November 2013 at http://phoenix.pnnl.gov/AR12 (last updated August 2013).
3. “Tank Waste Information System”. Pacific Northwest National Laboratory. Accessed November 2013 at https://twins.labworks.org/twinsdata/Forms/About.aspx?subject=TWINS (last updated January 2013).
4. “Hanford Federal Facility Agreement and Consent Order”, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington (1989).
5. “Hanford Site Groundwater Monitoring Report for 2011”, DOE/RL-2011-118, Rev. 0. United States Department of Energy, Richland, Washington (2012).
6. Hanford Environmental Information System, Hanford Site database, Richland, Washington.
7. B.L CHARBONEAU, “Change Request Number C-12-02: Addition of the 100-OL-1 Operable Unit to the Tri Party Agreement Appendix C”. United States Department of Energy, Richland WA (2012). Accessed November 2013 at http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1205091466.