CHPRC-01924 -FP
Revision 1

Lessons Learned from the 200 West Pump and Treatment Facility Construction Project at the US DOE Hanford Site - A Leadership for Energy and Environmental Design (LEED) Gold-Certified Facility

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

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ABSTRACT

CH2M Hill Plateau Remediation Company (CHPRC) designed, constructed, commissioned, and began operation of the largest groundwater pump and treatment facility in the U.S. Department of Energy's (DOE) nationwide complex. This one-of-a-kind groundwater pump and treatment facility, located at the Hanford Nuclear Reservation Site (Hanford Site) in Washington State, was built to an accelerated schedule with American Recovery and Reinvestment Act (ARRA) funds.

There were many contractual, technical, configuration management, quality, safety, and Leadership in Energy and Environmental Design (LEED) challenges associated with the design, procurement, construction, and commissioning of this $95 million, 52,000 ft groundwater pump and treatment facility to meet DOE's mission objective of treating contaminated groundwater at the Hanford Site with a new facility by June 28, 2012.

The project team's successful integration of the project's core values and green energy technology throughout design, procurement, construction, and start-up of this complex, first-of-its-kind Bio Process facility resulted in successful achievement of DOE's mission objective, as well as attainment of LEED GOLD certification (Figure 1), which makes this Bio Process facility the first non-administrative building in the DOE Office of Environmental Management complex to earn such an award.

Figure 1 - LEED Gold Facility

INTRODUCTION

The Hanford Site is a 1,517 km^2 (586 mi^2) federal facility located in southeastern Washington. The Site served as a plutonium production facility for nuclear weapons used in World War II. For administrative purposes, the Hanford Site was divided into four National Priorities List (NPL) sites in 1989 (40 CFR 300 APP B, 40 Code of Federal Regulations, Part 300 [1]) under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) (42 USC) [2]. One of these sites is the 200 Area. The 200 Area NPL site, which is commonly referred to as the Central Plateau, encompasses approximately 190 km^2 (75 mi^2) near the center of the Hanford Site and contains multiple waste sites, contaminated facilities, and groundwater contamination plumes. In September 2008, the *Record of Decision, Hanford 200 Area, 200-ZP-1 Superfund Site Benton County Washington* (EPA et al., 2008) was approved by DOE, the US Environmental Protection Agency (EPA), and the Washington State Department of Ecology. One of the selected remedies was the design, construction, testing, and operation of a 200 West Area Pump-and-Treat system.

The vision of the CH2M Hill plateau Remediation Company (CHPRC) was to execute the *200 West Area Pump-and-Treat System* project (2W P&T Project) safely, on schedule, and within budget, while meeting or exceeding technical requirements and customer expectations associated with removal of contamination from a groundwater plume (located beneath several facilities on the Hanford Site [Figure 2]) estimated to contain 2 trillion liters (450 billion gallons) of water and contaminated liquids that were discharged from facilities across the Hanford Site during the production years.

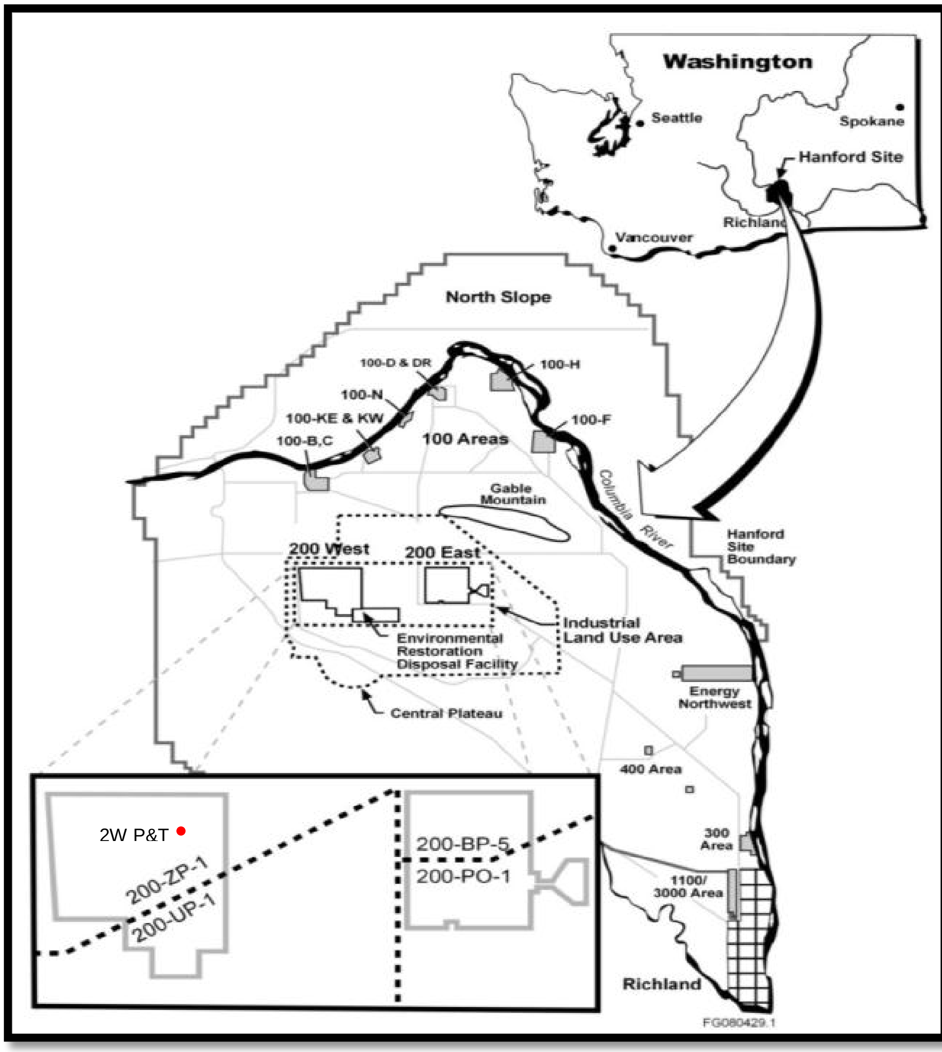

Figure 2 - Hanford Site Map

200 WEST GROUNDWATER PUMP AND TREATMENT SYSTEM BIOPROCESS FACILITY

The 2W P&T Bioprocess Facility is 4831 m^2 (52,000 ft^2) and has a flow capacity to treat approximately 9464 lpm (2,500 gpm), with future expansion capabilities to treat 14,200 lpm (3,750 gpm). The 2W P&T Facility was designed, constructed, and tested to treat the following contaminants of concern: Carbon tetrachloride, trichloroethylene, total chromium, hexavalent chromium, nitrate, and technetium 99.

The 2W P&T Facility (Figure 3) provides treatment capacity of 409 million liters (108 million gallons) per month (equivalent to 108 municipal water towers), which equates to approximately 5 billion liters (1.3 billion gallons) of water treated annually. The 2W P&T Facility will treat 91 billion liters (24 billion gallons) and remove between 35 million – 50 million grams (77,000 – 110,000 pounds) of carbon tetrachloride over its 25-year operational life.

Figure 3 - 2W P&T Facility

Process facilities required to support the 2W P&T Facility are as follows:

- One 4,831 m^2 (52,000 $ft^{2)}$ Biological Treatment Facility
- One 1,579 m^2 (17,000 $ft^{2)}$ Radiological Treatment Facility
- Five 232.2 m^2 (2,500 $ft^{2)}$ Transfer/Injection Buildings

The infrastructure required to be constructed/ installed in support of operation of the 2W P&T Facility consisted of the following:

- Construction of 76 road/railroad crossings
- Installation of 56 km (35 miles) of high-density polypropylene pipe
- Installation of 129 km (80 miles) of power and instrument cable
- Placement of over 9,175 m^3 (12,000 yd^3) of concrete
- Installation of 26 tanks (largest = 124,900 liters [33,000 gallons])
- Erection of air stripper towers 229 m (~75 feet tall)

HIGH–PERFORMANCE SUSTAINABLE BUILDING DESIGN AWARD

The 2W P&T Facility's LEED gold certification for sustainable design was the first gold certification (Figure 4) in the DOE Office of Environmental Management complex of sites that conducted nuclear weapons development and government-sponsored nuclear energy research.

Figure 4 - LEED Gold Certificate

The 2W P&T Project met stringent requirements for the LEED gold certification. The U.S. Green Building criteria required specific materials and waste-handling, plus environmentally responsible construction practices that reduce long-term costs. The 2W P&T Project accomplished the following:

- Building materials worth $906,794 were obtained from regional sources.

- Approximately 489 metric ton (539 US short ton) (over 75% of construction waste) was diverted from the landfill with a combined recycle value of $1,498,688.

  - 381 metric ton (420 US short ton) of recycled concrete (from washouts) was used.
  - 8 metric ton (9 US short ton) of paper/cardboard was recycled.
  - 38 metric ton (42 US short ton) of metal was recycled during construction.
  - Approximately 50% of steel used in construction was recycled.

- Process facilities were designed with Kalwall® Panels that reduce the need for interior lighting, which resulted in over 70 % in savings from the energy costs in the baseline building.

- The electric energy savings amount to 1,143,000 MJ/yr (317,470 kWh/yr), and propane savings are approximately 18,850,000 MJ/yr (178,669 thm/yr).

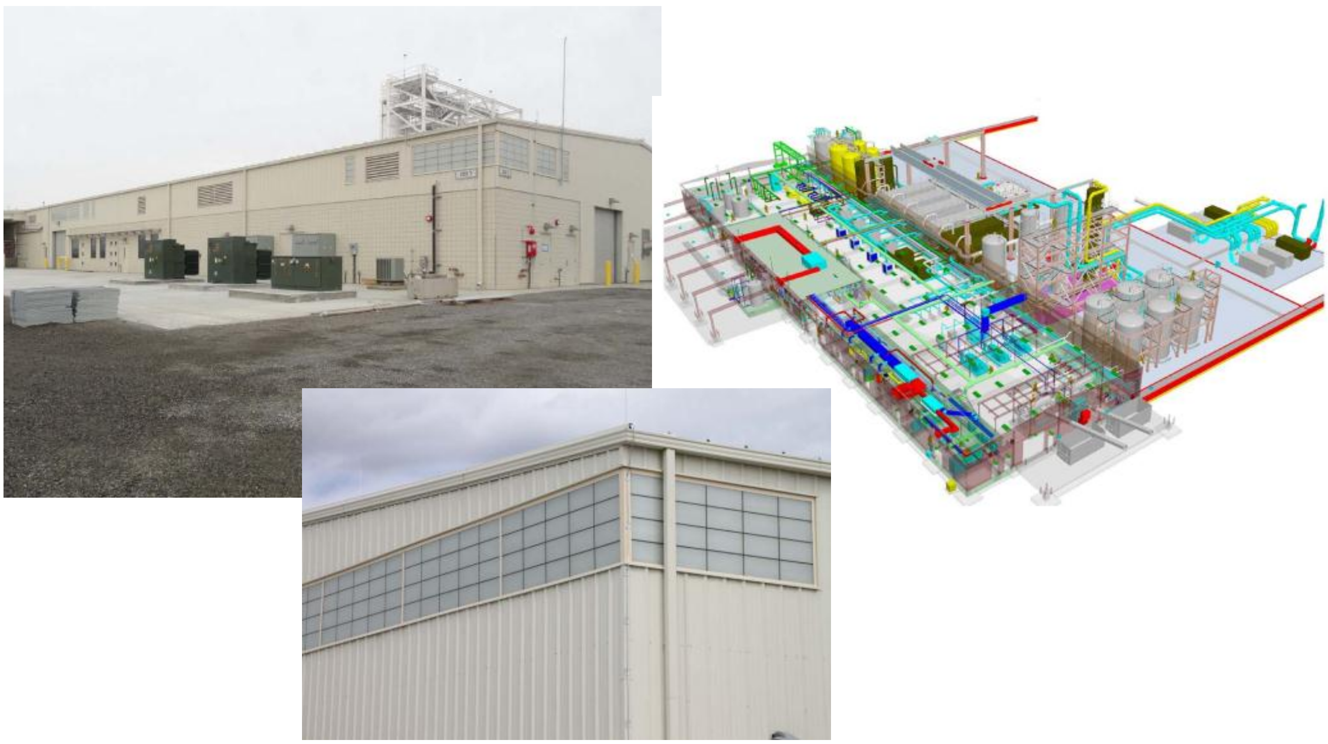

Figure 5 - 2W P&T Energy-Saving Design

The building's efficient design is expected to result in an energy cost savings of more than 70% over the life of the facility. The building will also meet new DOE-mandated green building standards that address site sustainability, water efficiency, renewable energy, conservation of materials and resources, and indoor environmental quality. (Figure 5 shows the energy efficiencies.)

Lessons Learned

There were numerous challenges encountered during the execution of the Project that had to be met while maintaining a high level of safety management for a DOE site. These challenges included the following:

- An accelerated best-value procurement schedule

- Receiving just-in-time deliveries of capital equipment to be installed by the general contractor

- Completing design for the final mechanical and electrical equipment and systems

- Suitable procurement specifications
- An accelerated completion date
- Inclement weather

Challenges were met and completed because of the project team's experience, diligence, and constant field presence. The specific challenges encountered and the lessons learned are grouped into seven categories and are presented in *200 West Groundwater Pump and Treatment Project – Lesson Learned*, CHPRC-01904, Rev. 1 [3]. An excerpt of each category of the Project's lessons learned follows.

Baseline and Critical Decision Processes Lessons Learned

During the construction phase, the 2W P&T Project's mission was accelerated and additional scope and funding were added. Instead of stopping the project and stepping back through the critical decision process, the project chose to continue by using a "Fast-Track Approach." The fast-track approach resulted in the need for strict design and construction integration and coordination between commercial and DOE Richland Operation's design engineers, numerous corporate offices, subcontractors, and vendors beyond anything seen on previous DOE groundwater pump and treatment projects.

Contracting / Procurement Lessons Learned

The Construction Contractor selected for facility construction had never worked on a U.S. government agency jobsite and was not prepared for the quality requirements, safety culture, and training rigor that were required of its craft workforce. This caused the Project to experience a tremendous learning curve, which required the Project to implement an additional level of quality and industrial safety oversight beyond what had been anticipated or planned.

Many pieces of long-lead process equipment were shipped without the appropriate regard to anticipated weather conditions or the potential roadway vibrations, causing some subcomponent items to be lost or damaged during transit. As a result, the Project increased the level of equipment receipt inspections and acceptance at the jobsite to 100%, which pressured the suppliers into using appropriate shipping techniques.

The Project separated out long-lead equipment procurements, thus creating parallel procurement paths that reduced the overall project's technical, commercial (warranty), and schedule risks. This procurement approach enabled the project to compress the construction schedule.

Figure 6 and Figure 7 show construction and plant equipment procured in support of the 2W P&T Project. Figure 8 shows long-lead chemical delivery equipment procured for Project.

Figure 6 - Assembly of 100-Ton Crane at 2W P&T

Figure 7 - Delivery of Avantech® IX Tank Skid for the 2W P&T Project

Figure 8 - Chemical Delivery Equipment in the Chem Room of Bio Building

Project Management

The 2W P&T Project's core values were:

- Perform all work safely using the core functions of the Integrated Safety Management System (ISMS) and the Environmental Management System (EMS).
- Ensure the safety of workers, the public, and the environment.
- Comply with applicable company, state, and federal procedures, standards, codes, and regulations.
- Design and construct a high-performance, green process facility, which is a long-term commitment to sustainability for the Hanford Site.
- Demonstrate strong, positive leadership.
- Strive for continued improvement.

Since there were many critical-path deliverables throughout the project, it was essential to integrate the design, procurement, and construction teams' tasks.

The project team instituted several work control tools, scope and cost controls, timely reviews and checkoffs, and processes to effectively manage deliverables. This information was then delivered to the project team using daily/weekly work sessions that communicated specific action items through all levels of the work force and to each task leader. Teamwork was the key that brought the Project to a successful completion, as demonstrated below:

- Working 24/7 night/day shifts
- Including an environmental expert to join the team for onsite regulatory guidance
- Involving stakeholders extensively, starting at the planning phase and continuing through construction and start-up testing
- Conducting multiple 2- to 3-day design reviews and inviting the client, regulators, and other CHPRC teams to discuss, consult, and problem solve during the design phase
- Awarding the construction subcontract for the design and construction while the mechanical, electrical, and instrumentation designs were being completed

Challenges associated with a large inexperienced work force, contractors and subcontracts not familiar with DOE requirements, and changing programmatic processes (e.g., work control, document management, and configuration control) were overcome by working through issues as a team. Also, having well-thought-out document cataloging and turnover processes at the beginning of a project can reap immeasurable benefits throughout the project life cycle. In addition, integrating a commercially available document control software product with hyperlinked spreadsheets enables quick information retrieval and improves the auditability and accountability of project records.

Engineering

Although a commercial design manual was reviewed and approved for use, there were differences in terminology that at times led to confusion and comments during the early phases of the project. Conducting alignment meetings that focused on terminology and commercial vs. government practices greatly improved communications and provided the ability to convey, earlier in the life-cycle of the project, the differences between expectations for design and construction in a commercial environment vs. design and operation of a radiological facility managed by the DOE. Not having to learn a new process for core design activities (e.g., preparing and formatting specifications, calculations, and drawings) saved the design team time and may have precluded editorial/format errors from occurring.

The Project realized that it needed to ensure that unique site-specific requirements were shown on the drawings and fully explained in the technical specifications, and that the use of "boilerplate" technical specifications was minimized. Otherwise, the supplier would not have a full understanding of what was being technically required on the drawings.

Figure 9 and Figure 10 depict intricate process and storage systems, which required coordination of technical specifications with site requirements and contractor designs.

Figure 9 - 2W P&T Lime System Process Piping Overview

Figure 10 - 2W P&T Lime Storage Silo

Construction

Unclear contract documents allowed the construction contractor to rely on each subcontractor to implement a site safety program, which created gaps in safety coverage and provided confusion as to who the decision-making authority was when numerous subcontractors were working in common areas. This lack of clarity resulted in the Project employing additional safety professionals to ensure site safety was implemented as required.

The project received multiple design-related requests through the formal submittal process as a result of construction interferences and in response to the contractor's request for information. Waiting to incorporate the technical solution into revised issued-for-construction drawings through the design change notice process caused delays to the construction progress/schedule. As a result, the Project implemented a "redline" approval process for minor design field changes, which provided an expeditious way to respond to the contractor's needs without hindering production performance. Figure 11 and Figure 12 depict steel and scaffold erection activities completed using the "redline" process.

Figure 11 - Steel Erection of Rad Building at 2W P&T

Figure 12 - Scaffold Erection at the Air Stripper Towers at 2W P&T

Quality Assurance

The Project established a quality program plan at the outset of the project. However, the construction contractor failed to implement the quality program outlined in the quality program plan across the entire project. As the project progressed, the need for additional quality resources became evident. The Project increased its utilization of the construction quality organization and quality corporate oversight resources and made project personnel changes to ensure the level of quality required was obtained.

The Project's design specifications did not always include the inspections and tests selected from the consensus standards. This left the selection of inspection requirements to those defined by the International Building Code. The Project overcame quality issues by correcting errors and reworking or analyzing items for which the quality was not acceptable.

Testing and Startup

The 2W P&T Project Startup Team consisted of an integrated, multi-discipline team whose scope was Construction Acceptance Tests, functional Acceptance Test Procedures, and procedure (maintenance and operation) development and implementation.

The early integration of operations personnel into the Startup Team yielded efficiencies and resulted in the development of a solid training and qualification program, as well as field support to the procedures development program.

During the startup and testing of the facility the following opportunity for improvement was identified:

> Plastic debris left behind from the fabrication process of several fiberglass tanks resulted in multiple Bio Plant influent pump and Fluidized Bed Reactor pump (Figure 13) strainer shutdowns, which required corrective maintenance evolutions to remove the plastic and impacted progress on the Operational Test Procedure. Although internal tank inspections were conducted for foreign objects, the condition of the internal plastic liner of the tank was not readily visible via the manway access.

Figure 13 - 2W P&T Fluidized Bed Reactor Pump

Conclusion

The use of an integrated project team, which consisted of DOE Richland Operations, CHPRC, and numerous subcontractors, was critical to meeting the many project challenges as well as successfully completing DOE's mission objective of treating contaminated groundwater at the Hanford Site with a new facility by June 28, 2012.

The 2W P&T Project demonstrated successful integration of the project's core values and green energy technology through design, procurement, construction, and start-up of this complex, first-of-its-kind Bio Process facility that attained the Leadership in Energy and Environmental Design (LEED) GOLD certification (Figure 1), which makes the Bio Process facility the first non-administrative building in the DOE Office of Environmental Management complex to earn such an award.

The Project team's strong "integrated projectized" approach in managing the facility's design, procurement, and construction resulted in construction of the 2W P&T Facility on time (work was completed in 15 months on an accelerated schedule), within budget, and without any Days Away Restricted or Transferred (DART) lost days due to injury.

During its operation lifetime, the 2W P&T Facility will treat nominally 91 billion liters (24 billion gallons) of groundwater and remove an estimated 50 million grams (110,000 pounds) of contaminants, cleaning up the aquifer for future generations.

The 2W P&T Project has been featured in numerous trade publications, including Nuclear Engineering International, Nuclear Decommissioning Report, Civil Engineering Magazine, and Engineering News-Record. It was recently highlighted as DOE Office of Environmental Management's Project of the Month (June 2012).

REFERENCES

1. 40 CFR 300, App B, *National Priorities List*, Code of Federal Regulations Title 40, *Protection of the Environment*, Part 300, *National Oil and Hazardous Substances Pollution Contingency Plan*, Office of the Federal Register, National Archives and Records Administration (NARA), 1989, amended July 2010.

2. 42 USC, Chapter 103, *Comprehensive Environmental Response, Compensation, and Liability*, United States Code, Title 42, *The Public Health and Welfare*, 1980.

3. CHPRC-01904, *200 West Groundwater Pump and Treatment Project – Lesson Learned*, Rev 1, Kent A. Dorr, Jhivaun R. Freeman-Pollard, September 2012.