TECHNOLOGY OVERVIEW

RE-USE AND REPROCESS (R^2) TECHNOLOGIES

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RE-USE AND REPROCESS (R^2) TECHNOLOGIES

1. INTRODUCTION

Re-use and Reprocessing (R^2) technologies can be effective for remediation of solid mining wastes and mining-influenced waters (MIW), turning mining waste into beneficial products and decreasing human and ecological exposure to contaminated materials. Re-use consists of using problematic mine waste either directly or following reprocessing or other treatment as a beneficial product that is environmentally safe in its re-used form. Reprocessing consists of subjecting mine waste to physical or chemical processes designed to extract minerals or other waste components for beneficial use, rendering the waste material suitable for other beneficial use or environmentally safe disposal on the mine site. Reprocessing is distinguished from treatment in the sense that reprocessing is designed to use the waste material as a feedstock for producing a beneficial product, such as metal recovery, whereas treatment is intended primarily to reduce a contaminated material's toxicity, mobility, or volume. Reprocessing also accomplishes some of the same objectives as treatment.

Ideally, implementation of R^2 technologies will generate income to offset remediation costs or even create a financial asset rather than a liability for a responsible party. However, the viability of R^2 technologies is commonly driven by economic and market considerations, which can change rapidly. New R^2 technologies may require developmental and startup costs to demonstrate effectiveness and ensure the safety and marketability of the end product. Careful consideration of market conditions, technology effectiveness and safety, and vendor reliability is necessary before selecting R^2 technologies for mine site remediation.

2. APPLICABILITY

R^2 technologies are applicable to the following:

- solid mining waste or MIW
- high or low volumes of material
- remote, rural, or urban areas
- a variety of contaminants
- as a single technology or applied in conjunction with other remediation technologies

R^2 technologies are applicable where mining wastes exist that can be put to cost-effective beneficial use either directly or following reprocessing or treatment or where reprocessing of the waste will render it safe for permanent disposal at the mine site. R^2 technologies have been used or proposed for use in remediating a variety of mine waste types. Examples are listed below:

- direct use of chat pile material as an asphalt component
- re-use of contaminated soil as cover material for site remediation

- use of waste rock and leach pad material as construction material either directly or following treatment or reprocessing
- re-use of metals-bearing material recovered during mine reclamation and water treatment in pottery glaze and as paint pigment
- use of treated MIW for irrigation, and reprocessing and treatment of leach pad material to extract gold and destroy residual cyanide

Millions of tons of chat piles dispersed throughout the abandoned tri-state lead and zinc mining district of northeast Oklahoma, southeast Kansas, and southwest Missouri have caused widespread environmental contamination from metals contained in the chat. Sale of chat material was selected as part of the remedy for the Tar Creek Superfund site in Oklahoma (Tar Creek Superfund Site Operable Unit 4 [OU4]). The sold chat material is being re-used in an environmentally safe way as aggregate encapsulated in asphalt and other approved materials. The engineering properties of chat—composed of mostly coarse sand sizes particles of chert, limestone, and dolomite—together with the huge accumulations in accessible chat piles, make it an ideal local source of aggregate for encapsulation in asphalt. Some reprocessing of the chat in the form of washing for size segregation is necessary to render the chat marketable for use. For the chat sales remedy to be effective, U.S. Environmental Protection Agency (EPA) evaluated the existing environmental data and the life cycle of asphalt containing chat in the so called "Chat Rule" (40 CFR Part 278) and determined that chat encapsulated in asphalt or epoxy is a safe environmental use.

In the Washington County Lead District, lead-contaminated soils in residential areas in Missouri, Kansas, and Oklahoma associated with lead and zinc mining and smelting are being re-used for vegetative cover material over nearby highly contaminated mine tailings areas (Washington County Lead District Potosi Area), thereby reducing exposures of contaminants to humans and the environment.

As part of the De Sale Phase 2 project addressing acid mine drainage from former coal mining in Pennsylvania, manganese-bearing material recovered from maintenance of passive limestone treatment systems is being re-used for pottery glaze (Denholm et al. 2008). Other industrial uses of the material are being investigated. At another Pennsylvania mine site, iron oxides have been recovered from abandoned mine channels and re-used in pigment manufacturing to produce a burnt sienna pigment for a variety of applications (Heden 2002). At the Bingham Canyon Mine Site in Copperton, Utah, MIW from a sulfate plume is treated using reverse osmosis technology for use as a source of drinking water.

Since cost-effective application of R^2 technologies often involves large initial capital investment in material handling and equipment, the technologies may be more applicable to large volumes of waste materials, depending on the type of material and its market characteristics. Where material is suitable as construction material or aggregate, large volumes are typically needed. For other re-use or reprocessing purposes, such as for paint pigment or gold recovery, application of R^2 technologies for smaller volumes of waste material may be cost-effective.

R^2 technologies can be employed almost anywhere and in any climate; the key is that a market exists for the beneficial product. As with most technologies, remoteness and difficult terrain can pose practical constraints on equipment and activities, as well as increase costs. For re-use of mine waste as construction materials or aggregate, the mine waste must typically be located within a reasonable proximity of urban areas or construction projects requiring the material. For the Tar Creek chat piles, the materials will be used by state and county highway departments for road construction projects, as well as in the nearer urban centers. Even so, the expected time frame for re-use of the material is 30 years.

R^2 technologies are typically associated with mine waste contaminated with metals, but waste containing other contaminants, such as radionuclides, cyanide, and certain organic chemicals, may also be suitable.

R^2 technologies can be applied alone but are often applied in conjunction with treatment technologies that address the contaminants in the material, making it safe for re-use, and/or other processes that convert the material to a usable form. For example, leach pads may undergo detoxification treatment to destroy cyanide prior to use of the material for construction material At the Tar Creek site, chat undergoes a mechanical wash process to separate the coarse chat from the fine material (which contain high concentrations of lead, cadmium, and zinc), making it suitable for re-use in construction materials.

3. ADVANTAGES

Advantages of R^2 technologies include the following:

- revenue stream generation for offsetting costs and/or cost avoidance
- can be permanent, requiring little or no long-term monitoring or institutional controls
- locally beneficial
- reduction in the volume of solid mining waste

Implementation of R^2 technologies can avoid remediation costs and/or generate significant income to offset remediation costs. At the Tar Creek site, the inclusion of chat sales in the remedy avoids costs for excavation and disposal or capping of approximately 40 million tons of chat that might otherwise have been incurred by the federal and state governments. Remedies involving R^2 technologies can be permanent when they result in complete removal of the mine materials or rendering of the materials into an environmentally safe form that can remain on site without need for long-term monitoring or institutional controls. They can also be beneficial to local communities, reducing costs for local improvement projects such as road construction and paving projects, decreasing stresses on other local resources such as rock quarries and mines, and creating jobs in local communities. For example at the Tar Creek Site, re-use of chat for asphalt aggregate in the Tri-State Mining District is providing jobs for local workers in an economically challenged area and reducing the costs of infrastructure improvements such as paving of local gravel roads and parking lots.

4. LIMITATIONS

- limited application
- viability subject to variable market conditions
- performance risk
- regulatory acceptance

For R^2 technologies to be viable at a site, potentially useful or valuable waste materials must be present, and there must be a viable market for those materials over a time frame consistent with the remediation time frame. These requirements eliminate many sites from consideration because the waste materials have no inherent value or there is simply no viable use for them because of location or market conditions at the time the remediation must be performed. Periodic downturns in the heavy construction industry may diminish the need for large volumes of construction materials, and the volatility of metals prices can quickly make a reprocessing strategy impractical.

Performance risk is a major consideration when evaluating the use of R^2 technologies as a key component of a mine site remedy. In some cases, remedies may require decades to complete. EPA estimates that more than 30 years will be required for Tar Creek to use the existing 30 million cubic yards of material at current rates of road construction (USEPA 2008). When considering whether a re-use or reprocessing strategy makes sense for a particular site, it may be necessary to rely on uncertain long-term economic forecasts. It may also require reliance on speculative investors and technology vendors that may fail in an economic downturn. In that event, the project may be left uncompleted, possibly even in a worse condition than existed before.

Where technologies are innovative and/or unproven, regulatory approval may be difficult to obtain. Expensive and time-consuming site-specific characterization and testing may be necessary simply to evaluate whether the technologies are viable and can be approved.

R^2 technologies may generate contaminated waste streams, albeit at a smaller volume or reduced concentrations, that must be managed and monitored. Metals recovery from mine waste commonly does not remove all the contaminants so the remnants of the processed material may still require remediation and/or long-term management. At the Tar Creek site, reprocessing of the chat through the chat-washing process results in a residual of about 10% of the material as fines containing high metals concentrations. This material will need to be remediated, reprocessed, or managed over the long term; however, the volume of material will be greatly reduced.

Potential future environmental liability may inhibit interest in re-use and reprocessing of mine waste material. Responsible parties, investors, and technology vendors may be reluctant to enter into projects that result in off-site removal or on-site reprocessing of material if it could lead to long-term financial liability under CERCLA or other applicable environmental regulations. At Tar Creek, EPA's "chat rule" (40 CFR Part 278) identifies environmentally safe uses for chat from the Tri-State Mining District and EPA's chat fact sheets are thought to reduce this concern. Although mine wastes are excluded as RCRA hazardous waste (Bevill Amendment, 40 CFR Part

261.4), the solid mining waste material may be considered hazardous waste if transported off site.

5. PERFORMANCE

R^2 technologies are well established and proven to be effective. However, whether these technologies are used at all depends on several nontechnical issues, e.g., market for product, regulatory acceptance, and cost/benefit.

For the Tar Creek project, performance criteria include the elimination of direct contact by removing chat and impacted surface material. The objectives of chat re-use are to reduce exposures of lead, cadmium, and zinc to human health and the environment. In this regard the remedial action objectives for source materials (e.g., chat) are zero discharges from source materials to surface water. The criteria for soils underlying the source material are 500 ppm for lead for protection of human health and 10 mg/kg cadmium and 1100 mg/kg zinc for the protection of terrestrial fauna. The specific criteria for chat re-use applicable to the SPLP tests or risk assessments are the maximum contaminant levels (MCLs) for lead (15 µg/L) and cadmium (5 µg/L) in potential drinking water sources and Water Quality Criterion (WQC) for zinc of 120 µg/L. The Tar Creek project is ongoing and is expected to require several decades to complete the chat re-use remedy. Performance data will be developed as the project progresses.

6. COSTS

Relative to active treatment technologies, R^2 technologies can be a cost-effective alternative for remediation of contaminated mine waste materials in specific situations. Costs factors to be considered include the following:

- upfront characterization and testing necessary to assess technology effectiveness and viability and to gain regulatory acceptance
- treatment, reprocessing, or material-handling costs necessary to create a beneficial product for re-use
- costs associated with treatment, disposal, and/or long-term management of residual contaminated material derived from the re-use or reprocessing
- transportation and handling costs
- current and future market value of the product

The costs of successfully implementing R^2 technologies are highly dependent on site-specific conditions and market conditions at any given point in time and will vary greatly from site to site and project to project, depending on a wide variety of factors. For the Tar Creek project, the capital and O&M costs are provided for informational purposes.

7. REGULATORY CONSIDERATIONS

Typically, implementation of R^2 technologies requires the approval of state and/or federal regulators. Depending on the policies and past experience of the regulating community, proposals to implement R^2 technologies may or may not be favorably received.

Although mine wastes may be exempt from certain environmental rules, such as characterization as hazardous waste, these exemptions may not apply if the wastes are reprocessed or taken off site for re-use. Also, if mine tailings are taken off site, then they may incur additional regulatory requirements, such as transportation rules and compliance with the "off-site rule"' (40 CFR 300.440). Additional regulatory actions or approvals may be needed depending on the specific situation. For chat sales to be incorporated into the ROD for the OU4 of the Tar Creek site, federal legislation in the form of the "chat rule" (40 CFR Part 278) and compliance with the "off-site rule" was required. It specifies the safe environmental uses for chat from the Tri-State Mining District (USEPA 2008).

8. STAKEHOLDER CONSIDERATIONS

Conceptually, environmentally safe re-use and reprocessing of mine waste should be acceptable to regulators, stakeholders, and the public. However, improper and failed re-use and reprocessing strategies implemented in the past have resulted, for some cases, in resistance to R^2 technologies. Even at Tar Creek site, where large-scale chat reprocessing and re-use have been approved, past improper re-use of bulk unencapsulated chat material for gravel roads, fill material in residential developments, sand for children's play areas, and base material for railroads resulted in regulator and public concerns. Today the use of chat is confined to uses in which it is encapsulated.

Complexities associated with resource valuation can also complicate regulator and public acceptance. Disagreements about the value of chat piles and compensation have inhibited some re-use of chat at the Tar Creek site.

9. LESSONS LEARNED

Widespread contamination exists from the improper use of unencapsulated chat, mine tailings, and uranium mill waste for construction materials; accidents involving cyanide reprocessing resulting in environmental degradation; creation of potentially unsafe products; and failed and/or uncompleted remediation projects. Avoiding these pitfalls requires a thorough understanding of the material characteristics and value at any given time, site conditions, technologies, and planned material uses, as well as a well-designed strategy for remediation or long-term management of residual contaminated materials remaining after reprocessing or re-use. To understand the economic viability of the technologies at a site, careful assessment is necessary of all project costs, including upfront characterization and testing costs necessary to gain regulatory acceptance, long-term costs for managing residuals and demonstrating compliance, and possible off-site environmental liabilities in perpetuity. Careful consideration must be given to estimating the likely future economic conditions that will drive the viability of the market for the beneficial product derived from the re-use or reprocessing, as well as the stability and reliability of investors and technology vendors relied upon for successful completion of the project.

10. CASE STUDIES

Table 10-1 Case studies including re-use or reprocessing

Tar Creek (Operable Unit 4)
Potosi Mine, MO

11. REFERENCES

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