APPENDIX B

Construction Quality Assurance Plan

GOLDER
MEMBER OF WSP

REPORT

Construction Quality Assurance Plan

Union Pacific Railroad, Aluminum Recycling Trentwood Site

Submitted to:

Union Pacific Railroad

Submitted by:

Golder Associates USA Inc.

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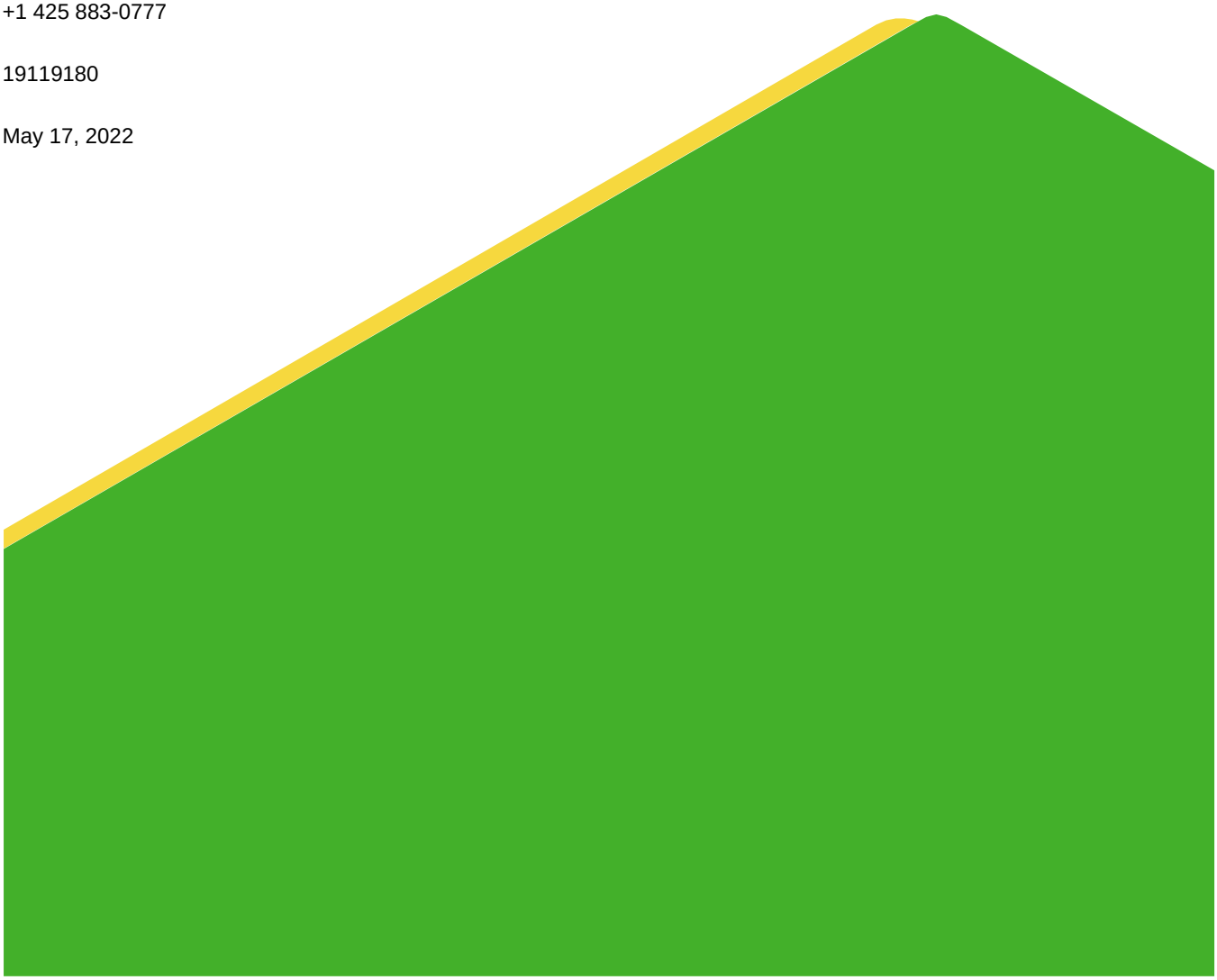
May 17, 2022



Construction Quality Assurance Plan

Union Pacific Railroad, Aluminum Recycling Trentwood Site

May 17, 2022

This report was prepared under the supervision and direction of the undersigned.

Frank S. Shuri — May 17, 2022

Frank S. Shuri, LG, LEG, PE
Golder Associates USA Inc.,
Principal Engineer

Date:

Ted J. Norton — May 17, 2022

Ted J. Norton
Golder Associates USA Inc.,
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Date:

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1.0 INTRODUCTION

This Construction Quality Assurance (CQA) Plan describes the CQA activities that will be performed during the Dross Removal Project at the Aluminum Recycling Trentwood Site in Spokane Valley, Washington.

1.1 Purpose

During construction, Quality Assurance activities will be performed to ensure that:

1) All components are constructed in accordance with the approved Drawings and Specifications, and

2) Requirements of regulatory agencies related to documentation are satisfied.

This CQA Plan has been prepared to describe the activities that will be performed during construction to satisfy these objectives. If problems related to achieving the technical requirements of the design documents are encountered during construction, the procedures described in this CQA Plan are intended to identify such problems in a timely manner and to document that these problems are corrected before construction is complete.

1.2 Scope

This plan establishes general administrative and documentation procedures and specific inspection and testing activities that will be applicable for all aspects of construction. Major work items include:

- Removing dross material and disposing of it in an off-site landfill.
- Removing native soil adjacent to the dross stockpile that contains contaminants of concern above cleanup levels (CULs) and disposing of these materials in an off-site landfill.
- Removing native soil adjacent to the dross stockpile that contains contaminants of concern above CULs but below remediation levels and placing it on the south-facing slope of the Union Pacific Railroad (UPRR) property.
- Constructing an ecological cap consisting of a gravel layer above geotextile over the former dross stockpile area and the south-facing slope of the UPRR property.
- Installing a geomembrane under surface water drainage ditch on the southwest portion of the ecological cap that will serve as a retention \ evaporation pond.
- Placing clean imported soil in areas adjacent to the ecological cap to restore the pre-existing topography.
- Reseeding disturbed areas.
- Restoring the surface water drainage ditch along the north side of the UPRR property as necessary.
- Installing chain link fencing around the UPRR property.

Construction activities are fully described in the approved Drawings and Specifications and may include activities not listed in the summary above.

This CQA Plan is intended to function independently of the Construction Contractor's Quality Control (QC) program. The Construction Contractor's QC activities during construction, including test methods, location, frequency, and similar requirements, may be established at the Construction Contractor’s discretion and are

independent of this CQA Plan. The Construction Contractor's QC program does not waive their responsibility to comply with all provisions of this CQA Plan and the approved construction documents.

1.3 Change Control Procedures

This CQA Plan and any implementing procedures are subject to the following change control procedures. Requests for modifications to the CQA Plan shall be made by memorandum from the CQA Manager to the Golder Associates USA Inc. (Golder) Project Manager (PM), with copies to the Construction Manager (CM). If the modification is acceptable, the modified CQA Plan will be distributed as a unique revision to all parties who received the original CQA Plan. The CQA Manager will collect and destroy all copies of previous versions, except that one copy of each revision shall be maintained in the project file.

2.0 PROJECT ORGANIZATION

This section describes the project organization for the Dross Removal Project. The following sub-sections list the organizations involved in the remedial construction and describe their respective roles in construction activities and the protocol for interactions between organizations. The organization chart for this project is shown in Figure 2-1.

Designation of a party by title implies either the specific individual or his \ her authorized representative.

2.1 Owner and Owner Project Coordinator

UPRR is the Owner of the Site, Kristen Stevens is the Owner's Project Coordinator (OPC) and will be responsible for overseeing implementation of the remedial action (RA) activities in accordance with the approved Cleanup Action Plan (CAP) and design documents under the oversight of the Washington State Department of Ecology (Ecology). The OPC will have final authority to supervise and direct RA activities as appropriate. The OPC or his designee will interface with the regulatory agencies, adjacent property owners, or other entities with operations at the Site as necessary. All coordination and other interactions with the Owner shall be through the OPC or approved designee.

2.2 Washington State Department of Ecology Project Coordinator

UPRR is conducting this remedial action under an enforcement order (EO) (DE 20752) with Ecology. Sandra Treccani is the Ecology project coordinator and is responsible for overseeing the implementation of the EO on behalf of the state and coordination with UPRR to ensure the requirements of the EO are met and remain on schedule.

2.3 Site Health and Safety Officer

Eric Adams, a Project Hydrogeologist, is the designated Site Health and Safety Officer (HSO). The HSO will observe construction activities and verify that all pertinent health and safety requirements as described in the site-specific Health and Safety Plans (HASPs) are being implemented. The HSO shall not be an employee or subcontractor of the Construction Contractor. Actions by the HSO shall not relieve the Construction Contractor or any other party of their responsibilities under the HASPs. The role of HSO may be combined with another role such as Construction Manager, with a single individual performing both activities.

The Site HSO will be responsible for:

- Ensuring that all site personnel have been trained in accordance with the requirements of the HASP.
- Verifying that documentation for specific specialized training (e.g., OSHA 40-hour HAZWOPER, equipment-specific training, etc.) has been received for all personnel involved in the associated activities.
- Reviewing job hazard analyses to verify that risks and mitigating measures have been identified.
- Conducting daily “tailgate” meetings prior to beginning work to discuss the planned activities for the day and any safety considerations.
- Periodically inspecting equipment and operations to verify compliance with the HASP.

A complete description of the duties and responsibilities of the HSO is contained in the HASP for this project.

2.4 Golder Associates Project Manager

Ted Norton, a Senior Environmental Project Manager, will be the Golder PM. The PM will oversee all work performed by other Golder personnel, including engineering support during construction, sampling and analysis, safety, and CQA activities. The Golder PM will also coordinate as directed with the regulatory agencies on behalf of the Owner to ensure that permitting requirements are satisfied. The Golder PM will report directly to and work closely with the OPC.

2.5 Design Engineer

Vanessa Nancarrow, a Senior Project Engineer registered in the State of Washington, was the lead engineer for the design of this project and will serve as the Design Engineer for the remedial action. The Design Engineer will work with the Golder PM and will interface with the CM and CQA Manager as required. Duties will include clarifying and interpreting the Drawings and Specifications, incorporating new or changed requirements, reviewing submittals as requested by the CM, and reviewing CQA documentation. All engineering work will be under the direct supervision of the Design Engineer.

2.6 Construction Manager

Ted Sager, a Project Geologist, will be the CM. He will serve as the single point of contact with the Construction Contractor and will in general coordinate activities on-site during construction. Duties will include:

- Schedule necessary meetings between parties and distribute meeting minutes as appropriate.
- Receive submittals from the Construction Contractor, review or distribute to the appropriate party as appropriate, and provide results to the Construction Contractor.
- Serve as the Construction Contractor’s point of contact for design clarification and change requests, pay requests, and other communications from the Construction Contractor.
- Monitor the Construction Contractor’s progress and quantity measurements.
- Notify the CQA Engineer of activities that require on-site CQA observation or testing.

The CM will report directly to the Golder PM.

2.7 CQA Manager

The CQA Manager (to be determined [TBD]) will directly supervise the quality assurance functions on-site, ensure that required inspections are performed at the appropriate locations and times, direct the location and frequency of CQA tests, monitor the results of tests, verify that deficiencies have been corrected, and prepare documentation of construction activities. The CQA Manager will also be responsible for training all CQA inspection personnel on requirements, procedures, scheduling, and inspection activities.

The CQA Manager will report directly to the Golder PM, but will also notify the CM, who will be responsible for implementing corrective actions, of any deficiencies or changes to CQA activities.

The CQA Manager shall possess, as a minimum, a Bachelor's degree in civil or construction engineering, engineering geology, or a closely related discipline, and shall have sufficient practical, technical, and managerial experience to successfully direct the CQA activities discussed in this plan.

2.8 CQA Personnel

CQA Personnel (TBD) include any personnel performing CQA inspection and testing activities under the direct supervision of the CQA Manager. As a minimum, CQA Personnel shall have a high school diploma and at least two years of construction-related experience for earthworks. Equivalent qualifications may be approved by the CQA Manager on a case-by-case basis.

Prior to beginning project activities, CQA Personnel shall receive any training required by the project HASP, specialty training for testing and inspection activities, and any other training that may be required to perform assigned activities. Training shall be performed under the supervision of the CQA Manager or Design Engineer and shall be documented by previous applicable experience listed on the individual’s resume or in a memo listing date of training and topics covered, together with the signatures of the trainee and the person administering the training.

2.9 Sampling and Analysis Lead

Eric Adams, the HSO, will also serve as the Sampling and Analysis Lead (SAL). He will direct sampling and analysis of subgrade soils to determine if required cleanup levels have been achieved. The SAL will work under the direction of the Golder PM and will interface with the CM and CQA Manager as required. Duties will include training all sampling personnel in the requirements of the Sampling and Analysis Plan (SAP); located in the Compliance Monitoring Plan (CMP), ensuring that sampling and analysis is performed in accordance with the requirements of the SAP, verifying that field equipment is functional and in current calibration, coordinating with the analytical laboratories, and reporting results to the Golder PM.

2.10 Construction Contractor

The Construction Contractor will perform all work activities associated with actual remedial construction. The Construction Contractor will be responsible for directing and supervising any subcontractors.

In addition to performing construction activities as described on the Drawings and in the Specifications, the Construction Contractor shall perform the following coordination aspects of the work:

- Coordinate with utility providers to arrange on-site inspection and support services related to excavating adjacent to or below electrical power service lines, both underground and above ground.
- Obtaining the Construction General Stormwater Permit and implementing the associated requirements.

- Preparing and submitting a Traffic Control Plan to the local authority having jurisdiction and implementing the associated plan requirements.
- Arranging for disposal of contaminated materials at the Graham Road Landfill and any other disposal facilities.
- Obtaining temporary utilities as required at the Site for his temporary facilities.

The Construction Contractor will communicate directly with the CM for all pay, contractual, design, and similar matters. The Construction Contractor shall have a Site Supervisor on-site at all times to serve as a point-of-contact. The Construction Contractor's Site Supervisor shall have authority to direct all of the Construction Contractor's and subcontractor's operations.

The Construction Contractor may implement their own internal Quality Control (QC) activities as they feel necessary to ensure the progress and quality of the work. However, should differences between CQA and QC test results arise, the CQA test results shall take precedence over QC results. CQA test results will be made available to the Construction Contractor on a timely basis; however, the use of such results shall not relieve them of the responsibility for performing any additional testing necessary to ensure the quality and progress of the work.

The Construction Contractor shall provide all required access and other logistical support for CQA activities, both before and during construction.

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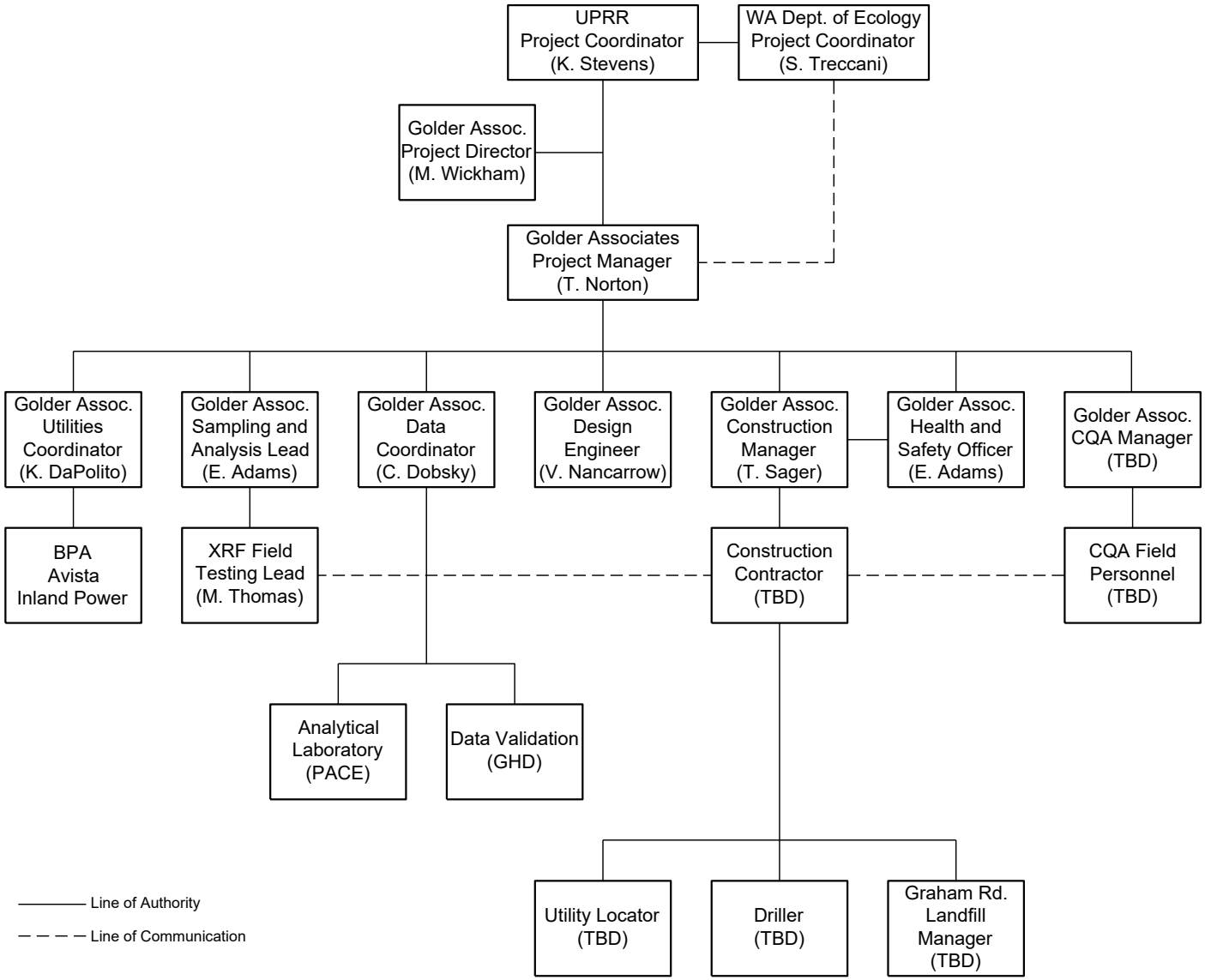

CLIENT
UNION PACIFIC RAILROAD CO.

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-12-16
DESIGNED	VMN
PREPARED	REDMOND
REVIEWED	FSS
APPROVED	TJN

PROJECT
ALUMINUM RECYCLING TRENTWOOD SITE
REMEDIAL ACTION - DROSS REMOVAL PROJECT
SPOKANE VALLEY, WASHINGTON

TITLE
PROJECT ORGANIZATION CHART

PROJECT NO.	PHASE	REV.	FIGURE
19119180	1000B	B	2-1

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3.0 PROJECT MEETINGS

This section discusses various progress and status meetings to be held throughout remedial construction activities. The intent of the meetings is to ensure satisfactory communication between all organizations involved in the remedial construction.

3.1 Pre-Construction CQA Meeting

A meeting will be held following the award of the construction contract, but prior to the start of construction, to clarify all CQA procedures and requirements for the Dross Removal Project. At a minimum, the meeting shall be attended by a representative of the OPC, the CM, the CQA Manager, the Design Engineer, the SAL, and the Construction Contractor. The topics of this meeting shall include but not be limited to:

- Reviewing the responsibilities of each organization.
- Reviewing lines of authority and communication for each organization.
- Providing each organization with all relevant CQA documents and supporting information.
- Familiarizing each organization with the CQA Plan and its role relative to the design criteria, Drawings, and Specifications.
- Determining any changes to the CQA Plan that may be needed.
- Discussing the established procedures or protocol for observations and tests, including sampling and analysis.
- Discussing the established procedures or protocol for handling construction deficiencies, repairs, and retesting, including "stop work" conditions.
- Reviewing methods for documenting and reporting inspection data.
- Reviewing methods for distributing and storing documents and reports.
- Reviewing Construction Contractor support requirements for CQA activities.
- Reviewing the proposed project schedule.

The meeting will be documented and minutes will be transmitted to the required distribution and meeting attendees.

3.2 Pre-Construction Health and Safety Meeting

Prior to the start of construction, a health and safety meeting will be held to orient all on-site personnel with the project health and safety requirements. This meeting will be led by the HSO and will cover potential hazards on the project, mitigating measures, training requirements, safety procedures, and other topics. A complete discussion of the health and safety meeting is included in the HASP for this project.

3.3 Weekly Progress Meetings

Weekly progress meetings will be held at the Site. At a minimum, weekly progress meetings will be attended by the CM, the SAL, the CQA Manager, the HSO, the Construction Contractor, and any major subcontractors performing significant activities on-site. The purpose of the meeting is to:

- Review the previous week's activities and accomplishments.

- Review pay requests, claims, change orders, delays, and similar items.
- Review any safety issues, training, and other related topics.
- Review planned activities for the upcoming week.
- Finalize resolution of problems from the previous week.
- Discuss any potential problems with the work planned for the upcoming week.

This meeting will be documented and minutes will be transmitted to the required distribution and meeting attendees.

3.4 Problem or Work Deficiency Meetings

Meetings will be convened as necessary to address inspection deficiencies and non-conformances. To the extent possible, deficiencies observed during construction will be brought to the attention of the Construction Contractor on a real-time, informal basis. If the requested corrective action is not completed to the CQA Manager's satisfaction, the deficiency shall be considered a nonconformance, documented on a nonconformance report (NCR) form, and submitted to the Design Engineer for resolution.

4.0 HOLD POINTS

Mandatory hold points will be established for certain key activities as described in the design documents and listed in Table 4-1. At these points, the Construction Contractor shall cease work on the affected activity until it has been reviewed and accepted by the CQA Manager. The schedule for hold points will be determined when the Construction Contractor develops his construction schedule for the project. The hold points listed in Table 4-1 are in addition to any submittal requirements prior to or during construction as described in the Specifications.

Table 4-1: Dross Removal Project - Hold Points

Hold Point No.	Description	Release Criteria
General	Prior to use or placement of any material	Required submittals have been received and demonstrate that the material conforms to the requirements of the Specifications
1	Prior to any ground disturbing activities on-site	Temporary Erosion and Sediment Control (TESC) measures installed and functional in accordance with TESC Plan
2	Prior to removing contaminated materials from the Site	Truck wheel wash has been installed and is functional
3	Prior to importing earth materials to the Site	Confirm that earth materials are free of contamination within allowable limits
4	Prior to backfilling any excavated areas	Sampling and analysis has been completed and confirms that remaining subgrade soils satisfy required cleanup limits

Hold Point No.	Description	Release Criteria
5	Prior to placing geotextile for the ecological cap	Survey measurements confirm that the placement surface is at the correct elevation and visual observations confirm that the placement surface is even and free of protrusions in accordance with the Specifications
6	Prior to placing materials above geomembrane liner	Vacuum box testing in accordance with ASTM D5641 confirms that all seams are water-tight and that any other construction damage has been successfully repaired
7	Prior to seeding disturbed areas	Survey data demonstrates that design grades have been achieved

5.0 INSPECTION ACTIVITIES

This section describes the inspection activities (observations and tests) that will be conducted by the CQA Personnel during the Dross Removal Project. The CQA Manager may increase or decrease the frequency of inspection and testing on the basis of experience as the project progresses.

The inspection activities described in this section do not include sampling and analysis of subgrade soils, which are described separately in the SAP.

5.1 General

5.1.1 Specifications

CQA personnel shall familiarize themselves with the requirements of the Specifications for this project prior to beginning CQA activities.

If discrepancies between this CQA Plan and the Specifications are identified, the Design Engineer shall be notified and shall determine which requirements shall apply. If the Design Engineer is not available, the requirements of the Specifications shall prevail.

5.1.2 Submittals

Submittals for all materials, as identified in the Specifications, shall be reviewed to verify that the specified requirements are satisfied.

5.2 Earth Materials

5.2.1 Earth Material Changes

Determining whether an earth material has changed significantly for purposes of additional testing as listed below shall be made in consultation with the Design Engineer, based on laboratory test results when available, and in general accordance with the procedures contained in ASTM D2488.

5.2.2 Earth Materials Contamination

Earth materials used for backfill, ecological cap, surface water management features, and other applications shall be free of contamination above acceptable limits, as listed in the SAP. The level of CQA inspection will differ depending on the source of the earth material, as described in the following subsections.

5.2.2.1 Materials from Off-Site Commercial Sources

Earth materials may be obtained from off-site commercial sources, such as gravel pits or quarries, whose regular business is to supply these types of products. For materials from such sources, CQA Personnel shall perform the following inspection activities:

- Obtain and review any analytical testing data from the facility operator on the products proposed for use on this project.
- Visually inspect the source and off-site stockpile area(s) of the proposed backfill material.
- If there is no analytical testing data for a particular product or specified parameter, and visual inspection of the material source area (e.g., gravel pit or quarry) indicates a potential for contamination, notify the SAL, who will collect samples and test the material for the parameters listed in the SAP. The SAL will review the test results to confirm that contaminants do not exceed the limits specified in the SAP.

5.2.2.2 Materials from Other Sources

For purposes of this subsection, other sources of earth materials include but are not limited to the following:

- Off-site borrow areas on private property.
- Off-site construction projects generating excess soil for disposal.
- On-site locations that have not been characterized.

The Golder PM will make the final determination of whether a material source is subject to the requirements of this subsection.

If the Construction Contractor proposed materials from other sources, the CQA Manager shall inform the Golder PM and SAL. The SAL shall then perform the following inspection activities:

- Obtain historical records for the source location to the extent practical and review to identify any industrial processes that could have resulted in contamination.
- Visit the source location to determine whether industrial processes occurred in the past, to screen potential soil material locations with a portable photoionization detector (PID) to determine if volatile organic compounds are present, and to collect samples for analytical testing.
- Collect samples and test the material for the parameters listed in Attachment A. Details of sampling procedures shall conform to the requirements of the SAP. Attachment A provides the list of constituent and analytical methods to be used for testing backfill. Sample at the following frequencies:
  - Backfill for subgrade below the dross stockpile footprint and in off-pile areas: 1 per 5,000 cubic yards (cy) or 1 per material type or source, whichever results in the greater number of tests.

  - Gravel for Ecological Cap: 1 per 1,000 cy or 1 per material type or source, whichever results in the greater number of tests.
  - All Other Earth Materials: 1 per 100 cy or 1 per material type or source, whichever results in the greater number of tests.
- Screen samples collected for analytical testing with the PID to develop correlations between volatile organic compound (VOC) concentrations in the earth materials and PID readings.
- Review the test results to confirm that contaminants do not exceed the limits specified in Attachment A.
- During construction, CQA Personnel shall visually observe earth materials at the placement location to confirm that they are similar to the materials previously tested. If determined necessary by the Golder PM, Sampling Field Personnel shall randomly screen incoming truckloads of material with the PID at an overall rate of not less than every 1 in 10 truckloads to verify that any readings are below the established correlations for acceptable levels of VOC concentrations.

5.2.3 Subgrade Backfill

CQA Personnel shall perform the following observations on subgrade backfill materials:

Table 5-1: CQA Observations - Subgrade Backfill

Property	Test Designation	Frequency
During Placement		
Material is consistent with tested sample	Visual observation	Continuous
No unsuitable materials are placed	Visual observation	Continuous
Compaction is applied	Visual observation	Continuous

5.2.4 Ecological Cap Gravel

CQA Personnel shall perform the following physical property tests and observations on gravel used for the ecological cap:

Table 5-2: CQA Tests and Observations – Ecological Cap Gravel

Property	Test Designation	Frequency
Prior to Placement		
Particle Size	ASTM D6913	1 per 500 cy or 1 per material type[(a)]

Property	Test Designation	Frequency
During Placement		
Material is consistent with tested sample	Visual observation	Continuous
No unsuitable materials are placed	Visual observation	Continuous
Minimum lift thickness is achieved	Visual observation and tape measure or scale	Continuous

Note:
(a) whichever results in the greater number of tests

5.2.5 Other Earth Materials

Other earth materials include but are not limited to the following:

- Ditch lining
- Armor rock

For other earth materials that are specified as Washington State Department of Transportation (WSDOT) standard materials and are obtained from commercial off-site sources, such as gravel pits or quarries, whose regular business is to supply these types of products, compliance with the project physical property specifications may be demonstrated by the supplier's standard QC test results. For on-site sources or commercial sources that do not have the required test data, CQA personnel shall obtain and test samples of the material as listed in Table 5-3.

Table 5-3: CQA Tests and Observations – Other Earth Materials

Property	Test Designation	Frequency
Prior to Placement		
Particle Size	ASTM D6913	1 per 100 cy or 3 per material type[(a) (b)]
During Placement		
Material is consistent with tested sample	Visual observation	Continuous
No unsuitable materials are placed	Visual observation	Continuous
Compaction is applied	Visual observation	Continuous

Notes:
(a) whichever results in the greater number of tests
(b) materials from commercial sources which can provide acceptable particle size data are exempt from this testing requirement.

5.3 Seeding

During seeding, CQA Personnel shall observe seeding operations to confirm that all materials have been placed and that all designated areas have received a uniform application of materials in accordance with the application rates listed in the Specifications.

5.4 Geosynthetics

5.4.1 General

CQA personnel shall perform the following activities related to placing geotextile and geomembrane materials:

- Confirm that the geosynthetic material is the specified type, has the minimum required unit weight, and conforms to all other specified requirements.
- Verify that the soil surface on which the geosynthetic material will be placed is firm, smooth, and free of protrusions that exceed specified limits.
- Confirm that geosynthetic material has been placed at the locations and to the limits shown on the Drawings.
- Confirm that geosynthetic material panels have the minimum required overlap.
- Prior to placing overlying materials, verify that the geosynthetic material has been correctly seamed (see following sections) and is free of damage, or that damaged areas have been acceptably repaired.
- During placement of overlying materials, observe that placement methods do not damage the geotextile.

5.4.2 Geotextile

Geotextiles may require seaming. In this case, CQA Personnel shall verify that the allowable seaming method and specified seaming materials are used.

5.4.3 Geomembrane

For geomembranes, CQA Personnel shall perform the following activities in addition to those listed above:

- Verify that seaming materials and equipment conform to the requirements of the Specifications.
- Confirm that personnel welding geomembranes have appropriate experience and qualifications.
- Observe seam testing.
- Verify that all seams have passing test results.
- Confirm that the geomembrane is smooth and free of wrinkles prior to placing overlying materials.

6.0 DOCUMENTATION

6.1 Notebooks and Daily Field Reports

6.1.1 Hard Copy Documentation

Daily Field Reports will be completed by each of the CQA Personnel when they are on-site. CQA Personnel will be assigned field books, which will be labeled with a unique number issued by the CQA Manager. CQA Personnel will record all field observations and the results of field tests either in their assigned field book or on standard field data sheets. After each book is filled (or at the end of the project), the field book will be returned to the CQA Manager and routed to the project files.

Each page of the field book shall be numbered, dated, and initialed by CQA Personnel. At the start of a new work shift, CQA Personnel shall list the following information at the top of the page:

- Job Name
- Job Number
- Date
- Name
- Weather conditions
- Page number (if pages are not pre-numbered)

The remaining individual entries shall be prefaced by an indication of the time at which they occurred. If the results of test data are being recorded on separate sheets, they shall be noted in the field book.

Entries in the field book shall include but not be limited to the following information:

- Reports on any meetings held and their results.
- Equipment and personnel being used in each location, including subcontractors.
- Descriptions of areas and operations being observed and documented.
- Description of materials delivered to the Site, including any quality verification (vendor certification) documentation.
- Description of stockpile material, dross containing soil or any other material being transported from the Site.
- Descriptions of materials incorporated into construction.
- Calibrations, or recalibrations, of test equipment, including actions taken as a result of recalibration.
- Decisions made regarding use of material and/or corrective actions to be taken in instances of substandard quality.
- Unique identifying sheet numbers of inspection data sheets and/or problem reporting and corrective measures reports used to substantiate the decisions described in the preceding item.

At the end of each day, CQA Personnel shall summarize the day's activities on a Daily Field Report form (see Attachment B). The field report shall include a brief summary of the day's activities and photographs of key activities and shall highlight any unresolved issues that must be addressed by the CM or CQA Manager the following day. In addition, the summary report shall reference the field book number and page numbers that cover that day's activities. The summary field reports shall be turned in to the CQA Manager at the end of each day.

The CQA Manager shall review and initial each daily field report before distribution. Distribution of the daily reports shall be as follows:

- Original shall be filed in Golder’s Redmond, Washington office.
- One copy transmitted to the OPC.
- One copy transmitted to the Golder PM.

- One copy transmitted to the Design Engineer.
- A summary of the daily reports will be provided to Ecology in the monthly progress reports.

6.1.2 Electronic Documentation

Electronic devices specifically designed for data collection, such as tablets, may be used, provided that they allow collection of all data listed above in a comparable format. Daily Field Reports may also be prepared and distributed electronically. Use of electronic devices and the associated software, reporting formats, and other aspects of electronic documentation shall be approved in advance by the CQA Manager, and all personnel using such devices shall receive formal training prior to field activities.

6.2 Requests for Information

If during the course of construction questions arise from the Construction Contractor regarding interpretation of the Drawings and/or Specifications, a Request for Information (RFI) form (Attachment B) will be completed. The Construction Contractor shall inform the CM of the requested information, and the CM shall prepare and route the RFI to the Design Engineer. The Design Engineer will obtain input from the CQA Manager on any questions that involve project quality. The clarification shall be documented on the RFI form, and routed to the Construction Contractor, the OPC, the Golder PM, the CQA Manager, and the project files for record.

6.3 Design Changes

Changes to the Drawings or Specifications may be necessary to accommodate unforeseen field conditions, alternative materials or methods that could improve the project schedule or lower costs, or for other reasons. Requests for such changes shall be submitted in writing to the CM, who shall refer them to the OPC, the Golder PM, and the Design Engineer for disposition. Technically significant design changes, i.e., those that may affect the potential effectiveness of a particular design feature, may also require review and approval by Ecology; the OPC and Golder PM will determine whether Ecology review is required.

The CQA Manager shall be involved in the design change process to ensure that appropriate quality requirements are included. Design changes shall be documented on Engineering Change Notice (ECN) Forms (Attachment B), and routed to the OPC, Golder PM, Design Engineer, Construction Contractor, CQA Manager, and other affected parties. A copy of the ECN shall also be placed in the project files for record.

6.4 Nonconformance Reporting

A nonconformance is considered to be a deficiency in characteristics, documentation, or procedures that renders the quality of an item or activity unacceptable or indeterminate. All potentially nonconforming situations shall be brought to the attention of the Design Engineer for concurrence prior to initiation of the NCR. If a deficiency cannot be repaired or replaced to the satisfaction of the CQA Manager within the guidelines established by this CQA Plan, then such a deficiency shall be considered a nonconformance and shall be documented on an NCR form (Attachment B) and referred to the Golder PM, the OPC, and the Design Engineer for disposition and initiation of corrective action processes. The CQA Manager will determine whether a given condition constitutes a deficiency and whether a nonconformance report should be initiated.

All documentation relating to NCR situations shall be retained in the project quality records.

6.5 Final Documentation

At the completion of remedial construction, a final construction summary and report shall be prepared by the CQA Manager. The summary report shall include documentation of each construction component monitored by CQA Personnel and the results of all testing. At a minimum, it shall include the following components:

- A signed and stamped statement by the Design Engineer that the project has been constructed in substantial conformance with the approved construction documents.
- A narrative text listing the contractors and subcontractors performing the construction, a description of the major work activities, and a chronology of the work.
- A summary of CQA activities and results, including numbers and types of tests, and a discussion of any data anomalies.
- Attachments providing all supporting information, including but not limited to:
  - As-built drawings
  - Submittal data and acceptance forms
  - Laboratory test data
  - Field test data
  - Daily field reports
  - All RFIs, ECNs, and NCRs
  - Pertinent photographic or video records in addition to those contained in the daily field reports
  - All other pertinent documentation

6.6 Records Management

At a minimum, all construction, design, permitting, correspondence, and other documents associated with the project shall be stored in Golder's Redmond, Washington office. Electronic files shall be stored in an organized manner on Golder's secure server system and periodically backed up in accordance with standard data management procedures.

7.0 REFERENCES

American Society for Testing and Materials (ASTM):

D2488 - Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)

D5641 - Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber

D6913 - Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

ATTACHMENT A

Backfill Source Analytical Criteria

Attachment A
Table 1: Imported Backfill Soil/Gravel Screening Levels
Aluminum Recycling Trentwood - CQA Plan
Union Pacific Railroad

Constituent Group	Analytical Method	Analytical Results Evaluation
Total Petroleum Hydrocarbons		
Gasoline range petroleum hydrocarbons	NWTPH- G	MTCA Method A
Diesel range petroleum hydrocarbons	NWTPH-Dx	MTCA Method A
Oil range petroleum hydrocarbons	NWTPH-Dx	MTCA Method A
Metals		
Site Constituents of Concern (Al, As, Ba, Cr, Cu, Hg)	EPA 6010 C and 7471A	Project Cleanup Levels
Remaining RCRA 8 metals (Cd, Pb, Se, Ag)	EPA 6010 C	MTCA Method A and B
Semi-Volatile Organic Compounds (SVOCs)		
SVOCs	8270C	MTCA Method A and B
cPAHs*	8270C	MTCA Method A and B

Notes:
MTCA Method B values will be used for evaluating backfill if Method A values are not applicable
Carcinogenic polyaromatic hydrocarbons (cPAHs) results will be evaluated based on toxicity equivalency factor methodology

ATTACHMENT B

Construction Quality Assurance Forms

Daily Field Report Form
Request for Information Form
Engineering Change Notice Form
Nonconformance Report

DAILY FIELD REPORT # XX

DATE: ON-SITE: XXXX PDT OFF-SITE: XXXX	
PROJECT: ALUMINUM RECYCLING TRENTWOOD – DROSS REMOVAL PROJECT	
LOCATION: SPOKANE VALLEY, WA	JOB NO.: 191-19180-XX.XXX
CLIENT: UNION PACIFIC RAILROAD	CONTRACTOR: [TBD]

HIGH TEMPERATURE:	WIND:
CLOUD COVER:	PRECIPITATION:

PERSONNEL ON SITE/COMPANY	RESPONSIBILITY
[TBD]	CONSTRUCTION MANAGER
[TBD]	CONTRACTOR SUPERINTENDENT
[TBD]	CQA

1.0 EQUIPMENT ON SITE:

- [List major equipment]

2.0 ACTIVITIES:

- Safety
  - [List safety meetings, topics discussed, potential hazards related to planned work activities for the shift]
- Work Activities [List work activities performed on site during shift]

3.0 PROBLEMS AND RESOLUTIONS:

- [Discuss any technical or administrative problems encountered during the shift and the resolutions, including action items and responsibilities]

4.0 SUMMARY OF H&S ISSUES

- [Discuss any health and safety issues that occurred on-site including corrective actions]

5.0 PHOTO LOG

- [Attach photos showing key activities and any problems]

[PHOTOS WITH CAPTIONS]

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REQUEST FOR INFORMATION (RFI)	RFI No. RFI-00x	Page No. Page 1 of x

Contract No. Golder Project No. 191-19180-xx Contractor Project No. xxx	Contract Title Aluminum Recycling Trentwood Site Dross Removal Project	Prime Contractor xxx

Contractor Request for Information

Requested By: xxx	Date Requested: xxx	Potential Cost Impact: Yes ☐ Potential Schedule Impact: Yes ☐
RFI Subject:		
Feature of Work:		
Specification Sections:		
Drawings:		

Information Requested:

Golder Construction Manager Response

Answered By: xxx Title: xxx	Date RFI Received: xxx	Date RFI Answered: xxx

Response to Contractor:

Distribution:

☑ xxx	OPM	☑ xxx	Golder SAL
☑ T. Norton	Golder PM	☑ xxx	Contractor
☑ V. Nancarrow	Golder Design Engineer	☐ xxx	xxx
☑ xxx	Golder CQA Manager	☑ Golder Project Files	

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ENGINEERING CHANGE NOTICE

Date: xxx	**ECN No.:** **00x**
Project: Aluminum Recycling Trentwood Site – Dross Removal Project	**Project No.:** 191-19180-xx.xxx
Engineering Change Notice Name: xxx	**Contract No.:** xxx
Project Feature:	
Affected Documents:	
Description of Change:	
Justification for Change:	

☐ Significant Design Change – Regulatory approval of this ECN is required prior to construction

☑ Insignificant Design Change – No regulatory approval is required

Prepared by:

Approvals:

Golder Associates Design Engineer: ..... Date: .....

Golder Associates Project Manager: ..... Date: .....

Golder Associates Construction Manager: ..... Date: .....

Owner Project Manager: ..... Date: .....

Regulatory Project Manager: ..... NA ..... Date: .....

Distribution:

☑ xxx	OPM	☑ xxx	Golder SAL
☑ T. Norton	Golder PM	☑ xxx	Golder CM
☑ V. Nancarrow	Golder Design Engineer	☑ xxx	Contractor
☑ xxx	Golder CQA Manager	☐ xxx	xxx
☐ xxx	Ecology Project Manager	☑ Golder Project Files	

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NONCONFORMANCE REPORT

Aluminum Recycling Trentwood Site – Dross Removal Project	**NCR No. 00x**
Golder Project No.: 191-19180-xx.xxx	☐ **Stop Work**
Initiated by: xxx	Date Initiated: xxx
Nonconforming Condition:	
Golder Quality Assurance Manager:	Date: .....
Proposed Corrective Action:	
Final Implementation:	

Approved by:

Golder Associates Quality Assurance Manager:	Date: .....
Owner Project Manager:	Date: .....
Golder Associates Project Manager:	Date: .....
Golder Associates Design Engineer:	Date: .....
Golder Associates Construction Manager:	Date: .....
Contractor Site Supervisor:	Date: .....

Distribution:

☑ xxx	OPM	☑ xxx	Golder SAL
☑ T. Norton	Golder PM	☑ xxx	Contractor
☑ V. Nancarrow	Golder Design Engineer	☐ xxx	xxx
☑ xxx	Golder CQA Manager	☐ xxx	xxx
☑ xxx	Golder CM	☑ Golder Project Files	

APPENDIX C

Design Calculations

Objective

Determine peak flows and runoff volumes to the project area to size the berm, overflow channel, and railroad ditch. Hydrologic parameters were developed for input into Autodesk Storm and Sanitary Analysis (SSA) to determine peak flows and runoff volumes. Bentley FlowMaster was then used to determine minimum sizing for the railroad ditch.

Hydrologic parameters to be developed for input into the SSA model include:
Design Storm and Precipitation
Drainage Basin Areas
Curve Number
Time of Concentration

Design Storm and Precipitation

Per the WSDOT Highway Runoff Manual (WSDOT 2019), the short-duration storm normally generates the greatest peak discharges from small impervious basins and should therefore be used to size stormwater conveyances. Design of conveyances based on the short-duration storm requires conversion of the 2-year, 2-hour precipitation to a 3-hour precipitation depth for a different recurrence interval (DOE 2019). The following equation (DOE 2019, Equation 4.2) was used to determine the 3-hour precipitation depth for the selected return period (100-year):

$P_{sds} = 1.06^{x} C_{sds}^{x} P_{2yr24hr}$

Where:

P_{sds} = 3-hour precipitation (inches) for a selected return period for the short-duration storm
1.06 = multiplier used for all climate regions to convert x-year, 2-hour precipitation to x-year, 3-hour precipitation
C_{sds} = coefficient (from Table 4.7) for converting 2-year, 2-hour precipitation to x-year, 2-hour precipitation depth
P_{2yr2hr} = 2-year, 2-hour precipitation (inches) from Figure 4.6: 2-Year, 2-Hour Isopluvial Map

C_{sds} =	2.48	Coefficient for 100-year, Climate Region 3
P_{2yr2hr} =	0.48	
P_{sds} =	1.26	100-year, 3-hour precipitation depth

Cumulative Rainfall Values

Short-duration storm hyetograph values (DOE 2019, Table 4.33) were converted for the 100-year recurrence interval by multipling the cumulative rainfall depth by P_{sds}.

Time (mins)	Time (hours)	Incremental Rainfall	Cumulative Rainfall	Cumulative Rainfall, 100-yr
0	0.00	0.0000	0.0000	0.0000
5	0.08	0.0047	0.0047	0.0059
10	0.05	0.0047	0.0094	0.0119
15	0.25	0.0057	0.0151	0.0191

20	0.33	0.0104	0.0255	0.0322
25	0.42	0.0123	0.0378	0.0477
30	0.50	0.0236	0.0614	0.0775
35	0.58	0.0292	0.0906	0.1143
40	0.67	0.0528	0.1434	0.1809
45	0.75	0.0736	0.2170	0.2738
50	0.83	0.1736	0.3906	0.4929
55	0.92	0.2377	0.6283	0.7928
60	1.00	0.1255	0.7538	0.9512
65	1.08	0.0604	0.8142	1.0274
70	1.17	0.0406	0.8548	1.0786
75	1.25	0.0151	0.8699	1.0977
80	1.33	0.0132	0.8831	1.1143
85	1.42	0.0113	0.8944	1.1286
90	1.50	0.0104	0.9048	1.1417
95	1.58	0.0085	0.9133	1.1524
100	1.67	0.0075	0.9208	1.1619
105	1.75	0.0057	0.9265	1.1691
110	1.83	0.0057	0.9322	1.1763
115	1.92	0.0057	0.9379	1.1835
120	2.00	0.0057	0.9436	1.1907
125	2.08	0.0047	0.9483	1.1966
130	2.17	0.0047	0.9530	1.2025
135	2.25	0.0047	0.9577	1.2084
140	2.33	0.0047	0.9624	1.2144
145	2.42	0.0047	0.9671	1.2203
150	2.50	0.0047	0.9718	1.2262
155	2.58	0.0047	0.9765	1.2322
160	2.67	0.0047	0.9812	1.2381
165	2.75	0.0047	0.9859	1.2440
170	2.83	0.0047	0.9906	1.2500
175	2.92	0.0047	0.9953	1.2559
180	3.00	0.0047	1.0000	1.2618

Drainage Basin Areas

Drainage basins were delineated in AutoCAD Civil 3D - see attached Drainage Areas Map.

	Area (acres)
Within Berm	1.67
Railroad Ditch	0.82

Curve Number

The drainage basin hydrologic soil group and cover type was identified to determine the curve number (CN)

from the TR-55 Manual (NRCS 1986). According to the USDA Web Soil Survey (USDA 2021), soils in the area are gravelly ashy loam, categorized as Hydrologic Soil Group B. The cover type was selected from Table 2-2a (NRCS 1986) for urban areas: Impervious areas - streets and roads - gravel.

CN Value
85

Time of Concentration
The time of concentration (Tc) was determined for each drainage basin.
The Tc calculations are presented in the attached sheets.

	Tc (min)
Overflow Channel	5
Railroad Ditch	5

References

Washington State Department of Ecology (DOE), 2019, Stormwater Management Manual for Eastern Washington (SWMMEW).

Washington State Department of Transportation (WSDOT), 2019, Highway Runoff Manual, M 31-16.05.

National Oceanic and Atmospheric Admin (NOAA), 1973, Atlas 2 Precipitation Frequency Estimates Available online at https://www.nws.noaa.gov/ohd/hdsc/noaaatlas2.htm, Accessed May 18, 2021.

Natural Resources Conservation Service (NRCS), 1986, Urban Hydrology for Small Watersheds, Technical Release 55 (TR-55).

United States Department of Agriculture (USDA), Web Soil Survey, Available online at https://websoilsurvey.nrcs.usda.gov/, Accessed May 18, 2021.

Time of Concentration (Tc) - Overflow Channel Drainage Basin

The sum of the travel times for sheet flow, shallow concentrated flow, and channel flow.
Equations and values taken from SWMMEW (DOE 2019), unless stated otherwise.

Sheet Flow

T_{sheet} (minutes) =[$0.42(n_s L)^{0.8}$]/[$(P_2)^{0.527} * s^{0.4}$]

Where:

n_s =	Manning's roughness coefficient for sheet flow
L =	flow length (ft) up to 100 feet maximum
P_2 =	2-year, 24-hour rainfall (in)
S =	slope of flow path (ft/ft)

Site Data:

n_s =	0.011	Smooth surfaces (gravel), Table 4.11
L =	100	feet
P_2 =	1.42	From NOAA Atlas 2 (NOAA 1973)
s =	0.01	sheet flow slope, ft/ft
T_{sheet} =	2.48	minutes

Shallow Concentrated Flow:

$T_{shallow}$ = Length of flow/V

$V = k_s(s)^{0.5}$

Where:

V =	Velocity (ft/s)
k_s =	time of concentration velocity factor (ft/s)

k_s =	27	Paved and gravel areas
s =	0.01	ft/ft
V =	3.00	ft/s
L =	292	ft
$T_{shallow,1}$ =	1.62	minutes

Open Channel Flow

Same Equation as Shallow Concentrated Flow but with different k value.

Site Data:

k_c =	15	Rock-lined waterway, intermittent channel flow (R = 0.2)
s =	0.00	ft/ft
V =	0.00	ft/s
L =	0	ft
$T_{channel}$ =	0.00	minutes

Time of Concentration for Basin:

T_{sheet} =	2.48	minutes
$T_{shallow}$ =	1.62	minutes
$T_{channel}$ =	0.00	minutes
TOTAL Tc	**5**	**minutes (minimum value is 5 minutes)**

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Time of Concentration Calculations
UPRR / Trentwood EDR
Project #: 19119180
Prepared by: VMN 6/3/2021
Reviewed by: SJS 6/4/2021

Time of Concentration (Tc) - Railroad Ditch Drainage Basin
The sum of the travel times for sheet flow, shallow concentrated flow, and channel flow.
Equations and values taken from SWMMEW (DOE 2019), unless stated otherwise.

Sheet Flow

T_{sheet} (minutes) =[$0.42(n_s L)^{0.8}$]/[$(P_2)^{0.527} * s^{0.4}$]

Where:

n_s =	Manning's roughness coefficient for sheet flow
L =	flow length (ft) up to 100 feet maximum
P_2 =	2-year, 24-hour rainfall (in)
S =	slope of flow path (ft/ft)

Site Data:

n_s =	0.011	Smooth surfaces (gravel), Table 4.11
L =	100	feet
P_2 =	1.42	From NOAA Atlas 2 (NOAA 1973)
s =	0.07	sheet flow slope, ft/ft
T_{sheet} =	1.08	minutes

Shallow Concentrated Flow:

$T_{shallow}$ = Length of flow/V

$V = k_s(s)^{0.5}$

Where:

V =	Velocity (ft/s)
k_s =	time of concentration velocity factor (ft/s)

Segment 1 Site Data:

k_s =	27	Paved and gravel areas
s =	0.01	ft/ft
V =	2.11	ft/s
L =	131	ft
$T_{shallow,1}$ =	1.03	minutes

Segment 2 Site Data:

k_s =	27	Paved and gravel areas
s =	0.02	ft/ft
V =	3.77	ft/s
L =	411	ft
$T_{shallow,2}$ =	1.82	minutes

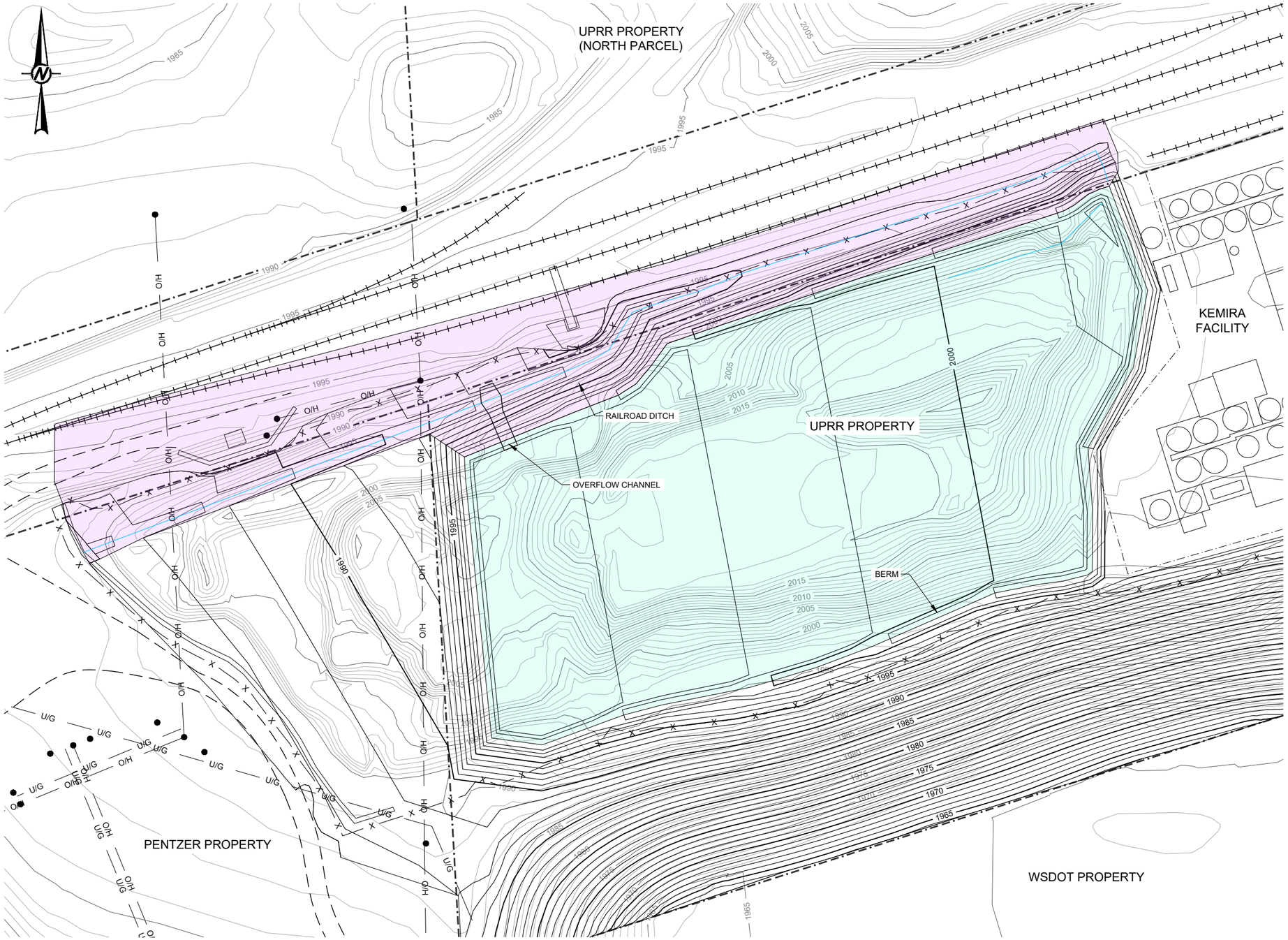
Open Channel Flow

Same Equation as Shallow Concentrated Flow but with different k value.
No open channel flow in this situation.

k_c =	15	Rock-lined waterway, intermittent channel flow (R = 0.2)
s =	0.00	ft/ft
V =	0.00	ft/s
L =	0	ft
$T_{channel}$ =	0.00	minutes

Time of Concentration for Basin:

T_{sheet} =	1.08	minutes
$T_{shallow,1}$ =	1.03	minutes
$T_{shallow,2}$ =	1.82	minutes
$T_{channel}$ =	0.00	minutes
TOTAL Tc	**5**	**minutes (minimum value is 5 minutes)**



LEGEND

- PROPERTY BOUNDARY
- ACCESS ROAD
- RAILROAD TRACK
- POWER POLE
- O/H — OVERHEAD POWER LINE
- U/G — UNDERGROUND POWER LINE
- APPROXIMATE EDGE OF PAVEMENT
- X — SECURITY FENCE
- EXISTING MAJOR CONTOUR (10-FT INTERVAL)
- EXISTING MINOR CONTOUR (2-FT INTERVAL)
- PROPOSED MAJOR CONTOUR (5-FT INTERVAL)
- PROPOSED MINOR CONTOUR (1-FT INTERVAL)
- RAILROAD DITCH DRAINAGE AREA
- BERM DRAINAGE AREA
- TIME OF CONCENTRATION FLOW PATH

REFERENCE(S)

1. BASE MAP PROVIDED BY MID-MOUNTAIN SURVEYORS, INC., DATED 3/8/2021.
2. PROPERTY BOUNDARIES PROVIDED BY MID-MOUNTAIN SURVEYORS, INC., DATED 3/18/2021.
3. EXISTING TOPOGRAPHY FROM CITY OF SPOKANE GIS DATABASE, DEVELOPED FROM 2007 LIDAR.
4. HORIZONTAL DATUM: NAD83 WASHINGTON STATE PLANE (2011), NORTH ZONE, US FOOT.
5. VERTICAL DATUM: NAVD88.

0 30 60
1" = 30' FEET

CLIENT
UNION PACIFIC RAILROAD CO.

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-05-17
DESIGNED	VMN
PREPARED	REDMOND
REVIEWED	SJS
APPROVED	TJN

PROJECT
ALUMINUM RECYCLING TRENTWOOD SITE
REMEDIAL ACTION - DROSS REMOVAL PROJECT
SPOKANE VALLEY, WASHINGTON

TITLE
DRAINAGE AREAS MAP

PROJECT NO.	PHASE	REV.	FIGURE
19119180	1000B	B	C-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

1 in 0

SSA Model

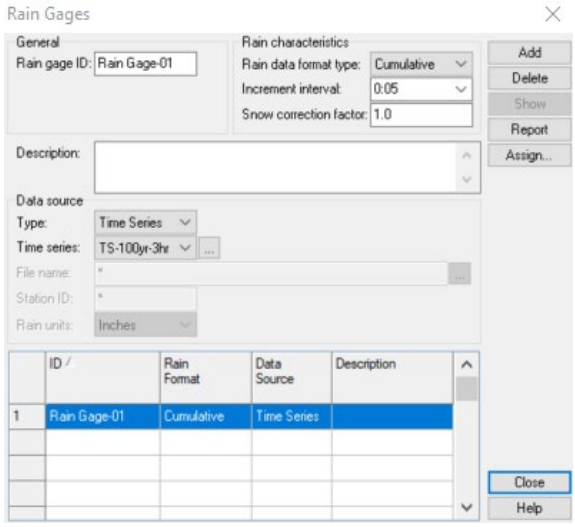
Autodesk Storm and Sanitary Analysis (SSA) was run with the 100-year, 3-hour (short duration) storm event to determine peak flows and runoff volumes to size the berm and railroad ditch. The berm on UPRR property was sized to retain the 100-year, 3-hour (short duration) storm event runoff volume and the railroad ditch was sized to convey the 100-year, 3-hour (short duration) storm event.

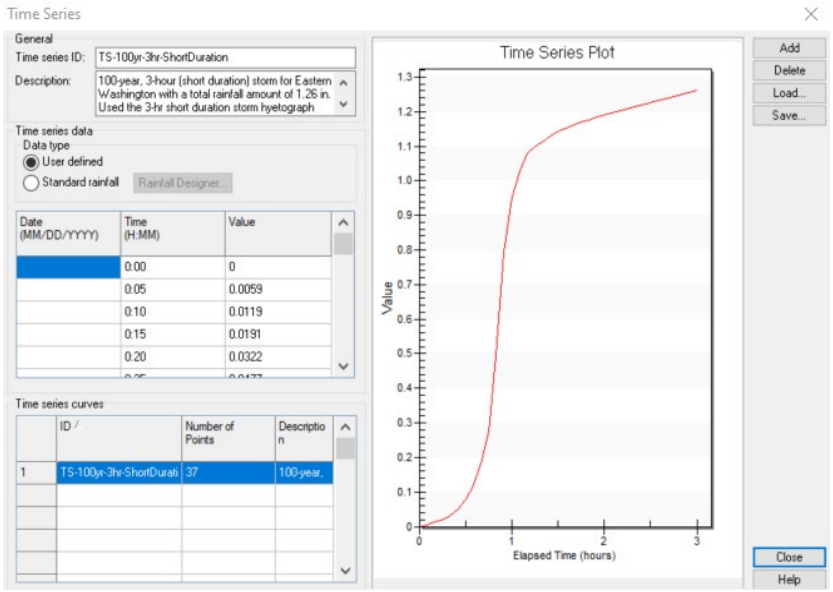
Model Input

Subbasin Summary

	Subbasin ID	Area	Peak Rate Factor	Wt. CN	TOC	Rain Gage ID
1	Sub-01_Overflow	1.670	484	85.00	5.00	Rain Gage-01
2	Sub-02_Railroad	0.820	484	85.00	5.00	Rain Gage-01

Precipitation





Model Results

Peak Flow Summary Table

Element ID	Sub-01_OverflowChannel	Sub-02_RailroadDitch
Maximum Runoff (cfs)	1.37	0.67
Minimum Runoff (cfs)	0.00	0.00
Event Mean Runoff (cfs)	0.01	0.01
Duration of Exceedances (hrs)	N/A	N/A
Duration of Deficits (hrs)	N/A	N/A
Number of Exceedances	N/A	N/A
Number of Deficits	N/A	N/A
Volume of Exceedance (ft³)	N/A	N/A
Volume of Deficit (ft³)	N/A	N/A
Total Runoff (ft³)	1849.38	905.01
Detention Storage (ft³)	N/A	N/A

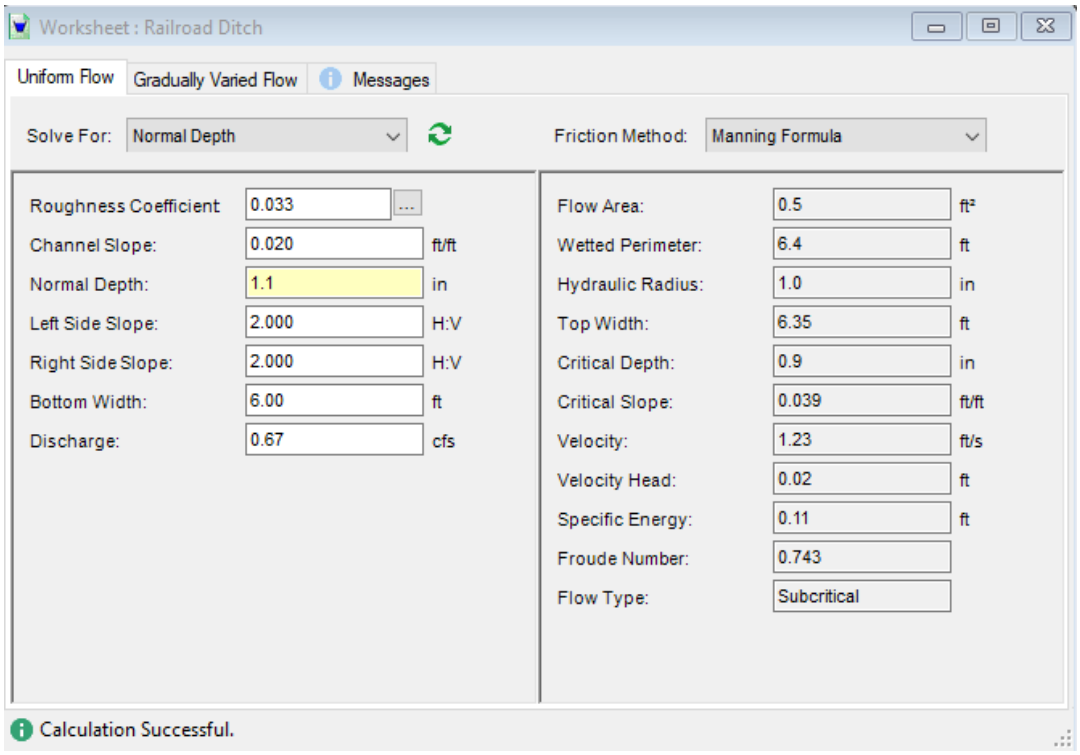
FlowMaster Model

Bentley FlowMaster was used to size the railroad ditch to convey the 100-year, 3-hour (short duration) storm event peak flow that was output from SSA.

Railroad Ditch

- Conveys flow running between the railroad and former Dross Stockpile area.

- With approximate dimensions of 1' deep, 6' bottom width, and 2H:1V side slopes, and a calculated normal depth of 1.1 inch, this ditch will have plenty of capacity to convey the peak flow from the short duration storm. These dimensions were selected to mimic the existing railroad ditch configuration.



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Rock Lining Calculations
UPRR / Trentwood EDR
Project #: 19119180
Prepared by: VMN 5/13/2022
Reviewed by: SJS 5/16/2022

Railroad Ditch

Reference: Robinson, Rice, Kadavy. 1998. *Design of Rock Chutes*. ASAE.

Input Data

discharge, cfs	0.67
base width, ft	6
slope, ft/ft	0.020
side slope, xH:1V	2
n (initial estimate, iterate to match calc'd below)	0.023
np, porosity	0.4
g, gravity, ft/s²	32.2
K'	4
SF, rock size safety factor	1.5

Calculate Surface Flow Regime (conservatively assume no subsurface flow)

normal depth (based on Manning's Eq.), ft	0.07
area (based on normal depth), sf	0.4
top width (based on normal depth), ft	6.28
average width, ft	6.14
velocity (Q=V/A), fps	1.5
critical depth (watertools.xla), ft	0.07
froude no. (watertools.xla)	1.0
flow regime	supercritical
unit discharge (discharge/average width), cfs/ft	0.11

Estimate Rock Size

$q = 9.76E-7\ D_{50}^{1.89}\ S_o^{-1.50}$ $\quad S_o < 0.10$

$q = 8.07E-6\ D_{50}^{1.89}\ S_o^{-0.58}$ $\quad 0.10 \le S_o \le 0.40$

D_{50} (s<0.1), mm	6
D_{50} (s>0.1), mm	13

D_{50} x SF, mm	9
D_{50} x SF, in	0.35

Calculate Manning's Roughness Coefficient

$n = 0.0292\ (D_{50}\ S_o)^{0.147}$

n, based on equation	0.023

Calculate Percent Subsurface Flow

Check initial condition. For long-term condition assume sediment will fill void space of rock.

$$V_m = n_p \left(\frac{S_o g D}{K'}\right)^{1/2}$$

Vm, velocity within rock, fps	0.03
Riprap thickness factor	1.50
Riprap thickness, factor*D_{50}, in	0.5
qm, unit flow in mantle, m3/s/m	0.00
Percent subsurface flow	1%

Rock Gradation

D_{100}, (D_{100} = 1.5* D_{50}), in	1
D_{85}, (D_{85} = 1.2* D_{50}), in	0
D_{50}, see above, in	0
D_{15}, (D_{15} = 0.6 * D_{50}), in	0
Liner thickness (2*D_{50}), in	1

Minimum Channel Depth

d, (normal depth), ft	0.07
Freeboard, ft	1.00
Lined channel depth, ft	1.07