UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION 8

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EPA REGION VIII
HEARING CLERK

IN THE MATTER OF:	)	CERCLA Docket No. **CERCLA-08-2017-0005**
Barker Hughesville Mining District Superfund Site	)	
Mt. Emmons Mining Company	)	
Respondent	)	**ADMINISTRATIVE SETTLEMENT AGREEMENT AND ORDER ON CONSENT FOR TREATABILITY STUDY**
Proceeding Under Sections 104, 107, and 122 of the Comprehensive Environmental Response, Compensation, and Liability Act, 42 U.S.C. §§ 9604, 9607, and 9622.	)	

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I. JURISDICTION AND GENERAL PROVISIONS

1. This Administrative Settlement Agreement and Order on Consent (Settlement) is entered into voluntarily by the United States Environmental Protection Agency (EPA) and Mt. Emmons Mining Company (Respondent). This Settlement provides for the performance of a lab-scale water treatability study by Respondent, which will help evaluate passive bioremediation as a potential treatment system for mine-influenced water (Treatability Study) and the payment of certain response costs incurred by the United States at or in connection with the Barker Hughesville Mining District Site (Site) generally located outside of Great Falls in the Little Belt Mountains in Cascade and Judith Basin Counties, Montana.

2. This Settlement is issued under the authority vested in the President of the United States by Sections 104, 107, and 122 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. §§ 9604, 9607 and 9622 (CERCLA), as amended. This authority was delegated to the Administrator of EPA on January 23, 1987, by Executive Order 12580, 52 Fed. Reg. 2923 (Jan. 29, 1987), and further delegated to Regional Administrators by EPA Delegation Nos. 14-14-C (Administrative Actions Through Consent Orders, Apr. 15, 1994) and 14-14-D (Cost Recovery Non-Judicial Agreements and Administrative Consent Orders, May 11, 1994). These authorities were further redelegated by the Regional Administrator of EPA Region 8 by EPA Delegation No. 14-14-D (Cost Recovery Non-Judicial Agreements and Administrative Consent Orders, December 20, 1996) and then further redelegated by the Assistant Regional Administrator to the supervisors in Region 8's Legal Enforcement Program and the supervisors in Region 8's Technical Enforcement Program by EPA Delegation No. 14-14-D (Cost Recovery Non-Judicial Agreements and Administrative Consent Orders, October 17, 1997).

3. EPA and Respondent recognize that this Settlement has been negotiated in good faith and that the actions undertaken by Respondent in accordance with this Settlement do not constitute an admission of any liability. Respondent does not admit, and retains the right to controvert in any subsequent proceedings other than proceedings to implement or enforce this Settlement, the validity of the findings of facts, conclusions of law, and determinations in Section IV (Findings of Fact) and V (Conclusions of Law and Determinations) of this Settlement. Respondent agrees to comply with and be bound by the terms of this Settlement and further agrees that it will not contest the basis or validity of this Settlement or its terms.

II. PARTIES BOUND

4. This Settlement is binding upon EPA and upon Respondent and its successors and assigns. Any change in ownership or corporate status of Respondent including, but not limited to, any transfer of assets or real or personal property associated with the Site shall not alter Respondent's responsibilities under this Settlement.

5. Each undersigned representative of Respondent certifies that he or she is fully authorized to enter into the terms and conditions of this Settlement and to execute and legally bind Respondent to this Settlement.

6. Respondent shall provide a copy of this Settlement to each contractor hired to perform the Work required by this Settlement and to each person representing Respondent with respect to the Site or the Work, and shall condition all contracts entered into under this Settlement upon performance of the Work in conformity with the terms of this Settlement. Respondent or its contractors shall provide written notice of the Settlement to all subcontractors hired to perform any portion of the Work required by this Settlement. Respondent shall nonetheless be responsible for ensuring that its contractors and subcontractors perform the Work in accordance with the terms of this Settlement.

III. DEFINITIONS

7. Unless otherwise expressly provided in this Settlement, terms used in this Settlement that are defined in CERCLA or in regulations promulgated under CERCLA shall have the meaning assigned to them in CERCLA or in such regulations. Whenever terms listed below are used in this Settlement or its attached appendix, the following definitions shall apply:

"Barker Hughesville Site" shall mean the Barker Hughesville Mining District Superfund Site, encompassing approximately 6,000 acres, located near the town of Monarch in Judith Basin and Cascade Counties, Montana. The Site includes approximately 46 known abandoned mines with waste rock dumps, tailings, and seeping mine openings.

"Barker Hughesville Mining District Special Account" shall mean the special account within the EPA Hazardous Substance Superfund, established for the Barker Hughesville Site by EPA pursuant to Section 122(b)(3) of CERCLA, 42 U.S.C. § 9622(b)(3).

"CERCLA" shall mean the Comprehensive Environmental Response, Compensation, and Liability Act, 42 U.S.C. §§9601-9675.

"Day" or "day" shall mean a calendar day. In computing any period of time under this Settlement, where the last day would fall on a Saturday, Sunday, or federal or State holiday, the period shall run until the close of business of the next working day.

"Effective Date" shall mean the effective date of this Settlement as provided in Section XXIX.

"EPA" shall mean the United States Environmental Protection Agency and its successor departments, agencies, or instrumentalities.

"Future Response Costs" shall mean all costs, including, but not limited to, direct and indirect costs, that the United States incurs in reviewing or developing deliverables submitted pursuant to this Settlement, in overseeing implementation of the Work, or otherwise implementing, overseeing, or enforcing this Settlement, including but not limited to payroll costs, contractor costs, travel costs, laboratory costs, the costs incurred pursuant to Section XI (Property Requirements) (including, but not limited to, cost of attorney time and any monies paid to secure or enforce access, including, but not limited to, the amount of just compensation).

"Interest" shall mean interest at the rate specified for interest on investments of the EPA Hazardous Substance Superfund established by 26 U.S.C. § 9507, compounded annually on October 1 of each year, in accordance with 42 U.S.C. § 9607(a). The applicable rate of interest shall be the rate in effect at the time the interest accrues. The rate of interest is subject to change on October 1 of each year. Rates are available online at https://www.epa.gov/superfund/superfund-interest-rates.

"National Contingency Plan" or "NCP" shall mean the National Oil and Hazardous Substances Pollution Contingency Plan promulgated pursuant to Section 105 of CERCLA, 42 U.S.C. § 9605, codified at 40 C.F.R. Part 300, and any amendments thereto.

"Paragraph" shall mean a portion of this Settlement identified by an Arabic numeral or an upper or lower case letter.

"Parties" shall mean EPA and Respondent.

"Respondent" shall mean Mt. Emmons Mining Company, a natural resources company headquartered in Phoenix, Arizona and incorporated in the State of Delaware.

"Section" shall mean a portion of this Settlement identified by a Roman numeral.

"Settlement" shall mean this Administrative Settlement Agreement and Order on Consent and all appendices attached hereto (listed in Section XXVIII (Integration/Appendices)). In the event of conflict between this Settlement and any appendix, this Settlement shall control.

"Site" shall mean the Barker Hughesville Site.

"State" shall mean the State of Montana.

"Transfer" shall mean to sell, assign, convey, lease, mortgage, or grant a security interest in, or where used as a noun, a sale, assignment, conveyance, or other disposition of any interest by operation of law or otherwise.

"United States" shall mean the United States of America and each department, agency, and instrumentality of the United States, including EPA.

"Work" shall mean all activities and obligations Respondent is required to perform under this Settlement and the Work Plan, except those required by Section XIII (Record Retention).

"Work Plan" shall mean the Work Plan attached hereto as Appendix A for the performance of a treatability study. The Parties agree that Mt. Emmons may submit a single Work Plan, which includes the Work Plan, Sampling and Analysis Plan, Health and Safety Plan, Field Sampling Plan, Quality Assurance Plan, and all other plans required under this Settlement.

IV. FINDINGS OF FACT

8. The Barker Hughesville Site is located in Cascade and Judith Basin Counties, Montana. The Barker Hughesville Site is near the Town of Monarch and encompasses approximately 6,000 acres.

9. The Barker Hughesville Site was listed on the National Priorities List (NPL) by EPA pursuant to CERCLA § 105, 42 U.S.C. § 9605, on September 13, 2001, 66 F.R. 47583, 47586.

10. EPA has investigated numerous historic, abandoned mines and discharges of impacted water from adits located within the Barker Hughesville Site, including the Danny T Adit.

11. Mt. Emmons formerly leased the mining claim on which the Danny T Adit is located. Mt. Emmons no longer leases the mining claim.

12. The Danny T Adit currently is discharging water that is impacted by historic mining operations and contains elevated levels of metals that requires further sampling, investigation, analysis, and study.

13. Exposure to heavy metals, including lead and arsenic, may cause adverse health effects in humans and adverse effects to ecosystems.

V. CONCLUSIONS OF LAW AND DETERMINATIONS

14. Based on the Findings of Fact set forth above, and the administrative record, EPA has determined that:

a. The Barker Hughesville Site is a "facility" as defined by Section 101(9) of CERCLA, 42 U.S.C. § 9601(9).

b. The contamination found at the Site, as identified in the Findings of Fact above, includes "hazardous substances" as defined by Section 101(14) of CERCLA, 42 U.S.C. § 9601(14).

c. Respondent is a "person" as defined by Section 101(21) of CERCLA, 42 U.S.C. § 9601(21).

d. Respondent is a responsible party under Section 107(a) of CERCLA, 42 U.S.C. § 9607(a).

(1) Respondent was the "owner(s)" of a portion of the facility at the time of disposal of hazardous substances at the facility, as defined by Section 101(20) of CERCLA, 42 U.S.C. § 9601(20), and within the meaning of Section 107(a)(2) of CERCLA, 42 U.S.C. § 9607(a)(2).

e. The conditions described in Paragraph 12 of the Findings of Fact above constitute an actual and/or threatened "release" of a hazardous substance from the facility as defined by Section 101(22) of CERCLA, 42 U.S.C. § 9601(22).

f. The actions required by this Settlement are necessary to protect the public health, welfare, or the environment, are in the public interest, 42 U.S.C. § 9622(a), are consistent with CERCLA and the NCP, 42 U.S.C. §§ 9604(a)(1), 9622(a), and will expedite effective remedial action and minimize litigation, 42 U.S.C. § 9622(a).

g. EPA has determined that Respondent is qualified to conduct the Work within the meaning of Section 104(a) of CERCLA, 42 U.S.C. § 9604(a), and will carry out the Work properly and promptly, in accordance with Sections 104(a) and 122(a) of CERCLA, 42 U.S.C. §§ 9604(a) and 9622(a), if Respondent complies with the terms of this Settlement.

VI. SETTLEMENT AGREEMENT AND ORDER

15. Based upon the Findings of Fact, Conclusions of Law and Determinations set forth above, and the administrative record, it is hereby ordered and agreed that Respondent shall comply with all provisions of this Settlement, including, but not limited to, all appendices to this Settlement and all documents incorporated by reference into this Settlement.

VII. DESIGNATION OF CONTRACTORS AND PROJECT COORDINATORS

16. **Selection of Contractors, Personnel.** All Work performed under this Settlement shall be under the direction and supervision of qualified personnel. Respondent has identified Freeport Minerals Corporation, which is performing the work on behalf of Respondent, as its contractor, which has been approved by the EPA. If, after the commencement of Work, Respondent retains additional contractors or subcontractors, Respondent shall notify EPA of the names, titles, contact information, and qualifications of such contractors or subcontractors retained to perform the Work at least three days prior to commencement of Work by such additional contractors or subcontractors. EPA retains the right, at any time, to disapprove of any or all of the contractors and/or subcontractors retained by Respondent. If EPA disapproves of a selected contractor or subcontractor, Respondent shall retain a different contractor or subcontractor and shall notify EPA of that contractor's or subcontractor's name, title, contact information, and qualifications within ten days after EPA's disapproval. The qualifications of the persons undertaking the Work for Respondent shall be subject to EPA's review for verification based on objective assessment criteria (e.g., experience, capacity, technical expertise) and that they do not have a conflict of interest with respect to the project.

17. Respondent has designated, and EPA has not disapproved, the following individual as Project Coordinator, who shall be responsible for administration of all actions by Respondent required by this Settlement: Barbara Nielsen, Remediation Projects Manager, 333 North Central Avenue, Phoenix, Arizona 85004, (602) 366-8270, bnielsen@fmi.com. To the greatest extent possible, the Project Coordinator shall be present on Site or readily available during the Work. EPA retains the right to disapprove of a designated Project Coordinator who does not meet the requirements of Paragraph 16 (Selection of Contractors, Personnel). If EPA disapproves of the designated Project Coordinator, Respondent shall retain a different Project

Coordinator and shall notify EPA of that person's name, title, contact information, and qualifications within ten days following EPA's disapproval. Notice or communication relating to this Settlement from EPA to Respondent's Project Coordinator shall constitute notice or communication to all Respondent.

18. EPA has designated Roger Hoogerheide of the Region 8 Montana Office, Region 8 Office of Ecosystems Protection and Remediation, as its Remedial Project Manager (RPM). EPA will notify Respondent of a change of its RPM. Communications between Respondent and EPA, and all documents concerning the activities performed pursuant to this Settlement, shall be directed to the EPA RPM in accordance with Paragraph 26.a.

19. EPA's RPM shall have the authority lawfully vested in an RPM and On-Scene Coordinator (OSC) by the NCP. In addition, EPA's RPM shall have the authority, consistent with the NCP, to halt, conduct, or direct any Work required by this Settlement, or to direct any other response action when s/he determines that conditions at the Site constitute an emergency situation or may present a threat to public health or welfare or the environment. Absence of the EPA RPM from the area under study pursuant to this Settlement shall not be cause for stoppage or delay of Work.

VIII. WORK TO BE PERFORMED

20. For any regulation or guidance referenced in the Settlement, the reference will be read to include any subsequent modification, amendment, or replacement of such regulation or guidance. Such modifications, amendments, or replacements apply to the Work only after Respondent receives notification from EPA of the modification, amendment, or replacement.

21. Respondent shall perform the Work and prepare all plans in accordance with the provisions of this Settlement, the Work Plan, CERCLA, the NCP, and EPA guidance.

22. All written documents prepared by Respondent pursuant to this Settlement shall be submitted by Respondent in accordance with Section IX (Submission and Approval of Deliverables). With the exception of the Health and Safety Plan, all such submittals will be reviewed and approved by EPA in accordance with Section IX (Submission and Approval of Deliverables). Respondent shall implement all EPA approved, conditionally-approved, or modified deliverables.

23. **Sampling and Analysis Plan**. The Sampling and Analysis Plan is included within the Work Plan. The Sampling and Analysis Plan consists of a Field Sampling Plan (FSP) and a Quality Assurance Project Plan (QAPP) that is consistent with the NCP, and includes all the data elements required in EPA's Region 8 Quality Assurance Document Review Crosswalk, "Guidance for Quality Assurance Project Plans (QA/G-5)," EPA/240/R-02/009 (December 2002), "Guidance for Quality Assurance Project Plans (QA/G-5)" EPA/240/R-02/009 (December 2002), "EPA Requirements for Quality Assurance Project Plans (QA/R-5)" EPA/240/B-01/003 (March 2001, reissued May 2006), and "Uniform Federal Policy for Quality Assurance Project Plans," Parts 1-3, EPA/505/B-04/900A-900C (March 2005).

24. **Health and Safety Plan**. The Health and Safety Plan is included within the Work Plan. The Health and Safety Plan was prepared in accordance with "OSWER Integrated Health

and Safety Program Operating Practices for OSWER Field Activities," Pub. 9285.0-01C (November 2002), available on the NSCEP database at https://www.epa.gov/nscep/index.html, and "EPA's Emergency Responder Health and Safety Manual," OSWER Directive 9285.3-12 (July 2005 and updates), available at https://www.epaosc.org/_HealthSafetyManual/manual-index.htm. In addition, the plan complies with all currently applicable Occupational Safety and Health Administration (OSHA) regulations found at 29 C.F.R. Part 1910.

25. **Off-Site Shipments.** Respondent may ship hazardous substances, pollutants, and contaminants from the Site to an off-Site facility only if they comply with Section 121(d)(3) of CERCLA, 42 U.S.C. § 9621(d)(3), and 40 C.F.R. § 300.440. Respondent will be deemed to be in compliance with CERCLA § 121(d)(3) and 40 C.F.R. § 300.440 regarding a shipment if Respondent obtains a prior determination from EPA that the proposed receiving facility for such shipment is acceptable under the criteria of 40 C.F.R. § 300.440(b).

IX. SUBMISSION AND APPROVAL OF DELIVERABLES

26. **Submission of Deliverables**

a. **General Requirements for Deliverables**

(1) Except as otherwise provided in this Settlement, Respondent shall direct all submissions required by this Settlement to EPA's RPM at Roger Hoogerheide, USEPA Region 8 Montana Operations Office Federal Building 10 West 15th Street, Suite 3200, Helena, MT 59626, (406) 457-5031, hoogerheide.roger@epa.gov. Respondent shall submit all deliverables required by this Settlement or any approved work plan in accordance with the schedule set forth in such plan.

(2) Respondent shall submit all deliverables in electronic form. Technical specifications for sampling and monitoring data and spatial data are addressed in Paragraph 26.b. All other deliverables shall be submitted in the electronic form specified by EPA's RPM. If any deliverable includes maps, drawings, or other exhibits that are larger than 8.5 x 11 inches, Respondent shall also provide paper copies of such exhibits.

b. **Technical Specifications for Deliverables**

(1) Sampling and monitoring data should be submitted in Microsoft access format as an appendix to the final report.

(2) Each file must include an attribute name for each site unit or sub-unit submitted. Consult https://www.epa.gov/geospatial/geospatial-policies-and-standards for any further available guidance on attribute identification and naming.

27. **Approval of Deliverables**

a. **Initial Submissions**

(1) After review of any deliverable that is required to be submitted for EPA approval under this Settlement EPA shall: (i) approve, in whole or in part, the submission; (ii) approve the submission upon specified conditions; (iii) disapprove, in whole or in part, the submission; or (iv) any combination of the foregoing.

(2) EPA also may modify the initial submission to cure deficiencies in the submission if: (i) EPA determines that disapproving the submission and awaiting a resubmission would cause substantial disruption to the Work; or (ii) previous submission(s) have been disapproved due to material defects and the deficiencies in the initial submission under consideration indicate a bad faith lack of effort to submit an acceptable deliverable.

28. Notwithstanding the receipt of a notice of disapproval, Respondent shall proceed to take any action required by any non-deficient portion of the submission, unless otherwise directed by EPA.

29. Neither failure of EPA to expressly approve or disapprove of Respondent's submissions within a specified time period, nor the absence of comments, shall be construed as approval by EPA.

X. QUALITY ASSURANCE, SAMPLING, AND DATA ANALYSIS

30. Respondent shall use quality assurance, quality control, and other technical activities and chain of custody procedures for all samples consistent with "EPA Requirements for Quality Assurance Project Plans (QA/R5)," EPA/240/B-01/003 (March 2001, reissued May 2006), "Guidance for Quality Assurance Project Plans (QA/G-5)," EPA/240/R-02/009 (December 2002), and "Uniform Federal Policy for Quality Assurance Project Plans, Parts 1-3, EPA/505/B-04/900A-900C (March 2005).

31. **Laboratories**

a. Respondent shall ensure that EPA personnel and its authorized representatives are allowed access at reasonable times to all laboratories utilized by Respondent pursuant to this Settlement. In addition, Respondent shall ensure that such laboratories shall analyze all samples submitted by EPA pursuant to the Quality Assurance Project Plan (QAPP) for quality assurance, quality control, and technical activities that will satisfy the stated performance criteria as specified in the QAPP and that sampling and field activities are conducted in accordance with EPA's "Field Operations Group Operational Guidelines for Field Activities" (http://www.epa.gov/region8/qa/FieldOperationsGroupOperationalGuidelinesForFieldActivities.pdf) and "EPA QA Field Activities Procedure" CIO 2105-P-02.1 (9/23/2014), available at https://www.epa.gov/irmpoli8/epa-qa-field-activities-procedures. Respondent shall ensure that the laboratories they utilize for the analysis of samples taken pursuant to this Settlement meet the competency requirements set forth in EPA's "Policy to Assure Competency of Laboratories, Field Sampling, and Other Organizations Generating Environmental Measurement Data under Agency-Funded Acquisitions," available at https://www.epa.gov/measurements/documents-about-measurement-competency-under-acquisition-agreements, and that the laboratories perform all analyses using EPA-accepted methods. Accepted EPA methods consist of, but are not limited to, methods that are documented in the EPA's Contract Laboratory Program (https://www.epa.gov/superfund/programs/clp/), SW 846 "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods" (https://www.epa.gov/hw-sw846), "Standard Methods for the Examination of Water and Wastewater" (http://www.standardmethods.org/), and 40 C.F.R. Part 136, "Air Toxics - Monitoring Methods" (https://www.epa.gov/ttnamti1/airtox.html).

b. Upon approval by EPA Respondent may use other appropriate analytical methods, as long as (i) quality assurance/quality control (QA/QC) criteria are contained in the methods and the methods are included in the QAPP, (ii) the analytical methods are at least as stringent as the methods listed above, and (iii) the methods have been approved for use by a nationally recognized organization responsible for verification and publication of analytical methods, e.g., EPA, ASTM, NIOSH, OSHA, etc.

c. Respondent shall ensure that all laboratories they use for analysis of samples taken pursuant to this Settlement have a documented Quality System that complies with ASQ/ANSI E4:2014 "Quality Management Systems for Environmental Information and Technology Programs – Requirements With Guidance for Use" (American Society for Quality, February 2014), and "EPA Requirements for Quality Management Plans (QA/R-2)" EPA/240/B-01/002 (March 2001, reissued May 2006), or equivalent documentation as determined by EPA. EPA may consider Environmental Response Laboratory Network (ERLN) laboratories, laboratories accredited under the National Environmental Laboratory Accreditation Program (NELAP), or laboratories that meet International Standardization Organization (ISO 17025) standards or other nationally recognized programs as meeting the Quality System requirements.

d. Respondent shall ensure that all field methodologies utilized in collecting samples for subsequent analysis pursuant to this Settlement are conducted in accordance with the procedures set forth in the approved QAPP.

32. **Sampling**

a. Upon request, Respondent shall provide split or duplicate samples to EPA or its authorized representatives if there is sufficient volume to allow for collection of a split or duplicate sample. Respondent shall notify EPA not less than 3 days in advance of any sample collection activity unless shorter notice is agreed to by EPA. In addition, EPA shall have the right to take any additional samples that EPA deems necessary. Upon request, EPA shall provide to Respondent split or duplicate samples of any samples it takes as part of EPA's oversight of Respondent's implementation of the Work, and any such samples shall be analyzed in accordance with the approved QAPP.

b. Respondent waives any objections to any data gathered, generated, or evaluated by EPA or Respondent in the performance or oversight of the Work that has been verified according to the quality assurance/quality control (QA/QC) procedures required by the Settlement or any EPA-approved Work Plans or Sampling and Analysis Plans. If Respondent objects to any other data relating to the Treatability Study, Respondent shall submit to EPA a report that specifically identifies and explains its objections, describes the acceptable uses of the data, if any, and identifies any limitations to the use of the data.

XI. PROPERTY REQUIREMENTS

33. For any portion of the Site, or any of the property where access is needed to implement this Settlement owned or controlled by Respondent, Respondent shall, commencing on the Effective Date, provide EPA and its representatives including contractors, with access at all reasonable times to such property for the purpose of conducting any activity related to this Settlement. For the portion of the Site in and around the Danny T Adit, Respondent shall use best efforts to secure from the property owners of the claim on which the Danny T Adit is located access that will allow Respondent to complete the Work. As used in this Section, "best efforts" means the efforts that a reasonable person in Respondent's position would use to achieve the goal in a timely manner. If Respondent is not able to accomplish what is required through "best efforts" it shall notify EPA and include a description of the steps taken to obtain access. If EPA deems it appropriate, it may assist Respondent, or take independent action in obtaining such access.

34. Notwithstanding any provision of the Settlement, EPA retains all of its access authorities and rights, as well as all of its rights to require land, water, or other resource use restrictions, including enforcement authorities related thereto under CERCLA, RCRA, and any other applicable statute or regulations.

XII. ACCESS TO INFORMATION

35. Respondent shall provide to EPA, upon request, copies of all records, reports, documents, and other information (including records, reports, documents, and other information in electronic form) (hereinafter referred to as "Records") within Respondent's possession or control or that of their contractors or agents relating to activities at the Site associated with this Settlement or to the implementation of this Settlement, including, but not limited to, sampling, analysis, chain of custody records, manifests, trucking logs, receipts, reports, sample traffic routing, correspondence, or other documents or information regarding the Work. Respondent shall also make available to EPA, for purposes of investigation, information gathering, or testimony, their employees, agents, or representatives with knowledge of relevant facts concerning the performance of the Work.

36. **Privileged and Protected Claims**

a. Respondent may assert that all or part of a Record requested by EPA is privileged or protected as provided under federal law, in lieu of providing the Record, provided Respondent complies with Paragraph 36.b, and except as provided in Paragraph 36.c.

b. If Respondent asserts a claim of privilege or protection, it shall provide EPA with the following information regarding such Record: its title; its date; the name, title, affiliation (e.g., company or firm), and address of the author, of each addressee, and of each recipient; a description of the Record's contents; and the privilege or protection asserted. If a claim of privilege or protection applies only to a portion of a Record, Respondent shall provide the Record to EPA in redacted form to mask the privileged or protected portion only. Respondent shall retain all Records that it claims to be privileged or protected until EPA has had a reasonable opportunity to dispute the privilege or protection claim and any such dispute has been resolved in Respondent's favor.

c. Respondent may make no claim of privilege or protection regarding: (1) any data regarding the Site, including, but not limited to, all sampling, analytical, monitoring, hydrogeologic, scientific, chemical, radiological, or engineering data, or the portion of any other Record that evidences conditions at or around the Site; or (2) the portion of any Record that Respondent is required to create or generate pursuant to this Settlement.

37. **Business Confidential Claims**. Respondent may assert that all or part of a Record provided to EPA under this Section or Section XIII (Record Retention) is business confidential to the extent permitted by and in accordance with Section 104(e)(7) of CERCLA, 42 U.S.C. § 9604(e)(7), and 40 C.F.R. § 2.203(b). Respondent shall segregate and clearly identify all Records or parts thereof submitted under this Settlement for which Respondent asserts business confidentiality claims. Records claimed as confidential business information will be afforded the protection specified in 40 C.F.R. Part 2, Subpart B. If no claim of confidentiality accompanies Records when they are submitted to EPA, or if EPA has notified Respondent that the Records are not confidential under the standards of Section 104(e)(7) of CERCLA or 40 C.F.R. Part 2, Subpart B, the public may be given access to such Records without further notice to Respondent.

38. Notwithstanding any provision of this Settlement, EPA retains all of its information gathering and inspection authorities and rights, including enforcement actions related thereto, under CERCLA, RCRA, and any other applicable statutes or regulations.

XIII. RECORD RETENTION

39. Until 10 years after EPA provides Respondent with notice, pursuant to Section XXVII (Notice of Completion of Work), that all Work has been fully performed in accordance with this Settlement, Respondent shall preserve and retain all non-identical copies of Records (including Records in electronic form) now in its possession or control, or that come into its possession or control, that relate in any manner to its liability under CERCLA with regard to the Site and all Records that relate to the liability of any other person under CERCLA with respect to the Site. Respondent must also retain, and instruct its contractors and agents to preserve, for the same period of time specified above all non-identical copies of the last draft or final version of any Records (including Records in electronic form) now in its possession or control or that come into its possession or control that relate in any manner to the performance of the Work, provided, however, that Respondent (and its contractors and agents) must retain, in addition, copies of all data generated during the performance of the Work and not contained in the aforementioned Records required to be retained. Each of the above record retention requirements shall apply regardless of any corporate retention policy to the contrary.

40. At the conclusion of the document retention period, Respondent shall notify EPA at least 90 days prior to the destruction of any such Records, and, upon request by EPA, and except as provided in Paragraph 36 (Privileged and Protected Claims), Respondent shall deliver any such Records to EPA.

41. Respondent certifies that, to the best of its knowledge and belief, after thorough inquiry, it has not altered, mutilated, discarded, destroyed, or otherwise disposed of any Records (other than identical copies) relating to its potential liability regarding the Site since receipt of EPA's February 14, 2017 Information Request Letter pursuant to Section 104(e) of CERCLA and that it has fully complied with any and all EPA and State requests for information regarding the Site pursuant to Sections 104(e) and 122(e) of CERCLA, 42 U.S.C. §§ 9604(e) and 9622(e), and Section 3007 of RCRA, 42 U.S.C. § 6927.

XIV. COMPLIANCE WITH OTHER LAWS

42. Nothing in this Settlement limits Respondent's obligations to comply with the requirements of all applicable state and federal laws and regulations when performing the Work. No local, state, or federal permit shall be required for any portion of the Work conducted entirely on-site (i.e., within the areal extent of contamination or in very close proximity to the contamination and necessary for implementation of the Work), including studies, if the action is selected and carried out in compliance with Section 121 of CERCLA, 42 U.S.C. § 9621. Where any portion of the Work that is not on-site requires a federal or state permit or approval, Respondent shall submit timely and complete applications and take all other actions necessary to obtain and to comply with all such permits or approvals. Respondent may seek relief under the provisions of Section XVIII (Force Majeure) for any delay in the performance of the Work resulting from a failure to obtain, or a delay in obtaining, any permit or approval required for the Work, provided that they have submitted timely and complete applications and taken all other actions necessary to obtain all such permits or approvals. This Settlement is not, and shall not be construed to be, a permit issued pursuant to any federal or state statute or regulation.

XV. EMERGENCY RESPONSE AND NOTIFICATION OF RELEASES

43. **Emergency Response**. If any event occurs during performance of the Work that causes or threatens to cause a release of hazardous substances on, at, or from the Site that either constitutes an emergency situation or that may present an immediate threat to public health or welfare or the environment, Respondent shall immediately take all appropriate action to prevent, abate, or minimize such release or threat of release. Respondent shall take these actions in accordance with all applicable provisions of this Settlement, including, but not limited to, the Health and Safety Plan. Respondent shall also immediately notify EPA's RPM or, in the event of his unavailability, the Regional Duty Officer at (303) 293-1788 and the Region 8 Emergency Response Spill Hotline at 1 (800) 227-8914 of the incident or Site conditions. In the event that Respondent fails to take appropriate response action as required by this Paragraph, and EPA takes such action instead, Respondent shall reimburse EPA for all costs of such response action not inconsistent with the NCP pursuant to Section XVI (Payment of Response Costs).

44. **Release Reporting.** Upon the occurrence of any event during performance of the Work that Respondent is required to report pursuant to Section 103 of CERCLA, 42 U.S.C. § 9603, or Section 304 of the Emergency Planning and Community Right-to-know Act (EPCRA), 42 U.S.C. § 11004, Respondent shall immediately orally notify EPA's Remedial Project Manager or, in the event of his unavailability, the Region 8 Emergency Response Spill Hotline at 1 (800) 227-8914 and the National Response Center at 1 (800) 424-8802. This reporting requirement is in addition to, and not in lieu of, reporting under Section 103(c) of

CERCLA, 42 U.S.C. § 9603(c), and Section 304 of the Emergency Planning and Community Right-To-Know Act of 1986, 42 U.S.C. § 11004.

45. For any event covered under this Section, Respondent shall submit a written report to EPA within 7 days after the onset of such event, setting forth the action or event that occurred and the measures taken, and to be taken, to mitigate any release or threat of release or endangerment caused or threatened by the release and to prevent the reoccurrence of such a release or threat of release.

XVI. PAYMENT OF RESPONSE COSTS

46. **Payments for Future Response Costs.** Respondent shall pay to EPA all Future Response Costs not inconsistent with the NCP.

47. On a periodic basis, EPA will send Respondent an electronic billing notification to the following recipient and email address: Barbara Nielsen, Remediation Projects Manager, bnielsen@fmi.com.

48. The billing notification will include a standard regionally-prepared cost report with the direct and indirect costs incurred by EPA and its contractors. Respondent shall make all payments within 45 days of receipt of the electronic bill. Respondent shall make payments using one of the payment methods set forth in the electronic billing notification.

49. Respondent may change its email billing address by providing notice of the new address to:

Financial Management Officer
US EPA Region 8 (TMS-FMP)
1595 Wynkoop Street
Denver, Colorado 80202

50. If the electronic billing notification is undeliverable, EPA will mail a paper copy of the billing notification to Respondent to Barbara Nielsen, Remediation Projects Manager, 333 North Central Avenue, Phoenix, Arizona 85004, (602) 366-8270, bnielsen@fmi.com.

51. **Deposit of Future Response Costs Payments.** The total amount to be paid by Respondent shall be deposited by EPA in the Barker Hughesville Mining District Special Account to be retained and used to conduct or finance response actions at or in connection with the Site, or to be transferred by EPA to the EPA Hazardous Substance Superfund.

52. **Contesting Future Response Costs.** Respondent may initiate the procedures of Section XVII (Dispute Resolution) regarding payment of any Future Response Costs billed under Paragraph 46 (Payments for Future Response Costs) if they determine that EPA has made a mathematical error or included a cost item that is not within the definition of Future Response Costs, or if they believe EPA incurred excess costs as a direct result of an EPA action that was inconsistent with a specific provision or provisions of the NCP. To initiate such a dispute, Respondent shall submit a Notice of Dispute in writing to EPA's RPM within 30 days after receipt of the bill. Any such Notice of Dispute shall specifically identify the contested Future

Response Costs and the basis for objection. If Respondent submits a Notice of Dispute, Respondent shall within the 30-day period, also as a requirement for initiating the dispute, (a) pay all uncontested Future Response Costs to EPA in the manner described in Paragraph 48, and (b) establish, in a duly chartered bank or trust company, an interest-bearing escrow account that is insured by the Federal Deposit Insurance Corporation (FDIC) and remit to that escrow account funds equivalent to the amount of the contested Future Response Costs. Respondent shall send to EPA's RPM a copy of the transmittal letter and check paying the uncontested Future Response Costs, and a copy of the correspondence that establishes and funds the escrow account, including, but not limited to, information containing the identity of the bank and bank account under which the escrow account is established as well as a bank statement showing the initial balance of the escrow account. If EPA prevails in the dispute, within 5 days after the resolution of the dispute, Respondent shall pay the sums due (with accrued interest) to EPA in the manner described in Paragraph 53. If Respondent prevails concerning any aspect of the contested costs, Respondent shall pay that portion of the costs (plus associated accrued interest) for which it did not prevail to EPA in the manner described in Paragraph 53. Respondent shall be disbursed any balance of the escrow account. The dispute resolution procedures set forth in this Paragraph in conjunction with the procedures set forth in Section XVII (Dispute Resolution) shall be the exclusive mechanisms for resolving disputes regarding Respondent's obligation to reimburse EPA for its Future Response Costs.

XVII. DISPUTE RESOLUTION

53. Unless otherwise expressly provided for in this Settlement, the dispute resolution procedures of this Section shall be the exclusive mechanism for resolving disputes arising under this Settlement. The Parties shall attempt to resolve any disagreements concerning this Settlement expeditiously and informally.

54. **Informal Dispute Resolution**. If Respondent objects to any EPA action taken pursuant to this Settlement, including billings for Future Response Costs, they shall send EPA a written Notice of Dispute describing the objection(s) within 7 days after such action. EPA and Respondent shall have 30 days from EPA's receipt of Respondent's Notice of Dispute to resolve the dispute through informal negotiations (Negotiation Period). The Negotiation Period may be extended at the sole discretion of EPA. Any agreement reached by the Parties pursuant to this Section shall be in writing and shall, upon signature by the Parties, be incorporated into and become an enforceable part of this Settlement.

55. **Formal Dispute Resolution**. If the Parties are unable to reach an agreement within the Negotiation Period, Respondent shall, within 20 days after the end of the Negotiation Period, submit a statement of position to EPA's RPM. EPA may, within 20 days thereafter, submit a statement of position. Thereafter, an EPA management official at the Assistant Regional Administrator level or higher will issue a written decision on the dispute to Respondent. EPA's decision shall be incorporated into and become an enforceable part of this Settlement. Respondent shall fulfill the requirement that was the subject of the dispute in accordance with the agreement reached or with EPA's decision, whichever occurs.

56. Except as provided in Paragraph 52 (Contesting Future Response Costs) or as agreed by EPA, the invocation of formal dispute resolution procedures under this Section does not extend, postpone, or affect in any way any obligation of Respondent under this Settlement.

XVIII. FORCE MAJEURE

57. "Force Majeure" for purposes of this Settlement, is defined as any event arising from causes beyond the control of Respondent, of any entity controlled by Respondent, or of Respondent's contractors that delays or prevents the performance of any obligation under this Settlement despite Respondent's best efforts to fulfill the obligation. The requirement that Respondent exercise "best efforts to fulfill the obligation" includes using best efforts to anticipate any potential force majeure and best efforts to address the effects of any potential force majeure (a) as it is occurring and (b) following the potential force majeure such that the delay and any adverse effects of the delay are minimized to the greatest extent possible. "Force majeure" does not include financial inability to complete the Work or increased cost of performance.

58. If any event occurs or has occurred that may delay the performance of any obligation under this Settlement, Respondent shall notify EPA's RPM orally or, in his absence, the alternate EPA RPM, or, in the event both of EPA's designated representatives are unavailable, the Director of the Waste Management Division, EPA Region 8, within 48 hours of when Respondent first knew that the event might cause a delay. Within 5 days thereafter, Respondent shall provide in writing to EPA an explanation and description of the reasons for the delay; the anticipated duration of the delay; all actions taken or to be taken to prevent or minimize the delay; a schedule for implementation of any measures to be taken to prevent or mitigate the delay or the effect of the delay; Respondent's rationale for attributing such delay to a force majeure; and a statement as to whether, in the opinion of Respondent, such event may cause or contribute to an endangerment to public health or welfare, or the environment. Respondent shall include with any notice all available documentation supporting its claim that the delay was attributable to a force majeure. Respondent shall be deemed to know of any circumstance of which Respondent, any entity controlled by Respondent, or Respondent's contractors knew or should have known. Failure to comply with the above requirements regarding an event shall preclude Respondent from asserting any claim of force majeure regarding that event, provided, however, that if EPA, despite the late or incomplete notice, is able to assess to its satisfaction whether the event is a force majeure under Paragraph 57 and whether Respondent has exercised its best efforts under Paragraph 57, EPA may, in its unreviewable discretion, excuse in writing Respondent's failure to submit timely or complete notices under this Paragraph.

59. If EPA agrees that the delay or anticipated delay is attributable to a force majeure, the time for performance of the obligations under this Settlement that are affected by the force majeure will be extended by EPA for such time as is necessary to complete those obligations. An extension of the time for performance of the obligations affected by the force majeure shall not, of itself, extend the time for performance of any other obligation. If EPA does not agree that the delay or anticipated delay has been or will be caused by a force majeure, EPA will notify Respondent in writing of its decision. If EPA agrees that the delay is attributable to a force

majeure, EPA will notify Respondent in writing of the length of the extension, if any, for performance of the obligations affected by the force majeure.

60. If Respondent elects to invoke the dispute resolution procedures set forth in Section XVII (Dispute Resolution), it shall do so no later than 15 days after receipt of EPA's notice. In any such proceeding, Respondent shall have the burden of demonstrating by a preponderance of the evidence that the delay or anticipated delay has been or will be caused by a force majeure, that the duration of the delay or the extension sought was or will be warranted under the circumstances, that best efforts were exercised to avoid and mitigate the effects of the delay, and that Respondent complied with the requirements of Paragraphs 57 and 58. If Respondent carries this burden, the delay at issue shall be deemed not to be a violation by Respondent of the affected obligation of this Settlement identified to EPA.

61. The failure by EPA to timely complete any obligation under the Settlement is not a violation of the Settlement, provided, however, that if such failure prevents Respondent from meeting one or more deadlines under the Settlement, Respondent may seek relief under this Section.

XIX. PENALTIES

62. Nothing in this Settlement shall be construed as prohibiting, altering, or in any way limiting the ability of EPA to seek any remedies or sanctions available by virtue of Respondent's violation of this Settlement or of the statutes and regulations upon which it is based, including, but not limited to, penalties pursuant to Section 122(*l*) of CERCLA, 42 U.S.C. § 9622(*l*), and punitive damages pursuant to Section 107(c)(3) of CERCLA, 42 U.S.C. § 9607(c)(3).

XX. COVENANTS BY EPA

63. In consideration of the actions that will be performed and the payments that will be made by Respondent under the terms of this Settlement, and except as provided in Section XXII (Reservations of Rights by EPA), EPA covenants not to sue or to take administrative action against Respondent pursuant to Sections 106 and 107(a) of CERCLA, 42 U.S.C. §§ 9606 and 9607(a), for the Work and Future Response Costs. These covenants shall take effect upon the Effective Date. These covenants are conditioned upon the complete and satisfactory performance by Respondent of its obligations under this Settlement. These covenants extend only to Respondent and do not extend to any other person.

XXI. RESERVATIONS OF RIGHTS BY EPA

64. Except as specifically provided in this Settlement, nothing in this Settlement shall limit the power and authority of EPA or the United States to take, direct, or order all actions necessary to protect public health, welfare, or the environment or to prevent, abate, or minimize an actual or threatened release of hazardous substances, pollutants, or contaminants, or hazardous or solid waste on, at, or from the Site. Further, nothing in this Settlement shall prevent EPA from seeking legal or equitable relief to enforce the terms of this Settlement, from taking other legal or equitable action as it deems appropriate and necessary, or from requiring

Respondent in the future to perform additional activities pursuant to CERCLA or any other applicable law.

65. The covenant not to sue set forth in Section XIX (Covenants by EPA) above does not pertain to any matters other than those expressly identified therein. EPA reserves, and this Settlement is without prejudice to, all rights against Respondent with respect to all other matters, including, but not limited to:

a. liability for failure by Respondent to meet a requirement of this Settlement;

b. liability for costs not included within the definition of Future Response Costs;

c. liability for performance of response action other than the Work;

d. criminal liability;

e. liability for violations of federal or state law that occur during or after implementation of the Work;

f. liability for damages for injury to, destruction of, or loss of natural resources, and for the costs of any natural resource damage assessments;

g. liability arising from the past, present, or future disposal, release or threat of release of hazardous substances outside of the Site; and

h. liability for costs incurred or to be incurred by the Agency for Toxic Substances and Disease Registry related to the Site not paid as Future Response Costs under this Settlement.

XXII. COVENANTS BY RESPONDENT

66. Respondent covenants not to sue and agrees not to assert any claims or causes of action against the United States, or its contractors or employees, with respect to the Work, Future Response Costs, or this Settlement, including, but not limited to:

a. any direct or indirect claim for reimbursement from the EPA Hazardous Substance Superfund through Sections 106(b)(2), 107, 111, 112, or 113 of CERCLA, 42 U.S.C. §§ 9606(b)(2), 9607, 9611, 9612, or 9613, or any other provision of law;

b. any claims under Sections 107 and 113 of CERCLA, Section 7002(a) of RCRA, 42 U.S.C. § 6972(a), or state law regarding the Work, Future Response Costs, and this Settlement; or

c. any claim arising out of response actions at or in connection with the Site, including any claim under the United States Constitution, the Montana Constitution, the Tucker Act, 28 U.S.C. § 1491, the Equal Access to Justice Act, 28 U.S.C. § 2412, or at common law.

67. These covenants not to sue shall not apply if the United States brings a cause of action or issues an order pursuant to the reservations set forth in Section XXII (Reservations of Rights by EPA), other than in Paragraph 65.a (liability for failure to meet a requirement of the Settlement), 65.d (criminal liability), or 65.e (liability for violations of federal or state law), but only to the extent that Respondent's claims arise from the same response action, response costs, or damages that the United States is seeking pursuant to the applicable reservation.

68. Nothing in this Agreement shall be deemed to constitute approval or preauthorization of a claim within the meaning of Section 111 of CERCLA, 42 U.S.C. § 9611, or 40 C.F.R. § 300.700(d).

69. Respondent reserves, and this Settlement is without prejudice to, claims against the United States, subject to the provisions of Chapter 171 of Title 28 of the United States Code, and brought pursuant to any statute other than CERCLA or RCRA and for which the waiver of sovereign immunity is found in a statute other than CERCLA or RCRA, for money damages for injury or loss of property or personal injury or death caused by the negligent or wrongful act or omission of any employee of the United States, as that term is defined in 28 U.S.C. § 2671, while acting within the scope of his or her office or employment under circumstances where the United States, if a private person, would be liable to the claimant in accordance with the law of the place where the act or omission occurred. However, the foregoing shall not include any claim based on EPA's selection of response actions, or the oversight or approval of Respondent's deliverables or activities.

XXIII. OTHER CLAIMS

70. By issuance of this Settlement, the United States and EPA assume no liability for injuries or damages to persons or property resulting from any acts or omissions of Respondent. The United States or EPA shall not be deemed a party to any contract entered into by Respondent or its directors, officers, employees, agents, successors, representatives, assigns, contractors, or consultants in carrying out actions pursuant to this Settlement.

71. Except as expressly provided in Section XIX (Covenants by EPA), nothing in this Settlement constitutes a satisfaction of or release from any claim or cause of action against Respondent or any person not a party to this Settlement, for any liability such person may have under CERCLA, other statutes, or common law, including but not limited to any claims of the United States for costs, damages, and interest under Sections 106 and 107 of CERCLA, 42 U.S.C. §§ 9606 and 9607.

72. No action or decision by EPA pursuant to this Settlement shall give rise to any right to judicial review, except as set forth in Section 113(h) of CERCLA, 42 U.S.C. § 9613(h).

XXIV. EFFECT OF SETTLEMENT/CONTRIBUTION

73. The Parties agree that this Settlement Agreement constitutes an administrative settlement for purposes of Section 113(f)(2) of CERCLA, 42 U.S.C.§ 9613(f)(2), and that Respondent is entitled, as of the Effective Date, to protection from contribution actions or claims as provided by Sections 113(f)(2) and 122(h)(4) of CERCLA, 42 U.S.C. §§ 9613(f)(2) and

9622(h)(4), or as may be otherwise provided by law, for "matters addressed" in this Settlement. The "matters addressed" in this Settlement are the Work and Future Response Costs.

74. The Parties agree that this Settlement constitutes an administrative settlement for purposes of Section 113(f)(3)(B) of CERCLA, 42 U.S.C. § 9613(f)(3)(B), pursuant to which Respondent has, as of the Effective Date, resolved its liability to the United States for the Work and Future Response Costs.

75. Nothing in this Settlement shall be construed to create any rights in, or grant any cause of action to, any person not a Party to this Settlement. Except as provided in Section XXII (Covenants by Respondent), each of the Parties expressly reserves any and all rights (including, but not limited to, pursuant to Section 113 of CERCLA, 42 U.S.C. § 9613), defenses, claims, demands, and causes of action which each Party may have with respect to any matter, transaction, or occurrence relating in any way to the Site against any person not a Party hereto. Nothing in this Settlement diminishes the right of the United States, pursuant to Section 113(f)(2) and (3) of CERCLA, 42 U.S.C. § 9613(f)(2)-(3), to pursue any such persons to obtain additional response costs or response action and to enter into settlements that give rise to contribution protection pursuant to Section 113(f)(2).

XXV. INDEMNIFICATION

76. The United States does not assume any liability by entering into this Settlement or by virtue of any designation of Respondent as EPA's authorized representative under Section 104(e) of CERCLA, 42 U.S.C. § 9604(e), and 40 C.F.R. § 300.400(d)(3). Respondent shall indemnify, save, and hold harmless the United States, its officials, agents, employees, contractors, subcontractors, and representatives for or from any and all claims or causes of action arising from, or on account of, negligent or other wrongful acts or omissions of Respondent, their officers, directors, employees, agents, contractors, or subcontractors, and any persons acting on Respondent's behalf or under its control, in carrying out activities pursuant to this Settlement. Further, Respondent agrees to pay the United States all costs it incurs, including but not limited to attorneys' fees and other expenses of litigation and settlement arising from, or on account of, claims made against the United States based on negligent or other wrongful acts or omissions of Respondent, its officers, directors, employees, agents, contractors, subcontractors, and any persons acting on its behalf or under its control, in carrying out activities pursuant to this Settlement. The United States shall not be held out as a party to any contract entered into by or on behalf of Respondent in carrying out activities pursuant to this Settlement. Neither Respondent nor any such contractor shall be considered an agent of the United States.

77. The United States shall give Respondent notice of any claim for which the United States plans to seek indemnification pursuant to this Section and shall consult with Respondent prior to settling such claim.

78. Respondent covenants not to sue and agrees not to assert any claims or causes of action against the United States for damages or reimbursement or for set-off of any payments made or to be made to the United States, arising from or on account of any contract, agreement, or arrangement between Respondent and any person for performance of Work on or relating to the Site, including, but not limited to, claims on account of construction delays. In addition,

Respondent shall indemnify and hold harmless the United States with respect to any and all claims for damages or reimbursement arising from or on account of any contract, agreement, or arrangement between Respondent and any person for performance of Work on or relating to the Site, including, but not limited to, claims on account of construction delays.

XXVI. INSURANCE

79. No later than 30 days before commencing any on-site Work, Respondent shall secure, and shall maintain until the first anniversary after issuance of Notice of Completion of Work pursuant to Section XXVII (Notice of Completion of Work), commercial general liability insurance with limits of liability of $1 million per occurrence, automobile liability insurance with limits of liability of $1 million per accident, and umbrella liability insurance with limits of liability of $5 million in excess of the required commercial general liability and automobile liability limits, naming EPA as an additional insured with respect to all liability arising out of the activities performed by or on behalf of Respondent pursuant to this Settlement. In addition, for the duration of the Settlement, Respondent shall provide EPA with certificates of such insurance and a copy of each insurance policy. Respondent shall resubmit such certificates and copies of policies each year on the anniversary of the Effective Date. In addition, for the duration of the Settlement, Respondent shall satisfy, or shall ensure that their contractors or subcontractors satisfy, all applicable laws and regulations regarding the provision of worker's compensation insurance for all persons performing Work on behalf of Respondent in furtherance of this Settlement. If Respondent demonstrates by evidence satisfactory to EPA that any contractor or subcontractor maintains insurance equivalent to that described above, or insurance covering some or all of the same risks but in a lesser amount, then, with respect to the contractor or subcontractor, Respondent need provide only that portion of the insurance described above that is not maintained by the contractor or subcontractor. Respondent shall ensure that all submittals to EPA under this Paragraph identify the Barker Hughesville Site, Montana, and the EPA docket number for this action.

XXVII. NOTICE OF COMPLETION OF WORK

80. When EPA determines that all Work has been fully performed in accordance with this Settlement, with the exception of any continuing obligations required by this Settlement, including payment of Future Response Costs, EPA will provide written notice to Respondent.

XXVIII. INTEGRATION/APPENDICES

81. This Settlement and its appendix constitute the final, complete, and exclusive agreement and understanding among the Parties with respect to the settlement embodied in this Settlement. The parties acknowledge that there are no representations, agreements, or understandings relating to the settlement other than those expressly contained in this Settlement. The following appendix is attached to and incorporated into this Settlement:

a. "Appendix A" is the Work Plan

XXIX. EFFECTIVE DATE

82. This Settlement shall be effective when it is signed by the Regional Administrator or his/her delegate.

U.S. ENVIRONMENTAL PROTECTION AGENCY:

7/6/17
Dated

Bill Murray, Director
Office of Ecosystems Protection and Remediation
U.S. Environmental Protection Agency, Region 8

Signature Page for Settlement Regarding Barker Hughesville Mining District Superfund Site

FOR MT. EMMONS MINING COMPANY

6-21-17
Dated

L. Richards McMillan, II
Senior Vice President
Mt. Emmons Mining Company

Work Plan

Lab-Scale Treatability Study of Danny T Mine Adit Discharge

Barker Hughesville Mining District Superfund Site
Cascade and Judith Basin Counties, Montana

Prepared for:
U.S. Environmental Protection Agency
Region VIII, Montana Office
Federal Building, Suite 3200
10 West 15th Street
Helena, Montana 59626

Prepared by:
Mt. Emmons Mining Company
333 North Central Avenue
Phoenix, Arizona 85004

Freeport Minerals Corporation, on behalf of Mt. Emmons Mining Company (hereinafter, "Mt. Emmons"), hereby submits this Work Plan for the performance of a treatability study at the Barker Hughesville Mining District Superfund Site pursuant to the terms and conditions of the Administrative Settlement Agreement and Order on Consent for Treatability Study entered into by the United States Environmental Protection Agency and Mt. Emmons (AOC).

Prepared by: __Dan S Ramey__ Date: 6-15-17

Dan Ramey, Director, Environmental Technologies

Reviewed by: __Brett Waterman__ Date: 6-15-17

Brett Waterman, Quality Assurance Manager

Issued by: __Barbara K Nielsen__ Date: 6-15-17

Barbara Nielsen, Manager, Remediation Projects

Approved by: __Roger Hoogerheide__ Date: 6-15-17

Roger Hoogerheide, Remedial Project Manager and Delegated Quality Assurance Approving Official, U. S. Environmental Protection Agency

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List of Acronyms and Abbreviations

AMSL	Above Mean Sea Level
AOC	Administrative Settlement Agreement and Order on Consent
BH	Barker Hughesville
BHMD	Barker Hughesville Mining District
BOD	Biochemical Oxygen Demand
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Constituent of Concern
DEQ	Montana Department of Environmental Quality
DQO	Data Quality Objectives
EPA	U.S. Environmental Protection Agency
ET	Environmental Technology
FMC	Freeport Minerals Corporation
FS	Feasibility Study
GPM	Gallons per Minute
HRT	Hydraulic Retention Time
LCAT	Life Cycle Analysis Team
MDL	Method Detection Limit
mg/L	Milligrams per Liter
MIW	Mining-Influenced Water
NRCS	Natural Resource Conservation Service
PARCCS	Precision, Accuracy, Representativeness, Completeness, Comparability, and Sensitivity
PPE	Personal Protective Equipment
PQL	Practical Quantitation Level
QA	Quality Assurance
QAP	Quality Assurance Plan
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMP	Quality Management Plan
RI	Remedial Investigation
ROD	Record of Decision
RPD	Relative Percent Difference
RPM	Remedial Project Manager
RSD	Relative Standard deviation
SAP	Sampling and Analysis Plan
SRB	Sulfate-Reducing Bacteria
SNOTEL	Snow pack monitoring station
SOP	Standard Operating Procedure
SOW	Scope of Work
SRBR	Sulfate-Reducing Bioreactor
TCT	Technology Center Tucson
USFS	United States Forest Service
µg/L	Micrograms per Liter
°C	Degree Celsius

Revision Tracking Table

Revision Number	Date	Section Revised	Changes/Comments	Revised Page Color
1	6/12/17	All	Addressed agency comments	Red-lined

1. Introduction

This Work Plan describes a lab-scale treatability study that evaluates passive bioremediation as a potential treatment system for mining-influenced water (MIW) emerging from the Danny T Mine adit (referred to as the Danny T Mine or Mine), located within the Barker Hughesville Mining District (BHMD) Superfund Site in Cascade and Judith Basin Counties, Montana. The treatability study will be conducted by Freeport Minerals Corporation (FMC), on behalf of Mt. Emmons Mining Company (Mt. Emmons; Respondent).

1.1. Purpose of the Work Plan

The Danny T Mine is located within the BHMD Superfund Site in west-central Montana, east of Monarch. The Danny T Mine is located in the Little Belt Mountains mostly within the Dry Fork Belt Creek Watershed covering almost 15 square miles of mostly forested land within the Helena-Lewis and Clark National Forest. The site encompasses the floodplain of Dry Fork Belt Creek, four tributary drainages (Galena Creek, McKay Gulch Creek, Spruce Creek, and Smoke in Hole Creek), and the upper portion of the Otter Creek drainage. Otter Creek flows toward the north and does not report to the Dry Fork Belt Creek.

Mining occurred within the BHMD Superfund Site from the later part of the 19th and early 20th centuries until 1943 when all operations ceased in the BHMD. Environmental data have been collected by the U.S. Environmental Protection Agency (EPA), Montana state agencies, and the United States Forest Service (USFS) since the 1970s on the quality of MIW discharging from mine openings, waste rock dumps, and tailings within the BHMD Superfund Site.

Passive, biologically-based water treatment can be a cost-effective and low maintenance technology for MIW, particularly for legacy mine sites such as the Danny T Mine. Biological sulfate reduction accomplished by sulfate-reducing bacteria (SRB) is a potential treatment technology for the Danny T Mine MIW. This technology increases alkalinity and pH of MIW while producing sulfide anions, which, in turn, remove aqueous metal ions through precipitation as metal sulfides. This technology can potentially reduce operation, maintenance, and monitoring costs compared to active MIW treatment strategies, while potentially achieving water quality objectives.

EPA and Mt. Emmons have determined that the Mine may be a candidate for passive, biologically-based water treatment. Accordingly, the primary goal of this lab-scale treatability study is to assess the effectiveness of passive MIW treatment for improving the quality of MIW discharge from the Danny T Mine. The focus of this study is an evaluation of the effectiveness of a pre-treatment stage, followed by a sulfate-reducing bioreactor (SRBR) and ending with a polishing post-treatment wetland. This study will also build upon prior studies conducted at the BHMD Superfund Site, as discussed below. It is worth noting that "passive" in the context of this treatability study does not equate to "no action" or "no maintenance". Rather, it describes the use of remediation technologies that utilize naturally-occurring biochemical processes. Ultimately, this study will provide valuable information critical for determining if passive treatment is feasible and cost-effective for implementation, as well as providing insight into potential design of a full-scale system.

1.2. Work Plan Organization

This Work Plan was prepared to comply with the terms of the Administrative Settlement Agreement and Order on Consent for Treatability Study entered into by the United States Environmental Protection Agency and Mt. Emmons (AOC). This Work Plan will guide the implementation of a treatability study using a lab-scale passive bioremediation treatment system. The lab-scale system will be constructed in 2017 and operated for one year, assuming necessary authorizations have been obtained, access is negotiated, and weather conditions allow, and adit discharge has been collected from the Mine. The lab-scale plan is based on the scientific literature and previous studies conducted at the Mine, best management practices, guidance documents, and ten years of experience designing and operating lab-scale, pilot-scale, and full-scale passive treatment systems.

This Work Plan includes the elements of a Sampling and Analysis Plan (SAP), a Field Sampling Plan (FSP), a Quality Assurance Project Plan (QAPP), a Quality Assurance/Quality Control (QA/QC) plan, and a Quality Management Plan (QMP). This Work Plan has been developed in general accordance with the EPA's *Requirements for Quality Assurance Project Plans*, EPA QA/R-5 (EPA, 2001), is consistent with the NCP, and includes all the data elements required in EPA's Region 8 Quality Assurance Document Review Crosswalk, *Guidance for Quality Assurance Project Plans (QA/G-5)*, EPA/240/R-02/009 (December 2002), *Guidance for Quality Assurance Project Plans (QA/G-5)* EPA/240/R-02/009 (December 2002), *EPA Requirements for Quality Assurance Project Plans (QA/R-5)* EPA/240/B-01/003 (March 2001, reissued May 2006), and *Uniform Federal Policy for Quality Assurance Project Plans*, Parts 1-3, EPA/505/B-04/900A-900C (March 2005). Sampling will be restricted to sampling and collection of Danny T Mine Adit MIW at the outset of the treatability study and sampling of water pre- and post-treatment using a passive treatment system. Defensibility of the data obtained will be ensured by following EPA-approved sample collection protocols in the field and lab, as well as EPA-approved analytical methods conducted by a certified external laboratory.

The organization of the Work Plan is as follows:

- Section 1.0: Introduction
- Section 2.0: Mine Background and Setting

Field Sampling Plan

- Section 3.0: Sampling Program, Rationale, and Locations
- Section 4.0: Activity Methods and Procedures

Quality Assurance Project Plan

- Section 5.0: Project Management and Coordination
- Section 6.0: Measurement and Data Acquisition
- Section 7.0: QA Assessment and Oversight
- Section 8.0: Data Validation and Usability
- Section 9.0: References
- Appendices
    - Appendix A – Standard Operating Procedures (SOPs)
    - Appendix B – Health and Safety Plan
    - Appendix C – Sample Chain of Custody Form
    - Appendix D – Calculation Brief
    - Appendix E – Quality Assurance Plan for ACZ Laboratories
    - Appendix F – Summary of Internal Quality Control for the Technology Center Tucson
    - Appendix G – Business Manual for the Technology Center Tucson
    - Appendix H – Curricula Vitae
    - Appendix I – Summary of Prior Relevant FMC Passive Bioremediation Projects

1.3. Project Management

1.3.1. Environmental Protection Agency

Mr. Roger Hoogerheide is the EPA Site Coordinator/Remedial Project Manager (RPM) for the BHMD Superfund Site. Souhail Al-Abed of EPA's National Risk Management Research Laboratory will provide technical assistance to Mr. Roger Hoogerheide. EPA is the lead agency and is responsible for all regulatory oversite of the project.

1.3.2. Mt. Emmons Mining Company (Mt. Emmons)

Mt. Emmons will perform the work identified in this Work Plan. The Project Team organizational chart is presented in Figure 1-1 and the contact information plus responsibilities for key project personnel are provided in Table 1-1. Mrs. Barbara Nielsen is Mt. Emmons' Remediation Projects Manager and primary project contact under the AOC. She will be assisted by Mr. Dan Ramey, Director for the Environmental Technology and Life Cycle Group. Mr. Erick Weiland is the Project Manager for the treatability study and is responsible for providing oversight of field and lab activities of this Work Plan. Mr. Brett Waterman is the Quality Assurance Manager and will remain independent from the Project Team generating the data while still working in cooperation with all levels of management and staff to plan, assess, and implement the Team's quality system. Mr. Waterman is responsible for maintaining the official, approved QA Project Plan. Dr. Leonard Santisteban is the Project Lead, treatment wetland subject matter expert, and is responsible for experimental design, project coordination, data analysis, and report preparation. Dr. Ilsu Lee is the bioremediation subject matter expert and will assist on experimental design, data analysis, and report preparation. Mr. Shane Hansen is the Environmental Technology Laboratory (ETL) Supervisor and is responsible for day-to-day management and planning of research activities at the ETL in Tucson, AZ, including sample handling and laboratory experiments. Mrs. Jill Schultz is the Health and Safety Manager and will ensure that all work is being done in compliance with all relevant safety regulations and policies. ACZ Laboratories, Inc. is the EPA-certified laboratory that the Respondent has subcontracted to perform much of the analytical work described later in this Work Plan. Other qualified individuals within the Environmental Technology group form the remainder of the Project Team and may be assigned duties by the Project Manager as necessary.

1.3.3. United States Forest Service

Mr. Steve Opp is the USFS Minerals and Geology Program Manager for the BHMD Superfund Site. Mr. Opp has all responsibilities on behalf of the USFS on the project and works directly with EPA in regulatory oversight of the project.

1.3.4. Montana Department of Environmental Quality (DEQ)

Mr. Keith Large is the DEQ Project Officer for the BHMD Superfund Site. Mr. Large has all responsibilities on behalf of the DEQ on the project and works directly with EPA in regulatory oversight of the project.

Table 1-1. Key Project Personnel Contact Information and Responsibilities.

Name	Phone/email	Responsibilities
Roger Hoogerheide	406-457-5031 Hoogerheide.roger@epa.gov	EPA Site Coordinator Remedial Project Manager
Barbara Nielsen	480-313-2895 bnielsen@fmi.com	Manager, Remediation Projects
Dan Ramey	520-498-6556 dramey@fmi.com	Director, Environmental Technology/Life Cycle
Erick Weiland	520-498-6591 eweiland@fmi.com	Project Manager, Environmental Technology/Life Cycle
Brett Waterman	520-498-6558 bwaterma@fmi.com	Quality Assurance Manager, Environmental Technology/Life Cycle
Leonard Santisteban	520-498-6575 lsantist@fmi.com	Project Lead and Research Scientist, Environmental Technology/Life Cycle
Ilsu Lee	520-498-6569 ilee@fmi.com	Environmental Engineer, Environmental Technology/Life Cycle
Shane Hansen	520-229-6644 shansen@fmi.com	Laboratory Supervisor, Environmental Technology/Life Cycle
Jill Schultz	520-498-6542 jschultz@fmi.com	Manager, Health and Safety
Scott Habermehl	800-334-5493 ext. 101 scotth@acz.com	ACZ Laboratories Senior Project Manager
Souhail Al-Abed	513-569-7849 Al-abed.souhail@epa.gov	National Risk Management Research Laboratory
Steve Opp	406-495-3716 jopp@fs.fed.us	USFS Minerals and Geology Program Manager
Keith Large	406-444-6569 klarge@mt.gov	DEQ State Project Officer

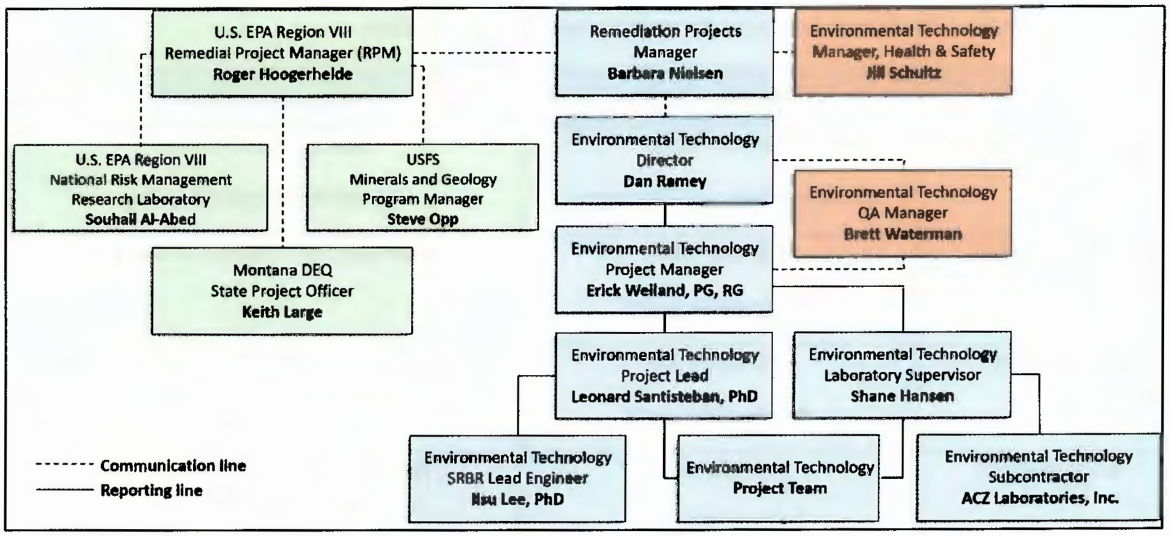

Figure 1-1. Organization chart illustrating project reporting and communication lines structure.

1.4. Project Schedule and Deliverables

The projected schedule for this Work Plan is triggered by execution of the AOC and is based on EPA's approval to proceed to sample and collect water, weather/access permitting, as shown in Table 1-2 below.

Table 1-2. Project Schedule and Deliverables.

			Month														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Work Plan Preparation	X																
Reconnaissance Trip		X															
Sample Collection			X														
Set-Up/Characterization			X	X													
Treatment Testing Phase				X	X	X	X	X	X	X	X	X	X	X	X		
Report Writing									X			X		X	X	X	X

1.5. Distribution List

Electronic copies of this Work Plan, as well as any updates that accurately reflect completed work, will be provided to the EPA Remedial Project Manager by the Remediation Project Manager. A signed copy of this Work Plan will be placed in the Superfund site file for the BHMD Superfund Site at the EPA office in Helena, Montana.

1.6. Special Training/Certifications

To ensure that all personnel performing work have the necessary skills to safely and effectively accomplish their work, special training requirements for this investigation will include the following:

- Documented task training on field and lab sampling and analysis SOPs
- *SOP ETL-MT-08-Data Entry, Validation, and Maintenance*
- Documented OSHA 40-hour HAZWOPER certification and current 8-hour refresher

Mt. Emmons will be responsible for providing these trainings using qualified trainers. The Project Team will document in the project file that personnel have and maintain the appropriate training, knowledge, skills, and qualifications necessary to perform the work outlined in this Work Plan and the need for retraining will be assessed if project requirements change.

2. Mine Background and Setting

The Danny T Mine is situated within the BHMD Superfund Site in west-central Montana, east of Monarch. The Danny T Mine is located down-gradient of the confluence of Galena Creek and Silver Creek. It is half mile north of Barker and has multiple cascading waste piles, buildings, load-out structures, and an adit. The Danny T Mine Adit was reported to be flowing up to 40 gpm during a 1993 sampling event (CDM Smith, 2016). However, flow rate is seasonally variable.

2.1. Mining History

The Danny T Mine is located on steep mountainside within the BHMD Superfund Site (Fig. 2-1). It is located on one of four adjacent claims (i.e., the Liberty, Emerald, Danny T, and Last Chance claims) that were, according to the EPA, located, explored, and mined by various parties beginning in the early 1880s (Fig. 2-2).

Figure 2-1. Map of the Danny T Mine.

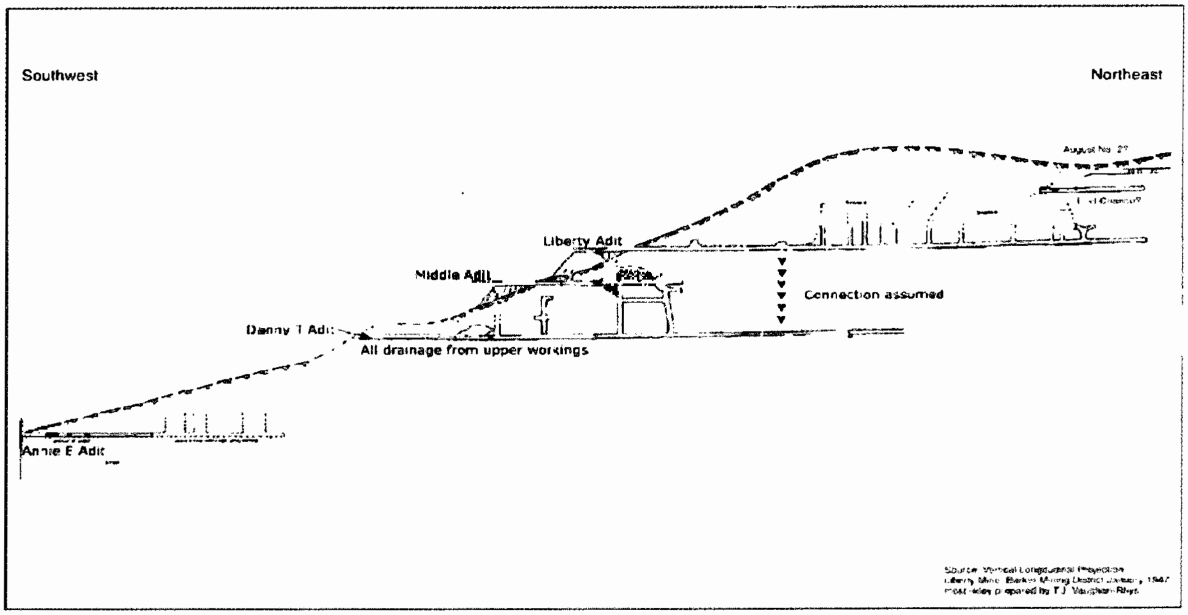

Figure 2-2. Cross-Section of the Danny T Adit and Mine (from EPA).

2.2. Investigation History

According to EPA, several studies and investigations have been conducted at the BHMD Superfund Site by federal, state, and county agencies to evaluate mine wastes, stream sediments, surface water, and groundwater. Regulatory involvement at the Danny T Mine began with the issuance of a mining permit to AMAX Exploration, Inc. (AMAX), now Mt. Emmons, by the Montana Department of Health and Environmental Sciences in 1981. A Montana Pollutant Discharge Elimination System permit was subsequently issued to AMAX in 1982.

According to EPA, abandoned mine site surveys were conducted on multiple mines in the district including the Danny T Mine between 1993 and 1995 (Pioneer 1995). EPA's involvement at the Danny T Mine began when the BHMD Superfund Site was listed on EPA's National Priorities List in 2001. The first recorded visit to the site by EPA and its contractor, CDM Smith, was in 2004 and documented in a 2005 report (CDM Smith, 2005). In 2011 and 2012, the Danny T Mine was surveyed and sampled by CDM Smith and Techlaw (CDM Smith 2016).

EPA has advised Mt. Emmons that a flume and continuous data logger were installed at the Danny T Adit on June 11, 2012 to allow continuous flow measurements to be recorded. This Adit was reported as discharging 40 gpm at the time of the 1993 sampling event. The flume location was identified during seep sampling in the first week of May 2012. EPA installed an adjustable Cutthroat flume (made by Baski) and set to a 1-inch throat width. EPA measured the water level with an *in-situ* Level Troll model 500 pressure transducer that was mounted in a stilling well connected to the flume. Pressure, temperature, and water level data were recorded at 15-minute intervals. EPA also has measured flow manually during its monthly trips to sample the Danny T Adit and download the flume data. Measurements were made by recording the amount of time it took to fill a container of known volume. According to EPA, the flume operated from June 11 through September 24, 2012, when it was removed. The Danny T Adit was also sampled monthly during EPA's 2012 sampling season. CDM Smith summarized its sampling results and the discharge from the Danny T Adit (CDM Smith 2016). EPA has determined that the concentration of metals in the MIW currently discharging from the Danny T Mine

Adit may exceed surface water and/or human health standards and require further evaluation and study.

EPA has advised Mt. Emmons that CDM Smith conducted bench-scale and pilot testing in 2013 and 2014 of MIW from the Danny T Adit (CDM Smith 2014, 2017). The treatability study activities were intended to evaluate potential passive treatment alternatives for the Danny T Adit MIW. The initial phase of the treatability study included bench-scale testing in the laboratory for determination of the most promising alternatives. Following these tests and preliminary assessment of results, the pilot-scale treatability testing was planned, installed, and operated for two field seasons. Because EPA determined that the Danny T Adit MIW is similar to other MIW within the BHMD Superfund Site, it intended to use the testing as a surrogate for other MIW discharges within the BHMD Superfund Site for purposes of its FS evaluations of the Site.

At the request of EPA, the results from EPA's work will be studied and evaluated by Mt. Emmons as part of its work under this Work Plan. For example, according to EPA, the cold conditions at the BHMD Superfund Site only allowed EPA to operate its pilot-scale system for approximately four months (CDM Smith 2014). This treatability study will be operated for one year in a controlled environment, thereby allowing for a more long-term evaluation of treatment system performance. Three of four SRBR reactors in the first year of EPA's pilot study were unable to maintain sulfate reduction. In the second year of EPA's pilot study, all four SRBR reactors maintained sulfate reduction for nearly the entire study duration of four months following modifications to treatment systems components based on lessons learned from Year 1. In Year 2, some reactors showed signs of decreasing performance near the conclusion of the project following increases in flow rates. Potential reasons identified by EPA and CDM Smith (2014) for the observed levels of treatment include insufficient hydraulic retention time and a concomitant excess in acidity loading, along with exhaustion of alkalinity production. The treatability study under this Work Plan will expand upon EPA's prior testing and study and base SRBR sizes on multiple design criteria, including acidity/alkalinity balances, which should result in further refinement of treatability design criteria. This treatability study will also evaluate the use of a limestone pre-treatment reactor, which was not previously evaluated by EPA.

2.3. Mining-Influenced Water Characteristics

Danny T Mine Adit MIW has previously been characterized by EPA and CDM Smith (2014) and is summarized in Tables 2-1 and D-1. Some of the analytes were quantified with method detection limits higher than the Montana DEQ 7 water quality standards shown in Table 3-1.

2.4. Setting and Climate

Local relief at the Danny T Mine ranges from 1,650 to 1,690 m above mean sea level (AMSL). Annual precipitation in the area ranges from 24 to 30 inches. Spruce-fir forests grow in most of the Galena Creek valley. There are no known year-round residents in the valley, but there are numerous recreational cabins. Logging and grazing activities may occur in the Galena Creek and Dry Fork Belt Creek watersheds.

Table 2-1. Danny T Mine Adit Water Quality and Field Sample Measurements

Analyte	Unit	Total Concentration or Value	Dissolved Concentration
Aluminum	µg/L	8,100 – 18,900	7,980 – 16,200
Antimony	µg/L	0.32 – 2.00	0.28 – 2.00
Arsenic	µg/L	123 – 419	93 - 400
Barium	µg/L	3.9 – 6.5	3.8 – 7.3
Beryllium	µg/L	4.8 – 20.0	4.9 – 20.0
Cadmium	µg/L	150 – 293	154 – 316
Calcium	µg/L	68,000 – 110,000	82,100 – 111,000
Chromium	µg/L	2.7 – 7.8	2.5 – 6.1
Cobalt	µg/L	13.7 – 56.0	18.7 – 58.0
Copper	µg/L	395 – 2,040	432 – 2,160
Iron	µg/L	79,200 – 185,000	95,900 – 184,000
Lead	µg/L	104 - 295	121 – 287
Magnesium	µg/L	17,800 – 24,200	18,100 – 25,000
Manganese	µg/L	67,800 – 129,000	73,300 – 128,000
Mercury	µg/L	ND	ND
Nickel	µg/L	20.9 – 48.2	17.9 – 53.9
Potassium	µg/L	625 – 1,000	539 – 1,000
Selenium	µg/L	1.9 – 11.9	2.5 – 6.6
Silver	µg/L	0.08 – 1.00	0.06 – 1.0
Sodium	µg/L	4,330 – 5,580	4,410 – 7,000
Thallium	µg/L	1.3 – 34.9	1.4 – 2.6
Vanadium	µg/L	1.8 – 5.4	2.4 – 5.2
Zinc	µg/L	32,600 – 71,000	42,000 – 69,100
Sulfate as SO_4^{2-}	mg/L		129 – 2,500
Total Dissolved Solids	mg/L		1,300 – 2,090
pH	s.u.	2.40 – 3.32	
Conductivity	mS/cm	1.19 – 3.39	
Temperature	°C	5.4 – 25.1	
Oxidation-Reduction Potential	mV	311.4 – 510.0	

Historical data provided by EPA
ND = Non-Detect
Single range values indicate a single data point

2.5. Geology

Weed (1900), Witkind (1971), and Baker (1991) identified the following geologic units as present beneath the Mine: Wosley Shale, Meagher Limestone, Park Share, and Pilgrim Limestone (Cambrian). The Mine is centered on the Hughesville Stock that is encircled by a group of three laccoliths and one brecciated volcanic pipe intruded into lower Paleozoic strata (Cambrian through Mississippian). The Paleozoic sedimentary sequence is underlain by Precambrian crystalline rock (gneiss) that is exposed south of the Dry Fork Belt Creek (Walker 1991).

2.6. Hydrogeology

Groundwater occurs in fractured bedrock and within relatively thin accumulations of unconsolidated alluvial deposits and colluvium along Dry Fork Belt Creek and its tributaries (CDM Smith, 2016). It also occurs in flooded underground mine workings and mill tailings deposits, mainly in the Galena drainage. The alluvial and bedrock aquifer are discussed in details in the CDM Smith (2016) Remedial Investigation (RI) report.

2.7. Hydrology

Surface water at the Mine is contained within the Galena Creek watershed, which consists of five distinct drainages:

- Green Creek
- Daisy Creek
- Gold Run Creek
- Silver Creek
- Monte Cristo

The primary surface water course adjacent to the mine is Galena Creek which empties into Dry Fork Belt Creek, a tributary of Belt Creek at Monarch. Belt Creek flows into the Missouri River approximately 10 miles northeast of Great Falls, Montana.

2.8. Land Use and Population

The primary land uses in the area are currently timber harvesting, livestock grazing, and recreation (CDM Smith, 2014). Private land available for residences is limited. According to the Montana Department of Administration, 78% of the land area (~7,570 acres) within the BHMD Superfund Site is public land administered by the Helena-Lewis and Clark National Forest, 2.4 percent (~230 acres) is public land administered by the U.S. Bureau of Land Management (BLM), and 19 percent (~1,850 acres) is private land.

Private land consists mainly of patented mining claims whose surface minerals are privately owned. Most of the seasonal residences consist of a few dozen log and frame structures situated along Galena Creek, and are mostly concentrated in the town of Barker. There are currently no known year-round residents living in the valley, but there are numerous recreational cabins. Logging and grazing activities may occur in the Galena Creek and Dry Fork Belt Creek watersheds.

3. Sampling Program, Rationale, and Locations

3.1. Data Quality Objectives (DQOs)

EPA's DQO process outlines a series of planning steps designed to provide the quality, quantity, and type of data required for sound and defensible decision-making to achieve the stated goals and objectives. The process consists of seven steps, which are described in Sections 3.1.1 to 3.1.7.

3.1.1. State the Problem

The first step in the DQO process requires describing or defining the environmental problem to be evaluated. Data obtained from this treatability study will be subjected to a validation determination prior to use by the EPA and Mt. Emmons.

3.1.1.1. Describe the Problem

MIW is currently flowing from the Danny T Mine Adit (e.g. CDM Smith, 2014). Table 2-1 provides a summary of aqueous chemistry parameters quantified by CDM Smith (2014). EPA has determined that the concentration of metals in the MIW currently discharging from the Danny T Mine Adit may exceed surface water and/or human health standards and require further evaluation and study.

3.1.1.2. Planning Team

The planning team (Table 1-1 and Figure 1-1) consists of EPA, DEQ, USFS and the members of the FMC and Mt. Emmons team that are key to the development of this Work Plan and project performance.

3.1.1.3. Conceptual Model of the Potential Hazard

Elevated concentrations of metals and sulfate and low pH identified during previous sampling events have been identified as potentially having an adverse impact on the receiving environment.

3.1.1.4. Available Resources, Constraints, and Deadlines

Mt. Emmons has identified the Project Team and determined resources required and a tentative schedule in this Work Plan. The treatability study is expected to last 12 months after initial bulk water collection, followed by 2 – 3 months of data evaluation and reporting. Potential constraints that could delay field work include, but are not limited to, adverse weather conditions at the Mine precluding access and property access issues. If lab-scale testing, in part or in whole, cannot be performed due to any constraints at any point during the testing, this will be recorded in the laboratory logs and reported as soon as possible to EPA Site Coordinator/Remedial Project Manager.

3.1.2. Goals of the Study

The goal of this lab-scale treatability study is to assess the effectiveness of passive MIW treatment for improving the quality of Danny T Mine MIW to meet applicable ambient water quality standards. The focal technology to be evaluated is a SRBR. The resulting information from this lab-scale treatability study will be used to determine if passive treatment is feasible and cost-effective. SRBRs have previously been evaluated for the Mine by EPA (CDM Smith, 2014, 2017) and this study will build upon that work. As discussed in greater detail below, this study will use larger columns containing a different substrate mixture, a range of flow rates, and will be operated for a greater length of time.

The lab-scale treatability study was developed based on the Project Team's experience with similar passive bioremediation systems at other mine sites (Appendix I), industry-standard best management practices, extensive in-house testing of the technology, and previous studies conducted by EPA at the Danny T Mine. Treatability will be assessed using data related to metal removal efficiency and changes in concentrations of the primary constituents of concern (COCs; see Table 3-1).

It should be noted that identifying design criteria for a potential full-scale application of this technology at the Mine is not a primary goal of this study. Discussion of site-specific challenges or design-related issues may be addressed in a final report and further elaborated on in a full-scale design document, but they will only be briefly discussed here and only in the context of the proposed work.

3.1.3. Principal Study Questions and Information Inputs

Goals and objectives established for this treatability study were the result of a planning process involving a series of study questions and data requirements. The treatability study questions are detailed below, along with a process for answering them. The methods and rationale for generating and acquiring study data are referenced elsewhere in this Work Plan. Section 4 provides additional details on experimental design, materials, and methods.

Initial design parameters will be calculated using previous characterization of the Danny T Mine Adit MIW (Tables 2-1 and D-1). As there is relatively limited recent characterization data from the Mine, additional sampling and characterization will be conducted at the time of water collection for use in this treatability study. SRBR influent chemistry will also be routinely characterized throughout the course of the study. Though influent water chemistry is expected to remain fairly constant (Fe may be an exception) throughout the treatability study, potential variability in influent water chemistry will be considered while evaluating SRBR treatment effectiveness.

1. What are the governing chemical and biological processes of a SRBR that control metal removal?

   Metal removal within a SRBR happens as a result of chemical processes facilitated by metabolic (biological) processes of sulfate reducing bacteria (SRB). Metal removal may occur via:

(i.) biological sulfate reduction and precipitation of insoluble metal sulfides,

$$SO_4^{2-}{}_{(aq)} + 2CH_2O_{(aq)} \rightarrow H_2S_{(aq)} + 2HCO_3^-{}_{(aq)}$$

$$Me^{2+}{}_{(aq)} + H_2S_{(aq)} \rightarrow MeS_{(s)} + 2H^+{}_{(aq)}$$

(ii.) precipitation of metal carbonates, and

$$Me^{2+}{}_{(aq)} + HCO_3^-{}_{(aq)} \rightarrow MeCO_{3(s)} + H^+{}_{(aq)}$$

(iii.) precipitation of metal hydroxides

$$Me^{2+}{}_{(aq)} + HCO_3^-{}_{(aq)} + H_2O_{(l)} \rightarrow Me(OH)_{2(s)} + CO_{2(g)} + H^+{}_{(aq)}$$

where,

$(CH_2O)_n$ – organic matter electron donor
Me^{2+} - divalent metals such as Zn^{2+}, Cu^{2+}, etc.

In addition, co-precipitation with iron and aluminum, and sorption to organic surfaces may also contribute to metal removal within a SRBR.

2. What pre-treatment steps, if any, are necessary to prepare the MIW for passive treatment?

Given the elevated concentrations of aluminum and iron previously reported (Table 2-1) for the MIW, the results from previous testing done by EPA (CDM Smith 2014, 2017), and prior experience with similar passive treatment systems, it was determined that pre-treatment may be necessary prior to the SRBR columns. Pre-treatment with an alkaline reagent to a minimum pH of 4.5 is necessary to effectively reduce the aluminum and iron concentrations. The remote nature of the Mine and the potentially hazardous nature of some pre-treatment alkaline reagents that require continual dosing, such as CaOH, NaOH, make these impractical for pre-treatment at the Danny T Mine. Alkaline reagents, such as limestone, may be required for this Mine discharge. Pre-treatment using limestone also requires less maintenance than other chemical dosing systems. A pre-treatment stage of the passive bioremediation system will not decrease sulfate concentrations but it will increase the hardness of the discharge by adding dissolved calcium. The test design includes raw MIW and pre-treated MIW as influent to the SRBRs.

The primary reactions that remove aluminum and iron from the water generating proton acidity are:

(i.) precipitation of metal hydroxides

$$Me^{3+}{}_{(aq)} + 3H_2O_{(l)} \rightarrow Me(OH)_{3(s)} + 3H^+{}_{(aq)}$$

To reduce the acidity of the water generated from the metal hydroxide precipitation, limestone is consumed based on the following general reaction:

(ii.) acid-consuming reaction with limestone

$$CaCO_{3(s)} + H^+{}_{(aq)} \rightarrow Ca^{2+}{}_{(aq)} + HCO_3^-{}_{(aq)}$$

3. What is the metal removal efficiency of the SRBR columns?

The effectiveness of an SRBR is primarily determined by its ability to remove metals from the MIW. This is true for lab-scale columns as well as a full-scale system. Therefore, the consistent removal of potential COCs (Table 3-1) to concentrations below applicable regulatory criteria and standards is the foremost quantifiable metric of treatment success. For this treatability study, effluent water samples will be collected from SRBRs on a weekly basis and analyzed for specific constituents (see Section 4.2 and Table 4-2). Results from these analyses will be compared to regulatory criteria and standards, as well as to influent water chemistry. The change in chemistry between the influent and effluent waters will serve as the basis for calculating metal removal efficiency for each constituent and column.

4. How is the magnitude of sulfate reduction in the SRBR columns measured?

   The precipitation of metal sulfides following microbial sulfate reduction is the primary means of metal removal within a SRBR. Therefore, understanding the degree of sulfate reduction within the reactors provides valuable insights as to the overall effectiveness of the reactors. So long as the amount of sulfate reduced to sulfide (i.e., sulfate load) exceeds the metal loading, which is the case here (Appendix D), then biological sulfate reduction will be sufficient (Appendix I). As such, the following metrics will be used to assess the extent of sulfate reduction.

   A change in sulfate concentration between SRBR influent and effluent is the most direct measure of sulfate reduction within the reactor and is therefore a second measure of treatment system performance. The sulfate reduction rate can be calculated using the influent and effluent sulfate concentrations, the system flow rate, and the substrate mass and volume.

   An increase in alkalinity is another indicator of sulfate reducing bacterial activity because bicarbonate alkalinity is a by-product of the sulfate reduction metabolic pathway. However, this alkalinity can be difficult to distinguish from that of limestone dissolution (limestone being part of the SRBR substrate mixture). Generally, constant or slowly decreasing alkalinity measurements can be attributed to limestone dissolution whereas punctuated increases in alkalinity may point to biological activity.

5. What are the chemical-specific discharge requirements that must be met in order for the SRBR to be considered effective?

   The principal measure of effectiveness will be whether or not the SRBR can meet regulatory water quality criteria and standards. In this case and for the purposes of this treatability study only, the applicable target values are set forth in the *Montana DEQ Water Quality Bureau Bulletin 7 (DEQ-7, 2017)* aquatic life criteria and human health drinking water standards. These values are provided in Table 3-1.

Table 3-1. Montana Water Quality Standards and Historical Characterization of the Danny T Mine Adit Water Chemistry.

Parameter	Concentration (µg/L)				
	Aquatic life		Human Health	Range of Historical Values	Potential COC
	Acute	Chronic			
Aluminum	750	87	n/a	7,980 – 16,200	Y
Antimony	n/a	n/a	5.6	0.28 – 2.00	N
Arsenic	340	150	10	93 – 400	Y
Barium	n/a	n/a	1,000	3.8 – 7.3	N
Beryllium	n/a	n/a	4	4.9 – 20.0	Y
Cadmium*	1.9	0.8	5	154 – 316	Y
Chromium*	1,803	86	100	2.5 – 6.1	N
Copper*	14	9.3	1,300	432 – 2.160	Y
Iron	n/a	1,000	n/a	95,900 – 184,000	Y
Lead*	82	3.2	15	121 – 287	Y
Manganese	n/a	n/a	n/a	73,300 – 128,000	N
Mercury	1.7	0.9	0.05	ND	N
Nickel*	469	52	100	17.9 – 53.9	Y
Selenium	20	5	50	2.5 – 6.6	Y
Silver*	4.1	n/a	100	0.06 – 1.00	N
Thallium	n/a	n/a	0.24	1.4 – 2.6	Y
Zinc*	120	120	2,000	42,000 – 69,100	Y
pH (surface water)	between 6 and 9			2.40 – 3.32	

All values are dissolved concentrations in µg/L, except for pH (s.u.).
Historical values are from Table 2-1 and were provided by the EPA.
Potential COC: Y=Yes; U= Unknown; N=No
Water Quality Standards are based on Montana DEQ-7, 2017.
n/a - No standard available
ND = Non-Detect
Single range values indicate a single data point
*Standard shown calculated at a hardness of 100 mg/L as $CaCO_3$

6. What post-treatment steps are necessary for effluent from the passive bioremediation system to be discharged from the Mine?

   While biochemical oxygen demand (BOD) and Mn are not regulated by DEQ (DEQ-7, 2017), their treatment is considered important in order to meet the overall goal for this treatability study: improve the quality of Danny T Mine Adit discharge. Treatment wetlands are frequently implemented after SRBRs, particularly when the MIW to be treated contains Mn. Wetlands can aerate SRBR effluent thereby reducing sulfides and BOD, and increasing dissolved oxygen. Wetland processes also promote settling of residual suspended solids and recalcitrant COCs and other elements, such as Mn. SRBR'S are generally ineffective in treating Mn so additional technologies may be incorporated to target Mn removal because of the elevated concentrations (73,300 – 128,000 µg/L; Table 2-1) previously documented in the MIW.

Vertical flow (VF) wetlands distribute water across the surface of a sand and gravel bed planted with wetland plants. Water is treated as it percolates downward (vertically) through the plant root zone and substrate media. The wetland will serve the primary function of reducing BOD—a common by-product of SRBRs—and increasing DO and ORP, thereby creating the conditions necessary for Mn oxidation. The treatment testing that will be accomplished during this study will determine whether BOD and Mn can be reduced using wetlands. However, because these constituents (BOD and Mn) are not regulated the decision to implement a wetland will be decided by the USEPA Remedial Project Manager and Mt. Emmons.

7. What are the effects of seasonal weather changes on treatability?

   Seasonal weather changes are not anticipated to play a significant role in the lab-scale evaluation, which is to take place in a controlled environment in southern Arizona. However, Mine-specific weather conditions may become relevant should EPA, in consultation with Mt. Emmons, determine installation of a full scale SRBR is appropriate. In that case, consideration must be given to colder temperatures during winter months, which depress microbial (sulfate-reducing) activity. While replicating site environmental conditions in the lab is not practical for this study, further evaluations of the viability of this technology at the Mine will require further consideration of design strategies for mitigating freezing temperatures. Specifically, bioreactors constructed in cold climates (see Appendix I for examples) can be designed and constructed to maintain internal temperatures above freezing using, for example, thermal insulation covers and below-ground construction techniques, but which is beyond the scope of this study.

   Discharging SRBR effluent within the media bed of a full-scale, post-treatment VF wetland reduces the likelihood of freezing as heat transfer from water to the air is greatly reduced through the media relative to an open water surface. Adding a 'thermal blanket' in the form of a layer of mulch at least 6 in. deep on top of the sand and gravel bed will contribute additional heat retention during winter months. This increases the total heat retention beyond that already offered by standing dead biomass, litter, and snow trapped in the senescent vegetation growing in the wetland. Maintaining temperatures above freezing improves the removal success of Mn through biologically-mediated oxidation. BOD treatment efficiency within a full-scale system is expected to vary with outside temperature fluctuations at the Mine but it is beyond the scope of this study.

8. How sensitive is SRBR treatment effectiveness to potential changes in influent water chemistry?

   Treatment effectiveness can be influenced by changes in water chemistry due to increases in sulfate or metal concentrations (i.e. loading). Generally, the design of a SRBR incorporates a sufficient operational safety factor with respect to substrate reagents and flow retention time to allow for changes in water chemistry. However, potential changes in influent water chemistry are not anticipated to play a significant role in the lab-scale evaluation, which is to take place in a controlled environment. The influent water for this lab-scale investigation is to come from a large volume sample of Mine MIW collected during a single sampling event at the outset of the treatability study. The collection of the water sample will be conducted in a manner such that minimal aeration occurs which might alter the iron solubility. If the pH of the aqueous remains below 3.0 then it can be assumed that iron precipitating out of solution due to oxidation will not be an issue. In addition, acidity of the water will not likely change from the precipitation of a small amount of Fe. MIW will be stored in approximately 20 sealed, locked 55-gallon barrels, which will be used one at a time to feed the reactors. During operation, the unopened barrels will be held in cold-storage at a secure facility in Tucson, Arizona with bung locks and custody seals secured until use. Each barrel will be logged in the project laboratory notebook and sampled as it is opened, and the new feed sample will be given a numeric identifier based on the individual sample number assigned to each barrel during initial filling. Influent water chemistry will be characterized according to the sampling schedule established for the columns in Section 4.2.1, allowing for the monitoring of changes in water chemistry. Ultimately, the focus of this study's assessment of performance is the differential between influent and effluent chemistry (i.e., treatment efficiency), with minor changes in chemistry following sample collection not expected to dramatically alter results.

While addressing design criteria for a full-scale system is beyond the scope of this study, we will briefly discuss potential changes in treatment effectiveness at the Danny T Mine. During the spring freshet, metals and sulfate should both be equally diluted while the ratio between them should remain relatively similar. Therefore, there should be no impact on SRBR performance from seasonal dilution specifically. More critical is contact time and avoiding excessively high flow rates that reduce HRT or flush out SRBs. Should sulfate levels decrease, microbial populations may also decrease but only until sulfate loadings rebound. A full-scale system would be designed to accommodate the seasonally variable flow rates previously observed at the Danny T Mine (CDM Smith 2016).

9. What SRBR hydraulic retention time (HRT) is necessary for effective treatment of the Mine's water during this treatability study?

   The HRT, or average length of time that water remains within SRBR columns and therefore subject to treatment, was calculated based on substrate mass and volume, anticipated flow rates, and substrate porosity. This evaluation will begin using the flow rate reported in Section 4.1.1. However, the initial flow rate may be adjusted in response to changes in effluent water chemistry. Specifically, if sulfate reduction appears to be occurring and effluent metal concentrations are below the target thresholds, then flow rates may be increased. Beginning low and then increasing the flow rate potentially allows for optimization of the SRBR design, while avoiding potential impacts on SRBs from beginning with a higher flow rate and then having to decrease it. Ultimately, a higher sustained flow rate potentially translates to a smaller footprint and lower capital and maintenance costs for the final design of a passive bioremediation system installed at the Mine.

10. What inoculation time is needed to prepare the SRBR for continuous flow conditions?

    During SRBR start-up, a period of no-flow is recommended in order to culture a substantial population of sulfate-reducing bacteria within the reactor. This will also ensure that the sulfate-reducing bacteria are not washed from the SRBR prior to establishing colonies within the substrate. While MIW remains stagnant in the reactor, weekly water ORP measurements will be taken. When the SRBR columns attain reducing conditions, which is estimated, based on prior testing conducted by FMC, to occur after 2 – 3 weeks, flow-through conditions will commence as detailed in Section 4.1.1.

11. What is the longevity of a full-scale SRBR?

    It is difficult to ascertain the lifetime of any given SRBR due to variations within the substrate materials and environmental conditions, including changes in quality of water to be treated. Full-scale SRBR longevity has previously been estimated at 20 or more years based on the assumption that the total organic carbon (total carbon minus total inorganic carbon) of a substrate will be degraded and used by microbes in a SRBR (e.g., Sheoran, et al., 2010). Generally, substrate longevity is inversely proportional to inflow metal loading and acidity. Results from this evaluation, including metal removal rate and sulfate reduction rate, will provide information that can be used to size a full-scale passive bioremediation system. Based on the acidity of pre-treated Danny T MIW (670 mg/L as $CaCO_3$), influent oxygen considerations, and prior lab-scale and pilot-scale test results, a full-scale SRBR is predicted to last at least ten years. However, this treatability study will not directly address the efficiency of SRBRs throughout its life cycle. Instead, Mt. Emmons will monitor changes in multiple parameters, which are discussed in greater detail in Section 4.1 and Appendix D, as metrics of performance throughout the duration of the project.

3.1.4. Boundaries of the Study

The statistical population of interest for this treatability study consists of the aqueous chemical and physical parameters for MIW collected from the Mine Adit during summer of 2017. The lab-scale tests will be conducted at the Environmental Technology Laboratory in Tucson, Arizona. The laboratory evaluation (i.e., treatment testing phase) will last approximately 12 months (Table 1-2). Laboratory sampling and analysis will be conducted as outlined in Section 4.2.1 (Sampling). Resulting data will be verified and evaluated as they are received. Findings from the study will be provided in an electronically-formatted final report to be issued approximately three months after the end of the treatability testing phase of the project (Table 1-2).

3.1.5. Analytical Approach

A quantitative assessment of treatability will be based on a variety of aqueous chemical and physical parameters, including total and dissolved metal concentrations, acidity, alkalinity, anion concentrations, BOD, pH, ORP, EC, DO, and temperature. Chemical parameters will be quantified by ACZ Labs. Measurements of field parameters will be performed in the lab using a multi-parameter meter.

3.1.6. Performance or Acceptance Criteria

Data validation procedures will be used to ensure that analytical results are within acceptable limits for decision making. All data will be verified. Precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS) parameters will be assessed throughout the treatability study. Significant issues with the data will be discussed with the EPA, who will then decide if it impacts their decision-making ability.

3.1.7. Plan for Obtaining Data

The experimental design (including field and laboratory sampling program) of the treatability study is presented in Section 4. The project will be managed based on lessons learned from previous professional experience and is subject to continual improvement.

3.2. Overview of Testing Strategy

A detailed discussion of the lab-scale treatability study strategy is included in Section 4 and so it will only be briefly discussed here. MIW will be collected from the Mine and fed through a series of SRBRs located at the ETL in Tucson, Arizona. Treatment strategies to be evaluated were selected with the intent of optimizing metal and sulfate removal efficiency. The resulting data will serve to support decision making regarding the feasibility of a full-scale treatment system. All laboratory evaluations will follow the QA/QC procedures outlined within this Work Plan.

3.2.1. Mine Access

Mt. Emmons does not own property or patented mining claims on which the Danny T Mine is located. It also does not have authorization from the owners of the Danny T Mine to access the Danny T Mine or take samples. However, EPA has authority and may provide escorted access to the Danny T Mine and obtain the samples required for this treatability study. Additionally, weather conditions may temporarily hinder safe access. In the event of inclement weather conditions, an alternate sampling schedule will be implemented.

3.2.2. Mine Water Discharge Data Collection

MIW discharging from the Danny T Mine Adit will be sampled in duplicate during the water collection Mine visit. The samples will be analyzed for total and dissolved metals and metalloids, anions, and field parameters (Table 4-3), including all elements on EPA's Target Analyte List. These analyses will provide an updated characterization of the water to be treated, which will be the basis of an evaluation of potential changes to water quality at the Mine versus that at the lab.

3.2.3. Danny T Mine Adit MIW Collection

MIW will be collected once the Mine is accessible by the Project Team with EPA oversight. Final approach to water collection and sampling will be finalized after the initial site reconnaissance visit. A possible approach to water collection is to direct water from the adit to a weir and install a pipe to transfer into a temporary small holding pond. The water can then be pumped into approximately 20 55-gallon barrels and moved to trucks using a barrel dolly depending on site conditions. The barrels will be sealed, locked, and transported to Tucson, Arizona under chain-of-custody. Mine location, sampling logistics, and condition and operability of a weir previously placed at the Mine by the EPA will be finalized during the initial reconnaissance trip. If possible, existing water collection and transference equipment may be used if they remain in operable condition. Site location and sampling logistics will be finalized during the initial reconnaissance trip.

3.2.4. Field Changes

It may become necessary to implement minor modifications to MIW sampling as presented in this Work Plan. When appropriate, the EPA Remedial Project Manager will be notified and a verbal and written approval will be obtained before implementing the changes. Modifications to the approved plan will be documented in the final treatability study report.

4. Methods and Procedures

This section describes activities to be performed during this treatability study, including process flow and implementation procedures, sampling and analysis, equipment and supplies, equipment decontamination, management of waste, and sample labeling and identification.

The lab-scale treatability study will be performed at the ETL in Tucson, Arizona under the direct guidance of the Project Lead and Laboratory Supervisor. The ETL will utilize EPA-approved SOPs, which are provided in Appendix A. Prior to beginning work, those involved with the study will meet to review the Work Plan and SOPs. Management (Project Lead and Laboratory Supervisor) will provide any required task and or safety training relevant to the Work Plan and SOPs. A record of the meeting(s) and training, along with any preparation and calibration work, will be archived in the project file. Throughout the course of the project, Management will assess the work being performed, ensuring that it is pursuant to the Work Plan and the approved planning and technical documents listed below.

SOPs relevant to the treatability study are presented in Appendix A and include:

- *ETL-MT-01-Measurement of pH of Aqueous Samples by Thermo Scientific VERSA STAR Meter*
- *ETL-MT-02-ORP Measurement by Thermo Scientific VERSA STAR Meter*
- *ETL-MT-03-Electrical Conductivity (Specific Conductance) Measurement by Thermo Scientific VERSA STAR Benchtop Meter*
- *ETL-MT-04-Dissolved Oxygen Measurement by Hach HQ30d LDO Meter*
- *ETL-MT-05-Field Water Sampling*
- *ETL-MT-07-Continuous Electrochemical Measurement*
- *ETL-MT-08-Data Entry, Validation, and Maintenance*
- *ETL-MT-09-Passive Bioremediation System Operation*
- *ETL-MT-10-Notebook and Photographic Management*

4.1. Process Flow Design and Implementation Procedures

This section details the lab-scale process flow design and implementation procedures including: MIW collection, conveyance, and storage; treatment system (pre-treatment; SRBR; and post-treatment design); and treatment system operation. A process flow diagram is shown in Figure 4-1.

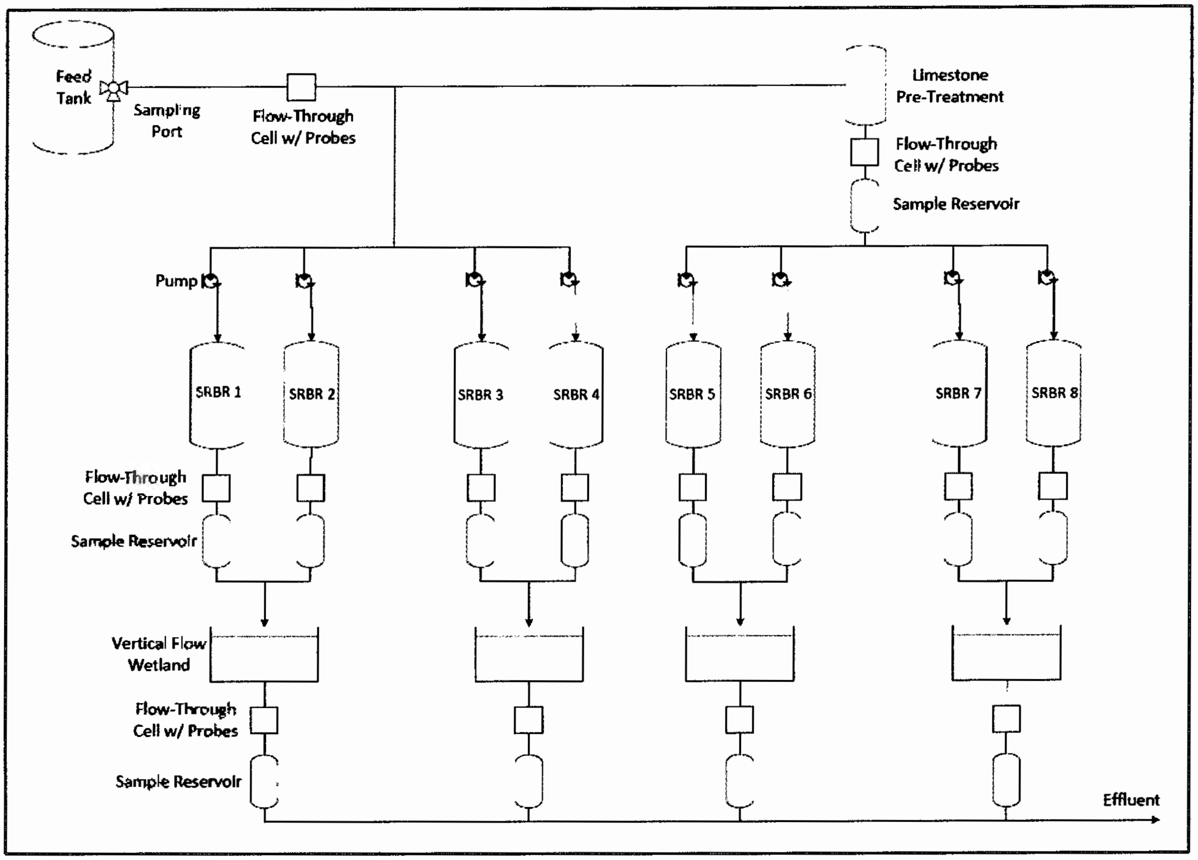

Figure 4-1. Process flow diagram for the treatability study.

4.1.1. System Flow Rate and Retention Time

The calculations underlying the design basis for this treatability study are detailed in Appendix D and will only briefly be discussed here. Flow rate of MIW through SRBRs is a critical factor in their design and evaluation of a treatment system's performance. Hydraulic retention time (HRT) is directly proportional to porosity and inversely proportional to flow rate:

$$HRT = \frac{V_p}{Q} = \frac{V_b - V_s}{Q}$$

where,

HRT= Hydraulic retention time [day]
V_p = pore volume [L]
V_b = substrate bulk volume [L]
V_s = substrate volume [L]
Q = flow rate [L/day]

As detailed in Appendix D, the recommended starting flow rate for the pre-treatment limestone reactor is 4.0 L/d, with a resulting HRT of 3.4 d (Table D-6). Starting flow rates for the SRBR columns receiving water that was and was not pre-treated are 1.0 and 0.9 L/day, respectively. The associated HRTs are 5 and 23 d, respectively (D-2 to D-5, respectively). The Project Team will characterize the Danny T Mine MIW collected and it is possible that starting flow rates may be modified according to system performance. ORP and metal and sulfate removal rates will be used to gauge whether or not flow rates should be increased or decreased. For example, ORP becoming positive and/or sulfate reduction rates decreasing would indicate that sulfate reduction is not being maintained and therefore flow rates should be decreased.

4.1.2. Influent MIW Collection, Conveyance, and Storage

MIW will be collected in the summer of 2017 by Project Team employees with oversight from the EPA RPM and/or his designee, once the AOC has been executed, the Work Plan has been approved, and the Mine is accessible. Water will be collected in approximately 20 55-gallon high density polyethylene (HDPE) barrels, which will be sealed and locked using bung locks and custody seals prior to transport back to Tucson, Arizona. Barrels will be filled to the top to mitigate sloshing and aeration. Based on the initial Mine assessment, the method to collect the water will be set up to provide sufficient depth of water in order to pump efficiently. This may be as simple as using the existing weir with a 2 – 3" PVC collection pipe inserted through the base of the weir and the outlet placed downhill if sufficient gradient exists. The outlet can be placed over a stock tank or other suitable reservoir to fill and allow pumping as the water flows in. Once sufficient water is collected, the flow path will be returned to the previous state by removal of the collection pipe and weir material. Alternatively, a small, temporary sump can be dug in the flow path of the solution stream of sufficient depth to insert a pump. Pumping would not commence until at least 24 hours later to allow for the settling of sediments. The pump will also be set at a rate less than the refill rate of the sump in order to pump the water out without cavitation and be kept relatively low to minimize agitation of the MIW. Once completed, the sump can be back-filled and the well pump will be decontaminated with a 5% Alconox solution and rinsed with copious amounts of DI water. Whatever sample collection method is selected, care will be taken to ensure that minimal solids/sediments are collected.

If the Mine conditions allow, the pump tubing may be ran to the location where the barrels are staged on the trailer. Otherwise, the barrels can be filled at the point of collection and a drum dolly or other suitable equipment for moving the barrels will be used to move them near the trailer. Once at the trailer, the water will be pumped into barrels already secured to the trailer.

Transportation of the collected MIW from Montana to Tucson will be completed using a DOT-certified, commercial hauling company. Barrels will be held in cold-storage at a secure facility in Tucson until ready for use. Bung locks and custody seals will remain in place until each drum is opened as needed. They will be opened one barrel at a time and used to supply MIW to the lab-scale SRBR columns. A pipe manifold will be set up from the barrel and peristaltic pumps will be used to continuously feed water from the barrel to the influent port at the top of the pre-treatment reactor and each SRBR column.

4.1.3. Pre-Treatment of Mine MIW

Under normal passive treatment system operations, elevated concentrations of aluminum and ferric iron in MIW may result in clogging within SRBRs due to precipitation of aluminum and iron hydroxide and oxide minerals. This fouling may render the SRBR less effective, require increased levels of maintenance, and shorten the longevity of the treatment system. Danny T Mine Adit MIW can contain up to 16,000 μg/L of aluminum and 184,000 μg/L of iron (Table 2-1). Therefore, it is important to evaluate the effectiveness of, and need for, pre-treatment. SRBRs will therefore be operated with and without pre-treatment, and this section details the operation of the pre-treatment columns.

In order to evaluate the effectiveness of pre-treatment, the Project Team will operate one pre-treatment reactor packed with limestone, which will feed four of the SRBRs. The pre-treatment reactor will be fabricated using a PVC column measuring 42" tall by 8" diameter. The reactor will be packed with 38 Kg (30 L) of limestone (1 – 1.5" diameter), which is equivalent to a 36" tall limestone bed (Figure 4-2). The amount of limestone bed volume required was calculated based on 4.0 L/day flow rate (Table D-5) and an acidity loading rate of <2 mmol acidity/L of limestone/day, which was derived from previous limestone column tests performed by the Team (Appendix D and I). Water level will be maintained at 2" above the top of the limestone bed with an additional 4" of freeboard above the standing water. The reactor will be capped with a rubber lid. The pre-treatment reactors will be operated in down-flow mode. Down-flow mode was chosen to mimic full-scale system operation without power or sufficient head for an up-flow design.

Performance of the limestone pre-treatment reactor will be monitored along with other system components. Armoring of the limestone substrate is likely to occur over time and it will be replaced when the reactor cannot maintain an effluent pH of >4.5 or Al and Fe removal efficiency markedly declines. The resulting sludge will be characterized using the Toxicity Characteristic Leaching Procedure method and managed accordingly. Time to replacement will be quantified throughout the project and used to make recommendations for full-scale design in the final report.

Pre-treatment reactor effluent and influent MIW will be directed through an inline flow-through cell for routine monitoring of key water chemistry parameters. Each flow-through cell will have the designated electrodes installed according to Section 4.2.1. Immediately after each column's flow-through cell, a covered, graduated sample reservoir of 3 L capacity will be installed. This reservoir will be used to collect composite samples for analyses during sampling intervals to monitor aluminum and iron removal efficiency. The reservoir will be designed for flow-through operation to allow effluent to flow unimpeded during normal operations into a collection bucket.

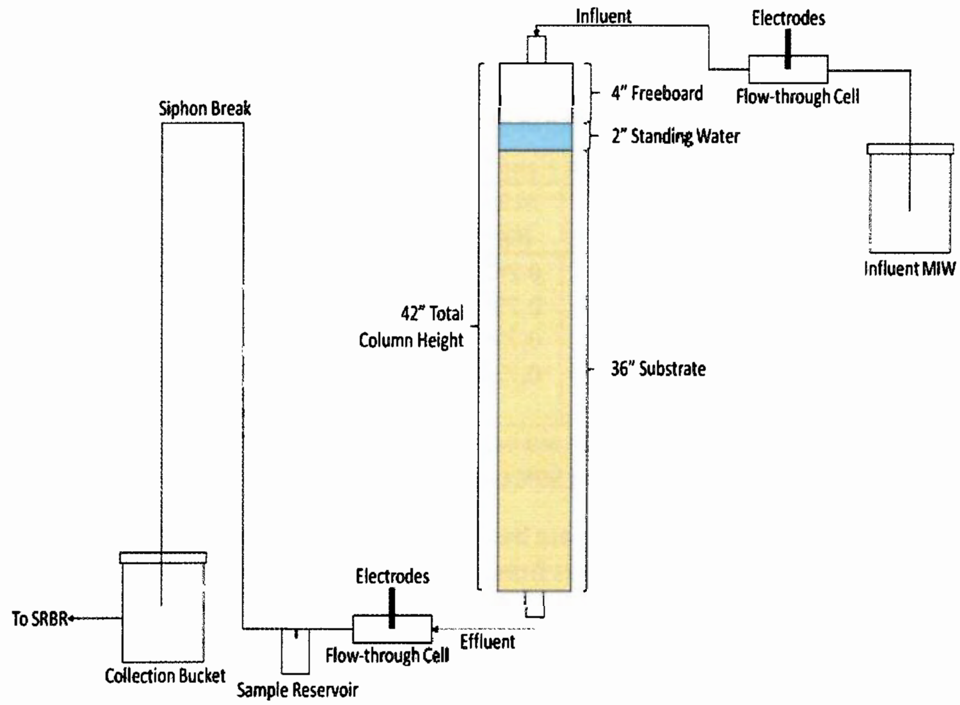

Figure 4-2. Schematic of the limestone column to be used in the treatability study.

4.1.4. SRBR Treatment of Mine MIW

MIW collected from the Danny T Mine will be fed directly into each of four SRBRs without first receiving pre-treatment. These SRBRs will be constructed from 8" diameter PVC pipe fashioned into 46"-tall columns (Figure 4-2). The bottom 4" of the column will be filled with pea gravel (for increased hydraulic conductivity at the effluent port), followed by 36" height of substrate mixture, and finally at least 2" of MIW at the top (inflow side of the column) will be maintained during operations.

The other four SRBRs, which receive pre-treated influent, will be smaller and constructed from 4" diameter PVC pipe fashioned into 46"-tall columns (Figure 4-2). The bottom 4" of the column will be filled with pea gravel (for increased hydraulic conductivity at the effluent port), followed by 36" height of substrate mixture, and finally at least 2" of MIW at the top (inflow side of the column) will be maintained during operations. The remaining 4" of column height will remain open.

All SRBRs will contain a mixture of labile and recalcitrant carbon sources, which serve as electron donors for the sulfate-reducing bacteria, as well as limestone as an alkalinity source. Additionally, a small amount of manure will be initially added to the reactor as an inoculant to stimulate biological colony growth. Substrates to be evaluated are shown in Table 4-1. The mass of each substrate component will vary as a function of water content and substrate particle size. Therefore, the mass shown in Table 4-1 is an approximate starting value and will likely change once columns are filled. The final mass of substrate component will be recorded in project logs and provided in the final report.

Table 4-1. Proposed Feed Solution and Substrate Composition for Lab-Scale Sulfate-Reducing Bioreactors (SRBRs)

Substrate	Particle Size (inch)	Danny T Mine Adit water following pre-treatment				Danny T Mine Adit water without pre-treatment			
		SRBR 1 and 2		SRBR 3 and 4		SRBR 5 and 6		SRBR 7 and 8	
		wt %	mass (Kg)	wt %	mass (Kg)	wt %	mass (Kg)	wt %	mass (Kg)
Alfalfa hay	< 4	10	0.245	10	0.259	10	0.98	10	1.04
Woodchips and Sawdust†	0.5 – 1.5	30	0.735	10	0.259	30	2.94	10	1.04
Walnut shells	1	30	0.735	50	1.260	30	2.94	50	5.04
Limestone	0.2	30	0.735	30	0.777	30	2.94	30	3.11
Manure	As is								

Note: Values are provided in dry weight (wt)% and estimated mass.
†Woodchips and Sawdust: 50% Douglas fir and 50% Lodgepole pine

The substrates selected and their proportions are based on prior studies conducted by FMC (Appendix I) and the literature. The proposed mixture differs from prior studies conducted at the site because FMC is not constrained to using locally-available materials and can therefore select components that have previously been found to perform well. The manure and alfalfa hay provide labile sources of carbon for the consortium of microbes that develop as the systems reach stable treatment conditions in the near-term. Alfalfa hay, for example, contains more than twice as much of the bioavailable cellulose than recalcitrant lignin (Meneses, et al. 2012, Sarkar, et al. 2014), which is not bioavailable.

The walnut shells and wood chips contain similar or greater amounts of cellulose (Mitchell and Ritter 1934, Mendu et al. 2011) than alfalfa hay and serve as long-term carbon sources. FMC found that walnut shells can also support sulfate reduction and metal removal in SRBRs more than other substrates in a previous column test (Appendix I). For example, a walnut shell-based SRBR (70% walnut shells plus 30% limestone by weight) removed 170 mg/L of zinc to below the detection limit after 6 days contact time, while a ponderosa pine-based SRBR removed the same amount of zinc after 14 days contact time. The walnut shells and woodchips also provide structural support to maintain hydraulic conductivity. Sawdust is provided to enhance particulate capture by filtration. With time, the more recalcitrant carbon sources are broken down by fermentative and methanogenic bacteria, releasing bioavailable carbon which is utilized in latter months and years of SRBR operation.

As is general industry practice, all FMC SRBRs contain limestone to neutralize acidity of MIW. The added alkalinity also buffers the system's pH to a range that is hospitable to sulfate-reducing bacteria—pH 6.0 to 9.0. In time, the effectiveness of limestone will deteriorate as it becomes armored with iron precipitation. However, this loss of limestone alkalinity is mitigated by carbonate and bicarbonate alkalinity generated during the reduction of sulfate to sulfide (Section 3.1.3).

All column effluents will be directed through an inline flow-through cell for routine monitoring of key water chemistry parameters. Each flow-through cell will have the designated electrodes installed according to Section 4.2.1. Immediately after each column's flow-through cell, a covered, graduated sample reservoir of 3 L capacity will be installed. This reservoir will be used to collect composite samples for analyses during sampling intervals. The reservoir will be designed for flow-through operation to allow effluent to flow unimpeded during normal operations into a collection bucket.

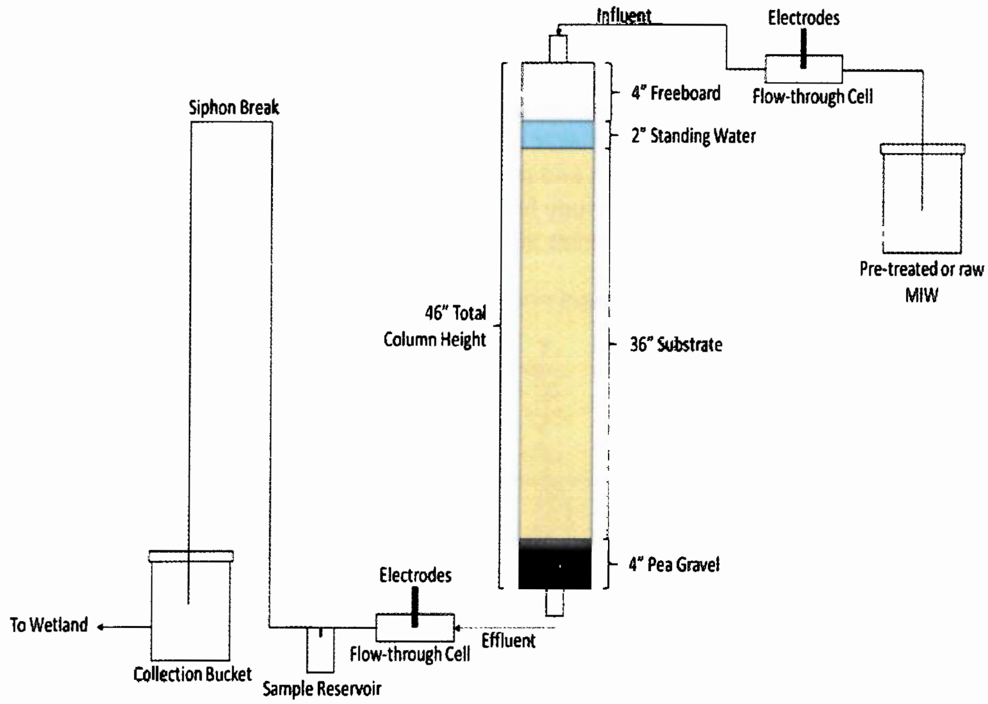

Figure 4-3. Schematic of the SRBR columns to be used in the treatability study.

4.1.5. Post-Treatment of Mine MIW

The final stage of the passive treatment system under evaluation is a containerized vertical flow treatment wetland (VFWs) for removing BOD and Mn. Vertical flow wetlands distribute water across the surface of a gravel bed planted with wetland vegetation and are characterized by downward percolation, ideally in unsaturated flow. Wetland plants promote an environment conducive to microbes that passively treat water, and root systems help maintain hydraulic conductivity of the media. This type of wetland has the added advantage of maintaining activity during the winter because water is distributed below the surface of the topmost media, thereby maintaining temperatures above freezing (Kadlec and Wallace, 2009), which would be critical for any full-scale system to be considered for the Mine.

The sizing of constructed treatment wetlands designed to treat MIW depends upon the loading rate of constituents to be removed. The general rule-of-thumb for sizing a wetland to remove Mn is 1 – 2 g of Mn removal/m^2/d (Hedin and Nairn, 1993, Skousen, 1997, Watzlaf et al., 2004). This sizing criteria is based upon estimates of contaminant removal from a diversity of treatment wetlands designed and constructed to remove Mn. More conservative sizing criteria have been proposed for treatment systems designed to meet regulatory requirements—0.5 g/m^2/d (Watzlaf et al., 2004). However, a sizing criteria equal to 1 g of Mn removal/m^2/d was selected because DEQ does not regulate Mn for surface waters (Table 3-1).

The dissolved concentration of Mn in the water used as the basis for design is 104,000 µg/L (Table 2-1 and Appendix D) and the lab-scale treatment system was designed to receive a flow rate of 1 L/d. Assuming a target effluent concentration of 2,000 µg/L and the sizing rule of 1 g Mn removal/m^2/d, the recommended total size of the wetland to treat 104,000 µg Mn/L is 1.2 ft^2. Incorporating a safety factor of 1.5 increases the wetland size required to 1.8 ft^2. Four wetlands will receive effluent from each replicate pair of SRBRs (Fig. 4-1), therefore doubling the size of wetland area required to 3.6 ft^2. Additional calculation details are provided in Appendix D.

Treatment wetlands will contain up to 16 in. depth of media with finer-grained materials used in the upper layers and progressively coarser materials in the lower layers (Figure 4-3). Coarse sand is recommended for the topmost 6 – 8 in. to ensure sufficient water storage capacity in the zone of primary root penetration, and to promote even distribution of effluent over the entire surface area. Media in deeper layers will consist of a single layer of 0.2 – 0.5 in. round, washed gravel. Water will be evenly distributed across the top of the VFWs and collected at the bottom via an underdrain system. Mulch will not be utilized in this treatability study because it does not directly contribute to water treatment—it merely serves as a thermal blanket in full-scale systems.

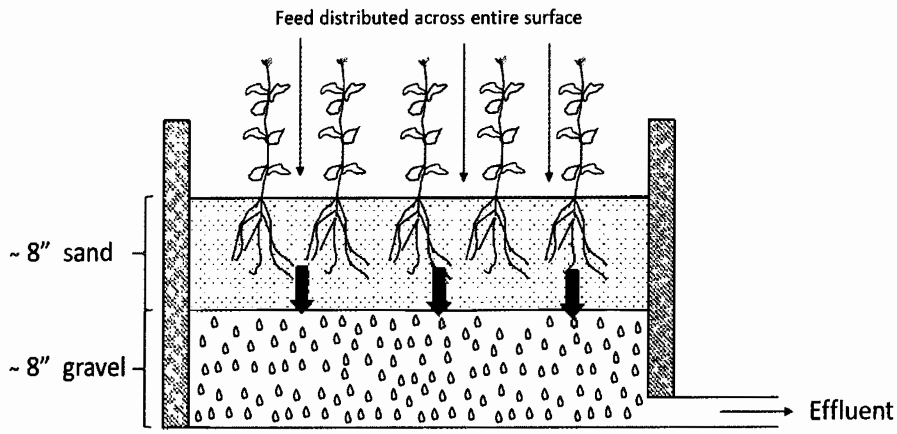

Figure 4-4. Schematic of treatment wetland to be used in the treatability study.

Wetlands will be populated with no more than two species of emergent wetland plants native to the Little Belt Mountains. Emergent wetland plants used in treatment wetlands are relatively well-studied and generally known to stabilize metals in their below-ground biomass. They are also more effective in trapping snow than other wetlands plant types (Kadlec and Wallace 2009). The final selection of plant species to be used will depend upon their availability from suppliers, but will likely include some of the species listed in Table 4-2. Because emergent wetland plants serve as a minor repository for Mn in treatment wetlands (Kadlec and Wallace 2009), they will not be evaluated for metal uptake in this treatability study.

Table 4-2. Wetland Plants for Potential Use in Treatment Wetlands.

Common name	Scientific name
Water sedge	*Carex aquatilis*
Northwest Territory sedge	*Carex utriculata*
Longstyle rush	*Juncus longistylis*
Broadleaf cattail	*Typha latifolia*
Bluejoint reedgrass	*Calamagrostis canadensis*
Tufted hairgrass	*Deschampsia caespitosa*

These species have been documented occurring in the Little Belt Mountains.

Wetland effluent will be directed through an inline flow-through cell for routine monitoring of key water chemistry parameters. Each flow-through cell will have the designated electrodes installed according to Section 4.2.1. A covered, graduated sample reservoir of 3 L capacity will be installed immediately after each flow-through cell to collect composite samples for analyses during sampling intervals. The reservoir will be designed for flow-through operation to allow effluent to flow unimpeded during normal operations into a collection bucket.

Operating the treatment wetlands in an arid climate may lead to elevated evapotranspiration rates that are greater than what would be experienced at the BHMD Superfund Site. Elevated evapotranspiration rates in the wetlands may then lead to increased concentration of residual CoCs. This effect will be mitigated, however, with the use of an evaporative cooler in the project area that will maintain humidity. Humidity will also be monitored throughout the project's duration. Ultimately, so long as CoC concentrations decrease and meet study objectives, the system is functioning and overcoming evaporation-related increases in concentration.

4.1.6. Test Start-Up

Pre-treatment limestone reactors will be dry-packed with limestone as detailed in Section 4.1.3. The columns will be filled with Mine MIW through the top/influent port (i.e., down-flow) until they are saturated.

The SRBRs will be dry-packed with the pea gravel and organic substrate mixture as detailed in Section 4.1.4. The columns will then be filled with Mine MIW through the bottom/effluent port (i.e., up-flow) until they are saturated. Additional pre-mixed substrate may be added to offset compaction during this initial saturation step in order to maintain adequate substrate height within the column. Using pre-mixed substrate reduces the risk of stratifying the material within the column. The total mass of substrate material within each SRBR column will be recorded.

During SRBR start-up, a period of no-flow is recommended in order to culture a substantial population of sulfate-reducing bacteria within the reactor. This will also ensure that the sulfate-reducing bacteria are not washed from the SRBR prior to establishing colonies within the substrate. While MIW remains stagnant in the reactor, weekly water ORP measurements will be taken. When SRBR columns attain reducing conditions, which is estimated, based on prior testing conducted by FMC, to occur after two to three weeks, flow-through conditions will commence. Should SRBR columns not attain reducing conditions after four weeks then they will be re-inoculated with manure. Columns will be staggered and started once they reach reducing conditions, with duplicates starting simultaneously. The columns will operate in down-flow mode during normal operations throughout the remainder of the study. Down-flow mode was chosen to mimic full-scale system operation without power or sufficient head for an up-flow design.

Post-treatment wetlands will be constructed first to allow plants to become established for several weeks prior to receiving SRBR effluent. During this time, plants will be routinely provided with potable water and plant nutrients to promote root growth and plant establishment. Once treatment system operation is started, no potable water or nutrient solution will be added to the wetlands.

4.2. Sampling, Analysis and Maintenance

Each stage of the lab-scale treatment system will be sampled regularly, with daily maintenance inspections and thrice-weekly calibrations of flow-through cell instruments, as detailed below.

4.2.1. Sampling

During initial MIW collection from the Mine, samples will be collected for characterization of water chemistry as described in Section 3.2.2 and Table 4-3. During the treatability study, characterization of Mine MIW within each of the barrels will be completed as they are opened.

In addition to the characterization sample analyses mentioned above and outlined in Table 4-3, a separate set of duplicate samples will be collected during initial water MIW collection, without preservative, allowed to equilibrate with the atmosphere for a minimum of six hours, and then submitted for analysis for both the total and dissolved phases. Not preserving the sample and allowing it to equilibrate with air will allow the water chemistry to adjust, based on exposure to oxygen, and provide information on what changes in water quality might be observed in the MIW barrels after opening. Plus a duplicate set of samples will be collected and analyzed for iron speciation to determine ferrous and ferric concentrations as well as provide an understanding of the oxidation-reduction state of the MIW at the time of collection. Sampling logistics will be finalized during the initial reconnaissance trip.

Water samples will not be collected from any treatment stage during the start-up phase. During flow-through (normal) operations, weekly samples will be collected from the influent feed (directly from the barrel), and from the effluent feeds of each treatment system stage (from the sample collection reservoir). The sampling frequency was established based on the Project Team's professional knowledge and experience with passive bioremediation system evaluations. With EPA's concurrence, sampling frequency for influent and effluent may be changed to bi-weekly when treatment system components are operating at steady-state. Additionally, a duplicate sample will be collected from one SRBR column and wetland every week for QA/QC purposes, with the column or wetland sampled rotating each time. Table 4-3 identifies the suite of analyses to be performed on the water samples, including the subset of analytes to be quantified during routine sampling, with EPA's approval. These include total and dissolved cations, anions, alkalinity, acidity, and BOD identified in Table 3-1 and D-1.

Field parameters for influent and effluent for each treatment stage will be continuously measured and routinely logged using Thermo Scientific VERSA STAR Benchtop Multiparameter Meters. These meters will be calibrated according to *SOP ETL-MT-07*: *Continuous Electrochemical Measurement* and used to continuously measure pH, EC, ORP, and temperature. One meter will be dedicated to measuring influent field parameters while additional meters of the same make and model will measure and log in-line effluent field parameters every 60 minutes for each SRBR. The log interval records the data as an average of the readings taken over the previous 60 seconds. Additionally, influent and effluent samples for each treatment stage will be analyzed weekly in the lab for pH, EC, ORP, and DO for QA/QC following the appropriate SOPs in Appendix A. DO will be measured using a Hach HQ30d portable meter with LDO probe while all other parameters will be measured with a lab-use only Thermo Scientific VERSA STAR Benchtop Multiparameter Meter. Effluent volumes at each treatment stage will be tracked by collecting and measuring the effluent from the collection buckets plus the volume of sample during sample collection.

For further information on sampling procedures, see *SOP ETL-MT-09: Passive Bioremediation System Operation*

All field parameters will be measured in the Environmental Technology Lab by authorized and qualified personnel. All water samples will be shipped to ACZ Laboratories under standard chain-of-custody based on the sample handling procedures in SOP *ETL-MT-05: Field Water Sampling* and *Sampler's Guide* (U.S. EPA, 2014) for analysis of the parameters listed in Table 4-3.

Table 4-3. Laboratory Methods, Reporting Limits, Sample Preservation Requirements, and Sample Holding Times for Water Quality Analyses at ACZ Laboratories.

Analyte	Number of Samples*	Analytical Method	MDL (mg/L)	PQL (mg/L)	Preservation and Bottle Requirement	Holding Times
Cations						
Aluminum	962* (117 total and 845 dissolved)	200.7	0.03	0.15	Total Metals: Acidify to pH < 2 with HNO_3 and cool <4°C Dissolved metals: After 0.45 µm filtering, acidify to pH < 2 with HNO_3 and cool <4°C	6 months
Antimony		200.8	0.0004	0.002		
Arsenic		200.8	0.0002	0.001		
Barium		200.7	0.003	0.015		
Beryllium		200.8	0.0002	0.001		
Boron		200.7	0.01	0.05		
Cadmium		200.8	0.0001	0.0005		
Calcium		200.7	0.1	0.5		
Chromium		200.8	0.0005	0.002		
Cobalt		200.7	0.01	0.05		
Copper		200.7	0.01	0.05		
Iron		200.7	0.02	0.05		
Iron, ferrous		SM-3500-Fe B	0.005	0.01		
Lead		200.8	0.0001	0.0005		
Magnesium		200.7	0.2	1		
Manganese		200.7	0.005	0.025		
Mercury		M245.1 CVAA	0.0002	0.001		
Molybdenum		200.8	0.0005	0.0025		
Nickel		200.7	0.008	0.04		
Potassium		200.7	0.2	1		
Selenium		200.8	0.0001	0.00025		
Silica		200.7	0.214	1.07		
Silver		200.8	0.00005	0.00025		
Sodium		200.7	0.2	1		
Strontium		200.7	0.005	0.025		
Thallium		200.8	0.0001	0.0005		
Vanadium		200.7	0.005	0.025		
Zinc		200.7	0.01	0.05		

* The sample numbers shown include 78 dissolved and 39 total analyses for QA/QC duplicate samples and the total number of samples will not exceed 962.

Italicized constituents will be quantified during initial characterization but not during routine sampling.

Table 4-3 (continued). Laboratory Methods, Reporting Limits, Sample Preservation Requirements, and Sample Holding Times for Water Quality Analyses at ACZ Laboratories

Analyte	Number of Samples	Analytical Method	MDL (mg/L)	PQL (mg/L)	Preservation and Bottle Requirement	Holding Times
Anions						
Bromide	845 (dissolved)	M300.0	0.05	0.25	Cool <4°C	28 days
Chloride		SM4500Cl-E	0.5	5	Filter at 0.45µm, cool to < 4°C	28 days
Fluoride		SM4500F-C	0.05	0.3		28 days
Sulfate		D516-02/-07 - Turbidimetric	1	5		28 days
Nitrate and Nitrite		M353.2	0.02	0.1	Acidify to pH < 2 with H_2SO_4 and cool <4°C	28 days
Other Analyses						
Acidity	117 (total)	SM2310B	10	20	Cool <4°C	14 days
Alkalinity		SN2320B-Titration	2	20	Cool <4°C	14 days
Phosphorous		M365.1	0.02	0.1	Acidify to pH < 2 with H_2SO_4 and cool <4°C	28 days
BOD		SM5210B	2	2	Cool <4°C	48 hours
TCLP	3	1311	0.0002 – 0.05	0.00025 – 0.015	Cool <4°C	180 days

* The sample numbers shown include 78 dissolved and 39 total analyses for QA/QC duplicate samples and the total number of samples will not exceed 962.
Italicized constituents will be quantified during initial characterization but not during routine sampling.

4.2.2. Maintenance

The lab-scale bioremediation treatment systems will be inspected daily and serviced as needed by Project Team support personnel. System check-ups will be made and recorded in field log books. Standard maintenance activities include, but are not limited to:

- Multiparameter meters will be inspected and calibrated according to their respective SOP. In-line meter probes will be cleaned as necessary. This will be executed in accordance with:
  - *SOP ETL-MT-05: Field Water Sampling;* and
  - *SOP ETL-MT-07: Continuous Electrochemical Measurement*;
- Inspecting the columns for leaks;
- Inspecting the tubing, collection reservoirs and in-line flow cells for clogging; and,
- Verifying that the pumps are all in working order and set to the pre-determined flow rates.

4.3. Equipment, Supplies, and Containers

This section details the critical supplies that are needed for construction and operation of the lab-scale passive treatment system. This list has been compiled for planning purposes. Actual construction materials may be subject to change. Mr. Shane Hansen (Laboratory Supervisor) is in charge of equipment procurement, testing, inspection before usage, and maintenance. Together with the Project Lead, he will ensure that all equipment procured for construction and ongoing maintenance (e.g., spare parts) are of acceptable quality by conducting source inspections and supplier audits. Quality assurance will be achieved through appropriate source selection and examination of deliverables. An assortment of spare parts for laboratory equipment will be kept on hand at the ETL.

4.3.1. Influent MIW Collection, Conveyance, and Storage

The following is required for collecting MIW from the Mine and transporting that water to a suitable transfer location in Montana:

- Labels for sample containers, chain-of-custody, seals, and shipping containers
- Trailer, with sides and appropriate strapping/tie-downs
- Approximately 20 55-gallon HDPE blue barrels with bung locks
- Clean, reinforced flexible PVC hose or suitable substitute
- Clean, 2" water collection pump
- 2.5kW Generator
- Barrel dolly or alternative transport device
- Assorted hand tools (wrenches, screwdrivers, etc.)
- Appropriate Personal Protective Equipment (PPE; see Appendix A and B for further guidance)
- 5% Alconox solution for decontaminating equipment
- DI water

Transportation of the collected MIW from Montana to Tucson will be completed using a DOT-certified, commercial hauling company under chain-of-custody.

Drums will be held in cold storage at a secure facility in Tucson, Arizona with drum locks and custody seals left in place until ready for use.

4.3.2. Pre-Treatment Processes

The following materials and equipment are required for the pre-treatment system:

- New, 4" clear PVC pipe, to be solvent-welded with suitable PVC cement
- Vertical holding rack for pre-treatment columns with pipe clamps
- New PVC Tubing (variety of sizing)
- Fittings and clamps suitable for contact with impacted water (nylon, 316 stainless steel, etc.)
- Thread sealant tape (Teflon) for all threaded connections
- Peristaltic pumps (capable of metering appropriate flow rates) with new tubing sets
- New or suitably cleaned acrylic flow-through cell with 3 ports for electrodes (as depicted in Fig. 4-1 and 4-2, plus one flow-through cell for influent MIW
- One graduated sample reservoir with flow- through connections, 3 L capacity, to be installed immediately following the flow-through cell
- Thermo Scientific VERSA STAR Multiparameter meter with pH/temp, ORP, and conductivity channels installed
- Field parameter (pH/temp, ORP, and conductivity) probes compatible with Multiparameter meter. Probes will be clean and calibrated.
- Limestone (1-1.5" size) – mass (Kg) and volume (L) as presented in Table D-6
- Effluent collection container of at least 10 L capacity for pre- treatment column effluent/SRBR treatment influent

One flow-through cell will be installed in line between the MIW barrel and the influent lines connected to the pretreatment column and SRBR columns receiving non- pretreated MIW. The flow-through cell and sample reservoir for the pre-treatment process will be installed as indicated in 4.1.3.

4.3.3. SRBR Treatment

The following materials and equipment are required for the SRBR treatment system:

- New, 4" clear PVC pipe, to be solvent-welded with suitable PVC cement
- Vertical holding rack for column SRBRs with pipe clamps
- New PVC Tubing (variety of sizing)
- Fittings and clamps suitable for contact with impacted water (nylon, 316 stainless steel, etc.)
- Thread sealant tape (Teflon) for all threaded connections
- Peristaltic pumps (capable of metering appropriate flow rates) with new tubing sets
- New or suitable cleaned acrylic flow-through cells with four access ports for probes (shown in Fig. 4-1 and 4-3), one each per column
- One graduated sample reservoir with flow-through connections, three L capacity, to be installed immediately following the flow-through cell
- Thermo Scientific VERSA STAR Multiparameter meter with pH/temp, ORP, and conductivity channels installed
- Field parameter (pH/temp, ORP, and conductivity) probes compatible with Multiparameter meter. Probes will be clean and calibrated.
- Substrate materials – Dry weight %/volumes as presented in Table 4-1.
- Effluent collection container of at least 10 L capacity for SRBR column effluent

The flow-through cell and sample reservoir will be installed as indicated in 4.1.4.

4.3.4. Post-Treatment Processes

The following materials and equipment are required for the post-treatment system:

- Wetland tanks
- New PVC Tubing (variety of sizing)
- Fittings and clamps suitable for contact with impacted water (nylon, 316 stainless steel, etc.)
- Thread sealant tape (Teflon) for all threaded connections
- New or suitable cleaned acrylic flow-through cells with four access ports for probes (shown in Fig. 4-1 and 4-4), one each per wetland
- One graduated sample reservoir with flow- through connections, three L capacity, to be installed immediately following the flow-through cell
- Thermo Scientific VERSA STAR Multiparameter meter with pH/temp, ORP, and conductivity channels installed
- Field parameter (pH/temp, ORP, and conductivity) probes compatible with Multiparameter meter. Probes will be clean and calibrated.
- Final effluent collection buckets
- Substrate materials discussed in Section 4.1.5.
- Wetland plant species that are native to the region.
- Final effluent collection container of 20 L capacity for final post-treatment effluent

The flow-through cell and sample reservoir will be installed as indicated in 4.1.5.

4.3.5. Miscellaneous Supplies and Tools

The following tools will be available for construction and maintenance of the passive treatment system:

- Hand tools such as screwdrivers, pliers, utility knives, wrenches, or other small tools as necessary
- Cordless driver with various bits
- Battery-operated Sawzall reciprocating saw
- Safety equipment, including Personal Protection Equipment (PPE), eyewash station, fire extinguisher, and other safety equipment as required

4.3.6. Sampling Supplies

The following equipment is required for sampling:

- Labels for sample containers, chain-of-custody, seals, and shipping containers
- Thermo Scientific VERSA STAR Benchtop Multiparameter meter and probes
- Calibration solutions
- Sample bottles obtained from ACZ Labs and preservatives
- Safety equipment including appropriate PPE, ventilated lab hoods, and face shields (concentrated acid safety)
- 0.45-µm Nylon or PVDF membrane filters
- Syringes for filtering
- Neoprene gloves
- 5% Alconox solution for decontaminating equipment
- 5-gallon buckets for decontaminating equipment
- DI water for various uses (including decontamination)
- Thermometer
- Dedicated Logbooks, forms, pens, camera
- Coolers and ice along with absorbent pads for shipping
- Paper towels
- Zip-top bags for samples and ice

4.4. Equipment Decontamination

Equipment decontamination is an important task in the construction and operation of the passive treatment system and sampling of waters, both field and lab. Decontamination procedures outlined in the SOPs found in Appendix A will be strictly followed throughout this investigation.

4.5. Investigation-Derived Waste

Following initial sampling activities at the Mine, the Project Team will leave the Mine relatively undisturbed. Aqueous and solid waste from the lab-scale evaluation will be characterized, handled, and disposed of at the ETL in accordance with approved facility waste management guidelines and procedures. Treatment system effluent will be treated by the facility's permitted water treatment process. Treatment system substrates (i.e., solid waste) will be evaluated using the Toxicity Characteristic Leaching Procedure (TCLP; EPA Method 1311) and managed accordingly.

4.6. Sample Labeling and Identification

Sample labeling of all analytical samples (attached to each container) will use a unique sample identifier following the coding system outlined below. These sample identifiers along with the date collected and other pertinent information (e.g., duplicate pair information, time collected, any sample observations of note, etc.) will be recorded in the ETL sampling logbook at the time of sampling. Additionally, as a security measure samples will have a computer generated bar code (unique to each container/sample) secured to each sample container and matched to the sample identifier in the logbook.

Following is the sample identifier coding system (10 characters total):

Example: 17DLB1D001

The year (2017) and Site name (i.e. Barker Hughesville – Danny T) are identified by the first three characters ("17D") of the sample identifier. This will be the same for all samples for this project. The remaining characters change based on the sample type and collection point.

The fourth letter denotes where the sample was collected; the field or in the laboratory (as either a sample to be analyzed at ACZ or ETL

- "S" = samples collected in the field (Mine)
- "L" = samples collected at the ETL and analyzed at ACZ
- "P" = samples collected at the ETL and analyzed at ETL (primarily field parameters)

The fifth letter in the coding denotes the sample location within the treatment system being evaluated:

- "F" = Feed water
- "P" = Pre-treatment effluent
- "B" = SRBR effluent
- "W" = Wetland effluent

The next character (6^{th}) denotes the treatment option (SRBR 1 through x –or– VF wetland 1 through x) sampled.

The next character (7^{th}) denotes whether or not the analysis is Total or Dissolved (T/D).

The final three characters represents the sample number within the series from "001" up to "999" and are sequentially generated.

5. Project Management and Coordination

5.1. Project Organization

Project organization is discussed in Section 1.3.

5.1.1. Management Organization

The Project Team management organization is:

- Mrs. Barbara Nielsen, Remediation Projects Manager, is the primary project contact responsible for overall management and coordination of this treatability study. She will be responsible for maintaining the official, approved Work Plan and documenting and distributing changes;
- Mr. Dan Ramey, Director of the ET/LCAT Group will be assisting the Remediation Projects Manager;
- Mr. Erick Weiland, Project Manager, will be responsible for providing oversight of field and lab activities;
- Mr. Brett Waterman, QA Manager, will be responsible for project data QA, working independently from the Project Team generating data;
- Dr. Leonard Santisteban, Project Lead, will be responsible for treatability study experimental design, project coordination, data analysis, and report preparation. He is also the treatment wetland subject matter expert;
- Dr. Ilsu Lee is the bioremediation subject matter expert and will assist with treatability study experimental design, data analysis, and report preparation; and
- Mr. Shane Hansen is the ETL Supervisor and is responsible for day-to-day management and planning of treatability study activities at the ETL in Tucson, Arizona.

5.1.2. Recipients of the Work Plan

Electronic copies of the Work Plan will be provided to the EPA Remedial Project Manager. A signed copy of the Work Plan will also be placed in the Superfund site file for the BHMD Superfund Site at EPA's office in Helena, Montana.

5.1.3. Quality Assurance Organization

Mt. Emmons QA Manager, Brett Waterman, implements the QA program and is independent of the Project Team. He communicates directly to the Director of the ET/LCAT Group on QA matters. The QA Manager objectively reviews projects and continually identifies opportunities to improve their quality.

5.1.4. EPA Management

The EPA RPM, Roger Hoogerheide, is the Respondent's primary contact responsible for coordinating work at the Mine, approving the Work Plan, and maintaining communication with Barbara Nielsen, Mt. Emmons Manager, Remediation Projects.

5.1.5. QAPP Organization

This Work Plan contains the relevant and necessary components of a QAPP in accordance with EPA's *Requirements for Quality Assurance Project Plans, EPA QA/R-5* (EPA, 2001), is consistent with the NCP, and includes all the data elements required in EPA's Region 8 Quality Assurance Document Review Crosswalk, *Guidance for Quality Assurance Project Plans (QA/G-5)*, EPA/240/R-02/009 (December 2002), *Guidance for Quality Assurance Project Plans (QA/G-5)* EPA/240/R-02/009 (December 2002), *EPA Requirements for Quality Assurance Project Plans (QA/R-5)* EPA/240/B-01/003 (March 2001, reissued May 2006), and *Uniform Federal Policy for Quality Assurance Project Plans*, Parts 1-3, EPA/505/B-04/900A-900C (March 2005). Section 5 presents project management and introductory information. Section 6 provides guidance for measurement and data acquisition. Section 7 describes assessment and oversight aspects of the project. Section 8 describes data validation and usability issues.

5.2. Background and Purpose

Danny T Mine background information is provided in Section 2, and the purpose and objectives of the work plan are discussed in Section 1.1.

5.2.1. Data Quality Objectives

DQOs are described in Section 3.1.

5.2.2. Data Measurement Objectives

Every reasonable attempt will be made to obtain a complete set of usable analytical data and to collect other information necessary for this treatability study. If a measurement cannot be obtained or is unusable for any reason, the effect of the missing data will be evaluated by the Remediation Project Manager, Project Manager, Project Lead, and QA Manager. This evaluation will be reported to EPA with a proposed corrective action as described in Section 7.1.

5.2.2.1. Quality Assurance Guidance

The components of this Work Plan were prepared in accordance with EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5 (U.S. EPA, 2001), is consistent with the NCP, and includes all the data elements required in EPA's *Region 8 Quality Assurance Document Review Crosswalk, Guidance for Quality Assurance Project Plans (QA/G-5), EPA/240/R-02/009 (December 2002), Guidance for Quality Assurance Project Plans (QA/G-5) EPA/240/R-02/009 (December 2002), EPA Requirements for Quality Assurance Project Plans (QA/R-5) EPA/240/B-01/003 (March 2001, reissued May 2006), and Uniform Federal Policy for Quality Assurance Project Plans, Parts 1-3, EPA/505/B-04/900A-900C (March 2005).* The ETL aligns with the Technology Center Tucson's (TCT's) Business Manual (Appendix F) and follows the QA protocols outlined here. The TCT has a quality policy that conforms to the ISO 9001:2008 standard, includes a commitment to comply with requirements and continually improve the effectiveness of the quality management system, provides a framework for establishing and reviewing quality objectives, is communicated to and understood among personnel, and is reviewed for continuing suitability.

5.2.2.2. PARCCS Criteria

PARCCS (Precision, Accuracy, Representativeness, Completeness, and Sensitivity) parameters are indicators of data quality. PARCCS goals are established for this treatability study to aid in assessing data quality. An evaluation of the PARCCS parameters will be conducted and reported in the final treatability study report.

- *Precision*: Precision refers to the closeness of two or more measurements of the same property and taken under prescribed similar conditions. Precision is often expressed in terms of relative percent difference (RPD). Precision will be controlled in the laboratory by adhering to the requirements of published EPA methods. Laboratory-related sources of variability are quantified with QC checks.
- *Accuracy*: Accuracy refers to the closeness of a measured value to the true value, and is a measure of bias. Accuracy is often expressed as the percent recovery (%R) of a sample result. Accuracy is controlled in the laboratories by adhering to method requirements, and the analysis of method blanks, and laboratory control samples (LCS).
- *Representativeness and Comparability*: Representativeness is a qualitative measurement that describes how well the analytical data characterizes an area of concern. Comparability is the degree to which results can be compared to other data produced under the same conditions. These criteria will be achieved through the use of standard or similar techniques to collect and analyze representative samples for this investigation.
- *Completeness*: Completeness is a quantitative measure of the amount of usable data obtained from a measurement system relative to the amount that was expected to be obtained assuming normal conditions. Completeness is usually expressed as a percentage of usable analytical data.
- *Sensitivity*: Sensitivity is related to the ability to compare analytical results with project-specific levels of interest, such as delineation levels or action levels. Sensitivity refers to the capability of a method or instrument to detect a given analyte at a given concentration and reliably quantify the analyte at that concentration. In the analysis of the baseline MIW water, reporting limits may be high (i.e., low sensitivity) based on dilutions that will be performed in the analysis of the high concentration analytes.

5.2.2.3. Test Measurements

Measurements will include temperature, conductivity, pH, DO, and ORP using laboratory meters following the operational manuals for those meters.

5.2.2.4. Laboratory Analysis

- *Analytical Methods*: All analyses will be conducted in accordance with Table 4-3.
- *Laboratory*: Samples will be submitted to ACZ's Steamboat Spring, CO laboratory for all analyses with the exception of test measurements, which will be conducted by the Project Team at the ETL.
- *Reporting Limits*: Reporting limits are the minimum levels the laboratory will report without a qualifier when an analyte is detected. Analytes can typically be detected at concentrations of up to an order of magnitude lower than reporting limits; in this case, when a positive detection is less than the reporting limit, the value may be reported and qualified as an estimated concentration. The reporting limits for metals are dependent on the concentrations in the samples.
- *Holding Times*: Holding times are storage times allowed between sample collection and sample extraction or analysis (depending on whether the holding time is an extraction or analytical holding time) when the designated preservation and storage techniques are employed. EPA's holding time requirements for all analytes will be adhered to throughout this project. Holding times are provided in Table 4-3.

- *Quality Control Analyses*: Laboratory QC samples will be used to measure the precision and accuracy of the analyses.
- *Turnaround Times*: Standard turnaround times will be acceptable unless expedited turnaround is requested.

5.2.2.5. Quality Control Samples

As discussed in Section 4.2.1, quality control samples will consist of field and lab duplicates along with field blanks as indicated in 6.5.2 Additional analytical duplicates, calibration standards, and matrix spikes will be used by ACZ labs according to their QAP (Appendix E).

5.2.3. Special Training Requirements

To ensure that all personnel performing work have the necessary skills to safely and effectively accomplish their work, special training requirements for this investigation will include the following:

- Documented task training on field and lab sampling and analysis SOPs
- SOP *ETL-MT-08-Data Entry, Validation, and Maintenance*
- Documented OSHA 40-hour HAZWOPER certification and current 8-hour refresher
- HASP training

Mt. Emmons will be responsible for providing these trainings using qualified trainers. The Project Team will document in the project file that personnel have and maintain the appropriate training, knowledge, skills, and qualifications necessary to perform the work outlined in this Work Plan and the need for retraining will be assessed if project requirements change.

5.2.4. Documentation and Records

ACZ and ETL will submit analytical data reports to appropriate project personnel. Each data report will contain a case narrative that briefly describes the number of samples, the analyses, and any analytical difficulties or QA/QC issues associated with the submitted samples. The data report will also include signed chain-of-custody forms (Appendix C), cooler receipt forms, analytical data, Level II technical data package, and any necessary raw data. The laboratories will provide an electronic copy of the data.

Additional documentation and records to be maintained includes field and lab log books, laboratory forms such as calibrations and analytical sequences and all photos. These records will be electronically scanned and stored in the project folder for each sampling event. Hardcopy originals will also be stored in the project file. ETL laboratory notebooks related to this project will be maintained in a locked filing cabinet within the ETL. Access will be restricted to appropriate individuals listed as project contacts per Table 1-1, plus the designated technicians as assigned by the ETL Supervisor. Project documentation (e.g., data, reports, etc.) will be stored for ten years beyond the notification date from EPA that the AOC has been terminated. Standard hardware and software will be used to store project data and information.

6. Measurement and Data Acquisition

This section covers experimental design, sampling method requirements, handling and custody requirements, analytical methods, quality control, equipment maintenance, instrument calibration, supply acceptance procedures, non-direct measurements, and data management.

6.1. Experimental Design

The principal goal of this treatability study is to evaluate the effectiveness of passive MIW treatment for improving the quality of Danny T Mine MIW to meet ambient water quality standards. Information collected during this lab-scale evaluation will be used to determine if passive treatment is feasible and cost-effective and may subsequently be used to design pilot- and full-sized treatment reactors for the

Danny T Mine MIW. Details on the experimental design of the treatability study are provided in Sections 3 and 4 of this Work Plan.

Quantifying the magnitude of improvement to water quality will serve as the basis for determining the feasibility of passive bioremediation for the Mine. The treatability study is designed to assess whether or not the passive technologies evaluated can ultimately meet the targeted endpoint values established (Table 3-1). Metal and sulfate-removal rates will serve as the primary metric for assessing treatment system performance and are critical data for this treatability study. The analyses (Table 4-3) conducted on the pre-treatment effluent, SRBR effluent and vertical flow wetlands effluent are also critical pieces of data for scaling the proposed system into larger pilot- or full-sized reactors. Field parameters, including pH, ORP, and DO, are also useful for guiding reactor design, construction and operation. Informational, non-critical data includes: test procedures, descriptions of sampling, and other information that adds to the overall understanding of this evaluation.

6.2. Sampling Methods Requirement

Sampling equipment, containers, and handling are addressed below.

6.2.1. Sampling Equipment and Preparation

Sampling methods and field or test preparation include development and review of relevant SOPs, equipment procurement, and development and review of a Health and Safety Plan. Relevant SOPs are located in Appendix A.

6.2.2. Sample Containers

Sample container requirements can be found in *SOP ETL-MT-05: Field Water Sampling* and *SOP ETL-MT-09: Passive Bioremediation System Operation*

6.2.3. Sample Collection, Handling, and Shipment

Samples collected during this treatability study include raw and treated Mine MIW as well as QC samples. All sampling will be conducted pursuant to *SOP ETL-MT-05: Field Water Sampling* and *SOP ETL-MT-09: Passive Bioremediation System Operation.*

6.3. Sample Handling and Custody Requirements

The following describes custody and documentation procedures for field and laboratory sampling, as well as procedures for corrections to sample handling and custody documentation.

6.3.1. Field Sample Custody and Documentation

Sample label information will match the chain-of-custody record. Details are as follows.

6.3.1.1. Sample Labeling and Identification

The sample labeling system is described in Section 4.6. This system is congruent with *SOP ETL-MT-09: Passive Bioremediation System Operation*. All samples submitted to the ACZ laboratory will adhere to ACZ sample handling and labeling requirements as detailed in their QAP (Appendix E).

6.3.1.2. Chain-of-Custody Requirements

Chain-of-custody procedures are detailed in *SOP ETL-MT-05: Field Water Sampling*. The chain-of-custody record serves as documentation of sample custody and control, from point of collection through final data reporting. A sample chain-of-custody form is included in Appendix C.

6.3.1.3. Sample Packaging and Shipping

Samples will be packaged and shipped following *SOP ETL-MT-05: Field Water Sampling*, and under ETL Supervisor guidance.

6.3.1.4. Logbooks and Records

Logbooks and photos will be maintained as detailed in *SOP ETL-MT-10: Notebook and Photographic Management*. The ETL Supervisor will be responsible for logbook maintenance and document control.

6.3.2. Laboratory Custody Procedures and Documentation

Laboratory custody procedures can be found in ACZ's QAP and *SOP ETL-MT-05: Field Water Sampling* ETL's SOPs (Appendix E and A, respectively). All sample shipments will be inspected upon receipt to ensure integrity of the shipping cooler and individual samples. If samples are required to be chilled, their temperature will be taken to verify that they are within the permissible temperature range of 4 ± 2°C. All samples will be checked against the chain-of-custody form, which will be signed by laboratory personnel upon acceptance of the samples. At this point, sample integrity becomes the laboratory's responsibility.

6.3.3. Corrections to and Deviations from Documentation

Changes to the content of ETL laboratory logbooks shall be indicated by a single strikeout accompanied by dated initials, with the corrected information entered in close proximity to the struck-out content. Changes to electronic files will be tracked via version history automatically logged by Microsoft SharePoint software as well as comments included by editors as the related documents are checked back in. All electronic data files will be maintained under the same software security protocols.

6.4. Analytical Methods Requirements

The laboratory QA program and analytical methods are discussed below.

6.4.1. Laboratory QA Program

All samples analyzed during this treatability study will be run subject to standard EPA and/or nationally-accepted analytical procedures. Procedures for mandatory quality-related documentation (e.g., QMP, QAP) from suppliers will be reviewed and approved. ACZ Laboratories will adhere to all applicable QA/QC requirements established by its contract with the Respondent.

6.4.2. Methods

Standard EPA methods will be used for chemical analysis and their associated holding times are found in Table 4-3.

6.5. Quality Control Requirements

Discussion of QC procedures used for this treatability study are provided below.

6.5.1. Laboratory Quality Control Samples

ACZ Laboratories will utilize established QC checks (e.g., blanks, spikes, and duplicates) to ensure precision and accuracy of reported results. Laboratory-based QC will be evaluated at a minimum rate of 20%. ACZ Laboratories shall report results from both client samples and all internal QC check data in the form of a Level II data validation package. Additional details on ACZ Laboratories QC program are detailed in their QAP (Appendix E).

6.5.2. Internal Quality Control Checks

ETL will utilize established QC checks to ensure precision and accuracy of reported results. As discussed in Section 4.2.1, influent and effluent samples from each stage will be analyzed weekly in the lab for pH, EC, ORP, and DO for QA/QC in addition to in-line continuous monitoring. Table F-1 identifies additional QC checks to be implemented by the ETL. Duplicate samples for experimental precision will be collected as two consecutive samples from the same sampling point. When control elements are exceeded, corrective actions will be taken and documented pursuant to the SOPs in Appendix A. Procedures and formulas for calculating QC statistics are detailed in *National Functional Guidelines for Inorganic Superfund Methods Data Review* (U.S. EPA, 2016). All treatability study deliverables will receive technical and QA reviews prior to being issued to EPA. These reviews will be conducted in accordance with this Work Plan. Completed reviews will be maintained in the project file.

6.6. Equipment Maintenance Procedures

All equipment will be maintained by the laboratory following relevant laboratory SOPs as detailed in Appendices A and E. This includes developing, installing, testing, (including verification and validation), using, maintaining, controlling, and documenting computer hardware and software used by the ETL and ACZ to ensure it meets technical and quality requirements.

6.7. Instrument Calibration Procedures and Frequency

ETL instruments will be calibrated prior to, and regularly throughout, treatment system operation following the appropriate SOPs detailed in Appendix A. Calibration intervals will be specified by the laboratory supervisor following manufacturer recommendations and any regulatory requirements. Calibration standards used as reference standards will be in accordance with the EPA, National Institute of Standards and Technology, or another nationally-recognized reference standard sources. Records of all calibration activities will be maintained by the laboratory. These records will be made available for data reporting purposes.

6.8. Acceptance Requirements for Supplies

The laboratory supervisor will identify critical supplies and consumables for field and laboratory, documenting supply source, acceptance criteria, and procedures for tracking, storing and retrieving materials. The Laboratory Supervisor is responsible for procuring all supplies and inspecting them upon receipt. All supplies, either at the ETL or ACZ, will be in satisfactory condition as a prerequisite to being used on the project.

6.9. Non-Direct Measurement Data Acquisition Requirements

Non-direct measurement data to be used in this treatability study include previously published data, pilot-test reports issued by EPA's contractor (e.g., CDM Smith 2014, 2017), site-specific background information provided by the EPA, FMC's prior experience conducting lab-, pilot-, and full-scale studies (Appendix I), and information obtained during the site reconnaissance visit. Non-direct measurement data must have been reviewed by someone other than the author to be used in this document.

6.10. Data Management

Analytical results will be delivered electronically by ACZ to the Project Lead. All electronic deliverables prepared by ETL will be maintained in a project SharePoint site—a cloud-based, restricted access electronic file repository that is automatically backed up and replicated nightly. Back-ups are retained for two months. The project SharePoint site will be secured with access (e.g., data storage and retrieval) granted only to approved Project Team members. The Project Lead will be responsible for compiling and analyzing data. The Manager, Remediation Projects will be responsible for transmitting data to the U.S. EPA RPM, utilizing Syncplicity, or another acceptable high volume data and information transfer platform. Logbooks, camera memory cards, and other hard copies (laboratory analytical results) of data will be kept in a locked cabinet at the ETL and access will be controlled by the ETL Supervisor. Standard hardware and software will be used to store and analyze treatability study data and information.

7. QA Assessment and Oversight

The QAP for ACZ Laboratories and the Business Manual for the TCT are provided in Appendix E and G, respectively.

7.1. Assessment and Response Actions

Performance assessments are quantitative checks on the quality of a measurement system which may be used for analytical work. Corrective action can be initiated at any time or as needed by any member of the Project Team. The following are examples of corrective actions that may be taken for data that do not meet QA objectives: (1) verify that the analytical measurement system was in compliance with QA controls; (2) verify that the analytical batch met internal laboratory QA/QC requirements; (3) use data qualifiers; and (4) assuming a sufficient quantity of sample is available, reanalyze the affected samples, if authorized by the EPA Remedial Project Manager.

7.2. Reports to Management

QA reports will be provided to the EPA Remedial Project Manager through the Manager, Remediation Projects when quality problems are encountered. The Project Team will record any quality issues encountered in the appropriate logbook and other documentation for the project file. The Project Lead will inform the QA Manager, who will, in turn, inform the Manager, Remediation Projects upon encountering quality issues that cannot be immediately rectified.

8. Data Validation and Usability

8.1. Validation and Verification Methods

The Project Team and the laboratories (ETL and ACZ) will perform data validation in accordance with the *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Methods Data Review, Final* (U.S. EPA, 2016). The Project Team will implement the QA/QC program included within this Work Plan to evaluate all analytical results and the Level II data validation package to determine if the results meet the project DQOs outlined in Section 3.1.

The laboratory project managers/supervisors and/or QA staff will be responsible parties for data validation and dissemination of the findings. The Project Team's Manager and/or QA Manager will be in charge of post-laboratory data validation of all data generated by the laboratories.

8.2. Reconciliation with User Requirements

8.2.1. Data Evaluation

The data evaluation review for this treatability study will address field and laboratory QC data quality indicators included in the PARCCS parameters. These parameters include precision, accuracy, representativeness, completeness, comparability, and sensitivity. PARCCS parameters are discussed in detail in Section 5 of this document. The data evaluation will be documented in worksheets that will be stored along with the project files. Any major findings from the data evaluation will be discussed in the final treatability study report.

8.2.2. Data Reduction and Tabulation

Sample data, along with their laboratory and data usability qualifiers, will be reported by ACZ Laboratories and maintained electronically by the Project Team. Data reduction and tabulation will be overseen by the Project Lead and ETL Supervisor.

9. References

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Appendices

Appendix A – Environmental Technology Laboratory Standard Operating Procedures (SOPs)

- ETL-MT-01-Measurement of pH of Aqueous Samples by Thermo Scientific VERSA STAR Meter
- ETL-MT-02-ORP Measurement by Thermo Scientific VERSA STAR Meter
- ETL-MT-03-Electrical Conductivity (Specific Conductance) Measurement by Thermo Scientific VERSA STAR Benchtop Meter
- ETL-MT-04-Dissolved Oxygen Measurement by Hach HQ30d LDO Meter
- ETL-MT-05-Field Water Sampling
- ETL-MT-07-Continuous Electrochemical Measurement
- ETL-MT-08-Data Entry, Validation, and Maintenance
- ETL-MT-09-Passive Bioremediation System Operation
- ETL-MT-10- Notebook and Photographic Management

SOP Name: Measurement of pH in aqueous samples with Thermo Scientific Versa Star Benchtop meter
SOP No.: ETL-MT-01
Area: Environmental Technology Lab
Issue Date: 12 January 2017
Version: V1
Revision Date/ Reviewed Date:
Issued By: Environmental Technology Lab Supervisor

Critical Hazards:

Critical Hazards	Possible Outcomes	Incident Potential	Critical Controls	Applicable GSR
None	N/A	N/A	N/A	N/A

Purpose:

This procedure is used to measure the pH in aqueous samples collected during laboratory activities.

Definitions: None

Equipment Needs:

1. Thermo Scientific Versa Star meter
   - pH or pH/ISE channel installed
   - pH electrode 8157BNUMD gel-sealed electrode
2. Reagents and Materials:
   - Standardized buffer, pH 4.01
   - Standardized buffer, pH 7.00
   - Standardized buffer, pH 10.01
   - Deionized (DI) water
3. Standard PPE:
   - Steel-toed boots, approved safety glasses, and neoprene gloves are required in the laboratory. A lab coat is recommended. Take care that loose lab coat/clothing will not overturn full sample flasks. Always use safe laboratory practices when handling chemicals. Read all applicable SDS' if unfamiliar with any of the chemicals used in this procedure.

Procedures:

- **pH Calibration**
  1. Prior to starting any calibration or analysis, the meter and electrode should be inspected for obvious signs of damage or compromised function. Verify probe tip is free from color, turbidity, or surface defects. The meter should start up normally and recognize the pH module in the channel connection. Inspections of the meter and electrode should be performed each week while in use. Any defects should be noted and the meter or electrode should be taken out of service until repairs or replacement are complete. When not in use, the meter should be stored in a safe location in the lab and pH electrodes should be stored in electrode storage solution or pH 4 buffer if storage solution is unavailable.
  2. Automatic temperature compensating (ATC) probes shall be used. Model number indicated above is appropriate for this purpose.

3. A three-buffer calibration should be performed using fresh buffers before attempting to measure pH in aqueous samples. The calibration should be performed every day the pH meter is in use, to ensure the electrode is working properly and to store the slope in memory. The instrument uses a point-to-point calibration scheme, i.e., the meter stores in memory the different electrode slopes for each portion of the calibration curve. When measuring in a particular region of the curve, the calibration-derived slope for that region is employed in the calculation of sample pH. After calibration, the average electrode slope for all the segments of the entire calibration curve is displayed. Use of this scheme increases accuracy in the different regions of the calibration curve. However, the electrode slope may appear lower than normal, especially if buffers from the pH extremes <2.00 or >12.00 are used.
4. Remove the protective electrode storage bottle or rubber cap of the probe before calibration or measurement. Rinse probe with DI water and either lightly shake or dab dry with a fresh Kimwipe to remove excess rinse water.
5. Attach the pH electrode to the meter, along with the temperature probe connector.
6. Press the F1 key (indicates "CAL" on the home screen) to initiate the calibration sequence. The screen changes to the semi-automatic calibration screen with the message to insert the probe in the pH 4.01 buffer.
7. Insert the probe in the first buffer and slowly swirl the probe in the buffer solution.
8. Press the F3 key to start the calibration.
9. When the display indicates the correct buffer and reads "ACCEPT?" indicating electrode stability, press the F3 key "YES".
10. Press the F3 key again after the display reads "PROCEED TO NEXT BUFFER". Rinse the electrode with DI water and place the electrode in the pH 7.00 buffer. Press F3 to start calibrating.
11. When the display indicates the correct buffer and reads "ACCEPT?" indicating electrode stability, press the F3 key "YES".
12. Press the F3 key again after the display reads "PROCEED TO NEXT BUFFER". Rinse the electrode with DI water and place the electrode in the pH 10.01 buffer. Press F3 to start calibrating.
13. When the display indicates the correct buffer and reads "ACCEPT?" indicating electrode stability, press the F3 key "YES". After the last buffer, press the F1 key "CALIBRATION COMPLETE". The slope percentage of the calibration will then be displayed on the screen. If the slope is ≤93%, the calibration must be performed again. If after a second attempt, the slope is still ≤93%, the probe must be changed out with a new pH probe and calibration performed again. The corrective action must be noted for the calibration record.

- **Analyzing pH**
  1. Verify meter is set up for continuous readings. This indicates the pH as the meter reaches stability with the measurement and reduces the time needed to allow for sample determinations.
  2. Rinse the electrode with DI water and dab dry with a fresh Kimwipe. Insert electrode in sample and measure sample pH allowing for adequate time for the meter to indicate stability with "READY" on the display.
  3. Record reading in laboratory notebook assigned to project.
  4. After every sampling and at the end of the sample run for the day, rinse the electrode with DI water, measure the pH of the calibration buffers, and record the results as calibration verification in the pH meter calibration logbook. Note any tolerances greater than +/- 0.1 from the stated buffer used. Any duplicate sampling must additionally be within +/- 0.2. If a tolerance beyond that is indicated, the probe must be recalibrated prior to the next use.

References

MSHA: CFR 30 Subpart N, Subpart O, Subpart Q & Subpart S
OSHA: 1910 Subparts: A, D, E, G, H, I, J, K, L & Z; OSHA Laboratory Safety Guidance
FCX: Resource Management General Code of Safe Practices; TC H&S Policies
HSMS: 4.4.6(5) Operational Controls
EPA: SM150.1- pH (Electrometric)
OTHER: Thermo Scientific Orion VERSA STAR Operator's Manual, ID 68X006501, Rev A, April 2014

SOP Name: Oxidation-Reduction Potential (ORP) Measurement with Thermo Scientific Versa Star Benchtop meter
SOP No.: ETL-MT-02
Area: Environmental Technology Lab
Issue Date: 12 January 2017
Version: V1
Revision Date/ Reviewed Date:
Issued By: Environmental Technology Lab Supervisor

Critical Hazards:

Critical Hazards	Possible Outcomes	Incident Potential	Critical Controls	Applicable GSR
None	N/A	N/A	N/A	N/A

Purpose:

This procedure applies to measurement of oxidation-reduction potential (ORP) in aqueous samples collected during laboratory activities.

Definitions: None

Equipment Needs:

1. Thermo Scientific VERSA STAR meter:
   - pH or pH/ISE channel installed
   - ORP electrode 9179BNMD gel-sealed electrode
2. Reagents and Materials:
   - pH buffers 4.01 and 7.00
   - Quinhydrone powder
   - Small beakers
   - Magnetic stir plate and stir bars
   - Digital temperature probe
   - Deionized water (DI)
3. Standard PPE:
   - Steel-toed boots, approved safety glasses, and neoprene gloves are required in the laboratory. A lab coat is recommended. Take care that loose lab coat/clothing will not overturn full sample flasks. Always use safe laboratory practices when handling chemicals. Read all applicable SDS' if you are unfamiliar with any of the chemicals used in this procedure.

Procedures:

- **ORP Calibration**
  1. Prior to starting any calibration or analysis, the meter and electrode should be inspected for obvious signs of damage or compromised function. Verify probe tip is free from defects and platinum wire is clean and free of any color or surface coatings. The meter should start up normally and recognize the pH/ISE module in the channel connection. Inspections of the meter and electrode should be performed each week while in use. Any defects should be

noted and the meter or electrode should be taken out of service until repairs or replacement are complete. When not in use, the meter should be stored in a safe location in the lab and ORP electrodes should be stored in electrode storage solution or pH 4 buffer if storage solution is unavailable.

2. A two-point calibration check should be performed using fresh solutions before ORP is measured. The calibration check should be performed every day the ORP is in use to ensure the electrode is working properly.
3. Remove the protective electrode storage bottle or rubber cap of the electrode before calibration or measurement. Rinse the electrode with DI water and lightly shake to remove excess rinse water or dab dry with a fresh Kimwipe.
4. Attach the ORP electrode to the meter.
5. Set up the stir plate and beakers with adequate ventilation. Pour 40 mL of pH 4 buffer solution into a clean beaker with magnetic stir bar. Add approximately 1-2 g of Quinhydrone powder to the solution and stir at a moderate speed. Allow the solution to mix for 5 minutes. There should be an excess of Quinhydrone powder. If there is not, use additional powder until there is an excess of undissolved powder.
6. Insert the electrode in the solution and slowly swirl the electrode in the solution.
7. Insert the temperature probe in solution and allow the reading to stabilize. Record temperature in calibration log.
8. When the display indicates the stabilized reading, record the value in the logbook for pH 4 buffer. Repeat steps 5-7 using pH buffer 7.
9. The values must be compared to the indicated temperature vs ORP table below. For instance, at 25˚C, the readings should be approximately 267 mV at pH4 and 90 mV at pH 7. The readings should be within +/- 15 mV of the indicated values and the difference between them should be approximately 173 mV. If outside of the indicated range, the electrode may be cleaned according to the manufacturer's instructions and the calibration checked again. If after a second attempt the reading is still outside the range, the electrode must be changed out with a new ORP electrode and calibration check performed again.
10. Quinhydrone mixtures will only maintain ideal values for 2 hours and must be disposed of by this this time. Dispose of the Quinhydrone-saturated buffers according to the existing site environmental management protocols.
11. Rinse the electrode in preparation for use. The temperature probe is not needed for analyzing ORP in samples and may be stored appropriately. Any corrective action must be noted for the calibration record.

- **Analyzing ORP**

1. Verify meter is set up for continuous readings. This indicates the ORP as the meter reaches stability with the measurement and reduces the time needed to allow for sample determinations.
2. Rinse the electrode with DI water and dab dry with a fresh Kimwipe. Insert electrode in sample and measure sample ORP, allowing for adequate time for the meter to indicate stability with "Ready" showing on the display.
3. After every sampling and at the end of the sample run for the day, rinse the electrode with DI water, measure the ORP of either pH 4 or pH 7 buffer with saturated Quinhydrone and record the results for calibration verification in the ORP meter calibration logbook. Note any tolerances greater than +/- 15mV. If a tolerance beyond that is indicated, the probe must be recalibrated prior to the next use.

References

MSHA: CFR 30 Subpart N, Subpart O, Subpart Q & Subpart S

OSHA: 1910 Subparts: A, D, E, G, H, I, J, K, L & Z; OSHA Laboratory Safety Guidance
FCX: Resource Management General Code of Safe Practices; TC H&S Policies
HSMS: 4.4.6(5) Operational Controls
EPA: SESPROC-113-R1- Field Measurement of Oxidation-Reduction Potential (ORP)
OTHER: Thermo Scientific Orion VERSA STAR Operator's Manual, ID 68X006501, Rev A, April 2014

SOP Name: Electrical Conductivity (Specific Conductance) Measurement by Thermo Scientific Versa Star Benchtop Meter
SOP No.: ETL-MT-03
Area: Environmental Technology Lab
Issue Date: 18 January 2017
Version: V1
Revision Date/ Reviewed Date:
Issued By: Environmental Technology Lab Supervisor

Critical Hazards:

Critical Hazards	Possible Outcomes	Incident Potential	Critical Controls	Applicable GSR
None	N/A	N/A	N/A	N/A

Purpose:
This procedure is used to measure Electrical Conductivity, reported in $\mu S/cm^2$, in aqueous samples generated during applicable tests in the lab.

Definitions: None

Equipment Needs:

1. Thermo Scientific Versa Star meter
   - Conductivity channel installed
   - Standard Conductivity cell 013005MD
2. Reagents and Materials:
   - KCl or NaCl Conductivity standard, 1413 $\mu S/cm^2$
   - Deionized (DI) water
3. Standard PPE:
   - Steel toed boots, approved safety glasses, and neoprene gloves are required in the laboratory. A lab coat is recommended. Take care that loose lab coat/clothing will not overturn full sample flasks. Always use safe laboratory practices when handling chemicals. Read all applicable SDS' if unfamiliar with any of the chemicals used in this procedure.

Procedures:

➢ *Conductivity Calibration*

1. Prior to starting any calibration or analysis, the meter and conductivity cell should be inspected for obvious signs of damage or compromised function. The meter should start up normally and recognize the Conductivity module in the channel connection. Inspections of the meter and conductivity cell should be performed each week while in use. Any defects should be noted and the meter or conductivity cell should be taken out of service until repairs or replacement are complete. When not in use, the meter and conductivity cell should be stored in a safe location in the lab.
2. Automatic temperature compensating (ATC) probes shall be used. Model number indicated above is appropriate for this purpose.
3. A single point calibration should be performed using fresh standard before attempting to measure conductivity in samples. If higher conductivity is expected for certain samples, a standard near the anticipated range should be used. The calibration check should be performed every day the meter is used to ensure the conductivity cell is working properly.

4. The cell should be cleaned and rinsed with DI water and dabbed with a Kimwipe.
5. Verify the cell is attached to the correct channel on the meter along with the temperature probe connector.
6. Press the F1 key (indicates "CAL" on the home screen) to initiate the calibration sequence. The screen changes to the manual calibration screen with the message to insert the probe in the standard solution.
7. Press F2 key ("Cell K") to verify the correct cell constant is entered for the conductivity cell as indicated by the manufacturer.
8. Pour fresh 1413 $\mu S/cm^2$ conductivity solution into a 50mL centrifuge tube.
9. Insert the cell in the solution and slowly swirl in the solution.
10. Press the F3 key to start the calibration.
11. When the display indicates the stabilized reading, the standard value should be indicated. Press the F3 key "YES". If outside of the indicated range, the probe may be cleaned according to the manufacturer's instructions and the calibration checked again. If the cell fails a second attempt, replace with a new cell and perform the calibration again.
12. Press the F1 key "CALIBRATION COMPLETE". The corrective action, if any, must be noted for the calibration record.

➢ *Analyzing Conductivity*

1. Verify meter is set up for continuous readings. This indicates the conductivity as the meter reaches stability with the measurement and reduces the time needed to allow for sample determinations.
2. Rinse the cell with DI water, dab with a fresh Kimwipe. Insert the cell into the aqueous sample making sure the solution level is above the gap between the cell contacts. Allow for adequate time for the meter to indicate stability with "Ready" on the display and record measurement.
3. After every sampling event and at the end of the sample run for the day, rinse the cell with DI water and measure the conductivity with another fresh sample of conductivity standard. Record the results as calibration verification in the conductivity meter calibration logbook. Note any tolerances greater than +/- 15 $\mu S/cm^2$ from the standard 1413 $\mu S/cm^2$. If an intolerance is noted, recalibrate the cell after verifying the cell constant (k) is entered correctly. This method results in a precision measurement of +/- 1%.

References

MSHA: CFR 30 Subpart N, Subpart O, Subpart Q & Subpart S
OSHA: 1910 Subparts: A, D, E, G, H, I, J, K, L & Z; OSHA Laboratory Safety Guidance
FCX: Resource Management General Code of Safe Practices; TC H&S Policies
HSMS: 4.4.6(5) Operational Controls
EPA: SM120.1- Conductance by Conductivity Meter
OTHER: Thermo Scientific Orion VERSA STAR Operator's Manual, ID 68X006501, Rev A, April 2014

SOP Name: Dissolved Oxygen Measurement by Hach HQ30d LDO Meter
SOP No.: ETL-MT-04
Area: Environmental Technology Lab
Issue Date: 6 February 2017
Version: V1
Revision Date/ Reviewed Date:
Issued By: Environmental Technology Lab Supervisor

Critical Hazards:

Critical Hazards	Possible Outcomes	Incident Potential	Critical Controls	Applicable GSR
None	N/A	N/A	N/A	N/A

Purpose:

This procedure is used to measure the dissolved oxygen (DO) in aqueous samples collected during laboratory activities.

Definitions:

LDO: Luminescent Dissolved Oxygen. A light sensor measures fluorescence from the probe light source to measure free oxygen concentration in mg/L.

Equipment Needs:

1. Hach HQ30d Meter
    - LDO101 probe

2. Reagents and Materials:
    - Deionized (DI) water
    - Narrow neck bottle with stopper

3. Standard PPE:
    - Steel-toed boots, approved safety glasses, and neoprene gloves are required in the laboratory. A lab coat is recommended. Take care that loose lab coat/clothing will not overturn full sample flasks. Always use safe laboratory practices when handling chemicals. Read all applicable SDSs if unfamiliar with any of the chemicals used in this procedure.

Procedures:

➢ LDO Probe Calibration

1. Prior to starting any calibration or analysis, the meter and probe should be inspected for obvious signs of damage or compromised function. The meter should start up normally and recognize the probe connection. Inspections of the meter and probe should be performed each week while in use. Any defects should be noted and the meter or probe should be taken out of service until repairs or replacement are complete. When not in use, the meter and probe should be stored in a safe location in the lab.
2. Rinse the probe with DI water blot dry with a fresh Kimwipe.
3. Push the "Calibrate" button. Push "Methods" and select "User Cal- 100%". Push "OK"
4. Add about 5mL of room temperature DI water to a narrow neck bottle. Stopper the bottle and shake vigorously for 30 seconds.

5. Remove the stopper and verify the probe cap is dry. Insert probe into the bottle making sure the probe tip is suspended in the center of the bottle and not directly in contact with any water.
6. Begin air calibration by pushing "Read". Once the reading stabilizes, the display will show the calibration value. If the display shows "Calibration Failed", attempt to recalibrate after allowing the probe and the stoppered bottle to equilibrate to room temperature for 20 minutes. If the probe fails a second time, probe cap or the entire probe may need to be replaced. Verify with Lab Supervisor and record corrective action taken. Perform a new calibration after corrective action.
7. Push "Done" to view the calibration summary. Record calibration data in calibration logbook. Push "Store" to accept the calibration and return to measurement mode.
8. Replace the shroud if removed for calibration. Calibration should be performed every 4 hours as needed, and checked after every sample run.

➢ **Analyzing DO**

1. After calibration, rinse the probe cap with DI water and blot dry with a fresh Kimwipe.
2. Immerse the probe above the level of the shroud and gently stir the sample. Suspend the probe in the middle of solution. Push "Read". Once the reading stabilizes, the display will indicate the measurement.
3. Record reading in laboratory notebook assigned to project.
4. After every sampling and at the end of the sample run for the day, rinse the probe with DI water, measure the DO in water-saturated air (Probe Calibration steps 17-18). Record the reading in the calibration log. Note any tolerances greater than +/- 2.0%. If a tolerance beyond that is indicated, the probe must be recalibrated prior to the next use. If the probe fails a second time then it will be replaced. The non-conformance and any corrective action must be recorded in the calibration log.

References

MSHA: CFR 30 Subpart N, Subpart O, Subpart Q & Subpart S
OSHA: 1910 Subparts: A, D, E, G, H, I, J, K, L & Z; OSHA Laboratory Safety Guidance
FCX: Resource Management General Code of Safe Practices; TC H&S Policies
HSMS: 4.4.6(5) Operational Controls
EPA: SM360.1- Oxygen, Dissolved (Membrane Electrode), SESDPROC-106-R3- Field Measurement of Dissolved Oxygen
OTHER: Luminescent Dissolved Oxygen Probe User Manual, Ed. 2, DOC022.53.80021, Hach Co. 05/2013

SOP Name: Field Water Sampling
SOP No.: ETL-MT-05
Area: Environmental Technology Lab
Issue Date: 2 February 2017
Review/Revision Date: V1
Issued By: Resource Management

Purpose:
Ensure that FMI employees that collect field solution samples at FMI sites perform sampling in a safe and correct manner.

Critical Hazards:

Critical Hazards	Possible Outcomes	Incident Potential	Critical Controls	Applicable GSR
None	N/A	N/A	N/A	N/A

Definitions: None

Procedures:
Preparation and Resources Required

1. Contact FMI site to be sampled to schedule extra resources needed for sampling (e.g. site escort, boat to sample pits, pumps to get the water from wells, etc.) If site is under special provisions, contact appropriate parties for permission to enter site.
2. Arrange all resources needed for each sampling site, if traveling to more than one per sampling trip.
   a. Sampling bottles:
      i. Arrange for pre-labeled bottles with preservatives already added, if requested for project plan. These may be ordered from ACZ Labs at least 3 weeks prior to the scheduled sampling event. Be sure to verify contents of cooler(s) based on the number of samples, blanks, and duplicates required according to the project plan.
      ii. If preparing sample bottles from existing supplies, prepare according to the sample volume requirements indicated per analyses by the receiving lab. Guidelines for this can be found in Table 2. Include duplicate samples and sample blanks in the preparation.
      iii. Prepare labels for bottles with the following information:
         - Sample ID (in addition to CLP lab ID) as indicated below under "Sample Nomenclature"
         - Type of sample (raw, filtered, unfiltered)
         - Preservative (as required, include type)
         - Analysis required
         - In the field, the date, time, and the sampler's initials should be written on the tag
   b. Verify field sampling tote has the resources needed, including 3 sets of sampling spares per sampling site, according to Table 1. Also include spare blank CoCs as a precaution.
3. On sampling day, load the following into the truck after completing truck inspection:
   a. Standard PPE needed for site visit: hardhat and safety vest (site-specific), safety glasses, and steel toed boots with defined heel.
   b. Water-safety PPE as needed per site conditions, i.e. lifejackets, lifesaver and rope. Required for sampling at all bodies of water with potential to fall into: lakes, natural or artificial ponds, etc.
   c. Coolers with sample bottles
   d. Tote(s) with additional supplies
   e. Extendible sample pole

f. Buggy whip (site-specific)
g. Ice.
   - *Ice is going to be packed in Ziploc bags and added to the coolers for shipping. This can be purchased just prior to sampling. If the sample location is more than one hour away from the nearest facilities, additional ice must be purchased, or a large ice-chest with bagged water ice and covered with a layer a bagged dry ice may be used for maintaining a supply of ice to add to the sample coolers. Ice may be changed out once back to available facilities to maintain chilled samples.*
h. Additional supplies as needed based on the project sampling plan.

4. Contact via email or phone ACZ Labs to inform them of the impending shipment. It is preferred to plan sampling events Mon. – Thur. to allow for the lab to receive the samples via Next-Day Air shipment.
5. Conduct site-specific training upon arrival to site as needed. Generally, this will require early arrival approximately 30 minutes prior to scheduled arrival to avoid delays.
6. Before starting sampling conduct a safety review and the sampling plan with all people involved in the sampling, including the site escort. Cover any hazards not explicitly outlined in the HASP or new upon arrival to the site. Include the following: safety share, safety concerns about water sampling, sampling procedures, and role of everybody on sampling date.

Sample Nomenclature

Following is the sample identifier coding system (10 characters total):

Example: 17DLB1D001

The year (2017) and site name (i.e. Barker Hughesville – Danny T) are identified by the first three characters ("17D") of the sample identifier. This will be the same for all samples for this project unless it is changed by the project lead. The remaining characters change based on the sample type and collection point.

- The fourth letter, "S", denotes where the sample was collected (in the field, Site)

The fifth letter in the coding denotes the sample location within the treatment system being evaluated:

- "F" = Feed water
- "P" = Pre-treatment effluent
- "B" = SRBR effluent
- "W" = Wetland effluent

The next character (6^{th}) denotes the specific sample location:

- "A" = Sampled directly from the active flow of the creek
- "C" = Sampled from the bulk sample collection structure

The next character (7^{th}) denotes whether or not the analysis is Total or Dissolved (T/D)

The final three characters represents the sample number within the series from "001" up to "999" and are sequentially generated.

Sampling procedure

1. Collect 1000 mL sample from location, using sampling pole as needed. Rinse the new 1000 mL bottle with raw sample twice, then collect 1000 mL of sample. Transfer 500 mL of raw sample into the appropriate 500 mL sample bottle, cap bottle, and refill 1000 mL sample bottle. Wear neoprene or nitrile gloves when handling samples.
2. The 500 mL sample bottle should be labeled for BOD analysis. Place sample in cooler as soon as possible to chill to <4°C.
3. Decontaminate sampling pole between samples and at the end of the sampling event by spraying down with 5% Alconox solution and scrubbing lightly. Rinse off with DI water.
4. From the bulk 1000 mL sample, take measurements with the field multiparameter meter. Verify that sample location name is correct in the meter sample ID field.
5. Log the measurement on the multimeter and record readings in field notebook (as backup in case of data loss). Also include GPS location as near to the sample location as feasible.
6. Don appropriate PPE for acid handling for all acid-preserved sample bottles.
7. From the bulk 1000 mL sample, pour 250 mL raw sample into the appropriate bottle containing sulfuric acid preservative. This sample should be labeled for nitrate/ nitrite analysis. Verify pH < 2 with pH strip.
8. Pour 125 mL raw sample into the appropriate bottle containing nitric acid preservative. This sample should be labeled for ICP-Total metals (and total Mercury) analysis. Verify pH < 2 with pH strip.
9. Syringe- filter (with clean 60 mL syringe and 0.45 µm filter) 250 mL of sample into appropriate 250 mL bottle without preservative and close bottle. This sample should be labeled for acidity, alkalinity, and desired anions analysis (except nitrate/ nitrite). Place sample in cooler immediately to chill to <4°C. *NOTE: If filtration gets difficult (requires too much pressure), change the filter as needed. This may require between 2-4 filters per sample.*
10. From the bulk 1000 mL sample, syringe- filter 125 mL of sample into appropriate 125 mL bottle containing nitric acid preservative and close bottle. This sample should be labeled for ICP-Dissolved Metals (and dissolved Mercury). Verify pH < 2 with pH strip.
11. Initial and date all sample labels and place a strip of clear packing tape over labels to preserve information. Transfer all prepped samples to zip- top bags.
12. Verify sample coolers are lined with sufficient absorbent pads. Double bag all ACZ samples in a large trash bag in the cooler, squeeze out excess air from trash bags, and double- tie off (twist bag material at top and fold over) with zip-tie.
13. Place double bagged ice in cooler for shipping to ACZ, and place completed chain-of-custody in a sealed zip- top bag in cooler (See *Sampling Documentation* below).
14. Fill out required information on custody seals (if required) and affix over lid and base of each cooler. Secure cooler lids by wrapping with clear packing tape around cooler.
15. Clean up any contaminated equipment with Alconox solution and lightly scrubbing followed by rinsing with DI water. Place all equipment back in its appropriate bag/box.
16. Pour any unused sample back into sample collection point. Used bulk 1000 mL sample bottles, used gloves, paper towels, syringes, filters, and disposable lab coats go into trash bag. Tie off and secure trash after clean-up is completed.
17. Transfer data from field meter to a computer spreadsheet upon return to the lab.

Sampling documentation

1. Fill out chain-of-custody forms for ACZ Lab that are prefilled with FMI project, site, and PO information. Include sampler name, initials, and signature with date and time released.
2. Each cooler needs to have its own chain-of-custody form for the samples it contains. In a Ziploc bag, place the chain-of-custody form and add it to the samples in the cooler.
3. Make a copy of each chain-of-custody form and keep it for records (if feasible).
4. Shipping information:
    - ACZ Laboratories, Inc.
      2773 Downhill Drive Steamboat Springs, CO 80487

- Contact information.
  Scott Habermehl
  ACZ Project Manager
  scotth@acz.com
  970-879-6590 ext. 101
  http://www.acz.com

References

MSHA: CFR 30 Subpart N, Subpart O, Subpart Q & Subpart S
OSHA: 1910 Subparts: A, D, E, G, H, I, J, K, L & Z; OSHA Laboratory Safety Guidance
FCX: Resource Management General Code of Safe Practices
HSMS: 4.4.6(5) Operational Controls
OTHER:

Table 1 - Resources Required

Sampling materials	Field equipment and supplies	Other resources needed
1000mL pre-cleaned wide mouth sample bottles for bulk sampling	Field notebook	Neoprene Gloves
Sample bottles (see Table 2)	Pens and Sharpie markers	Safety glasses, including tinted versions
60mL Syringes	Field Multiparameter meter (calibrated, batteries charged, and initial sample ID entered)	Face shield
Labels for samples	Camera, with batteries and memory card	Disposable lab coat
Nylon or PVDF membrane syringe filters, 0.45µm rated	Plastic trash bags (13 gallon capacity)	Steel-toed boots with defined heel and ankle support
Ziploc bags, including spares for ice and back-up	Clear packaging tape	Large trash bags (30 gallon capacity)
Preservatives, stored in a Ziploc bag (See Table 2)	Paper towels	Sunscreen and personal bug spray
Sample cooler(s)	Extendible sampling pole with 1000 mL bottle holder attached	Hearing protection, as needed
Custody seals	DI water	Leather gloves, as needed
4 Pre-filled ACZ Labs Chain of Custody (COC) forms. Sample ID fields may be left blank and entered in the field	5% Alconox solution in spray bottles for decontaminating equipment, plus additional if using portable well sampling pump	Wood and brush-cutting tools may be required. Mine assessment from reconnaissance required in advance.*
Contaminant free water (for blanks, if needed)	Well sampling pump with hose reel and VFD controller, as needed	Water safety equipment (personal flotation device, lifesaver with recovery rope)
pH indicator strips, 0-14 range	Well pump cleaning apparatus, if needed	
	Generator (for well pump)	

* If chainsaw is intended for use in order to access Mine, additional resources are required: chainsaw safety chaps, chainsaw helmet with face-shield and hearing protection, safety-gas can, oil for fuel

mixture, chainsaw chain oil, absorbent pads and plastic work-tray (to contain drips of oils or gasoline). Training on the proper use of chainsaws is also required. Other tools such as axes, hatchets, machetes, or saws require the use of leather gloves.

SOP Name: Continuous Electrochemical Measurement
SOP No.: ETL-MT-07
Area: Environmental Technology Lab
Issue Date: 2 February 2017
Revision Date/ Reviewed Date:
Version: V1
Issued By: Environmental Technology Lab Supervisor

Critical Hazards:

Critical Hazards	Possible Outcomes	Incident Potential	Critical Controls	Applicable GSR
None	N/A	N/A	N/A	N/A

Purpose:

This procedure is used to measure pH, ORP, EC, and/ or Temperature in aqueous samples continuously using a Thermo Scientific Versa Star benchtop meter.

Definitions: None

Equipment Needs:

1. Thermo Scientific Versa Star meter
   - pH or pH/ISE channel installed (for pH or ORP)
   - Conductivity channel installed
   - Suitable pH or ORP electrode(s) according to manufacturer
   - Suitable Conductivity cell according to manufacturer

2. Reagents and Materials (as needed):
   - Standardized pH buffers, pH 4.01, 7.00, 10.01
   - Light's Solution
   - Conductivity standard 1413�S/cm, or equivalent to range in sample
   - Deionized (DI) water

3. Standard PPE:
   - Steel-toed boots, approved safety glasses, and neoprene gloves are required for handling chemicals or samples related to this procedure. Always use safe laboratory practices when handling chemicals. Read all applicable SDS' if unfamiliar with any of the chemicals used in this procedure.

Procedures:

➢ Setup and Operation

- o Set up an acrylic flow-through cell (flow cell) with the correct number and size of ports based on the desired measurement electrodes. Each flow cell should accommodate up to four electrodes, one per channel from the Versa Star meter.
- o Verify connections to tubing lines to and from flow cell are leak free and account for the full flow of sample through the flow cell.

- Set Versa Star meter in a location that is suitably stable and does not interfere with project operations. Verify location is protected from splashes and that meter is placed close enough to connect all electrodes without straining any cable connections.
- Enter Setup menu and set each channel to the appropriate mode and data logging interval as outlined in project documentation. Follow manufacturer's instructions to clear the data log prior to starting logging of readings in order to begin a new data set.
- Install individual electrodes after calibrating according to appropriate procedure.
- Once all electrodes have been calibrated and inserted into the flow cell, press the "CHANNEL" button to cycle through the display options for all connected modules. Once all modules in use are displayed, the meter will begin logging samples according to the interval set in the Channel Setup Menu (once every minute).
- The logged data should be downloaded to a laptop computer, at least weekly, and then saved to the appropriate electronic file location assigned to the project. The meter interface software, *Star Com 1.0*, must be installed on the computer used to download the data along with the USB drivers to interface with the meter. Follow the software instructions to download the meter data.
- After verifying the data was successfully downloaded and saved to the computer, the data log should be cleared to begin a fresh data set. Disconnect the meter from the computer.
- Press the "log view 9" button to access the data log menu from the measurement mode. Press the down arrow button to "Delete All" and press F3 "SELECT". Once the data log is cleared, press the "measure (esc) 1" button to return to the measurement mode. Verify the "AR" symbol is displayed. If it is not, the setup menu for each channel in use must be entered to reset the measurement mode to "Timed". The logging interval previously entered should be the same. Once reset, press the "measure (esc) 1" button to begin taking readings and logging data again.

➢ Electrode Calibration

1. Calibration should be performed prior to initial installation of each electrode used for continuous monitoring. Calibration should be repeated a minimum of weekly or more frequently for processes with fluctuating electrochemical levels.
2. All Quality control measures indicated in the individual electrode calibration procedures apply to each respective probe. A calibration log will be maintained for each type of electrode and will include all continuous monitoring meters used for the project. For example, a pH calibration logbook for all continuous meters will be used, another logbook for ORP, and so forth.
3. Calibrate the pH electrode according to SOP *ETL-MT-01- Measurement of pH of Aqueous Samples by Thermo Scientific Versa Star Meter.*
4. Calibrate the ORP electrode (if used) according to SOP *ETL-MT-02-ORP Measurement by Thermo Scientific Versa Star Meter.*
5. Calibrate the Conductivity cell (if used) according to SOP *ETL-MT-03-Electrical Conductivity (Specific Conductance) Measurement by Thermo Scientific Versa Star Meter.*
6. Perform an indirect calibration check once per week from a grab sample taken immediately after the flow cell. Take the readings and temperature of the grab sample using a lab pH, ORP, and/ or conductivity meter that has been calibrated appropriately. Readings should be taken as soon as possible after collecting the grab sample to maintain electrochemical and temperature conditions.
7. Include the indirect calibration checks in the calibration logbook. If the readings do not compare directly within tolerance indicated in the standard procedures, the continuous electrode(s) should be recalibrated. If recalibration is not successful, the electrode(s) should be replaced and a new calibration should be performed. Record any corrective actions taken in the correct calibration logbook.

References

MSHA: CFR 30 Subpart N, Subpart O, Subpart Q & Subpart S
OSHA: 1910 Subparts: A, D, E, G, H, I, J, K, L & Z; OSHA Laboratory Safety Guidance
FCX: Resource Management General Code of Safe Practices; TC H&S Policies
HSMS: 4.4.6(5) Operational Controls
EPA: SM150.2- pH, Continuous Monitoring (Electrometric)
OTHER: Thermo Scientific Orion VERSA STAR Operator's Manual, ID 68X006501, Rev A, April 2014

SOP Name: Data Entry, Validation, and Maintenance
SOP No.: ETL-MT-08
Area: Environmental Technology Lab
Issue Date: 10 February 2017
Version: V1
Revision/ Reviewed Date:
Issued By: Environmental Technology Lab Supervisor

Critical Hazards:

Critical Hazards	Possible Outcomes	Incident Potential	Critical Controls	Applicable GSR
None	N/A	N/A	N/A	N/A

Purpose:

This procedure is used to evaluate final results of data collected in the field or lab and to verify quality controls are effective in maintaining optimal data quality.

Definitions: None

Equipment Needs: None

Process:

- **Data Entry**
  - All data collected from lab testing is entered and uploaded to the appropriate spreadsheet or tracking document on the project SharePoint following completion of analyses. Data collected from field analyses is entered as soon as is feasible depending on the nature of the field activities.
  - All data is reviewed by the Lab Supervisor and Project Manager/ Lead twice weekly to ensure correct data is being presented. Additionally, the Quality Manager reviews the calibration records and any corrective actions included in the lab notebook to identify potential discrepancies in data collected.
  - QA/QC checks on duplicate sampling will be reviewed weekly by the Quality Manager to verify experimental precision.
  - Data stored electronically is compared to hard-copies daily as entered by the analyst or another individual authorized to review the data to verify general trends in data collection, recording, and transcription.

- **Validation**

1. Prior to analysis, sample prep and analysis holding times must be adhered to strictly.
2. All reagents, standard, calibration buffers, and intermediate solutions should be checked for expiration dates. All expired chemicals must be disposed of according to TCT Waste Management protocols and new chemicals must be ordered.
3. Maintain all COAs or other certifications of reagents to provide complete traceability for standards used. Each standard used must be documented in the appropriate calibration log as the standard is initially opened, and the expiration date should be included with the analyst's initials.

4. Equipment must be maintained and calibrated in accordance with relevant SOPs and manufacturer's guidelines. Any equipment deficiencies must be noted and reported to the Lab Supervisor immediately.
5. All sample containers, reagents, and solutions or solids being used or tested shall be clearly labeled and identified.
6. Sample volumes and amounts must be checked to verify sufficient material is available for all analyses needed.
7. Maintain accurate hand-written logs, and all notebooks or logbooks shall be written in ink. Any discrepancies or corrections shall have the incorrect data struck through with a single line, initialed and dated by the analyst, and the corrected data written adjacent to the struck-out data.
8. All documents containing data on the project SharePoint will have version history maintained and will be set at single-editor control level. This will require the documents or files to be checked out by one person at a time followed by checking in the document and including comments about the changes made while the file was in their possession.

- **Maintenance**
  - All lab notebooks shall be reviewed, signed, and dated on a bi-weekly basis or more frequently depending on project activity.
  - Equipment will be inspected initially when put in service and every week while in use. This includes cord inspection for all plugged-in equipment, visual inspection, basic functionality and operation, and QC verification based on calibration records.
  - Raw data files for all continuous monitoring data will be reviewed weekly to ensure adequacy and correct transfer to the working project documents.

References

MSHA: CFR 30 Subpart N, Subpart O, Subpart Q & Subpart S
OSHA: 1910 Subparts: A, D, E, G, H, I, J, K, L & Z; OSHA Laboratory Safety Guidance
FCX: Resource Management General Code of Safe Practices; TC H&S Policies
HSMS: 4.4.6(5) Operational Controls
EPA: SM150.2- pH, Continuous Monitoring (Electrometric)
OTHER:

Table 2- ACZ's Inorganic Bottle Preservation Chart

ACZ Laboratories, Inc

INORGANIC BOTTLE PRESERVATION CHART

Color	None	EDTA	White	Red	Green	Yellow	Blue	Tan	Purple	Pink	Black	Sterile
Letter Code **	U	EDTA	W	R [PC]	G [PC]	Y	B	T	P	PK	BK	ST
Sample Type	Raw	Raw	Filtered	Raw	Filtered	Raw	Filtered	Raw	Raw	Filtered	Filtered	Raw
Preservative	None	2.5mL 25% EDTA	None	2mL 50% HNO_3		2mL 25% H_2SO_4	2mL 25% H_2SO_4	1mL each 5N NaOH + 2N ZnAc	5mL 10N NaOH	5mL 10N NaOH	1mL 50% HNO_3	Sodium Thiosulfate tablet
Bottle Size	250 - 500 mL **	250mL	250 mL	250 mL		250 mL	250 mL	125 mL	500 mL	500 mL	125 mL	125 mL
Bottle Type	HDPE	HDPE	HDPE	HDPE	HDPE	HDPE or GLASS	HDPE or GLASS	HDPE	HDPE	HDPE	HDPE	HDPE
Storage	4 °C N walk-in cooler			Room Temp (Metals)		4 °C S walk-in cooler		4 °C N walk-in cooler	4 °C S walk-in cooler			N / A
Analytes	Acidity Alkalinity BOD SS TDS + TSS TSS only TVS Color Turbidity Odor EC PO_4 (Total) pH Surfactant Fe^{2+}	Sulfite	Iodide Nitrogen NO_3/NO_2 NO_2 (calc) NO_3 PO_4 (Diss) Bromide Chloride Fluoride Sulfate TDS only Cr^{+6}	Metals: Total, TRs	Metals: Dissolved, PDs Cations: B Ca K Na Mg	COD Phenol * Total Organic C * Phosphorus (Total) NH_3, (Total) NO_3/NO_2 "Yellow"	N-NH_3 (Dissolved) Phos (Dissolved) Phenol Dissolved Organic C * COD	Sulfide	Cyanide: Total 'Free' ISE WAD MACRO	Dissolved Cyanide: Total 'Free' ISE WAD	SCN	Coliform

SHORT HOLD TIMES: 24 HOUR – 48 HOURS

** Additional abbreviations may be provided by Log-in after the color code, which are used for information purposes only and are not intended for bottle type designation at the analytical level.

PC For trace metal analyses by EPA Method 200.8, sample containers that are ensured to be free of As, Be, Pb, Cd, Cr, Cu, Ni, Pb, Sb, Se, and Tl contamination are required. Pre-Cleaned (PC) Red or Green containers may be used. ACZ verifies each lot to be contaminant free prior to utilizing bottles for client samples [refer to SOPAD024].

** Settleable Solids analyses requires 1 L sample volume (UL).

* Use Glass

FRMAD045.12.11.10

SOP Name: Passive Bioremediation System Operation
SOP No.: ETL-MT-09
Area: Environmental Technology Lab
Issue Date: 1 February 2017
Version: V1
Revision Date/ Reviewed Date:
Issued By: Resource Management Health and Safety

Purpose:
Mining-Influenced Water (MIW) will be passed through PVC columns and treated biologically. To verify operation and performance of Sulfate Reducing Bioreactor (SRBR) columns, aqueous sampling must be performed.

Critical Hazards:

Critical Hazards	Possible Outcomes	Incident Potential	Critical Controls	Applicable GSR
Respiratory Irritation	Respiratory Illness	Lost Time	Air Monitoring, PPE	FCX-17 Hazardous Gas Policy

Definitions:
Hydrogen Sulfide (H_2S): Toxic by inhalation. May cause respiratory irritation. Prolonged exposure may reduce sense of smell (rotten egg odor). *Always verify safe atmosphere with properly calibrated and bump-tested personal gas meter and follow entry protocols for SRBR column area. Verify ventilation is operational and functioning prior to entry.*

Equipment Needed:

a. Personal H_2S meter
b. 1000mL environmentally cleaned HDPE sample bottles with closures
c. Pre-preserved sample bottles as required:
    i. 500mL HDPE (Raw sample - no preservative)
    ii. 250mL HDPE (Filtered sample - no preservative)
    iii. 2 x 125mL HDPE (both with HNO_3 preservative for metals analysis)
d. 0.45mm Nylon or PVDF membrane syringe filters
e. 60mL syringes with Luer-Lok tips
f. 50mL centrifuge tubes with closures (for electrode sampling only)
g. Fume hood
h. Other equipment as required for analyses - see relevant SOPs

Reagents:

a. Trace metals grade concentrated nitric acid, if needed
b. Trace metals grade concentrated sulfuric acid, if needed
c. Other reagents as needed according to meter operation SOPs and calibration procedures.

PPE:

Wear required protective equipment, such as steel toed boots or shoes, approved safety glasses, and neoprene gloves. Personal H_2S monitor is mandatory while in the SRBR column enclosure. Always bump test personal gas meter daily according to manufacturer's directions and record results on the appropriate log sheet. When handling concentrated acids, additional PPE including face shield, lab coat, and double-neoprene gloves is required. Always use safe laboratory practices when handling chemicals. Read the SDS if unfamiliar with any of the chemicals used in this procedure.

Procedures:

- *Sampling Collection and Analysis*

1. Collect sample bottles according to sampling requirements from Table 1 and the needed amounts from Table 2. Sampling is based on which phase the column is in (acclimation or continuous phase).
2. Calibrate lab benchtop pH, ORP, EC, and DO multimeter for weekly measurements according to appropriate SOP. This will be performed only on days when conducting weekly measurements. If corrective actions are taken and noted in the calibration logs, record corrective action in lab notebook as well.
3. Log all samples and label all containers for that day according to *Sampling Nomenclature* indicated below. Verify applicable paperwork with sample containers and labels.
4. After verifying all equipment is calibrated, open entry door to column area enclosure and verify ventilation fan and fresh air cooler are operational. Enter enclosure and verify H_2S concentration at entrance with personal gas meter. For all activities, the door must remain open.
5. Perform a work area inspection and fill out appropriate log sheet, including H_2S level indicated on personal monitor. Immediately report any leaks, obvious pump malfunctions, or other issues to Lab Supervisor. Record issues in the lab notebook.
6. To obtain sample, remove 1000mL sample reservoir from fitting by unscrewing from cap. Immediately place cap on sample bottle then place a new sample reservoir bottle by screwing into cap. Collect effluent samples from all columns (pre-treatment and SRBR) and tanks in this manner. These effluent samples will be further sub-sampled for individual analyses.
7. Collect BOD samples from each column by inserting BOD sample bottle directly under sample port located on the side of the column. BOD sample bottles can be plastic or glass, and clear. Open the valve and fill bottle to the top, close valve, and immediately cap sample bottle with minimal headspace. Place all BOD samples in sample refrigerator as soon as possible to chill to < 4°C.
8. All samples shall be handled under fume hood with sash at correct height. Using the sample collected under task 6, analyze each sample for DO, ORP, pH, and EC using appropriate calibrated meters. All four electrodes should fit in the wide-mouth 1000mL sample bottle at the same time. Ensure that all electrodes are thoroughly cleaned and rinsed in between each sample. Take care to not agitate the sample more than necessary to reduce fluctuations in CO_2 or O_2 levels.
9. Record all data in the lab notebook. Indicate any discrepancies in the lab notebook. Note any corrections by striking through the incorrect data, initial, date, and write in the corrected data adjacent to the struck-out data.
10. Once the above analyses are complete, syringe-filter the dissolved ICP-metals sample from the 1000mL bulk sample according to the bottle and amount listed in Table 2. Add the amount of acid indicated in Table 2 to bring the pH < 2.

11. Syringe filter the sulfate sample (includes alkalinity / acidity samples) into the bottle listed in Table 2.
12. Syringe transfer the total ICP-metals sample and the nitrate/ nitrite sample into the appropriate bottles. If the bottles requiring preservation do not already contain the appropriate acid, add the amount of acid indicated in Table 2 to bring the pH < 2.
13. Collect influent MIW samples prior to any column operation startup and after each fresh barrel of MIW is opened. To sample, fill a new 1000 mL sample bottle and a new 500 mL sample bottle from the sample collection valve located below the feed container. Perform all sample prep as indicated in steps 8-11.
14. Place all prepped samples in the sample refrigerator to cool to < 4°C.
15. Measure volumes collected in each effluent bucket by pouring contents into a graduated cylinder of appropriate size. Record all volumes in lab notebook.
16. Verify all samples being shipped to ACZ and package according to SOP *ETL-MT-05- Field Water Sampling.* Fill out chain-of-custody form and include in shipping cooler(s). Log sample shipment into log book. Ship out samples via Next Day Air.
17. Transfer all data collected each day to the appropriate spreadsheet located on the project SharePoint.

➢ *Maintenance*

1. After all samples have been collected, perform following checks. Document and report all leaks or poor connections in the lab notebook and to Lab Supervisor prior to repairs:
   a. Verify pump operation, flow rate settings, pump tubing, and connections
   b. Inspect area for leaks or clogging in influent and effluent drain lines, all column connections, collection reservoirs, flow-cells, and influent manifold
   c. Check H_2S vapor traps for proper connections and correct indicator color.
2. Calibrate all continuous monitoring pH, ORP, and EC multimeters per appropriate SOP every Monday, Wednesday, and Friday. Document all calibrations in appropriate log book and report any non-conformances or corrective actions in calibration log.
3. Drain effluent collection barrel twice weekly into appropriate temporary containers. Close containers immediately, and transport to lab when full. Dispose of solutions in cup sink in fume hood, or as appropriate according to TCT Waste Management protocols. Special samples or modified treatment requires permission prior to disposal via TCT Environmental Management.
4. Clean up as needed and replace covers over any columns that were removed to maintain darkness. Close door to enclosure. Return personal H_2S monitors to proper storage location.

Sample Nomenclature

Following is the sample identifier coding system (10 characters total):

Example: 17DLB1D001

The year (2017) and site name (i.e. Barker Hughesville – Danny T) are identified by the first three characters ("17D") of the sample identifier. This will be the same for all samples for this project. The remaining characters change based on the sample type and collection point.

The fourth letter denotes where the sample was collected; the field or in the laboratory (as either a sample to be analyzed at ACZ or ETL

- "S" = samples collected in the field (Site)
- "L" = samples collected at the ETL and analyzed at ACZ
- "P" = samples collected at the ETL and analyzed at ETL (primarily field parameters)

The fifth letter in the coding denotes the sample location within the treatment system being evaluated:

- "F" = Feed water
- "P" = Pre-treatment effluent
- "B" = SRBR effluent
- "W" = Wetland effluent

The next character (6^{th}) denotes the treatment option (SRBR 1 through x –or– APC 1 through x) sampled
The next character (7^{th}) denotes whether or not the analysis is Total or Dissolved (T/D)
The final three characters represents the sample number within the series from "001" up to "999" and are sequentially generated.

Training:
Training specific to this SOP required. Additional training on accompanying SOPs for gas meter bump testing or meter calibrations also required.

References:

MSHA: CFR 30 Subpart N, Subpart O, Subpart Q & Subpart S
OSHA: 1910 Subparts: A, D, E, G, H, I, J, K, L & Z; OSHA Laboratory Safety Guidance
FCX: Resource Management General code of Safe Practices; TC H&S Policies; JHA BCR Columns, FCX-17 Hazardous Gas Policy
HSMS: 4.4.6(5) Operational Controls OTHER: See Tables 1 & 2

Table 1 Required sampling based on column phase

Operations Phase	Pre-operation	Inoculation Phase	Treatment Phase
Aqueous Samples	Influent MIW sampled for pH, temperature, ORP, EC, DO, ICP-metals, Sulfate, Nitrate/Nitrite, BOD, Acidity, Alkalinity	ORP	pH, temperature, ORP, EC, DO, ICP-metals, Sulfate, Nitrate/Nitrite, BOD, Acidity, Alkalinity

Table 2 Required sample volume for each analysis and sample hold time

Analyte	pH, ORP, DO, EC	Total metals	Dissolved metals	Sulfate	Nitrate/ Nitrite	BOD	Acidity, Alkalinity
Sample Required	*50mL	125mL	125mL	250mL	250mL	500mL	**100mL
Preservation	None	pH<2 with Nitric acid,	0.45□m filter, pH<2 with nitric acid	0.45□m filter, Cool to 4°C	pH<2 with sulfuric acid, Cool to 4°C	Cool to 4°C	Cool to 4°C
Hold Time	Immediate	6 months	6 months	28 days	28 days	48 hrs.	†28 days

*Electrochemical measurements may be taken from 1000mL bulk sample
**Acidity and Alkalinity samples may be obtained from the sulfate anion sample
†Acidity or alkalinity samples are preferably analyzed within 7 days to reduce potential for bacterial activity influencing alkalinity in the sample

SOP Name: Notebook and Photographic Management
SOP No.: ETL-MT-10
Area: Environmental Technology Lab
Issue Date: 19 May 2017
Version: V1
Revision/ Reviewed Date:
Issued By: Environmental Technology Lab Supervisor

Critical Hazards:

Critical Hazards	Possible Outcomes	Incident Potential	Critical Controls	Applicable GSR
None	N/A	N/A	N/A	N/A

Purpose:

This procedure provides guidance on the correct use of laboratory and field notebooks as well as outlining the process for maintaining all photographic records used for project purposes.

Definitions: None

Equipment Needs: None

Process:

➢ **Notebook Use and Verification**

- For projects operated through the Environmental Technology Lab, lab notebooks and field notebooks are obtained from the Lab Supervisor. Each notebook is assigned a unique identification number according to the notebook-tracking log maintained by the Lab Supervisor.
- Lab notebooks for sensitive projects are required to be kept in a secure location when not in use. All laboratory staff will have access to controlled documents via key or passcode controls.
- All data collected from lab testing and field measurements shall be hand-written in blue or black ink only. "Write-in-the-Rain" notebooks are acceptable in the field, and require suitable rainproof pens with blue or black ink. Any mistakes shall be crossed out with a single line followed by initial and date by the individual making the correction.
- The Table of Contents at the beginning of each lab notebook is generally kept blank until a project is completed, and filled in with the information contained therein prior to submitting the notebook for archival.
- Every page shall be dated at the top from the first entry for that page. Each new day where data is entered shall indicate the date entered.
- All pages will be reviewed, signed, and dated on the appropriate location by the Lab Supervisor or Designee. Preferably, this will be completed twice weekly to ensure correct data is being presented. At minimum, this shall be done at least twice a month. Additionally, the Project Manager/Lead will review the notebooks at least once monthly.
- Any computer-generated and printed forms containing data should be of sufficient size to fit within the borders of the lab notebook pages and are to be taped in place.

- When multiple individuals are entering data in the notebooks, they shall initial the start of each set of data.
- Any pages intentionally left blank shall be struck through with a single diagonal line with the initials of the individual indicating, date struck, and stating the page left blank or "NO DATA"

➢ **Photographic Record Management**

- Photographs taken for record and documentation of project activities may include, but are not necessarily limited to, site overviews, sampling locations, site modifications, project equipment, or test apparatuses.
- Any photographs taken with digital cameras should be saved initially to the removable storage device and then uploaded to the project electronic project folder for archival. After project completion, the removable storage media should be collected and archived along with hard copy data such as notebooks.
- Photographs that are saved and uploaded to the electronic project folder should be labeled with an appropriate identifier including the date the picture was taken as well as a basic location descriptor. Consecutive pictures from the same areas should include consecutive enumeration.

    For Example: 170412 HSMine 001, 170412 HSMine 002
- Any sensitive areas where pictures are to be taken require the approval of the Project Manager/Lead and the Site Coordinator prior to taking the pictures.
- Pictures that are subsequently included in any reports must also have the approval of the appropriate parties. All pictures must be uploaded to the correct electronic project folder, and no other pictures shall be included in the project folder. Any pictures inclusive to any historical reports that are included with any references contained in the electronic project folders specific to the project are sufficient to be in the report.
- All hard-copy materials containing photographic records (i.e. flash drive, removable digital memory cards, physical photos, etc.) that are taken in the field are to be archived as soon as feasible after digital versions have been uploaded.

References
MSHA:
OSHA:
FCX: Resource Management General Code of Safe Practices; MIS End User Policies
HSMS:
EPA: Sampler's Guide, EPA-540-R-014-013, Oct. 2014
OTHER:

Appendix B – Health and Safety Plan

SITE SPECIFIC HEALTH & SAFETY PLAN

Treatability Study of Danny T Mine Adit Discharge

Barker Hughesville Mining District Superfund Site

Judith Basin and Cascade Counties, Montana

February 2017

Prepared by

Freeport Minerals Corporation,
on behalf of Mt. Emmons Mining Company
1600 E. Hanley Blvd.
Oro Valley, AZ 85737

Document	Description of Change or Modification	Date	Initials
HASP	Initial Release	2/13/17	JS

SECTION 1

APPROVALS

By their signatures, the undersigned certify that this Site Specific Health and Safety Plan is approved and will be utilized for the Danny T Mine Treatability Study.

6/15/17

Dan Ramey
Director, Environmental Technology/Life Cycle

Date

6/15/2017

Barb Nielsen
Manager, Remediation Projects

Date

6/15/2017

Erick Weiland
Project Manager, Environmental Technology/ Life Cycle

Date

6/15/2017

Brett Waterman
Quality Assurance Manager, Environmental Technology/Life Cycle

Date

6/15/2017

Jill Schultz
Manager, Health and Safety

Date

1.0 INTRODUCTION

1.1 Objective

This Health and Safety Plan (HASP) has been developed by Freeport Minerals Corporation (FMC) on behalf of Mt. Emmons Mining Company (Mt. Emmons) to provide direction and authority for establishing safe working conditions for the lab-scale treatability study of a passive bioremediation treatment system for mining-influenced water emerging from the Danny T Mine (Mine) at the Barker Hughesville Mining District Superfund Site (Site) in Judith Basin and Cascade Counties, Montana. The safety organization, procedures, and protective equipment identified have been established based upon an analysis of potential hazards and have been evaluated and selected to minimize the potential for accident or injury. Changes in this plan or operations that could affect the health and safety of personnel, the community, or the environment will not be made without the prior approval of Mt. Emmons Project Director, Remediation Manager, Project Manager, QA Manager, and the Health & Safety Manager. Specific requirements may be revised if new information is received or conditions change. Any changes to this HASP will be lined out and a written amendment will document all changes made to the plan and will be incorporated in the HASP Amendment Log. All changes will be reviewed with affected employees.

The provisions of this plan are mandatory for all personnel and subcontractors assigned to the project. All visitors to the work site must abide by the requirements of the plan.

2.0 BACKGROUND AND SCOPE OF WORK

2.1 Mine Location and History

The Mine is an abandoned mine located within the Barker Hughesville Mining District Superfund Site in west-central Montana, east of Monarch. Mine is accessible by traveling approximately 8 miles east on Hughesville Road off U.S. Highway 89 from the town of Monarch, Montana.

Map of the Mine. Inset denotes the Mine with a star and Google Earth imagery denotes the Mine with a pin.

Sample collection will be performed at the Danny T Mine and laboratory bioremediation testing will be conducted at the Environmental Technology Laboratory (ETL) located in Tucson, Arizona. Day to day management and planning including sample handling and laboratory experiments will be conducted at the ETL facility.

Scope of Work

Mt. Emmons will be conducting a lab-scale treatability study of the mine-influenced water (MIW) from the Mine's adit and includes the following activities:

1. Sample and collect adit discharge, and
2. Conduct a lab-scale bioremediation treatability study.

The above tasks and associated activities for this project are covered by this HASP. The HASP delineates procedures that will allow personnel to work safely and respond quickly and appropriately to site emergencies. The HASP will be on site and readily available during site activities to all project personnel. It is anticipated that field activities will begin in the spring of 2017 and remain in effect through project completion.

3.0 HEALTH AND SAFETY REQUIREMENTS

3.1 Policy Statement

Mt. Emmons is committed to the philosophy of zero incidents, injuries, fatalities and occupational illnesses. Employees will be properly trained and held accountable for following all prescribed safety procedures and practices. In addition, this HASP will be reviewed with all employees associated with this project before they begin work. Safety and Health will not be compromised. Project Supervision as well as each employee is responsible for worksite safety and for the environment in which they work. No job will be considered so important, and no schedule so urgent that time cannot be taken to perform work in a safe manner. Working safely is a condition of employment.

For all project personnel, there will be 100% reporting of all work-related injuries and occupational illnesses, including "near-misses" to Mt. Emmons site management. All site work will also be conducted in accordance with Occupational Safety and Health Administration (OSHA) regulations and Hazardous Waste and Emergency Response (HAZWOPER) guidelines as applicable.

3.2 Stop Work Authority

All employees have the responsibility to stop work if conditions that jeopardize health or safety are identified. Mt. Emmons is responsible for the overall project coordination and development of the HASP. Each field team member is responsible for conducting work in a safe manner in compliance with the HASP. Key Employees as well as all site employees have the right and duty to stop work when conditions are unsafe, or when established safety procedures, permits, or environmental controls are being disregarded. Whenever an employee determines that workplace conditions present an immediate uncontrolled risk of injury or illness, immediate resolution with the appropriate supervisor shall be sought. Should the supervisor be unable or unwilling to correct the unsafe conditions, the employee is authorized and required to stop work. The specific activity or operation in question shall be discontinued until the issue is resolved.

Resumption of safe operations is the primary objective; however, operations shall not resume until a Health and Safety (H&S) representative has given approval that workplace conditions now meet acceptable safety standards. Any supervisor or manager responsible for resuming operations without H&S approval, thereby endangering project personnel, shall be subject to disciplinary action.

3.3 Employee Acknowledgement of HASP Requirements

This HASP summarizes health and safety hazard information for both field and laboratory site activities. In addition, all site work will be conducted in accordance with requirements of Mt. Emmons certified 18001 Health & Safety Management System (HSMS), which is incorporated by reference. All employees covered by this HASP, who cannot or will not comply with the HSMS, will be excluded from site activities. All project personnel must participate in a review of this HASP prior to work beginning and acknowledge that they have done so by signing the Employee Acknowledgement Form (**Attachment A**).

4.0 KEY PERSONNEL / ORGANIZATIONAL STRUCTURE

Key personnel for project are as follows:

Name	Phone/email	Responsibilities
Roger Hoogerheide	406-457-5031 Hoogerheidi.roger@epa.gov	EPA Site Coordinator Remedial Project Manager
Barbara Nielsen	480-313-2895 bnielsen@fmi.com	Manager, Remediation Projects
Dan Ramey	520-498-6556 dramey@fmi.com	Director, Environmental Technology/Life Cycle
Erick Weiland	520-498-6591 eweiland@fmi.com	Project Manager, Environmental Technology/Life Cycle
Brett Waterman	520-498-6558 bwaterma@fmi.com	Quality Assurance Manager, Environmental Technology/Life Cycle
Leonard Santisteban	520-498-6575 lsantist@fmi.com	Project Lead and Research Scientist, Environmental Technology/Life Cycle
Ilsu Lee	520-498-6569 ilee@fmi.com	Environmental Engineer, Environmental Technology/Life Cycle
Shane Hansen	520-229-6644 shansen@fmi.com	Laboratory Supervisor, Environmental Technology/Life Cycle
Jill Schultz	520-498-6542 jschultz@fmi.com	Manager, Health & Safety
Frank Demer	520-498-6561 fdemer@fmi.com	Sr. Industrial Hygienist, Health & Safety
ACZ Laboratories		

4.1 Key Personnel Responsibilities

The implementation of this Health and Safety Plan will be the shared responsibility of the Project Manager(s), Project Lead, Health and Safety Manager, and the Laboratory Supervisor. All project personnel are expected to participate in the implementation of the plan as well as compliance with it at all times.

4.2 Site Remediation Project Manager

The Site Remediation Project Manager is the primary contact responsible for overall management and coordination of the study. To the extent necessary, the Site Manager will coordinate on-site activities with regulatory representatives and other resource personnel. The Site Manager has authority to suspend all work that poses any health and safety risk.

4.3 Project Lead

The Project Lead has direct supervision over all Mt. Emmons on-site personnel and coordination of daily field site-specific work efforts to ensure all activities are in strict compliance with site-specific health and safety plan and the HSMS. He or she will coordinate daily site-specific work efforts and ensure all activities are in strict compliance with this site-specific health and safety plan and the Project Work Plan. The Project Lead has authority to suspend all work that poses any health and safety risk. Some specific health and safety responsibilities include:

- Ensuring that all personnel, to whom this HASP applies have reviewed it and have a copy available to them at all times.
- The HASP shall be reviewed and signed by all project personnel and before work begins. New site personnel are also required to review and sign the HASP acknowledging their acceptance of site rules and understanding of site hazards prior to beginning work.
- Conducting pre-entry briefing and subsequent safety meetings as required.
- Ensure that the necessary PPE and safety equipment required for this project is being used and kept in good working order by employees.
- Initiating emergency response procedures in accordance with this HASP and working with the Remediation Manager to reduce the probability of an incident or injury to the site personnel, visitors or the public.
- Providing the Health & Safety Manager with updated information regarding the scope of site work and any changes that may occur.
- Escorting all site visitors, regulators or other non-project specific personnel.
- It is also the responsibility of the Project Lead to respond to emergencies that may require on-site or off-site assistance (e.g., injuries, spill, etc.).

4.4 Health and Safety Manager

The Health and Safety Manager is responsible for oversight of the Health and Safety Management System and the site HASP. The Health and Safety Manager may designate a fully trained and experienced individual to be the Sr. Health and Safety Specialist (and other personnel as necessary) who will assist in enforcement of safety policies and procedures on-site. The Health and Safety Manager will verify compliance with the HASP through frequent audits and assist with the preparation and review of JHA, review of exposure monitoring data, as well as review of compliance with regulatory criteria. The Health and Safety Manager/Sr. Health and Safety Specialist has the authority to immediately correct all situations where noncompliance with this HASP is noted and to immediately stop work in cases where an immediate danger is perceived. Some specific responsibilities may include:

- Assisting the crew with the Job Hazard Analyses (JHA) as necessary to ensure that all hazardous tasks have been properly addressed and that sufficient control measures have been identified for those tasks.

- Work with the Industrial Hygienist and the project Health and Safety Technician to ensure that all required monitoring is completed, documented and reported.
- Maintain the project Health and Safety Records, Safety Data Sheets (SDS), employee training records and other pertinent regulatory and technical references.

4.6 Senior Industrial Hygienist

The Sr. Industrial Hygienist will provide the necessary technical, occupational health and safety and compliance regulatory oversight to ensure that this program is implemented in accordance with the requirements outlined in the Work Plan and this HASP. Support will be provided to the Health and Safety Manager/Sr. Health and Safety Specialist regarding selection of PPE, respiratory protection, training and biological monitoring of personnel when required. The Sr. Industrial Hygienist will conduct frequent audits of the program to verify compliance with the HASP and ensure the proper operation of the monitoring, recordkeeping and reporting criteria, as necessary.

5.0 SAFE PRODUCTION COMMUNICATION

5.1 Pre-Entry Briefing (HASP Review Meeting)

No person will be allowed at the Mine (including laboratories) without first receiving a site hazard briefing. Individuals who are to work on the project will be required to review the HASP and any updates or changes that have been made including the requirement to participate in daily tailgate meetings. All personnel who are Mine visitors will review and sign the site-specific tailgate safety meeting form as a record of their presence on site.

5.2 Daily Tail Gate Meetings

Mine/Laboratory supervision and all personnel will participate in daily "tailgate" safety meetings to discuss site hazards, the effectiveness of health and safety procedures, and any need for revision. These meetings will be held at the onset of activities each day, at the beginning of new tasks, or when revisions that may affect worker health and safety are made to existing tasks. All meeting attendees shall sign in and the topics recorded on a tailgate safety meeting form.

5.3 Monthly Safety Meeting

Each month there will be a formal "All Hands" Safety Meeting that will have an agenda to address recent incidents and corrective actions taken, status of project safety performance, project safety and health concerns, achievement of site Safety Objectives and recognition of those employees demonstrating outstanding Safety behavior and contribution. Attendance at Monthly Safety Meetings will be documented.

Hazard Communication

A safety data sheet (SDS) must be available for each hazardous substance that Mt. Emmons employees bring on site. Mt. Emmons will be responsible for maintaining a copy of their Hazard Communication Program and ensuring SDSs are accessible to project employees. Mt. Emmons personnel are required to submit a request for approval of any chemicals/materials before bringing the item on site. Each request for review shall have the respective Safety Data Sheet submitted with it. This should be done at least a week in advance of beginning work to avoid delay of work start up. Each material will also have been reviewed by Industrial Hygiene and the Environmental Engineer prior to use. This review will also generate an electronic file of those SDSs approved for use on site.

In addition, all containers of hazardous materials must be labeled in accordance with the company's Hazard Communication Standard. Either the original manufacturer's label or an OSHA required GHS label specific to the chemical is required.

6.0 POTENTIAL HEALTH AND SAFETY HAZARDS

6.1 Chemical Hazards on Site

EPA has alleged that the Mine may contain elevated levels of various metals in surface water, sediments, and soils, including arsenic, cadmium, copper, iron, lead, manganese, mercury, nickel, and zinc (Pioneer Technical Inc., 1995). Due to the levels of metals and low pH, personnel performing adit discharge sampling will be required to wear chemical resistant gloves, safety glasses, safety boots, pants and long-sleeved shirt. Coveralls are optional.

Standard laboratory hazards such as acids/bases and other laboratory chemicals exist within the ETL. PPE required is procedural and chemical dependent and typically is lab coat/apron, safety glasses/goggles, chemical resistant gloves and safety shoes.

6.2 Physical Hazards on Site

Physical hazards include but are not limited to: drums, rugged terrain, slips, trips, falls, traffic, lifting, electricity, sharp objects, weather, noise, and laboratory equipment (i.e., shakers, centrifuges, etc.).

Mt. Emmons and site supervision will conduct Hazard Identification and Risk Assessments/Job Hazard Analysis when encountering hazards not covered by instruction. Safe Operation Procedures (SOP's) will be used as part of the instruction training and will continue to be updated when encountering any hazards.

6.3 Biological Hazards on Site

Biological hazards include insects, and poisonous animals (e.g., rattlesnakes, black widow spiders), and pathogens (e.g., Hantavirus, West Nile virus).

Snakes

The Prairie Rattlesnake is the only venomous snake found in Montana and contact is not likely. This snake favors open and arid country in rock outcrops but can be found in mixed grass-coniferous forests. Discovery of a venomous snake, or snakes, requires employees to back off.

To minimize the threat of snake bites and insect hazards, all personnel walking through vegetated areas will be made aware of (during training) the potential for encountering snakes and will avoid actions such as turning over logs, rocks, etc., that could increase the potential for snake bite. If bitten by a snake, the victim should be kept still and transported to the nearest hospital as soon as possible. First aid consists of: remaining calm and moving beyond the snake's striking distance; removing jewelry and tight clothing before swelling ensues; positioning yourself, so that the bite is at or below the level of the heart; cleaning the wound, but don't flush it with water, and cover it with a clean, dry dressing. Don't use a tourniquet or apply ice. No cutting and sucking should be performed.

Black Widow Spider

Shiny, black, with a red hourglass marking on the abdomen of the female, The Black Widow Spider is found in dark corners of sheds, under logs, and in rock piles. Black widows are found in both settled and unsettled areas. The spider will bite, if provoked, and the bite can be dangerous to all ages. It is seldom fatal. However, if the pain spreads throughout the body, accompanied by headache, dizziness, nausea, and excruciating cramps. First aid consists of: cleaning the wound (Use mild soap and water and apply an antibiotic ointment; apply a cool compress. Use a cloth dampened with cold water or filled with ice (This helps reduce pain and swelling); if the bite is on an arm or leg, elevate it; use over-the-counter medications (acetaminophen or ibuprofen for pain relief, or an antihistamine).

Ticks

The wood or deer tick is common in Montana and may be the cause of tick-borne infection and/or illness. Common symptoms of infections include fever and chills, aches and pains, rash, and fever. Timely removal of attached ticks can reduce the likelihood of contracting a tick-borne illness. Conduct a full-body tick check upon returning from tick-infested areas. Most infections and illnesses can be treated with antibiotics.

Ticks are often found in areas with tall grass, shrubs and woody ornaments. Wearing long sleeved shirts and long pants and tucking the shirt into your pants will help minimize ticks ability to attach to your skin. Using insect repellent on skin, pant legs and shoes will also help prevent ticks from crawling on you. Use repellents that contain 20 to 30% DEET (N, N-diethyl-m-toluamide) on exposed skin. Use products that contain 0.5% permethrin on clothing.

Bears

Black bears are predominantly the type of bears that live in Judith Basin and Cascade Counties, MT. However in recent years there have been sightings of grizzly bears in the western and northwestern areas of the county. Black bears can be black, blue-black, dark brown, or cinnamon, and are typically timid in nature. Grizzly bears are more aggressive and have a pronounced shoulder hump and a concave facial profile, smaller ears and much larger claws than black bear. Although grizzlies normally avoid contact with people, they may attack when surprised or if they are attempting to defend their cubs.

In open country be sure to scan the horizon for the presence of bears; whereas in forested areas it is recommended that you make lots of noise to make your presence known. Black bears are agile climbers and grizzlies can climb short distances up trees so if you are in a situation where a bear is going to attack look for a tree that will get you at least 33 feet above ground. Bears can charge at 30 mph so do not attempt to outrun the bear.

If you observe a bear at a distance of more than 350 feet and it has not seen you, slowly and quietly leave the area. If a bear is at a distance and sees you, act in a way so the bear can identify you as a human. Speak calmly and back away slowly while keeping a close eye on the bear. If a bear acts aggressive the following steps should be taken: assess the situation (i.e. are their cubs involved, etc.), do not run, try to retreat slowly, and climb a tree if available. If the bear charges you then use bear spray if available otherwise if a black bear fight back. If the bear is a grizzly fighting back may cause more harm and it is advised that playing dead (i.e. on side in a fetal position with head in-between legs) may reduce the level of injuries. Remember bears are attracted to food and food should be kept inside a container locked in a vehicle.

Northern Goshawk

The Northern Goshawk (Goshawk) is a raptor of the northern U.S. and inhabits mature woodlands found in lowlands and mountainous areas. The Goshawk is considered a permanent resident of western Montana and can be found year-round. Goshawks build their nests near breaks in the forest canopy such as a hiking trail, forest road or in areas of downed trees and prefer sites with a creek, pond or lake nearby. Typically the species is very territorial especially during nesting season and may exhibit an aggressive behavior if they believe their nest and/or young are threatened. Goshawks may make repeated passes, flying low overhead, to scare off intruders near a nest. Rarely will they make physical contact. However, if hard hats are not being worn and a Goshawk is dive-bombing, then holding equipment or backpacks above your head will provide sufficient protection. Since the project will occur during nesting season, precautions will be taken to ensure that interaction with these birds are minimized.

6.4 Noise

Employee noise exposure at or above the Mt. Emmons action level, 85 decibels dB (A), is not likely to occur in the field during this project. Any laboratory areas that have a potential to be at or above the action level are delineated with signage. In these areas employees are required to wear hearing protection.

6.5 High Altitude

The field work of this project will be conducted at sea levels above 5,000 feet which is considered high altitude. Individuals working at these heights may experience altitude sickness or Acute Mountain Sickness (AMS). The cause of AMS is the decrease amount of oxygen available as altitude increases. Symptoms may include headaches, fatigue or weakness, stomach illness (lack of appetite, nausea, or vomiting), dizziness or light-headedness, shortness of breath upon exertion, insomnia, persistent rapid pulse peripheral edema (swelling of hands, feet and face) and feeling of discomfort. Typically symptoms will disappear after acclimatization (1-3 days). However if symptoms persist personnel should descend to a lower altitude and/or seek medical assistance.

To prevent or minimize AMS, employees should ascend to high altitude slowly. This will give the body time to adjust or acclimatize. Drink plenty of water, maintain a balanced diet and take frequent rest brakes during work activities. Avoid consuming alcohol during the first two days at high altitude.

6.6 Heat Stress/Sun Protection

Heat related problems include heat rash, fainting, heat cramps, heat exhaustion and heat stroke. Heat rash can occur when sweat isn't allowed to evaporate; leaving the skin wet most of the time and making it subject to irritation. Fainting may occur when blood pools to lower parts of the body and as a result, does not return to the heart to be pumped to the brain. Heat related fainting often occurs during activities that require standing erect and immobile in the heat for long periods of time. Heat cramps are painful spasms of the muscles due to excessive salt loss associated with profuse sweating.

Heat exhaustion results from the loss of large amounts of fluid and excessive loss of salt from profuse sweating. The skin will be clammy and moist and the affected individual may exhibit giddiness, nausea and headache. Heat stroke occurs when the body's temperature regulatory system has failed. The skin is hot, dry, red and spotted. The affected person may be mentally confused and delirious. Increased body temperature and physical discomfort also promote irritability and a decreased attention to the performance of hazardous tasks. Convulsions could occur. EARLY RECOGNITION AND TREATMENT OF HEAT STROKE ARE THE ONLY MEANS OF PREVENTING BRAIN DAMAGE OR DEATH. A person exhibiting signs of heat stroke should be removed from the work area to a shaded area. The person should be soaked with water to promote evaporation. Fan the person's body to increase cooling. Prompt medical attention needs to be provided including calling "911" and getting the individual to a hospital immediately.

Early Symptoms of Heat-Related Health Problems:

- decline in task performance
- excessive fatigue
- decline in alertness
- muscle cramps

- dizziness

Susceptibility to Heat Stress Increases due to:

- lack of physical fitness
- obesity
- lack of acclimatization
- drug or alcohol use
- increased age
- sunburn
- dehydration
- infection

The following guidelines should be followed when working in high temperatures:

- Establish work-rest cycles (short and frequent are most beneficial).
- Identify a shaded, cool rest area.
- Rotate personnel, alternative job functions.
- Water intake should be equal to the sweat produced. Most workers exposed to hot conditions drink less fluid than needed because of an insufficient thirst. DO NOT DEPEND ON THIRST TO SIGNAL WHEN AND HOW MUCH TO DRINK. For an 8-hour work day, a worker's intake should be 50 ounces of fluids.
- Eat lightly salted foods; drink electrolyte containing drinks (Gatorade).
- Save most strenuous tasks for non-peak heat hours.
- Avoid alcohol during prolonged periods of heat. It causes dehydration.
- Avoid double shifts.

Sun Protection:

Protection from the effects of sunburn is equally important to consider in any environment where prolonged exposure to the sun is required. Because field work is at high altitude, personnel will be exposed to higher ultraviolet radiation from the sun. Outdoor exposure to excessive Ultraviolet radiation, particularly UVB, can lead to skin cancer. It is important to use Sun Burn Protection lotions or creams with a Sun Protection factor (SPF) of 30, 40 or above to minimize the effects of sun exposure. The information below shows the types of ultraviolet light and, particularly, UVB that is known to be sunburn radiation. Sun protection lotions that provide an SPF of 30 or greater against UVA and UVB are commonly available.

Types of Ultraviolet Radiation and Their Features	
Ultraviolet Radiation Type	General Features
Ultraviolet A (UVA, long-wave UV)	-not filtered out in the atmosphere -passes through glass -produces some tanning

	-once considered harmless but now believed harmful (long term) -levels remain relatively constant throughout the day
Ultraviolet B (UVB, sunburn radiation)	-some filtered out in the atmosphere by the ozone layer -does not pass through glass -causes sunburn, tanning, wrinkling, skin aging and skin cancer -highest intensity at noontime
Ultraviolet C (UVC, short-wave UV)	-filtered out by the ozone layer before reaching earth -major artificial sources are germicidal lamps -burns the skin and causes skin cancer

6.7 Wildfires

The project location is considered to be an area where there is a medium or high potential for wildfire. On a daily basis, fire conditions should be checked prior to accessing the site. Conditions can be checked by accessing the following websites:

- http://mt.gov/fire.mcpx,
- https://gacc.nifc.gov/nrcc/
- http://fwp.mt.gov/news/drought/default.html

Field activities should be postponed if there is a report of fire in the project area and/or if there is a threat that site access will be impacted by fire. If personnel are in the project area and the smell of smoke is evident, the area should be evacuated immediately. Return to the site should not occur until the threat of fire has been eliminated.

6.8 Chainsaw Safety – Tree/Brush Clearing

At times access to the site may be hindered by brush or small trees and may require pathway clearing utilizing a chain saw. Prior to felling trees or clearing brush, personnel will be required to perform a JHA. The purpose of the JHA is to identify and control potential hazards of the surrounding area. Types of hazards and possible ways to eliminate or avoid them are:

Hazard	Ways to Eliminate or Avoid
Throwback – when a tree falls branches or objects get thrown back towards the individual (s) making the cut	Avoid felling into other trees or onto objects. Look up as tree falls and as you retreat

Lodged Tree – tree that has not completely fallen to the ground	Do not work in the presence of the lodged trees.
Widowmaker – broken off limbs that are hanging freely in the tree to be felled or close by	Avoid working underneath them
Snag – standing dead tree, standing broken tree, or a standing rotted tree to be felled or nearby	Avoid the area by at least two tree lengths
Extreme Weather – high wind	Do not fell trees during high winds

Source: OSHA Logging etool, Felling Trees: Potential Hazards

Personnel will be task trained prior to operating a chainsaw. Task training will include:

- Review of operator's manual
- Proper PPE (hard hat, face shield, safety glasses, hearing protection, protective clothing, gloves, safety toed boots, leg chaps)
- Evaluation of hazards and ensuring an escape
- Pre-operational checks
- Chainsaw maintenance
- Proper cutting (i.e. handling, body position, cutting techniques, etc.)

6.9 Utility Locate

Mt. Emmons will follow Montana state laws in notifying One-Call utility locators prior to any ground penetration greater than one inch. Montana Law (Annotated Code 2011, 69-4-501 through 503) requires contacting the One-Call utility notification center (811 or 800-424-5555) a minimum of 3 days (specified minimum) prior to excavating or digging. Mt. Emmons Utility Locate (Blue Stake) procedures (FCX-13) will be followed unless there is an approved Blue Stake variance on file. The Blue Stake policy requires a completed permit to be approved prior to any digging (see Attachment B). This policy prohibits mechanized digging within a 24 inch utility offset. Any digging within this offset must be completed by soft dig methods.

A variance from the FCX Blue Stake permit requirements will be submitted for the project based on geographic remoteness of the project site. For purposes of the blue stake permit, a remote area is defined as:

- Accessibility by hiking and/or 4-wheel drive ATV/UTV or 4-wheel drive vehicle, and
- Outside town or city limits.

Plus, at least one of the following:

- Terrain that is currently used for remote ranching (grazing), logging and recreational activities (i.e. hiking, hunting, etc.), or
- Areas with cabins having no utilities (i.e. typically hunting/fishing cabins), or

- Terrain that has steep mountainsides or deep canyons with significant vegetation and/or rock outcroppings, or
- Undeveloped two-track roads with or without overhead transmission lines.

If the project performs any penetration work activity within 50 feet of an undeveloped two-track road (i.e. forest service, BLM, etc.) that has an adjacent gas line (typically marked yellow) or other marked underground utilities (i.e. cable, etc.) FCX Blue Stake Procedures will be followed.

6.10 UTV Use

Mt. Emmons employees may be operating Utility Terrain Vehicles (UTVs) to minimize injury as a result of handling sampling material(s). UTVs seat three or more individuals and have roll-over protection (ROPS). UTVs handle differently from other vehicles, such as motorcycles and cars and proper instruction and practice are important. Do not operate UTVs without proper training and approval. It is important to carefully read and follow the instructions and warnings in the owner's manual and on labels.

Equipment

UTVs must be equipped with ROPS and seat belts. UTVs are typically side-by-side, 4-wheeled, recreational vehicles with steering wheels rather than handle bars. Deviation from this requirement (e.g., ATVs without ROPS or seat belts) must be reviewed and approved by project management and health and safety before being used.

Training

Selected Mt. Emmons personnel will receive UTV operator training (classroom instruction plus hands-on evaluation), provided by the FMC Resource Management training department.

PPE

To operate/ride in an approved UTV occupants are required to wear the following PPE:

- DOT-approved helmets
- ANSI Z87+ eyewear
- Hearing protection (optional)
- Pants and long-sleeved shirts
- Work or leather gloves to protect hands from flying debris or branches while driving/riding, when necessary.

Equipment Inspection:

- A documented pre-shift inspection shall be performed daily prior to use. Inspections are also required after any incident or damage to the UTV.

Transporting the UTV:

- Vehicle must be in gear and parking brake must be set at all times when a vehicle is being connected to a trailer. Trailers must be secured to the vehicle receiver and chained prior loading the UTV.
- Always check that the lights on the trailer are in good working order after connecting them.

- UTVs must be secured to the trailer by appropriate straps.
- When placing the ramp on the trailer they must be properly aligned and all locking mechanisms engaged.
- A spotter is required when driving UTVs on and off of the trailer. All other personnel shall remain clear from the area.
- Perform a 360-degree walk around inspection of the vehicle and trailer before starting your journey, checking for the following items:
- Ensure all lights are working properly, including the turn signal indicators.
- Ensure that the trailer stand has been rolled up and properly secured.
- Ensure that the safety chains have been hooked up to the vehicle.
- Ensure that the load rating on the trailer has not been exceeded. The load rating according to the manufacturer's directions should be on the trailer itself.
- Drive the vehicle pulling the trailer no faster than speed limits and/or weather conditions allow.

UTV General operating rules:

- UTVs must always be operated in accordance with guidance outlined in its owner's manual.
- Before starting the UTV, make sure the park brake is set and the transmission is in Neutral or Park position. Use the choke or wait for glow plugs to heat. Sound horn once, start the UTV and allow it to idle for several minutes.
- Seat belts shall be worn at all times by all occupants of the vehicle.
- UTVs may be operated on public roadways where safe to do so and lawful. Because laws related to UTV operation vary among states, it is necessary to know the laws of the state where you are working.
- Never carry a passenger on a single-rider vehicle unless there is an emergency.
- Operate at safe speeds for the conditions and within guidelines recommended by the UTV's owner's manual.
- Be extremely cautious on rough terrain, and watch carefully for sharp bumps, holes ruts or obstacles.

When riding through mud or water:

- Determine water depth before attempting a crossing; do not exceed the water depth specified in your owner's manual.
- Avoid fast-flowing water.
- If you cross a stream, use an established place where the stream banks have a gradual incline.
- Watch for submerged obstacles.
- Test brakes after leaving water.
- Know the special skills required to safely operate a UTV on terrain, such as going up, going down, traversing hills, turning, braking and riding over obstacles.
- Interaction with wildlife while traveling on UTVs shall be avoided at all costs. If wildlife is encountered unexpectedly, you should stop and allow the animal to escape and be at a reasonable distance before you proceed.
- If the terrain becomes too rough for the vehicle to safely traverse, occupants must exit the vehicle and walk to complete the task.

- In the event of a rollover keep your arms, legs, and head inside the vehicle. Do not try to stop the roll over or bail out of the vehicle. Severe injury or death to the operator may result. The ROPS system and proper seat belt use increases your chance of surviving a rollover.

6.11 Hazard Controls

Chemical, physical, and biological hazards will be minimized through employee training, engineering controls, administrative controls, and when necessary personal protective equipment (PPE). Risk Assessments on task specific areas of the project will be done to minimize the risk and exposure to hazards. Specific controls are addressed throughout the HASP, in the HSMS and Safe Operating Procedures.

6.12 Emergency Entry and Exit

People entering the site on an emergency basis will be briefed of the hazards by the Site Project Lead. All activities will cease in the event of an emergency. People exiting the site because of an emergency will gather in a pre-defined safe assembly area for a head count. The Site Project Lead will be responsible for ensuring that all people who entered the work area have exited in the event of an emergency.

6.13 General Site Safety Practices

The following measures are designed to augment the specific health and safety guidelines provided in this plan:

- The "buddy system" will be used at all times by all field personnel. No one is to perform field work alone and particular emphasis on the buddy system is to be placed when working on sloping, irregular walking or working surfaces.
- All personnel must be intimately familiar with the procedures for initiating an emergency response. Emergency decontamination procedures must be known and understood by all personnel who are in active work areas.
- Smoking is prohibited with the exception in those areas designated by the Project Lead.
- Hands and face must be thoroughly washed upon leaving the work area and before eating, drinking or any other activities.
- The use of alcohol or illicit drugs is prohibited; random drug testing during the hours of field operations is a company policy and violation of the company substance abuse policy can lead to dismissal.
- Firearms are prohibited at all times.

6.14 Lock Out –Tag Out

Any task or operation that requires equipment to be de-energized and locked out prior to working on it for repair, maintenance or inspection, must adhere to the company lock out/tag out/try out procedures. All employees must be tasked trained prior to performing LOTOTO.

6.15 Sanitation

Adequate washing and toilet facilities are provided for employees at the ETL facility. However toilet facilities are not available or within close proximity to the Mine. Washing and toilet facilities are located at the Barker Hughesville campground or in the town of Monarch which are several miles from the Mine. If driving to town is not an option, backcountry toilet options should be employed: dig a hole (cat hole) and bury solid waste or pack it out. The cat hole must be a minimum of 200 feet away from water, trails and campsites and six to eight inches deep.

Hand sanitizer or soap and water will be transported to provide employees with a way to minimize exposures to hazardous materials. The Project Lead will be responsible for ensuring sanitation procedures are established and followed.

6.16 Buddy System

The ***Buddy system*** means a system of organizing employees into work groups in such a manner that each employee of the work group is designated to be observed by at least one other employee in the work group. The purpose of the buddy system is to provide rapid assistance to employees in the event of an emergency. The majority of tasks performed on this project will be conducted with more than one individual present at all times. The site work crew will also interact with and be observed by site supervisors and personnel documenting the progress of work.

6.17 Level D Protection

The minimum level of protection that will be required of site personnel and subcontractors at the site will be Level D, which will be worn as the initial protection level for site operations. The following equipment will be used:

- Long sleeved shirt and pants
- Safety toe work boots, ANSI approved while working with drums
- Chemical resistant boots (i.e. rubber boots, waders, etc.) while working in potentially impacted water or streams
- Safety glasses or goggles, ANSI approved
- Chemical resistant work gloves appropriate to the task
- ANSI Class 2 min fluorescent vest with reflective strips or comparable substitute when vehicular traffic or heavy equipment is present
- Hearing protection for tasks >85 dB(A)

6.18 Decontamination

Impermeable PPE that has contacted potentially impacted water or streams, will be disposed of appropriately and replaced as needed or cleaned with an Alconox solution and rinsed with clean water before re-use. Permeable PPE that has contacted potentially impacted water or streams will be immediately removed, disposed of appropriately and replaced or washed with Alconox solution and rinsed with clean water before re-use.

6.19 Other Safety Equipment

In addition to the PPE specified above, the following safety items shall be available at the site and will be required in multiple quantities depending on the number and distribution of active personnel:

- Portable, hand-held eyewash bottles for all site vehicles and vehicle cabs
- First aid kits
- Type A-B-C fire extinguisher
- Portable or satellite phones/radios (best device that has a signal)
- Storage area for PPE and instrumentation
- Drum handling truck cart

7.0 EMPLOYEE TRAINING REQUIREMENTS

7.1 Training

Before the start of work, all employees associated with this project must be trained regarding the contents of this HASP. This training is considered a part of task training for this project.

In addition, site supervision and all personnel will participate in daily "tailgate" safety meetings to discuss site hazards, the effectiveness of health and safety procedures, and any need for revision. These meetings will be held at the onset of activities each day, at the beginning of new tasks, or when revisions that may affect worker health and safety are made to existing tasks. Meeting attendance and topics should be recorded in a tailgate safety meeting form.

In accordance with the regulatory agencies currently having site jurisdiction Hazardous Waste Operations and Emergency Response (**HAZWOPER** as mandated by OSHA 29 CFR 1910.120) training is required for field personnel. In addition to FMC general Health and Safety training (i.e. LOTOTO awareness, proper lifting, etc.), field employees will also be required to complete First Aid/CPR, Wilderness first aid, and defensive driving training. Site Supervisors are required to complete 8 additional hours of hazardous waste site (HAZWOPER) supervisor training. If any mobile or heavy equipment is utilized (i.e. skid steer, ATV, etc.) operators will be required to complete task training specific to the equipment they operate.

8.0 EXPOSURE MONITORING/AIR SAMPLING PROGRAM

It is not anticipated that personnel working on this project will be exposed to chemicals of concern that can't be minimized by donning the proper PPE. Therefore exposure monitoring (i.e. air) and/or surveillance is not warranted.

9.0 ENGINEERING AND ADMINISTRATION CONTROLS

To the extent practicable, project operation employees and will implement engineering and administrative controls to reduce hazards (i.e. lifting drums, stream samplers, etc.).

9.1 Engineering Controls – drum handling

Drum truck handcarts will be utilized to move drums to and from sampling locations and within the laboratory. Engineering controls such as lifting devices and/or ramps will be utilized to move drums onto vehicles or trailers. Man-handling drums onto vehicles or trailers is not an accepted practice.

9.2 Sanitation and Sanitary Facilities

Site sanitation will be maintained according to OSHA requirements. Restroom facilities are located at the ETL facility for laboratory work and available at the Barker Hughesville campground or in the town of Monarch for field activities. Employees may also use backcountry toilet options while in the field. These are: dig a hole (cat hole) and bury solid waste or pack it out. The cat hole must be a minimum of 200 feet away from water, trails and campsites and six to eight inches deep.

9.3 Break Area

Breaks will be taken away from areas where there is the potential for personnel to interact with mobile equipment unless they are in an enclosed vehicle. The consumption of food is not allowed near any area that may have chemicals of concern. Because of the potential of the presence of wildlife (i.e. bears) it is recommended that food be consumed within an enclosed vehicle.

Consumption of food/liquids is not allowed in laboratories. Established breakrooms are to be utilized for these activities.

9.4 Potable Water

The following rules apply for all project field operations:

- An adequate supply of potable water will be provided at each work site.
- Consumption of bottled water to prevent altitude sickness and heat stress symptoms is permitted without restriction.
- Portable containers used to dispense drinking water will be capable of being tightly closed and will be equipped with a tap dispenser. Water will not be consumed directly from the container or dipped from the container.
- Containers used for drinking water will be clearly marked and will not be used for any other purpose.

10.0 MEDICAL SURVEILLANCE

All personnel on this project will have received a Medical Examination at the time of hire as part of the Mt. Emmons medical surveillance examination program which includes:

- Medical/occupational history
- Physical exam: height, weight, BMI, blood pressure, head turn (A/P and lateral), overhead lift (15 pounds), 90° deep knee bends (5), hand/wrist movement with grip and walk/climb steps (4)
- Vision testing.
- Audiometric examination.
- Complete blood count.
- Blood chemistry panel.
- Routine urinalysis.
- Resting EKG

While there is no anticipated need for continued medical surveillance tests on the project, it is necessary that each employee be aware of their need to be fit for duty as well as their right to access and inspect their personal medical records.

12.0 SITE CONTROLS AND BEST MANAGEMENT PRACTICES

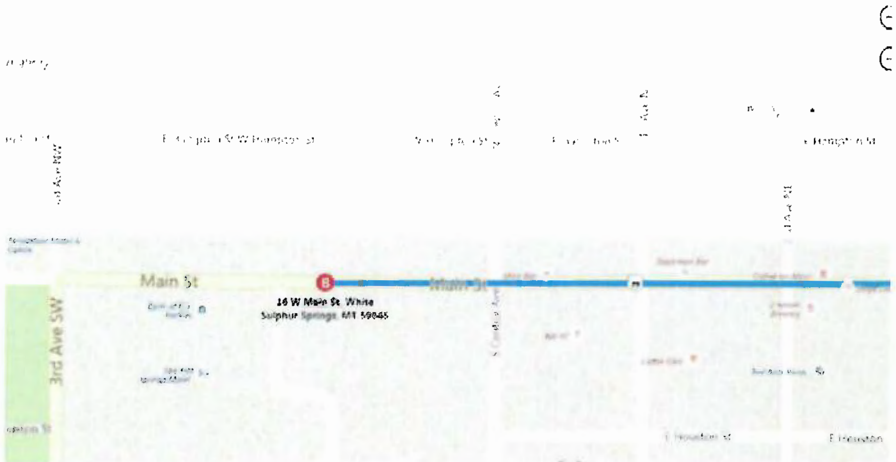
12.1 Emergency Contingency Plan

In the event of an emergency at the site, first contact the appropriate emergency services, next secure the site if it is safe to do so, and then notify the Project Lead, Project Manager and the Health and Safety Manager or designee. Follow site emergency procedures. The Project Lead will notify the Project Manager and Health and Safety Manager prior to any notification to regulatory agencies where possible. In the event of an incident or accident, follow the reporting procedures established by Mt. Emmons.

The approximate GPS coordinates are: 47.0833, -110.6304

Medical Emergencies

For serious injuries or illnesses, dial **911** so the patient can be transported to the nearest hospital. The nearest hospital is Benefits Hospital located in Great Falls approximately 45 miles north of the town of Monarch.



Benefits Hospital

1101 26th St
Great Falls, MT 59405
(406) 455-5000

Travel north on US-89 merging with US-89 N/US-87/MT-200W/MT-3N and continue straight towards Great Falls. Turn left onto 26th Street. Hospital is past 12th Avenue A

Medical Air Transportation

Benefits Hospital's Mercy Flight-Med Flight

Great Falls, MT

Attachment A

Employee Acknowledgement Form

This form is to confirm that the employees named

have reviewed the HASP for:

LAB-SCALE TREATABILITY STUDY OF DANNY T MINE DISCHARGE

Training Attendance Form

Subject: Lab-Scale Evaluation of Passive Treatment Project

Location: Cascade County, MT

Instructor Name(s):			Date:
Print Name	**Employee Number**	**Department**	**Employee Signature**
1			
2			
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22			

Appendix C – Sample Chain of Custody Form

ACZ Laboratories, Inc. — CHAIN of CUSTODY

[illegible]

Report to:

Name:	Address:
Company:	
E-mail:	Telephone:

Copy of Report to:

Name:	E-mail:
Company:	Telephone:

Invoice to:

Name:	Address:
Company:	
E-mail:	Telephone:

[illegible] YES / NO

[illegible] Yes / No

[illegible]

Sampler's Name: ______ Sampler's Site Information: State ______ Zip code ______ Time Zone ______

*Sampler's Signature: ______

PROJECT INFORMATION — ANALYSES REQUESTED [illegible]

Quote #:

PO#:

Reporting state for compliance testing:

Check box if samples include NRC licensed material?

SAMPLE IDENTIFICATION	DATE TIME	Matrix	# of Containers								

Matrix: [illegible]

REMARKS

Please refer to ACZ's terms & conditions located on the reverse side of this COC.

RELINQUISHED BY:	DATE TIME	RECEIVED BY:	DATE TIME

[illegible] White – Return with sample. Yellow – Retain for your records.

Appendix D – Calculation Brief

This Appendix contains the description and formulas for the calculations that serve as the basis of design presented in Section 4.

EPA and Mt. Emmons have determined that the Mine may be a candidate for passive, biologically-based water treatment. Accordingly, the primary goal of this lab-scale treatability study is to assess the effectiveness of passive MIW treatment for improving the quality of Danny T Mine MIW (Table D-1) to meet discharge standards (Table 3-1). Information collected during this treatability study will be used to determine if passive treatment is feasible and cost-effective for implementation.

Danny T Adit Water Quality

Table D-1. MIW chemistry. The analytes included here are a subset of Table 2-1 and represent the primary targets for removal by the SRBR.

Analytes (Dissolved)	Range of Historical Values (µg/L)	Design Basis Value (µg/L)	MW	Design Basis Value (mmol/L)
Aluminum	7,980 – 16,200	16,100	26.98	0.597
Antimony	0.3 – 2.0	<5	121.76	<0.00004
Arsenic	93 – 400	397	74.92	0.0053
Barium	3.8 – 7.3	<50	137.3	0.00036
Beryllium	4.9 – 20.0	<20	9.01	<0.0022
Cadmium	154 – 316	283	112.4	0.0025
Chromium	2.5 – 6.1	<10	51.99	<0.00019
Copper	432 – 2,160	1,430	63.55	0.0225
Iron	95,900 – 184,000	173,000	55.84	3.098
Lead	121 – 287	277	207.2	0.0013
Manganese	73,300 – 128,000	104,000	54.94	1.89
Mercury	ND	<0.1	200.59	<0.0000005
Nickel	17.9 – 53.9	30.3	58.69	0.00052
Selenium	2.5 – 6.6	6.53	78.97	0.000083
Silver	0.06 – 1.00	<5	107.87	<0.000046
Thallium	1.4 – 2.6	<5	204.38	<0.000024
Zinc	42,000 – 69,100	62,500	65.38	0.956
Sulfate (mg/L)	129 – 2,500	1,230	96.06	12.80
pH (s.u.)	2.40 – 3.32	2.66 s.u.	-	-

Values are in µg/L, unless otherwise noted.
Design basis values are from CDM Smith (2016).
MW – Molecular weight;
ND – Non-Detect;
Historical values provided by EPA.

Design flow rate calculation

Three flow rate calculation methods will be used to guide the design of the lab-scale passive treatment system: metal reduction, sulfate reduction, and oxygen loading. The lowest calculated flow rate will be selected as the most conservative. The selected flow rate will serve as the starting value, which may later be adjusted depending upon the analytical results of Danny T Mine MIW quality and treatment system performance. For each of the three methods, two related approaches will be presented: mass-based and volume-based. The mass-based approach is most appropriate for evaluating performance because mass balances can be directly calculated. The volume-based approach is widely used in the industry and allows for comparability.

The first flow rate calculation method is based on the metal reduction rate, which is the preferred method of many SRBR practitioners. The rate at which metals are removed is controlled by abiotic (limestone) and biotic (sulfate reduction) processes, which are proportional to the sulfate reduction rate. Therefore, the design flow rate was calculated using 200 mmol/m³·day of sulfate reduction rate (metal removal rate) based on the Project team's prior laboratory and pilot-scale experience (Appendix I). Manganese and aluminum are excluded from this calculation because these metals do not form metal sulfides in the SRBR. Flow rates were calculated separately for SRBRs with and without limestone pre-treatment, which is assumed to remove nearly all Al and Fe and increase pH to >4.5. The HRT's are much higher without pre-treatment but the flow rates are similar because the SRBR's without pre-treatment are twice the diameter of those with pre-treatment.

$$Q_d = \frac{MeRR_v \times V_b}{\Sigma Metals} \; or \; \frac{MeRR_m \times M_s}{\Sigma Metals}$$

where, Q_d = design flow rate [L/day]

V_b = substrate bulk volume [m^3]

M_s = substrate mass [Kg]

$MeRR_v$ = metal removal rate [mmol/m^3·day]

$MeRR_m$ = metal removal rate [mmol/Kg·day]

ΣMetals = sum of influent metal concentration, excluding Al and Mn [mmol/L]

Table D-2. Flow rate calculation based on metal loading rate.

Assumed or calculated parameter	Unit	Value	
		w/ pre-treatment	w/o pre-treatment
ΣMetals	mmol/L	0.983[1]	4.081
Substrate bulk volume	m^3	0.0074	0.030
Substrate mass	Kg	2.52	10.1
Substrate bulk density	Kg/m^3	340	340
Substrate volume-based metal removal rate	mmol/m^3-day	200[2]	200[2]
Substrate mass-based metal removal rate	mmol/Kg-day	0.6	0.6
Flow rate	**L/day**	**1.5**	**1.5**
HRT	**day**	**3.44**[3]	**14.5**[3]

[1]assuming 100% Fe removal by limestone pre-treatment

[2]equivalent to 200 mmol/m³·day of SRR

[3]assuming 70% porosity

The second calculation method is based on sulfate reduction. This approach evaluates total acidity (metal acidity plus proton acidity) along with sulfate reduction. The rate at which acidity is neutralized is balanced by the rate of alkalinity produced by biological sulfate reduction. Biological sulfate reduction also has the added benefit of forming insoluble metal sulfides. Manganese and aluminum are excluded from this calculation because manganese is not precipitated within the SRBR operating pH range, and aluminum removal is independent of sulfate reduction in the SRBR. Flow rates were calculated separately for SRBRs with and without limestone pre-treatment. Limestone pre-treatment is assumed to remove nearly all Al and Fe and increase pH to >4.5. The design flow rate was calculated as below:

$$Q_d = \frac{SRR_m \times M_s}{\Sigma Acidity} \times \frac{2\ mmol\ akalinity}{mmol\ sulfate\ reduction}\ or$$
$$= \frac{SRR_v \times V_b}{\Sigma Acidity} \times \frac{2\ mmol\ akalinity}{mmol\ sulfate\ reduction}$$

$$\Sigma acidity = \Sigma\left[metal\ concentration\left({}^{mmol}/_{L}\right) \times acid\ equivalent\ per\ millimole\right] + 10^{(3-pH)}$$

where, Q_d = design flow rate [L/day]

M_s = substrate mass [Kg]

V_b = substrate bulk volume [m^3]

SRR_m = sulfate reduction rate [mmol/Kg·day]

SRR_v = sulfate reduction rate [mmol/m^3·day]

ΣAcidity = sum of influent acidity, excluding Al and Mn [mmol/L]

Table D-3. Flow rate calculation based on acidity-alkalinity balance

Assumed or calculated parameter	Unit	Value	
		w/ pre-treatment	w/o pre-treatment
ΣAcidity	mmol/L	2.00[1]	13.5
Substrate bulk volume	m^3	0.0074	0.030
Substrate mass	Kg	2.52	10.1
Substrate bulk density	Kg/m^3	340	340
Substrate volume-based sulfate reduction rate	mmol/m^3-day	200	200
Substrate mass-based sulfate reduction rate	mmol/Kg-day	0.6	0.6
Flow rate	**L/day**	**1.48**	**0.90**
HRT	**day**	**3.50[2]**	**23[2]**

[1]assuming 100% Fe removal and > pH 4.5 by limestone pre-treatment

[2]assuming 70% porosity

The third method for calculating design flow rate is based on oxygen loading because oxygen hinders anaerobic conditions required for sulfate-reduction. Based on the previous laboratory and pilot-scale experiments, the Project Team recommends that the electron consumption ratio for oxygen reduction to sulfate reduction be <10%. This value should provide sufficient protection to maintain an anaerobic environment. Flow rates were calculated separately for SRBRs with and without limestone pre-treatment, which is assumed to remove nearly all Al and Fe and increase pH to >4.5. The required electrons for sulfate and oxygen reduction are calculated as:

$$e_{SR} = SRR_m \times M_s \times \frac{8\ me^-}{mmol\ of\ sulfate\ reduction}\ or$$

$$e_{SR} = SRR_v \times V_b \times \frac{8\ me^-}{mmol\ of\ sulfate\ reduction}$$

where, e_{SR} = electrons required for sulfate reduction [me^-/day]

SRR_m =sulfate reduction rate [mmol/Kg·day]

SRR_v =sulfate reduction rate [mmol/m^3·day]

M_s = substrate mass [Kg]

V_b = substrate bulk volume [m^3]

$$e_{OR} = [O_2] \times Q_d \times \frac{mmol\ O_2}{32\ mg\ O_2} \times \frac{4\ me^-}{mmol\ O_2}$$

$$Q_d = R_e \times e_{SR} \times \frac{32\ mg\ O_2}{mmol\ O_2} \times \frac{1}{[O_2]} \times \frac{mmol\ O_2}{4\ me^-}$$

where, e_{OR} = electrons required for oxygen reduction [me^-/day]

$[O_2]$ = influent oxygen concentration [mg/L]

Q_d = design flow rate [L/day]

R_e = empirical ratio of the electron consumption for oxygen reduction to sulfate reduction, 0.1

Assuming 9.2 mg/L of oxygen concentration of influent MIW, 200 mmol/m^3-day (0.6 mmol/kg-day) of sulfate reduction rate, and 1.48 L/day of flow rate (Table D-3 w/ pre-treatment), the electron consumption for oxygen reduction is 14.4% of the consumption for sulfate reduction, which is higher than 10% and means that it is hard to maintain anaerobic condition within a SRBR. The low concentration of metals in the pretreated Adit water relative to dissolved oxygen makes consideration of dissolved oxygen more important for the treatment of the pretreated Adit water (Table D-4). To meet <10% of the electron consumption ratio for oxygen reduction, the Project Team therefore recommends an initial flow rate of 1.0 L/day for the treatment of pretreated Adit water. On the other hand, the calculation based on acidity loading resulted in the most conservative flow rate, 0.22 L/day, which is recommend as an initial flow rate for the direct treatment of the Adit water.

Table D-4. Flow rate calculation with consideration of limiting influent oxygen mass.

Assumed or calculated parameter	Unit	Value	
		w/ pre-treatment	w/o pre-treatment
Substrate volume-based sulfate reduction rate	mmol/m^3-day	200	200
Substrate mass-based sulfate reduction rate	mmol/Kg-day	0.6	0.6
Substrate mass	Kg	2.52	10.1
Substrate bulk volume	m^3	0.0074	0.030
Required electrons for sulfate reduction	me^-/day	11.9	11.9
Oxygen concentration	mg/L	9.2	9.2
Electron ratio (oxygen/sulfate) reduction	-	0.1	0.1
Flow rate	**L/day**	**1.0**	**1.0**
HRT	**day**	**5.0†**	**5.0†**
Required electrons for oxygen reduction	me^-/day	1.2	1.2

† assuming 70% porosity

Table D-5. Comparison of flow rate calculation methods.

Method	Flow Rate (L/d)		Limiting Factor
	w/ pre-treatment	w/o pre-treatment	
Metal Reduction	1.51	1.50	To remove all metals, except Mn
Sulfate Reduction	1.48	**0.90**	To neutralize all acidity
Oxygen Loading	**1.00**	1.00	To maintain anaerobic conditions

Pre-treatment

In order to evaluate the effectiveness of limestone pre-treatment for Adit discharge and provide SRBR-1 to 4 with consistent pretreated water, the Project Team calculated the required limestone bed volume. The limestone volume calculation is based on the total flow rate required for four SRBRs (4 L/day) receiving pre-treatment (Table D-5). Calculations were based on an acidity loading rate (ALR_d = 2 mmol acidity/L·day) derived from previous FMC limestone column tests:

$$V_{LS} = \frac{\Sigma Acidity_{(Al,Fe,pH)} \times Q}{ALR_d}$$

$$\Sigma Acidity_{(Al,Fe,pH)} = \Sigma \left[Al, Fe\ concentration \left({}^{mmol}/_{L}\right) \times acid\ equivalent\ per\ millimole\right] + 10^{(3-pH)}$$

where, V_{LS} = Limestone bed volume [L]

$\Sigma Acidity_{(Al, Fe, pH)}$ = Sum of Al, Fe, and proton acidity [mmol/L]

Q = flow rate [L/day]

ALR_d = Design acidity loading rate per unit volume of limestone bed, 2 mmol/L·day

Table D-6. Pre-treatment reactor design for the treatment of Danny T Adit discharge.

Parameter	Specification
Reactor dimension (with rubber lid)	
Diameter	8"
Height	42"
Limestone bed	
Mass	38 kg
Depth	36"
Volume (column volume)	29.6 L
Limestone size	1 – 1.5"
HRT (assuming 50% porosity)	3.4 days
Flow rate	4.0 L/day

Post-Treatment

The final stage of the passive treatment system is a containerized vertical flow treatment wetland for removing BOD and Mn. Vertical flow wetlands distribute water across the surface of a gravel bed planted with wetland vegetation and are characterized by downward percolation, ideally in unsaturated flow. Wetland plants promote an environment conducive to microbes that passively treat water, and root systems help maintain hydraulic conductivity of the media. This type of wetland offer the added advantage of maintaining activity during the winter because water is distributed below the surface of the topmost media, thereby maintaining temperatures above freezing (Kadlec and Wallace, 2009).

The sizing of constructed wetlands designed to treat MIW depends upon the loading rate of constituents to be removed and reaction kinetics. A fixed load removal model fixes the Mn removal rate per unit area of a wetland irrespective of Mn loading:

$$R_A = \frac{Q}{A}(C_i - C_o)$$

where A is wetland area, C_i is inlet concentration (mg/L), C_o is outlet concentration (mg/L), Q is flow rate, and R_A is the area-adjusted metal removal rate (g/m^2·d). A general guideline for sizing a wetland to remove Mn is 1 – 2 g of Mn removal/m^2/d (Hedin and Nairn, 1993, Skousen, 1997, Watzlaf et al., 2004). This sizing criteria is based upon estimates of Mn removal relative to wetland treatment area from a variety of treatment wetlands designed for treating Mn. More conservative sizing criteria have been proposed for treatment systems designed to meet regulatory requirements—0.5 g/m^2/d (Watzlaf et al., 2004). However, since DEQ does not regulate Mn for surface waters (Table 3-1), we selected a sizing criteria equal to 1 g Mn removal/m^2/d.

The equation above is then solved for A, which is the wetland size needed to remove the desired amount of Mn:

$$A = \frac{Q(C_i - C_t)}{R_A}$$

where C_t is now the target effluent concentration. The dissolved concentration of Mn in the water to be treated is 104,000 µg/L (Table 2-1) and the lab-scale treatment system was designed to receive a flow rate of 1 L/d. Assuming a target effluent concentration of 2,000 µg/L and the sizing rule of 1 g Mn removal/m^2/d, the recommended total size of the wetland to treat incoming Mn is 1.2 ft^2. Incorporating a safety factor of 1.5 increases the wetland size to 1.8 ft^2. Four wetlands will receive effluent from each replicate pair of SRBRs, therefore doubling the size of each wetland to 3.6 ft^2. The dimensions and quantity of substrate material are discussed in Section 4.1.5 and shown in Table D-7.

Table D-7. Post-treatment wetland design for Danny T Adit discharge.

Parameter	Specification
Wetland dimension	
Area (including 1.5 safety factor)	3.6 ft^2
Substrate depth	16"
Substrate Components	
Sand	8"
Gravel (0.2 – 0.5 in. round, washed)	8"
Volume	136 L
Flow rate	2.0 L/day

Data analysis

Pre-treatment, SRBR, and post-treatment efficiency assessment will be based on analytical results of samples collected from the influent and effluent at each stage of the treatment system. Treatment effectiveness will be evaluated by quantifying the removal of metals and sulfate, in addition to improvements in pH and alkalinity. Metal removal efficiency will be calculated as the percent difference of concentrations in the effluent versus the influent of each treatment stage. Metal removal rate will be calculated per unit mass of substrate for each treatment stage:

Metal treatment efficiency (%): $\frac{C_{in}-C_{out}}{C_{in}} \times 100$

Metal or sulfate removal rate (mmol/Kg·day): $(C_{in} - C_{out})\frac{Q}{M_s}$

where, C_{in} is influent concentration (mg/L), C_{out} is effluent concentration (mg/L), Q is flow rate (L/day), and M_s is the mass (Kg) of the treatment stage substrate.

The Project Team will provide metrics required to determine if passive SRBR is feasible and effective for implementation at the Danny T Mine. In addition, the Team will recommend optimal substrate composition for an SRBR to treat Danny T Mine MIW, an initial estimate of substrate requirements needed to treat the MIW, and preliminary design criteria that may be used for an on-site pilot-scale study or a full-scale passive SRBR system.

Appendix E – Quality Assurance Plan for ACZ Laboratories

This Appendix serves as a placeholder for the complete ACZ's Quality Assurance Plan, which is not included here.

ACZ Laboratories, Inc.

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Quality Assurance Plan v.23

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[1] Emails & read receipt constitute approval signatures.

DISCLAIMER: *To confirm a hardcopy is the effective version, the SOP ID must match the SOP ID on LabWeb exactly. Invalid or obsolete hardcopies must be promptly removed from all points of use or clearly marked to indicate the purpose of retention.*

Appendix F – Summary of Internal Quality Control for the Technology Center Tucson

Table F-1 Summary of Internal Quality Control Checks

ysis	Matrix	QC Checks	Method	Frequency	Acceptance Criteria	Corrective Action
eous e pH	Aqueous solution/Sample Matrix	Calibration Verification	Any one of the pH buffers used for calibration (pH 4, 7 and 10)	At the beginning of analysis After every 20 samples End of analytical run	Within 0.1 pH units of the expected value	Recalibrate
	Aqueous solution/Sample Matrix	Duplicate	Random experimental sample will be analyzed two times	One per experimental run	RSD ≤ 10%	Investigate problem, re-analyze samp
inity	Aqueous solution / Sample Matrix	Analytical Precision	Random experimental sample will be analyzed two times	One per experimental run	RSD ≤ 10%	Investigate problem, re-analyze samp
lved gen	Aqueous solution / Sample Matrix	Analytical Precision	Random experimental sample will be analyzed two times	One per experimental run	RSD ≤ 10%	Investigate problem, re-analyze samp
tion- ction ntial	Aqueous solution / Sample Matrix	Calibration verification	Check calibration as specified in manual of each ORP probe; uses pH Buffers 4 and 7 saturated with quinhydrone	Calibrated and checked before column experiment begins; checked after column experiment ends	± 20 mV of target ORP	Recalibrate
ons get: ate)	1, 2: Aqueous solution/Sample Matrix 3: De-ionized water 4: Same as sample matrix 5: Same as sample matrix	1. Accuracy 2. Precision 3. Method blank 4. Calibration verification 5. Analytical Precision	1. Initial Calibration 2. Second source check standards 3. Blank 4. Spike sample with known concentration of analytes 5. Duplicate	1. Initially 2. Every 10 samples 3. Every 10 samples 4. 10% of samples 5. 10% of samples	1. $R^2 \geq 0.995$ 2. ± 10 % of the actual concentration 3. ≤ Method Reporting Limit 4. ± 30 % LFM 5. ± 10% RPD	1. Recalibrate 2. Recalibrate 3. Investigate problem, remove contamination, check other blan 4. Investigate problem, reanalyze sample, dilute sample if needed 5. Investigate problem, reanalyze sample
(ICP- S)	Aqueous solution/Sample Matrix	Experimental Precision	Duplicate samples from experiment and controls	Every 10th sample per sampling event, random duplicate per test parameters	RSD ≤ 10%	Occasional data outside acceptance l will be flagged. In case of frequent violation (>20% of the samples), the problem will be investigated and the whole experiment will be repeated.

Analysis	Matrix	QC Checks	Method	Frequency	Acceptance Criteria	Corrective Action
	Aqueous solution/Sample Matrix	Analytical Precision	Random experimental sample will be analyzed in duplicate	One per experimental run	RSD ≤ 10%	Investigate problem, re-analyze sample
	Aqueous solution	MRL verification	MRL calibration check	Run with each new calibration	Within 50% of the expected value	Investigate problem, re-analyze sample, recalibrate if needed
	De-ionized Water	Method Blank	DI water used through the whole experiment	One per experimental run	Below reporting limit	Investigate problem, re-analyze blank
	Aqueous solution	Initial and Continuous Calibration Verification (ICV and CCV)	Second source calibration standard prepared in the sample matrix: mid-range and low level (if needed according to the obtained concentrations)	At the beginning of analysis After every 10 samples End of analytical run	Within 10 % of expected value for the mid-range of calibration and 30% for the low range	Recalibrate
	De-ionized Water	Calibration blank	Analyze independently prepared calibration standard without analyte	Immediately after initial calibration	Below reporting limit	Evaluate the check standard, re-run it; re-calibrate if necessary

Appendix G – Business Manual for the Technology Center Tucson

Freeport-McMoRan Mining Company

Technology Center

ISO Quality / Business Manual

Table of Contents

Scope

General

The Technology Center has integrated quality management into its routine business practices, therefore the words "business" and "quality" are interchangeable at the Technology Center, and within this manual.

This Business Manual defines the quality management system that the Technology Center utilizes to provide its product, which is primarily informational reports resulting from research projects and data resulting from the analysis of production materials. These projects are primarily initiated by customers, who are typically other Freeport-McMoRan entities. Many projects provide on-going support to other Freeport-McMoRan properties, and some projects involve extended research that is expected to result in breakthrough technological improvements for the parent company, Freeport-McMoRan Mining Company.

Application

The following requirements are documented and justified exclusions because they do not apply to the quality management system at the Technology Center.

7.2.1 – 7.2.2 Determination and Review of requirements related to product, because the requirements for the data reported by the Technology Center are determined by Freeport Americas, PTFI, or TFM.

7.4 Purchasing, because the responsibilities for procurement and verification of materials and service are assigned to the Global Supply Chain Management Group. This group consists of Purchasing and Accounting

7.5.2 Validation of Processes for Production and Service Provision, because the Technology Center processes which generate test results that are incorporated into reports can be verified by subsequent monitoring or measurement, therefore, validation of these processes is not required.

7.5.4 Customer Property, because materials used within the Technology Center are received from affiliate Freeport-McMoRan facilities.

Quality Management System

General Requirements

The Technology Center has established, documented, implemented, and maintains a quality management system and continually strives to improve its effectiveness and performance in accordance with ANSI/ISO/ASQ Q9001:2008. Each required business process is defined in a Process Map, and belongs to a responsible Process Owner who speaks for the process in the organization. Each Process Owner captures best business practices within their assigned process, ensures that the process reflects current practice, and revises the process when improvement opportunities present themselves. Sufficient resources and information are allocated to support and monitor these processes. Monitoring, measurement, and analysis of these processes are achieved by means of data collection and analysis, or external or internal auditing. Any, and all, outsourced processes that affect product conformity are controlled and the extent of the control has been determined by the Technology Center's Top Management.

Documentation Requirements

General

The Technology Center's quality management system includes documented statements of a quality policy and quality objectives, this business manual, and the documents and records which are necessary to ensure the effective planning, operation and control of the process used. These documented procedures pertain to document control, control of records, internal audits, control of non-conforming product, and corrective and preventive action.

Other documents may be used to enhance the Technology Center's processes and operations, and are not required by the quality management system. The level of control for these documents has been determined by Top Management.

Required Documents

4.2.P2 Document Control

4.2.P5 Control of Records

8.2.P2 Internal Audit

8.3.P1 Ctrl Nonconforming Product

8.5.P1 Corrective Preventive Action

Quality Manual

This business manual describes the scope of the Technology Center's quality management system, justified exclusions, references to documented procedures, and the description of the interaction between its processes.

Document Control

This documented procedure defines the controls needed to approve documents prior to issue, review and update as necessary and re-approve, ensure changes and current revisions are identified, ensure relevant versions are available, ensure documents remain legible and readily identifiable, ensure external documents are identified and controlled, and prevent the unintended use of obsolete documents.

Control of Records

Records required for the quality management system are maintained to provide evidence of conformity to requirements and of the effective operation of the organization. This document defines the controls needed for the identification, storage, protection, retrieval, retention, and disposition of records. At all times, records remain legible, readily identifiable, and retrievable.

Management Responsibility

Management Commitment

The Technology Center's Leadership Team demonstrates its commitment to the development and implementation of the quality management system and strives to continually improve its effectiveness by focusing the organization on customer needs, establishing the quality policy and objectives, conducting management reviews, and ensuring sufficient resources are available.

Customer Focus

The Technology Center's Leadership Team ensures that customer requirements are determined and are met with the aim of enhancing customer satisfaction.

Quality Policy

The Technology Center has established a quality policy that is appropriate to the purpose of the organization, includes a commitment to comply with requirements and continually improve the effectiveness of the quality management system, provides a framework for establishing and reviewing quality objectives, is communicated to and understood within the organization, and is reviewed for continuing suitability.

Planning

Quality Objectives

The Technology Center's Leadership Team ensures that quality objectives, including those needed to meet product requirements are established at relevant functions and levels within the organization. The quality objectives are measurable and consistent with the quality policy.

Quality Management System Planning

The Technology Center's Leadership Team ensures that the planning of the quality management system is carried out in order to meet requirements, and the integrity of the quality management system is maintained whenever changes are planned and implemented.

Responsibility, Authority and Communication

Responsibility and Authority

The Technology Center's Leadership Team ensures that responsibilities and authorities are defined and communicated within the local organization.

Management Representative (MR)

The Technology Center's Top Management has appointed a member of the Leadership Team to act as the Representative for ISO. This Representative has responsibility and authority that includes ensuring the processes needed for the quality management system are established, implemented and maintained, reporting to the Leadership Team on the performance of the quality management system and any need for improvement, and ensuring the promotion of awareness of customer requirements throughout the organization.

Internal Communication

The Technology Center's Leadership Team communicates the effectiveness of the quality management system to the organization via, but not limited to, electronic communication and periodic ISO meetings.

Management Review

General

The Technology Center's Leadership Team conducts management reviews, at least once per year, to ensure the quality management system's continuing suitability, adequacy, and effectiveness. These reviews include assessing opportunities for improvement and the need for changes to the quality management system, including the quality policy and objectives. Records of management review are maintained.

Review Input

Results of audits, customer feedback, process performance and product conformity, status of preventive and corrective actions, follow-up actions from previous management reviews, changes that could affect the quality management system, and recommendations for improvement.

Review Output

Improvement of the effectiveness of the quality management system and its processes, improvement of product related to customer requirements, and resource needs.

Resource Management

Provision of Resources

The Technology Center identifies, determines and provides the resources needed to implement and maintain the quality management system and enhance customer satisfaction.

Human Resources

General

Personnel performing work affecting quality are competent on the basis of appropriate training, education, skills, and experience.

Competence, Awareness and Training

The Technology Center has developed processes for identifying the required competencies of all personnel performing quality-related activities. The Technology Center recruits competent personnel or provides the training necessary to achieve these competencies. The effectiveness of this training is evaluated at specified intervals. Records of personnel training are maintained and controlled. The Technology Center ensures that personnel are aware of the relevance and importance of their activities, and how they contribute to the achievement of the quality objectives. Work instructions and/or SOPs are used only as training and reference materials.

Infrastructure

The appropriate infrastructure to meet or exceed customer requirements is identified, provided, and maintained by Top Management for its employees. This includes, but is not limited to, buildings, workspace, equipment (hardware and software), utilities, and support.

Work Environment

The Technology Center provides its employees with a work environment that focuses on safety, quality, customer satisfaction, and open communication. This includes providing and managing adequate temperature and noise controls, lighting, and work spaces throughout the facilities.

Product Realization

Planning of Product Realization

Technology Center Management ranks projects, and assigns resources. The planning process is consistent with the requirements of the other processes of the quality management system. In planning projects, the Technology Center determines quality objectives and requirements for the project, project specific resource needs, processes and documents, project specific verification, validation, monitoring, measurement, inspection, test activities, acceptance criteria and records that provide evidence that the planning process and resulting product meet requirements.

Customer Related Processes

Customer Communication

The Technology Center has implemented effective arrangements for communicating with customers regarding project information, enquiries, project management, including project amendments and customer feedback, including customer complaints.

Design and Development

Design and Development Planning

The Technology Center plans and controls the design and development of products and processes. This planning establishes the design and development stages, the review, verification, and validation appropriate to each design and development stage, and responsibilities and authorities for design and development. Organizational and technical interfaces between departments providing input into the design and development process are managed to ensure effective communication and clear assignment of responsibility. Planning output is updated, as appropriate, throughout the design and development process.

Design and Development Inputs

Design and development input requirements are established and reviewed. Records are maintained as project records. The inputs are complete, unambiguous, and not in conflict with each other. These inputs include functional and performance requirements, applicable statutory and regulatory requirements, information derived from previous similar designs, where applicable, and other requirements essential for design and development.

Design and Development Outputs

Design and development outputs are provided in forms that are verifiable against design and development input requirements and are approved prior to release. Design and development outputs meet the input requirements for design and development, provide appropriate information for purchasing, production, and service provision, contain or reference product or process acceptance criteria, and identify product characteristics that are essential to its proper use.

Design and Development Review

Formal design reviews are conducted at defined stages to evaluate the ability of the results to meet requirements, identify any problems, and propose necessary actions. These reviews include the appropriate organizational and technical interfaces, as well as other specialist personnel, when required. Records of these reviews and necessary actions are maintained as project review records.

Design and Development Verification

Design verification is performed as planned to ensure that design and development outputs meet design and development input requirements. Records of the results of the verification and any necessary actions are maintained as project records.

Design and Development Validation

Design and development validation is performed as planned to ensure that the resulting product conforms to the specified requirements for the specified application or intended use. Records of the results of the validation and any necessary actions are maintained as project records.

Control of Design and Development Changes

Design and development changes are identified, reviewed, verified and validated as appropriate and approved by authorized personnel prior to their implementation. This review includes evaluation of the effect of the changes on constituent parts and product already delivered. Records of the results of the review of changes and any necessary actions are maintained as project records.

Production and Service Provision

Control of Production and Service Provision

The Technology Center plans and conducts production and service provision under controlled conditions that include the availability of information that describes the characteristics of the product, availability of necessary work instructions, use of suitable equipment, availability and use of monitoring and measuring equipment, implementation of monitoring and measurement and implementation of release, and delivery and post-delivery activities.

Identification and traceability

Where necessary to determine valid results, as determined by laboratory/departmental management, Technology Center products are suitably identified from receipt, throughout all stages of production, and delivery. Monitoring and measurement status is suitably identified at appropriate stages. Traceability of product data is maintained in the project records.

Preservation of product

The Technology Center preserves product conformity during internal processing and delivery to intended destinations. This preservation includes identification, handling, packaging, storage and protection. This also applies to the constituent parts of a product, such as the preservation of the underlying project data, which may include memos, reports, emails, as well as process data.

Control of Monitoring and Measuring Equipment

The Technology Center establishes what monitoring and measuring will occur, when it will occur, and which monitoring and measuring devices are needed to provide evidence of conformity to requirements. Processes are designed to ensure that monitoring and measurement can be, and is, performed in a way that is consistent with the monitoring and measurement requirements.

Where necessary to ensure valid results, as determined by laboratory/departmental management, measuring equipment is calibrated and verified at specified intervals, or prior to use, against measurement standards traceable to international or national measurement standards; where no such standards exist, the Technology Center records the basis used for calibration. Measuring equipment is adjusted or re-adjusted as necessary, identified in order to determine its calibration status, safeguarded from adjustments that would invalidate the measurement result and protected from damage and deterioration during handling, maintenance and storage.

When measuring equipment is found to be out of calibration, the Technology Center assesses and records the validity of previous measuring results and takes appropriate Corrective Action on the equipment, and any product affected.

When computer software is used to monitor and measure the specified requirements, its ability to satisfy the intended application is confirmed prior to initial use. This ability is reconfirmed as necessary during routine equipment maintenance. Records of the results of calibration and verification are maintained.

Measurement, Analysis and Improvement

General

The Technology Center plans and implements monitoring, measurement, analysis, and improvement processes needed to demonstrate product conformity, ensure conformity of the quality management system, and continually improve the effectiveness of the quality management system.

Monitoring and Measurement

Customer Satisfaction

The Technology Center surveys customers to collect and monitor information to determine customer perception as to whether the Technology Center has met customer requirements. Other methods of determining customer satisfaction are monitored, as needed, including, customer emails and verbal conversations. This information is reviewed by management and is acted upon, as appropriate, to improve customer satisfaction.

Internal Audit

The Technology Center plans and conducts internal audits to determine if the quality management system is effectively implemented and maintained, conforms to planned arrangements and the requirements of ISO9001 and other integrated systems. This documented procedure establishes and defines the responsibilities and requirements for planning and conducting audits, establishing records, and reporting results.

The status and importance of the processes and areas to be audited are considered when the audit schedule is planned, as well as the results of previous audits. Audit criteria, scope, frequency, and methods are defined, and Auditees are notified of same. Auditors are trained, and audits are conducted with objectivity and impartiality. Auditors do not audit their own work.

Responsible Process Owners take timely actions to eliminate detected nonconformities and their causes. Follow-up auditing occurs to ensure that the actions taken were effective. Records of internal audits are maintained.

Monitoring and Measurement of Processes

Processes are monitored primarily by routine departmental supervision. Where applicable, these processes are measured to demonstrate the ability of the processes to achieve planned results. Correction and Corrective Action are taken when planned results are not achieved to ensure product conformity.

Monitoring and Measurement of Product

During appropriate stages of product realization, and according to planned arrangements, the Technology Center monitors projects to verify that requirements have been met. Evidence of conformity with acceptance criteria is maintained as project records. Final release only proceeds when the project requirements have been satisfactorily completed, unless otherwise approved by a relevant authority, or by the customer.

Control of Nonconforming Product

Technology Center project managers and project leaders ensure that products not meeting customer requirements are identified and controlled to prevent unintended use or delivery. This documented procedure defines the controls and related responsibilities and authorities for dealing with nonconforming project reports. This procedure ensures that nonconforming products are dealt with by taking action to eliminate detected nonconformities, authorizing use, release, or acceptance under concession by relevant authority, and where applicable, by the customer, taking action to preclude the original intended use or application, and taking action appropriate to the effects, or potential effects, of the nonconformity when nonconforming product is detected.

Records of nonconformity, actions taken, and nonconformity acceptances are maintained. Re-verification is performed on re-worked nonconforming product to demonstrate conformity to requirements. When nonconforming product is detected after delivery or use has started, the Technology Center takes action appropriate to the effects, or potential effects of the nonconformity.

Analysis of Data

Technology Center departmental and laboratory managers determine the appropriate data to collect and analyze to demonstrate the suitability and effectiveness of the quality management system. These business metrics are used to evaluate where continual improvements can be made. The analysis is a result of monitoring and measurement and provides information relating to customer satisfaction, conformity to product requirements and characteristics and trends of processes and products including opportunities for preventive action.

Improvement

Continual Improvement

The Technology Center continually improves the effectiveness of the quality management system through the use of the quality policy, quality objectives, audit results, analysis of data, corrective and preventive actions, and management review. Process Improvements are captured in Project Planners, AR's, Work Orders, and PARs.

Corrective Action

The Technology Center takes corrective action to eliminate the cause of nonconformities in order to prevent recurrence. Actions taken are appropriate to the effects of the nonconformities encountered. The corrective action procedure defines the requirements for reviewing nonconformities (including customer complaints), determining the causes of nonconformities, evaluating the need for action to ensure that nonconformities do not recur, determining and implementing action needed, recording the results of actions taken, and reviewing corrective action taken.

Preventive Action

The Technology Center determines the action required to eliminate the causes of potential nonconformities in order to prevent their occurrence. Preventive actions are appropriate to the effects of the potential problems. The preventive action procedure defines requirements for determining potential nonconformities and their causes, evaluating the need for action to prevent occurrence of nonconformities, determining and implementing action needed, recording the results of action taken, and reviewing preventive action taken.

Appendix H – Curricula Vitae

Dan Ramey, Director

Life Cycle and Environmental Technology

An internationally respected mining professional with thirty-five years of professional experience and technical knowledge spanning multiple disciplines. Mr. Ramey has successfully developed and operated mine projects in the US and throughout the world. In addition he managed permitting of mining and processing facilities for base metals and energy minerals. Most recently he works with emerging technology to manage and reduce environmental liabilities.

Mr. Ramey provides technical and administrative support to engineering and environmental projects including:

- Evaluation of emerged or emerging environmental technologies for source control, migration control, water treatment and residual resource extraction;
- Providing current operations alternative options to reduce potential future liabilities;
- Creating offset opportunities which change liabilities into assets;
- Identification and monetization of non-core assets;
- Mine remediation, reclamation, and closure planning and implementation;
- Ground water characterization and remediation option evaluation;
- Permitting and maintaining compliance with federal (RCRA, NPDES) and state (APP, others) regulations;
- CERCLA alternatives evaluation.

Specializing in:
Program Management
Project Management
Liability Characterization
Technology Evaluation
Remediation Evaluation
Remediation Design
Remediation Implementation
Mine and Facility Operation
Environmental Engineering

Years of Experience: 35

Education
M.B.A.-Finance 1999
M.S.- Environmental Science 1980
M.S.- Aquatic Ecology 1980
B.S. Biology/Geology 1975

Special Training
Mine Life Cycle
Leadership Coaching Program
DuPont Safety Training
Financial Analysis of Mining Properties
Leadership Development Program
Geostatistical Analysis
Fractured Rock Hydrology
Landmark Training
Supervisory Training (DDI)
Mathematical Foundation of Ground Water Models
Computer Implementation of Ground Water Models
Fundamentals of Ground Water Quality Protection
MSHA Training
HAZWOPER Training

Publications:
20 – Publications

Presentations: More than 30 formal professional presentations

Invited Speaker: 10 invited primary speaker presentations

Short Courses: Instructor for short courses with:
SME
Arizona Dept. of Environmental Quality
US Environmental Protection Agency
US Bureau of Land Management
Hopi Indian Nation
Phillips Petroleum Company
Magma Copper Company
Broken Hill Proprietary, Ltd.

Erick Weiland, Manager

RG (AZ / TN), PG (KY / WY), CPG

An internationally respected geochemist with over forty years of professional experience and technical knowledge spanning multiple disciplines, Mr. Weiland has successfully completed projects across many countries through the applied use of sound geochemical principals, methods, and interpretation.

Mr. Weiland provides geochemical support to, and management of, engineering and environmental projects including:

- Design, implementation, and evaluation of field and laboratory investigations related to geochemical processes in the surface and sub-surface environments
- Fate and transport analysis of metals and non-metals within the natural environment
- Assessing acid generation potential (acid rock drainage) with associated leaching of hazardous constituents from natural materials
- Computer modeling of anthropogenic systems in natural environments using geochemical, hydrogeological, and contamination processes and attributes
- Water quality investigations in both the surface and sub-surface environments
- Evaluations of recharge systems for wastewater and surface water storage and retrieval
- Attaining and maintaining compliance with federal and state regulations and permits including RCRA, NPDES, APP, and others
- CERCLA emergency clean-up actions
- Remediation and compliance investigations for metals and non-metals in soils
- Engineering and design of waste rock dumps and tailings dams
- Laboratory operations & management
- Mine remediation, reclamation, and closure planning and implementation

Specializing in:
Project Management
Applied Geochemistry & Geology
Environmental Engineering

Years of Experience: 40+

Education

BS Geological Engineering, Colorado School of Mines, 1973
MS Geochemistry, Colorado School of Mines, 1979

Registrations & Certifications

Registered Geologist: Arizona (1985), Tennessee (1991)
Professional Geologist: Kentucky (1993), Wyoming (1992)
Certified Professional Geologist: American Institute of Professional Geologists (1985)

Special Training

Computer Modeling of Natural Attenuation and Bioremediation Systems
Principles and Applications of Modeling Chemical Reactions in Ground Water
Transport and Fate of Organic Chemicals in Soil and Groundwater
Fractured Rocks: Characterization, Flow & Transport
Statistical Methods for Environmental Monitoring
Advanced Statistical Techniques for Environmental Monitoring
Advanced Topics in Statistical Analysis
40-hour Mine Safety and Health (MSHA) New Miner and Annual Refreshers
40-hour Hazardous Waste Operations and Annual Refreshers

Publications

12 – Peer reviewed Journal Articles
27 – Proceedings and Presentations
Reviewer for: EXPLORE (AAG Newsletter); and, Geochemistry, Exploration, Environment, Analysis (GEEA)

Brett Waterman

Mine water treatment expert and metallurgist with over 25 years of professional experience and technical knowledge related to water treatment, ARD and hydrometallurgy. Mr. Waterman has successfully provided technical support and completed projects and installations throughout the Americas:

- Innovative with focus on improving and developing new water treatment and metal recovery technologies
- Process optimization of gold and silver plant performance resulting in improved gold recovery while significantly reducing costs
- Owner oversight of design and construction of water treatment plants
- Development of site-wide water balance models to include infiltration, precipitation, evaporation and leach drain down used to estimate future mine water balance as mines transitioned from operation to closure.
- Successful design, construction and operation of multiple full-scale water treatment plants and processes
- Implemented biological cyanide treatment at 5 mine sites to reduced cyanide concentrations in gold and silver heap leach operations during closure
- Developed operating strategies and training for new and existing plants
- Managed water treatment and metal recovery operations and laboratory personnel at multiple facilities
- Evaluated alternative technologies for pretreatment of refractory gold ores for new and existing ore bodies
- Options analysis at multiple sites for metals treatment and removal including selenium, arsenic, iron, manganese and others

Specializing In:
Mine water treatment
Hydrometallurgy
Project Management

Years of Experience: 27

Education

BS Metallurgical Engineering, University of Utah, 1982
MS Metallurgy, University of Utah, 1984, Thesis: *Electrowinning of Gold with a Fluidized Bed Electrode*

Professional Activities

Society of Mining, Metallurgy, and Exploration

Session Chairman Water Treatment Session
Current Second Vice Chair AZ SME Section
Board of Directors 2013 AZ SME Section

Special Training

INAP Sulfate Treatment Workshop
Detoxification Chemistry Seminar
40-hour Mine Safety and Health (MSHA) New Miner and Annual Refreshers
40-hour Hazardous Waste Operations and Annual Refreshers

Publications

7 Publications and Proceedings

Patents

US Patent No. 8,361,192
US Patent No. 4,891,067
US Patent Application 20130153435

Leonard Santisteban, PhD

Respected research scientist with twenty years of academic and professional experience working across multiple disciplines within the field of biology. Successfully developed and implemented value-oriented projects nationally and internationally while integrating sound scientific principles and rigorous evaluation methods to ensure quality results. An effective communicator adept at identifying and filling information gaps. Skilled in adapting to new challenges and identifying solutions in a collaborative manner. A dynamic team leader and engaged participant across projects covering a wide range of topics and scale.

Dr. Santisteban provides scientific technical support, guidance, and management of environmental projects including:

- Design, implementation, and evaluation of laboratory- and field-scale investigations on emerged and emerging phytotechnologies and passive bioremediation
- Fate and transport analysis of metals and non-metals within soils, water, and plants
- Fate and transport analysis of wind-blown dust and tailings in order to rigorously compare and evaluate alternative dust suppression strategies
- Identification and development of emerged and emerging remediation technologies with potential applications to mining
- Technical design, operation, maintenance, and monitoring of passive bioremediation systems
- Mine remediation, reclamation, and closure planning and implementation
- Compiling and evaluating large data sets with statistics to distill the most salient information to ensure project success

Specializing in:
Applied Phytotechnology and Ecology
Environmental Remediation
Project Management

Years of Experience: 15

Education

BSc Wildlife Ecology and Conservation, University of Florida, 1996
MSc Wildlife Ecology and Conservation, University of Florida, 2001
PhD Ecology and Evolutionary Biology and Minor in Experimental Statistics, New Mexico State University, 2010

Special Training

Practicing Phytotechnologies
Phytotechnology Technical and Regulatory Guidance and Decision Trees
Decision Analytics for Remediation
Mine Waste Treatment with Natural Systems
Green and Sustainable Remediation
Project Risk Management for Site Remediation
Soil Sampling and Decision Making Using Incremental Sampling Methodology
Using Biosolids and Coal Combustion Products for Soil Remediation at Mining Sites
Pore water Concentrations and Bioavailability
Mining Remediation and Sustainability
Wetland Restoration and Construction
40-hour Mine Safety and Health (MSHA) New Miner and Annual Refreshers
40-hour Hazardous Waste Operations and Annual Refreshers
10-hour Occupational Safety and Health Administration (OSHA) training
16-hour Fatality Prevention Training
First Aid and CPR Training

Publications

6 – Peer-Reviewed Journal Articles
5 – Published Reports and Presentations

Key Achievements and Awards

Working while remaining safety incident-free due to a growing understanding of safety issues, risks, consequence thinking, and active dialogue with colleagues.

Designed and deployed a pilot-scale treatment wetland designed to treat concentrations of elements never before attempted.

Developed and fostered strategic partnerships with non-profit organizations, local stakeholders, and active mine sites to broaden environmental education opportunities

Ilsu Lee, PhD

Specializing in Environmental Engineering, waste water, soil, and groundwater remediation and Bioenergy production. Fifteen years of professional experience and technical knowledge spanning multiple disciplines, Dr. Lee has successfully completed projects in the US and South Korea through the applied use of sound environmental engineering principals, methods, and interpretation including the development of innovative soil and water treatments and bioenergy production technologies.

Providing professional support to environmental, engineering, and research projects including:

- Sustainable low cost/maintenance remediation of mining-influenced water using natural organic substrate packed sulfate reducing bioreactor (SRBR) and permeable reactive barrier (PRB)
- Metal removal from mining-influenced water using limestone reactors or chemical treatment
- Investigation of biogeochemical metal removal mechanisms using environmental, geochemical, and molecular biology tools; including DNA sequencing and real time PCR
- Modeling of *in situ* sulfate and metal plume biological and chemical remediation of organic contaminants in groundwater systems
- Mine tailings dust control using biopolymer suppressants
- Design, implementation, and evaluation of field and laboratory investigations related to soil and water treatment processes in surface and sub-surface environments
- Design, implementation, and evaluation of field and laboratory investigations related to nutrient removal processes from municipal wastewater, industrial wastewater, and landfill leachate
- Optimization of anaerobic digestion system operation to treat wastewater and solid waste and to produce maximum biogas (e.g., methane)
- Bioenergy (methane and hydrogen) production using anaerobic digestion combined with pre-treatment and Biofuel production from algae and cyanobacteria

Specializing in:
Environmental Engineering
Waste Water, Soil, and Groundwater Remediation
Bioenergy Production

Years of Experience: 15+

Education

Ph.D. Environmental Engineering, Inha University, S. Korea, 2005
Dissertation: *Competition for Hydrogen among Electron Acceptors during Reductive Dechlorination of Chlorinated Ethenes*
MS Environmental Engineering, Inha University, S. Korea, 1996
Thesis: Removal of Nitrogen and Phosphorus from Sewage by A2/O and VIP Processes
BS Environmental Engineering, Inha University, S. Korea, 1996

Registrations & Certifications

Engineer Water Pollution Environmental, S. Korea, 1996
Engineer Air Pollution Environmental, S. Korea, 1996

Special Training

40-hour Mine Safety and Health (MSHA) New Miner and Annual Refreshers
40-hour Hazardous Waste Operations and Annual Refreshers
16-hour Fatal Prevention Training
First Aid and CPR Training
Customized Environmental Geochemistry of Metals: Investigation and Remediation (#603)
Radiation Safety Awareness Training
Handling and Transporting Hazardous Material: A General Awareness Program
Introduction to Groundwater Geochemistry with Applications to the Alkaline Flush Remediation Technology

Publications

20 – Peer reviewed Journal Articles
31 – Proceedings and Presentations
Reviewer for: Water Research, Water Environment Research, and Journal of Environmental Engineering

Olufunsho Ogungbade, EI

An environmental engineer with rigorous educational background plus five years of research experience in developing emerged and emerging remediation technologies for environmental liability management. Olu provides technical support and guidance on research, bench-scale testing, data analysis and interpretation, and technical report writing. He currently serves as the **Project Lead** in the development of the alkaline flush (ALF) technology for treating mining influenced waters.

Providing technical expertise to remediation research and environmental engineering projects including:

- Development of Alkaline Flush Technology to facilitate *in situ* remediation of acidic metal impacted groundwater and aquifer sediments at potentially reduced cost and time frame compared to natural attenuation
- Development of emerged and emerging technologies for source control in active and inactive mine sites
- Sediment and groundwater sampling for site characterization
- Remediation and compliance investigations for metals and non-metals in sediments and groundwater
- Scope of work (SOW and standard operating procedures (SOPs) development, data analysis and interpretation, report writing, and technical presentations
- Solid and hazardous waste management, environmental audits, environmental laws and regulation

Specializing in:
Environmental Remediation
Source and Migration Control
Industrial water and waste water treatment

Years of Experience: 5

Education
BS Civil Engineering, Obafemi Awolowo University, Ile Ife, Nigeria, December 2007
MS Environmental Engineering, New Mexico Tech, Socorro, NM, December 2011

Certifications
New Mexico State Board of Licensure for Professional Engineers and Professional Surveyors certified Engineer Intern (EI)

Special Training
40-hour Mine Safety and Health Administration (MSHA) New Miner training and Annual Refreshers
10-hour Occupational Safety and Health Administration (OSHA) training
40-hour OSHA Hazardous Waste Operations and Emergency Response (HAZWOPER) training and Annual Refreshers
First Aid and CPR Training
Introduction to Groundwater Geochemistry with Applications to the Alkaline Flush Remediation Technology

Publications
3 – Proceedings and Presentations

Madhumitha Raghav, PhD, EIT

A motivated environmental engineer having a multi-disciplinary technical background and work experience. Dr. Raghav provides technical support and guidance on the geochemical and engineering aspects of environmental projects. She currently serves as the **Project Lead** for projects focused on reducing environmental liabilities through the development of alternative remediation technologies.

Providing engineering and geochemical expertise to environmental projects including:

- Design, implementation, and evaluation of laboratory and field investigations related to geochemical processes in the surface and sub-surface environments
- Fate and transport analysis of metals and non-metals within the natural environment
- Assessing acid generation (acid rock drainage) and metal leaching potential with associated leaching of hazardous constituents from natural materials
- Computer modeling of anthropogenic systems in natural environments using geochemical, and contamination processes and attributes
- Development of Alkaline Flush Technology to facilitate *in situ* remediation of acidic metal impacted groundwater and aquifer sediments at potentially reduced cost and time frame compared to natural attenuation
- Development of emerged and emerging technologies for source and migration control in active and inactive mine sites
- Development of passive/semi-passive treatment technologies for removal of aluminum, iron, copper, zinc, cadmium, and manganese from mine impacted waters
- Development of neutralization technologies for treatment of closed copper heap leach facilities
- Development of arsenic solid waste stabilization under landfill conditions by novel and environmentally benign techniques

Specializing in:
Environmental Remediation
Source and Migration Control
Fate and Transport of Contaminants in the Environment
Mine Waste Rock/Tailings Geochemical Characterization

Years of Experience: 6

Education

Bachelor of Engineering (Honors) in Chemical Engineering, June 2007
Master of Science (Honors) in Biological Sciences, June 2007
Master of Science in Environmental Engineering, December 2009
PhD in Environmental Engineering, August 2013

Certifications

Arizona Board of Technical Registration certified Engineer-in-Training (EIT)

Special Training

40-hour Mine Safety and Health Administration (MSHA) New Miner and Annual Refreshers
10-hour Occupational Safety and Health Administration (OSHA) training
First Aid and CPR Training
Introduction to Groundwater Geochemistry with Applications to the Alkaline Flush Remediation Technology
Introduction to Water-Management Modeling with GoldSim Dynamic Simulation Software
Hands-on Training for Water Management Modeling with GoldSim Software workshop

Publications

3 – Peer reviewed Journal Articles
8 – Technical Articles, Proceedings and Presentations

Key Achievements and Honors

Awarded 'Outstanding Graduate Student in Environmental Engineering' Award at the University of Arizona for 2012-2013.

Awarded the prestigious Science Foundation of Arizona Graduate Fellowship (2007-2009) for being one of the top graduate students in Arizona pursuing research in strategic fields like water management and environmental services.

Selected as a Superfund Training Core Fellow (2009-2011) of the University of Arizona Superfund Research Program (UA SRP).

Awarded AZ Water Scholarship in the 86th Annual AZ Water Conference & Exhibition.

Awarded the Best Research Abstract Award in the 85th Annual AZ Water Conference & Exhibition.

Jeffrey Ladderud, M.S.

A young and diligent engineer with strong writing skills, an aptitude for learning, and attention to detail, Mr. Ladderud brings to the table a critical eye grounded in a broad academic base. He serves as the project lead for ET/LCAT's dust control efforts.

Providing engineering and geochemical expertise and support to environmental projects including:

- Design, implementation, and analysis of laboratory and field investigations related to the evaluation of dust suppression technologies
- Laboratory experiments investigating potential impacts of chemical dust suppressants on surface water quality
- Design, implementation, and evaluation of laboratory and field investigations related to geochemical processes in the surface and sub-surface environments
- Metal removal from mining-influenced water using limestone reactors or chemical treatment
- Sustainable low cost/maintenance remediation of mining-influenced water using natural organic substrate packed sulfate-reducing bioreactor (SRBR)
- Investigation of biogeochemical metal removal mechanisms using environmental, geochemical, and molecular biology tools; including DNA sequencing and real time PCR
- Fate and transport analysis of metals and non-metals within the natural environment
- Computer modeling of anthropogenic systems in natural environments
- Remediation and compliance investigations for metals and non-metals in soils
- Hydrologic field testing of surface and ground waters

Specializing in:
Waste Water, Soil, and Groundwater Remediation
Fugitive Dust Source and Migration Control
Fate and Transport of Contaminants in the Environment

Years of Experience: 2

Education

M.S. Hydrology, Colorado School of Mines, 2014
Thesis: The effects of substrate selection and inoculation on the performance of laboratory-scale sulfate-reducing bioreactor columns

B.S. Geology, Washington State University, 2013
Honors, *summa cum laude*

Special Training

24-hour Mine Safety and Health Administration (MSHA) New Miner and Annual Refreshers
40-hour Hazardous Waste Operations and Annual Refreshers
10-hour Occupational Safety and Health Administration (OSHA) training
First Aid and CPR Training
Fluent in Spanish

Publications

4 – Peer reviewed Journal Articles
4 – Proceedings and Presentations

Key Achievements and Honors

Awarded 'Outstanding Senior in Geology' Award at Washington State University for 2012-2013.

Awarded a prestigious Sussman Fellowship (2014) given to graduate students to help them pursue careers which interface with environmental concerns

Earned a National Association of Geosciences Teachers scholarship by excelling in coursework at the Indiana University Geology Field Camp (2012). This led to an internship with the USGS in Reston, VA (2013).

Awarded the full-ride, Distinguished Regents Scholarship given to only 25 students in the state of Washington on the basis of academic achievement (2009-2013)

Recipient of the Auvil Fellowship for undergraduate research (2010)

National Merit Scholar (2009)

Shane Hansen

Experienced research associate with seventeen years professional and academic experience in various fields within physical and biological sciences and geotechnical assessments. Extensive experience developing and coordinating applied research in copper leaching, bioleaching, water treatment, remediation, and source and migration control of environmental liabilities.

Resourceful usage of design and fabrication experience to create novel experimentation systems for lab and pilot scale project design including construction phases. Experienced team leader and laboratory manager working with a diverse team covering several disciplines and backgrounds.

Provides technical support to environmental engineering and research projects including:

- Technical expertise and recommendations for the design, construction, and operation of lab-scale to pilot-scale research projects, and the design of full-scale systems
- Coordinate multiple domestic and international projects concurrently between internal and external stakeholders
- Organize and maintain testing data according to established quality assurance and quality control procedures
- Update procedures according to best laboratory practices and safe operations
- Maintain safety standard for laboratory staff as well as visiting project leads, including providing or scheduling necessary training to safely perform all testing and analyses in the lab environment
- Initiate and support review of potentially hazardous chemicals and potential reactivity for anticipated testing and experimentation
- Coordinate and direct field work-related logistics for sample collection, project planning, site schedules, and pilot testing
- Coordinate new projects with facility management for approvals, recommendations, and establish needs from local site and facility
- Serve as intermediary between internal and external analytical laboratories, including all Environmental Protection Agency (EPA) mandated testing and sampling
- Expert in field sampling, sample preservation, and laboratory techniques according to local, state, and federal protocols

Specializing in:

Environmental Technology and Research

Laboratory Operations

Field Application and Design

Technical Design

Years of Experience: 12

Education

BSc Physical Sciences, Northern Arizona University, 2003

Special Training

40-hour Mine Safety and Health (MSHA) New Miner and Annual Refreshers
40-hour Hazardous Waste Operations and Annual Refreshers
10-hour Occupational Safety and Health Administration (OSHA) training
24-hour Fatality Prevention Training, Management Level
First Aid and CPR training
IATA Hazardous Air Shipments certified
USDOT Hazardous Materials Awareness and tri-annual refreshers

Appendix I – Summary of Prior Relevant FMC Passive Bioremediation Projects

Freeport Minerals Corporation has conducted applied research and constructed/operated bioremediation projects in the western United States (Arizona, New Mexico, and Colorado) and Indonesia. These projects include column tests, pilot tests, and full-scale passive bioremediation operations. Many of the pilot tests include pre-treatment reactors, usually limestone, and all of the operating facilities include post-treatment wetlands.

More than 50 sulfate-reducing bioreactor columns have been evaluated either at FMC's laboratory facilities or at the remediation project site. Study objectives included determining the efficacy of single and combined alternative organic substrates and to generate design-based information utilized for full-scale facilities. Typical column size utilized for these tests was 4-inch diameter by 4-foot long, although larger columns, both in diameter and length, have also been previously used depending on the testing requirements of the project. The column test program allows staff to determine the performance of organic substrates in response to each unique water from the project sites (or a synthesized analog based on specific site water characteristics) in a controlled setting. The controlled setting allows staff to modify organic substrate mixtures, flow rates, bacterial inoculation types and amounts, incubation time, pre-and post-organic substrate analyses, and any requirements for pre- and post-treatment.

Pilot-scale evaluations, which typically follow column tests, are conducted in 55- to 90-gallon barrel reactors at project sites. FMC has operated approximately 100 barrel reactors as part of pilot-scale evaluations. Although pilot tests are controlled, they are influenced by relatively variable environmental conditions that allow for observations of any resultant performance changes. Barrel-based pilot tests provide key information for the design basis for full-scale passive bioremediation systems, from pre-treatment through to post-treatment wetlands.

Performance and design information for two full-scale operating passive bioremediation systems is presented in Table I-1. In addition, pilot-scale results for a walnut shell-based reactor are also presented. The operating systems were selected for environmental conditions that are comparable to the conditions anticipated for Haystack Creek and Danny T sites in Montana. These two examples are operating in northern Arizona and western Colorado. The operating systems were constructed for volunteer remediation projects and performance based on the removal of metals. Metal removal typically exceeds 95%, with the exception of manganese, which is removed in post-treatment wetlands. The Iron King information is represented as total metal demonstrating that particulate metals are not being released from the system. The Garfield system, has a somewhat lower metal removal rate at the moment, but was only recently commissioned and performance continues to improve.

The Bruce pilot-scale system demonstrates the effectiveness of walnut shell as an organic substrate. FMC has used walnut shells in many column and pilot-scale evaluations and data indicates that it is a long-term carbon source and may also provide additional structure to the reactor to help maintain flow through the system.

Table I-1: Selected Performance Information for Bioremediation Projects

	Iron King			Garfield			Bruce		
formation									
e		Operational			Operational			Pilot	
(gpm)		1-10			1-3			5.3 gpd	
lonthly Average Air re (°C)		-17 to 35			-11 to 29			-1.5 to 34	
Mixture		Cow manure (0.5%), Limestone (30%), Alfalfa Hay (10%), Saw Dust (10%), Wood Chips (49.5%)			Sheep manure (0.5%), Wood chips (79.5%), Limestone (10%), hay/straw (10%)			Cow manure (1%), Limestone (30%), Alfalfa Hay (9%), Walnut Shell (60%)	
^{2})		18,000			1,350			265 L	
^{2})		13,000			980				
)peration		>8 years			<1 Year			18 months	
nce Indicators	Influent	Effluent	Efficiency (% Removed)	Influent	Effluent	Efficiency (% Removed)	Influent	Effluent	Efficie (% Rem
l	6.3	7.1		7.9	6.3		3.5	6.8	
RP (mV)	20	-70		200	-270		380	-320	
(mg/L Diss)	34.7	<0.1	99.7	N/A	N/A	N/A	57.3	<1.0	99.
(mg/L Diss)	101	0.41	99.6	N/A	N/A	N/A	<1.0	<1.0	N/
l (mg/L Diss)	0.106	<0.001	99.1	N/A	N/A	N/A	0.3	<0.1	67.
(mg/L Diss)	0.159	0.004	97.5	N/A	N/A	N/A	0.44	<0.1	77.
(mg/L Diss)	17.4	0.35	99.8	N/A	N/A	N/A	13.3	<0.1	99.
n (mg/L Diss)	11.2	6.9	38.2	N/A	N/A	N/A	14	11.7	16.
(mg/L Diss)	34.1	<0.001	100	0.22	0.03	86.4	109	<1.0	99.
)4 (mg/L Diss)	1673	769	54.0	204	15	93.0	3290	2450	25.
lfate Removal Rate (mol/d/m^3)		0.120	54.0		0.07	93.0		0.663	25.
etal Removal Rate (mol/d/m3)		0.0162	99.3		0.0001	86.4		0.307	95
Polishing		6 Tier APC All water remains within APC. No discharge			APC to be constructed in 2017			BCR and APC not yet constructed	

NOTE: Iron King Performance Indicators expressed as mg/L Total