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Brown to green – developing a solar project and cover study on a mine tailings facility

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Abstract

In 2010, Chevron Technology Ventures (CTV), in conjunction with Chevron Mining Inc. (CMI) designed and constructed a solar facility (solar project) and demonstration alternative cover depth study on an inactive area of CMI's Questa Mine Tailings Facility. The solar project required securing agreements with U.S. Environmental Protection Agency (EPA) Region 6, the New Mexico Mining and Minerals Division and the New Mexico Environment Department, CTV and the local electric utility. The objective of the solar project was to demonstrate the beneficial reuse of an environmentally impacted site for renewable energy production as contemplated by EPA's "RE-Powering America's Lands" initiative and the local community's interest in solar energy as part of their economic development goals. The objective of the cover depth study was to assess the effectiveness of a monolithic store-and-release soil cover at three cover depths; 0.3, 0.6 and 0.9 m.

Construction of the cover study area, which comprises approximately 12 ha of a 485 ha tailings facility, was completed in December 2010. The solar project uses concentrating photovoltaic (CPV) technology and has a nameplate capacity of approximately one megawatt (MW). Power from the solar facility is metered and purchased by Kit Carson Electric Cooperative through a power purchase agreement. The cover depth study includes a five-year monitoring programme to evaluate three components of cover effectiveness: vegetation growth and uptake of metals, soil molybdenum concentrations, and net percolation through cover.

This paper will discuss the considerations and lessons learned during the feasibility and construction phases of the projects. These considerations include geotechnical stability of the tailings; cover design and protectiveness in limiting net percolation and metals exposure to wildlife, incorporation of site characteristics into solar design; regulatory and community stakeholder engagement; power purchase agreements; and permitting.

1 Background

1.1 History of operations

Chevron Mining Inc.'s (CMI) Questa Mine (the site) is located on the western slope of the Taos Range of the Sangre de Cristo Mountains, Taos County, Northern New Mexico. The Site is comprised of two separate non-contiguous areas, the mine and mill area, and the tailings facility. The tailings pond area is located on the relatively flat Taos plain about 10 km west of the mine. The tailings facility is composed of three impoundment systems covering approximately 485 ha.

Tailings are transported from the mill to the tailings ponds in two 14 km long tailings lines in a slurry of 38% by weight solids. The tailings are deposited from spigot points located around the perimeter of the tailings disposal area. After the tailings are deposited into the disposal area, the tailings water is retained for a long enough period to allow the solids to settle out. Current operations focus tailings deposition in the western impoundments; impoundments to the east have not been used for several years, interim soil cover has been placed and the areas have vegetative cover established.

In 1996 CMI received a permit to discharge to groundwater from the NM Environment Department (NMED) and in 2000 a closure permit from the NM Mining and Minerals Division (MMD); these two permits address both operational and closure requirements. Additionally in 2000, CMI entered into an Administrative Order on Consent with the US Environmental Protection Agency (EPA) to conduct a remedial investigation and feasibility study (RI/FS) for the Molycorp Site, currently owned and operated by CMI, (the site) which included the tailings facility.

1.2 Identification of opportunity

In 2008 Chevron Technology Ventures (CTV) and CMI identified the Questa tailings facility as a potential location for a joint project focused on renewable energy due to the availability of currently unused land, presence of a strong solar resource, existing requirements for closure under State regulations and the ongoing RI/FS. Subsequently, EPA and CMI discussed the potential for a renewable energy project (the solar project) at the tailings facility. Two complementary opportunities were identified–the first was to demonstrate implementation of a beneficial reuse for an environmentally impacted (Brownfield) property, the second was to demonstrate an emerging solar technology.

The solar project screening phase included identification of a viable emerging technology, identification of suitable land areas on the tailings facility without compromising ongoing operations and exploratory discussions with the local community, electric cooperative (power provider/purchaser), and regulatory agencies to evaluate the opportunity and allow for scoping of the solar project.

2 Design considerations

2.1 Technology selection

A number of solar technologies were considered and screened for potential use for the solar project. Screening considerations for the technology selection included type of solar technology to best fit with CTVs objectives of demonstrating an emerging technology; type and size of footing required to support equipment, for example, non-penetrating or penetrating, and geotechnical assessment of ability for tailings to support the equipment; visual impact of the equipment to the community; availability of equipment within the required timeframe; and reliability of equipment. Based on these criteria, a concentrating photovoltaic system (CPV) was selected.

2.2 Energy produced

CMI and CTV determined early in the solar project development that the power produced from the solar plant would be transmitted and sold to the local electric utility, Kit Carson Electric Cooperative through a power purchase agreement (PPA). The site of the CPV solar project is approximately 16 km from CMI's primary electricity-consuming equipment at the Questa Mine and using the electricity generated by the facility for Chevron's needs was not feasible. New Mexico State legislations mandate that utilities in the State provide a stipulated percentage of their retail electricity sales from renewable sources starting in 2015 (referred to as a Renewable Portfolio Standard (RPS)) and purchasing electricity from the CPV solar facility will help the utility meet the RPS.

PPAs in New Mexico have thus far been relatively infrequent, so identifying a model containing appropriate components for renewable electricity sales that was an acceptable starting point took time and required some specific expertise that Chevron sought out as part of the project. Chevron and Kit Carson worked together collaboratively to negotiate and agree to the terms of the agreement.

2.3 Cover depth project

During the feasibility assessment of the solar project, CMI identified an opportunity to incorporate an evaluation of different cover depths (the cover depth study) with the solar project. The cover depth evaluation was designed to provide information on annual net percolation and potential uptake of molybdenum by vegetation that is relevant to closure of the tailings facility at the cessation of mining. The cover project was to evaluate the amount of soil cover needed to protect groundwater and the environment.

3 Permitting

3.1 Environmental agencies

The State and Federal environmental agencies regulating/investigating the site and subsequently involved with the solar project had no known prior experience in permitting or regulating the installation of a solar plant on an active tailings facility. In addition the site is under a *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) agreement with EPA to perform the RI/FS. CMI and CTV met with the agencies, EPA, NMED and MMD, during the feasibility assessment to discuss a solar project and identify potential concerns and permits that may be required. As a result of the discussions the agencies identified areas they believed needed addressed and or permitted prior to the initiation of construction. A review of regulatory requirements by CTV and CMI in some instances identified differing requirements for permitting. Resolution of these differences was time consuming and challenging. Addressing agency expectations regarding submittals is discussed in more detail in stakeholder engagement below.

The agencies communicated a conceptual roadmap to CTV and CMI, which included stability analysis (of the tailings material), cap design including maintenance and infiltration issues, documentation of protection of groundwater, and a financial assurance component for eventual decommissioning of the solar plant.

Legal and regulatory review of the solar project concluded that no permit modifications were required and financial assurance was adequately addressed by existing financial assurance. However, in order to move the solar project forward, agreements on agency requirements and an amendment to the existing tailings facility NMED discharge permit were required prior to construction.

3.2 Agency requirements

It was recognised early in both projects development that agreements with various agencies would be needed prior to the initiation of construction. For the most part the agencies' concerns were focussed on the cover depth project and the development of a work plan that could be approved by the agencies. The requirements and conditions developed by NMED, MMD and EPA are largely documented in the State permit amendment for the tailings facility. The permit amendment predominantly focused on the components of the cover demonstration project and included requirements such as:

- Construction of three equally sized (2.4 ha each) plots with CPV panels having a cover depth of 0.3, 0.6 and 0.9 metres of alluvial soil, and a 0.4 ha plot for each cover depth containing no panels.
- Installation of nine 14 by 20 m instrumented lysimeters , six within the solar plant (2 per cover depth) and three in the 0.4 ha plots outside the solar plant (one per cover depth).
- Completion of a geotechnical investigation for the solar project that included predictions on settlement.
- Conditions for the cover depth project success that included:
    - Demonstrating the capacity of the cover system to limit net percolation by storing precipitation within the cover system (which includes alluvial soils and tailings).
    - Demonstrating that water stored in the cover system will be removed by evaporation and transpiration and that net percolation will not cause an exceedence of ground water standards.
    - Periodic inspection of the lysimeters outflow and requirements for analysing the outflow if sufficient volume is collected.
    - Requirements for specific probes and sensors to be used in the lysimeters (based on CMIs proposal).
    - Detailed sampling and monitoring requirements of soil and vegetation during the five year project life.
    - Preparation and submittal of a construction quality assurance plan.
    - An annual progress report containing data and observations from the cover depth project.

- ○ Required additional financial assurance for the solar facility eventual closure.

4 Lessons learned

4.1 Stakeholder engagement

4.1.1 Develop stakeholder engagement plan–revisit frequently

The team that worked together on both projects determined that a comprehensive stakeholder plan needed to be developed early in the feasibility phase of the projects. An attempt was made to identify potential stakeholders associated with the projects, define the appropriate time to engage the stakeholders, and consider key stakeholder views. The stakeholder plan was developed early and updated throughout the design and construction phases as new stakeholders were identified or new project information was identified that could impact stakeholder views.

4.1.2 Identify partners–internal and external

There were a number of internal and external partners on these projects. Multiple Chevron entities (CMI, CTV, environmental management company (EMC), and energy technology company (ETC)) were involved as well as a number of external partners including regulatory agencies, government authorities, county permitting authorities, the Village of Questa (village), and various non government organisations (NGOs) and community groups. Communication with all partners with varying degrees of involvement was critical to a successful outcome. To this end, multiple meetings were held with the agencies, Kit Carson, and village officials during the design phase, a public information meeting was held prior to construction, monthly construction updates were provided to the agencies, and NMED and MMD staff visited the projects frequently during construction. Also a number of tours were provided for various external partners including NGOs and State/village/Federal officials throughout construction to encourage continued participation by the stakeholders.

4.1.3 Addressing expectations

Throughout the feasibility study design and construction phases there was an effort to address stakeholder expectations. As mentioned above, the regulatory agencies did not have experience with this type of solar project as part of an active tailings facility and the brownfield programme viewed the solar project as a new and exciting opportunity for redevelopment of a brownfield site. Due to interest in the solar project, lack of previous experience by most of the parties involved and the potential for lessons learned for similar future projects, design and construction occasionally became challenging. Throughout the process the village of Questa was very interested in and enthusiastic about the solar project and the potential for this solar project to encourage economic development by the location of other such solar projects. Additionally, CMI is working with the community to explore opportunities for developing educational programmes, incorporating an information kiosk at a nearby nature trail, and identifying other potential beneficial opportunities related to the solar project.

4.1.4 Focus

Prior to construction, a public meeting was held to help the community understand how the facility would fit into the community and provide information on how the construction could affect village residents. The village has sought alternative energy facilities in the past and this solar project presented a win-win opportunity to achieve that vision.

The solar project also provided an opportunity to demonstrate to the agencies a beneficial reuse at a brownfield site that fits directly into the EPA’s “Re-Powering America's Lands” initiative. In addition, the cover project monitoring will provide a direct opportunity to study the potential impacts of a solar facility on a brownfield site. During the solar project design phase there was significant concern expressed by the agencies related to potential sheet flow off of the face of the trackers creating a preferential pathway to groundwater via the footers. The monitoring of net percolation using the nine lysimeters, six of which contain solar trackers, enables potential impacts to groundwater related to runoff from the panels to be identified. To address agency concerns, Chevron and the solar manufacturer redesigned the type of footers used to support the solar trackers to limit runoff and developed models to measure potential impacts to groundwater. In addition, tracker layout was designed to help minimise sheet flow.

4.2 Identify agency concerns (staff level)

4.2.1 Potential policy shift / setting a precedent

Once the opportunity to evaluate alternative cover depths as part of the solar project construction was identified by CMI, in addition to being cost effective, it became a major component of the decision analysis for completing the solar project. The cover depth project was designed to evaluate the potential for molybdenum uptake by plants and the effectiveness of an alluvial store and release cover. Previous agency concerns regarding lysimeter studies at the tailings facility could also be evaluated. As a result of the solar project and cover depth discussions, CMI and the agencies entered into an agreement to evaluate the three cover depths and, based on that information, incorporate the shallowest depth (0.3, 0.6 or 0.9 m) that demonstrated protectiveness of human health and the environment into the closure plan (as measured by no significant difference between the parameters monitored for each cover depth). This presented a policy shift for the State which required management approval.

4.2.2 Potential land end-use changes

The closure plan for the tailings facility identifies a post closure land-use of wildlife habitat/self-sustaining ecosystem. The construction of the solar project required incorporating light industrial as a potential end use for the tailings facility. This change in land-use is consistent with the village’s vision of post closure land-use. Annexation of the tailings facility into the village provided for more local input into permitting issues.

4.2.3 EPA approval on these type of projects–need to understand federal/local EPA relationship

From the beginning of the process Chevron worked to foster a collaborative relationship with the agencies. This was done by listening to ideas and identifying concerns early in the feasibility and design phases of the projects and conducting at least a preliminary evaluation of options and opportunities even those that seemed conservative or out of scope at the time.

In general, the EPA, MMD and NMED were supportive of these projects but the bulk of the discussions were with NMED. State agency personnel were more frequently onsite to observe various stages of the projects.

4.2.4 Get approval from higher up – government level

As indicated above, while staff at the agencies was supportive and interested in the projects, because there was no prior experience there was uncertainty around decision-making. Involvement by management in both the State and EPA was therefore necessary for decision-making. At times, senior level managers were involved in the permitting decisions, in part because of the precedent setting nature of the projects.

4.3 Permitting plan–local, state and federal

4.3.1 Identify permits and engage permitting agencies as early as possible

As a new type of facility on an active brownfield site there were many gray areas and unknowns related to what permits were actually required for construction and operation. Permits related to the generation of power were readily identified and a mechanism for obtaining those permits was relatively easy to develop. The construction and operating permits were harder to define. As mentioned previously, an amendment to the existing discharge permit at the tailings facility was required by the State before construction was authorised to begin. In addition, building permits were required though they were not initially identified by the team as necessary.

A lesson from this was the need to get the local construction team involved in the process as early as possible. This team was instrumental in identifying what permits were needed, identifying the officials to engage, and identifying what documents needed to be included with the applications so they could be submitted in a timely fashion. Because some permits were not identified until near the start of construction, changes had to be made in the construction schedule which resulted in delays of some components of the solar project. It is important to engage the permitting agencies early and to bring visuals to the initial discussions so there is no confusion as to the type of facility being constructed and the various components.

An added benefit of engaging the construction team early in the design process is they can provide insight into the design and the feasibility of constructing various components. Also it will allow for a more realistic cost estimate to be developed.

4.3.2 Get agreements in writing (or e-mail as second choice)

As discussed in the previous section, the internal evaluation of required permits found that some building/construction permits were not required. In some cases this conclusion was derived as a result of discussions with the permitting agency. Later in the process, when the agency was apprised of additional project details they determined that additional permits were indeed required. A lesson learned from this was to make sure agreements and decisions were documented in writing or at least through an e-mail. A related lesson was to build time into the construction schedule for permit review and potential project delays such as weather.

4.4 Design work

4.4.1 Involve someone with historical knowledge in design development

Onsite resources were consulted during the design phase and used to determine appropriate borrow and disposal areas. The primary contractor had done an extensive amount of work on the tailings facility in the past so they were able to foresee issues with construction on the tailings facility. Having these resources available provided a wealth of historical knowledge that the design team drew upon to minimise construction issues.

4.4.2 Spend the money to characterise the site as part of design (topographic surveys, geotechnical surveys, contaminants)

Geotechnical surveys, borrow material surveys and vegetation surveys were completed prior to construction. The geotechnical survey in particular was critical to completing an effective foundation design for the solar trackers. As a result of the geotechnical survey, the size of the foundations was increased to account for slight variability in the tailings.

A pre-existing (and older) topographical survey was used. As a result there was a significant physical feature that was unknowingly improperly characterised during the design and some areas of the project site were poorly delineated. A visible berm was present through the southern two thirds of the project area. It was also visible on the older survey which was used for the design; however, it appeared shallower on the drawing than in reality. These issues were not identified until construction had started. The construction managers had to improvise in the field and the additional earthwork resulted in a change order. A new topographical survey would have provided a more accurate representation of the existing land surface prior to design so additional excavation and disposal could have been avoided.

4.4.3 Involve construction contractor as early as reasonable in design process (before IFC drawings go out or at least at 60 to 90% complete stage)

As stated previously, involving the construction contractor early in the design process will help identify permits, allow for more realistic cost estimates, and help define flaws or technically unachievable elements of the design. For the cover depth project the area where this would have been most useful was in the construction of the lysimeters. The lysimeter design contractor provided specific details about how the lysimeters should be constructed using experience from previous projects. However, the lysimeters used in the cover depth project were larger and required a different type of liner than typically used and a different approach (top down instead of bottom up) to construction. The method identified in the design (and successfully used at other sites) required significant physical labour and awkward manipulation of the geosynthetic liner which turned out to be more difficult given the type of liner used. While reportedly successful at other sites and consistent with standard lysimeter construction practices, the construction contractor had a difficult time following the design specifications. Ultimately, the construction contractor proposed another solution which met the design criteria, met safety standards, and was much less physically taxing on the crew. Earlier consultation with the contractor on the lysimeter design may have resulted in less wasted field time coming up with an alternative solution.

5 Summary

The solar facility was commissioned in April 2011. The two projects took approximately 12 months to construct and commission. As indicated in the paper, there were many challenges, both expected and unexpected, in developing and building the project but it has met CMI/CTV's objectives of demonstrating the implementation of a beneficial reuse for an environmentally impacted (brownfield) site and demonstrating an emerging solar technology. The lessons learned in these projects will ultimately facilitate the development of other brownfield projects.