CITY OF HEALDSBURG
Municipal Utility Department

401 Grove Street
Healdsburg, CA 95448-4723
Phone (707) 431-3346
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Visit us at ***www.ci.healdsburg.ca.us***

December 21, 2016

To: (See attached list)

Re: **Request for Proposals (RFP) for Magnolia Force Main Relocation Design Services**

Objective

The City of Healdsburg (City) is seeking proposals from qualified firms to provide civil/geotechnical engineering services to prepare plans and specifications for the relocation of the two force mains that cross Dry Creek from the Magnolia Pump Station. The plans and specifications will be used to bid and construct the relocation of the force mains.

Instructions

The proposer must demonstrate through this RFP knowledge and experience in:

- the development of plans and specifications for trenchless pipeline construction using horizontal directional drilling (HDD) methods
- connection and interconnection of new pipes and fittings to existing pipes and fittings
- construction cost estimating
- design and construction project management
- construction inspection, including specialty construction inspection

Where proposer does not have all capabilities in house, teaming to obtain the appropriate expertise is encouraged.

All proposers who intend to respond to this RFP must register as a prospective proposer by completing and returning by fax or email, the **proposal registration form** provided in the RFP document. The proposal registration form should be submitted back to the City no later than January 13, 2017.

Proposer selection will be based upon weighted criteria as cited in the RFP document. Standard selection criteria include, but are not limited to: project understanding, experience, work approach; project team and firm qualifications, level of effort, and location of firm. The City reserves the right to reject any and all proposals, to waive formalities or to accept any proposal which appears to serve the best interest of the City of Healdsburg.

Proposers will be asked to sign and return to the City the Statement of Compliance page of this RFP-Attachment A. The compliance page is a statement that says the Proposer has read the terms and conditions of the PSA *and agrees to comply with the language. It is strongly suggested that the Proposer provide the insurance requirements to your insurance carrier in order to make sure you can comply with the City requirements. Any costs to obtain this insurance should be included in the cost proposal. The City will not agree to pay for any insurance costs that are not included in the cost proposal submitted by the Proposer.*

Proposals should be submitted by February 15, 2017, at 2:00 PM. The proposal shall delivered in PDF format via e-mail to: pfuss@ci.healdsburg.ca.us, Attention: Patrick Fuss, P.E. Subject: **City of Healdsburg – Magnolia Force Main Relocation Design PROPOSAL.**

In a separate e-mail, submit the fee proposal, Subject : **City of Healdsburg –Magnolia Force Main Relocation Design FEE.** The City will not accept proposals submitted after the specified deadline. The City is not responsible for and will not accept mis-delivered proposals.

Schedule of RFP process for City Council approval:

City Issue RFP	December 21, 2016
Proposal Registration Form is due	January 13, 2017
Pre-proposal site visit – Starting at 550 Westside Road, Healdsburg, CA	January 18, 2017 10:00 AM
Last date to submit request for information	February 8, 2017
Proposal submittal deadline	February 15, 2017, 2:00 PM
Staff review proposals and negotiate scope and fee with the most qualified proposer*	February 16 to February 21, 2017
Staff Recommend Design Consultant	February 21, 2017
Council Awards Design Contract	March 6, 2017
Insurance submittal & execution of PSA	March 24, 2017
Notice to Proceed	March 27, 2017

General Background Information

The City owns and operates the sewer collection system consisting of approximately 42 miles of sewer pipeline and 10 lift stations in the City. The largest lift station is the Magnolia lift station, which conveys all of the flow from the City to the Water Reclamation Facility.

Sewage is discharged from the Magnolia Pump Station via two 14-inch force mains. The two 14-inch force mains were constructed via open trench construction below the stream bed of Dry Creek. **See Attachment A1**. One or both of the force mains has become exposed on the bottom of the stream. **See Attachment A2**.

Having the pipelines exposed makes them vulnerable to damage. The City would like to relocate the pipelines below the scour zone of the stream bed. The City has conducted a scour analysis of Dry Creek in the vicinity of the Magnolia Force Mains. **See Attachment A3**. The scour analysis indicates that the depth of scour due to the 100-year stream flow in Dry Creek with low levels in the Russian River is approximately 27 feet below the streambed.

At the time of the construction of original force mains in the 1970s, Dry Creek ran dry during the summer. However, in the 1980s after the construction of Warm Springs Dam, Dry Creek has flow year round. The City believes that open-cut construction is not feasible. An aerial crossing on a suspension bridge was planned and a design developed for the bridge. However, an underground crossing was not explored fully until recently. The City commissioned a feasibility investigation to determine if the force mains could cross Dry Creek using microtunneling or horizontal directional drilling methods. **See Attachment A4**.

The feasibility investigation determined that both were feasible and that horizontal directional drilling would have costs similar to the aerial crossing. The underground crossing approach has significant advantages of lower

maintenance requirements and risk of disruption from high creek level or vandalism when compared to the aerial crossing.

While both existing pipelines are 14 inches in diameter, the new pipelines crossing Dry Creek will be one 14-inch and one 21 –inch pipeline to better accommodate the potential for future growth. The existing piping outside of the creek crossing will remain 14-inch nominally.

The City wishes to engage a qualified engineering firm to design

- the crossing using horizontal directional methods
- the connection of the new piping to the existing piping
- an interconnection between the two force mains

The City also seeks assistance in the construction management and inspection of the project. These are to be offered as optional services in that the City may conduct these activities with its own forces.

Scope of Services

The Proposer should prepare a scope of services similar to the following.

- Preliminary Design
    - Conduct site survey and mapping necessary for preparation of contract drawings.
    - Identify a final horizontal and vertical alignment for the pipelines.
    - Coordinate with the California Department of Fish and Wildlife, and the Sonoma County Water Agency for access to the riparian zones of Dry Creek for geotechnical work and to obtain outside agency approval for the crossing as designed.
    - Assume the City will address CEQA documentation under a categorically exemption for CEQA compliance.
    - Conduct subsurface investigation along the pipeline alignment and penetrating approximately 10 feet below the drill path and conductor casing.
    - Pothole and locate existing utilities and underground facilities in the project area.
    - Prepare plans and details to approximately 30 percent level.
    - Provide outline /overview of contract specifications in CSI 1 through 16 division format.
    - Prepare construction cost estimate.
- Detailed Design
    - Provide design submittals at 60 percent, 90percent and 100 percent level. The 90 percent submittal will include an internal constructability review technical memorandum by the consultant's construction management staff.
    - Each detailed design submittal will include plans, specifications and updated construction cost estimates for City review.
    - Interim deliverables will consist of one PDF file for drawings, one PDF file for specifications, one PDF file for construction cost estimate, and four paper copies of each on bond paper. Hard copies of the plans shall be 11 x 17 single sided; specification shall be bound book format double sided.
    - Final plans and specifications bearing the seal and signature civil engineer in responsible charge of the work registered in California Plans and specifications shall be delivered in PDF format.
- Bid Period Services
    - Attend the prebid meeting conducted by the City.
    - Respond to technical questions forwarded to the design team and maintain a log of questions and responses and submit log to City for files.

  - Prepare addenda as required.
  - Assist City in review of bidders qualifications and responsiveness to the bidding requirements.
- Construction Period Services
  - Conduct site visits (4) during construction at appropriate stages.
  - Provide submittal list, review shop drawings and provide written responses to submittals reviewed.
  - Review change order requests and provide written recommendations to the City.
  - Review and respond to contractor's request for information and clarifications during construction and provide written recommendations to the City.
  - Participate in the final inspection and assist with punch list of deficiencies.
  - Preparation and submittal of digital record drawings to the City.
- Project Management and Coordination
  - Provide project coordination, monitoring and administration.
  - Conduct project kickoff meeting, progress meetings to receive City comments to the preliminary design and detailed design progress submittals. Prepare agendas and minutes for each meeting.
  - Maintain decision log and action item log.
  - Monitor task budgets and project schedule.
  - Perform quality assurance/quality control (QA/QC) activities.
  - Prepare monthly progress and cost summaries report, and invoices. Monthly reports will include by task: progress complete, work remaining, issues noted that require resolution.
- Construction Management (Optional Task)
  - Provide Construction Manager (CM) that will be responsible for the day to day tasks for managing the construction.
  - Office space / desk space can be provided by the City at the City's corporation yard, approximately 1 mile from the project site.
  - CM services will include:
    - Conduct preconstruction and construction progress meetings with City project manager, design engineer, and contractor.
    - Document all relevant project communications and promptly distribute to the City and applicable parties.
    - Prepare and submit to the City monthly progress reports with the Contractor's application for payment.
    - Monitor contractor's conformance to contract schedule and quality requirements.
    - Identify key progress problems, action items and issues along with recommendation for solutions.
    - Submit final payment requests from the Contractor following filing of Notice of Completion by the City's project manager.
- Inspect Services (Optional Task)
  - Inspect construction activities to ensure that the work is in accordance with the contract documents and applicable regulatory requirements. Provide specialty inspection as needed.
  - Resolve of day-to-day construction issues raised. Coordinate with inspectors, design engineer, Contractor and City's project manager as required to reach resolution.
  - Maintain daily photographs of representative project activities .
  - Review contractor's baseline and monthly schedule updates.
  - Prepare detailed project punch lists at substantial completion of the project.

- Review and certify that the Contractor's project record drawings are complete and accurate.

The above list of scope items should not be consider exhaustive. The Proposer should add definition to the scope items and modify the scope as necessary to provide the best project for the City.

Submittal of Proposals

A copy of the City's PSA including indemnification and insurance requirements has been attached. Please review the business terms carefully before submitting a proposal. A City business license is required.

Proposers are encouraged to provide concise proposals that explain your approach and your ability to carry it out to the benefit of the City. The proposal shall be limited to not more than 25 pages, including figures. Cover letter and appendix material does not count against the page count, but is deemed as additional information and might not be viewed by the City.

Proposals shall include the following:

- A statement of project understanding and approach
- Scope of services /Task descriptions/Deliverables
- Schedule for completion including 2-week allowances for City review of deliverables
- A statement of similar work previously performed, including at least three references with:
  - Name of project and description
  - This project team's members on the previous project and role on that project
  - Organization, project manager contact, and telephone number of the reference
- A statement of qualifications and a list of personnel to be assigned to the work and their anticipated roles on the project. Resumes for each team member, listing education, experience, and expertise in this type of work shall be provided in an appendix, which does not count against page limit.
- Level of effort in labor hours by labor classification and task, including subconsultant/subcontractor labor hours.
- State of Compliance- Attachment A of this RFP. (not included in page limit)

Proposals shall be submitted by e-mail with the subject line indicating: Magnolia Force Mains Relocation Design PROPOSAL Proposers are advised that **e-mail is limited to 15 MB**. Please reduce files size prior to attempting to send the proposal.

A breakdown of estimated hours and fee per task, and billing schedule in PDF file format shall be submitted in separate e-mail with subject line indicating: Magnolia Force Mains Relocation Design FEE.

Evaluation Process

A selection committee will be appointed to review the proposals which will be evaluated on the following criteria only, with values assigned to each item representing its relative importance:

Criteria	Maximum Score
Understanding of requested services, work plan and methodology.	30
Qualifications of the project manager and team	20
Qualifications of the proposing company/firm	15

Proposers recent experience in conducting work, of similar scope, complexity and magnitude in particular for government agencies.	20
Ability to meet contract requirements	5
Appropriateness of level of Effort	5
Location of Firm (Prime firms located in Healdsburg, CA will be awarded 5 points; Prime firms outside of Healdsburg, CA will be awarded 0 points)	5
	Total points: 100

The City reserves the right to rank proposals based on other criteria and factors. In the event the City judges multiple proposals to be of equal value, interview may be performed to further assess the proposal that has been submitted.

The City intends to negotiate final scope, fee and schedule with the top ranked proposer. If negotiations are not successful with the top ranked proposer, the City will negotiate with the next highest proposer, and continue in this process until a successful negotiation is reached or the pool of qualified proposers is exhausted.

By submitting qualifications, the Proposer authorizes the City to undertake such investigation as may be necessary to verify the Proposers qualifications and reputation, including compliance with current City ordinances. The Proposer may be requested to execute a release(s) in favor of third parties who have information relative to the Proposers qualifications and reputation. Refusal to execute a release may result in disqualification. The City may, at its discretion, select a Proposer outright or select a finalist(s) for interviews.

Upon selection, the Proposer will receive a PSA and will be expected to execute the contract within ten (10) business days of receipt. The length of the PSA will be one year.

Additional RFP Information

Precedence of Terms and Conditions- All other terms and conditions of the PSA attached within this RFP are hereby incorporated into the terms and conditions of this RFP. In the event of a conflict of terms and conditions between the RFP document and the PSA, the terms and conditions expressed in the PSA shall take precedence.

Public Record- Upon submission of a proposal and other materials for consideration by the City, such proposals and materials shall become the property of the City of Healdsburg. Proposals may be subject to public inspection and disclosure pursuant to state and federal law after the award of a PSA for this Project/service. Prior to the RFP deadline, proposals may be modified or withdrawn by an authorized representative of the Proposer by written notice to the City of Healdsburg Utility Department.

Specificity of Information- No verbal or written information which is obtained other than through this RFP or its addenda shall be binding on the City. No employee of the City is authorized to interpret any portion of this RFP or give information as to the requirements of the RFP in addition to that contained in or amended to this written RFP document.

Errors and Omissions- This RFP cannot identify each specific, individual task required to successfully and completely implement this Project/service. The City relies on the professionalism and competence of Proposers to be knowledgeable of the general areas identified in the scope of work and to include in their proposals all materials, equipment, required tasks and subtasks, personnel commitments, man-hours, labor, direct and indirect

costs, etc. Proposers shall not take advantage of any errors and/or omissions in this RFP document or in the firm's specifications submitted with their proposals. Where such errors or omissions are discovered by the City, full instructions will be given by the City in the form of an addenda.

Proposal Validity- Unless otherwise noted by the Proposer, all proposals shall be held valid for a period of 180 days.

Right of Rejection - The City reserves the right to: (1) Accept or reject any and all proposals or any part of any proposal, and to waive minor defects or technicalities in such; (2) Request clarification of any information contained in a proposal; (3) Solicit new proposals on the same project, or on a modified project, which may include portions of the original RFP as the City may deem necessary; (4) Disregard all non-conforming, non-responsive, or conditional proposals, (5) Reject the response of any proposer who does not pass the evaluation to the City's satisfaction, (6) Allow for the correction of errors and/or omissions; (7) Select the proposal that will best meet the needs of the City, and (8) Negotiate service contract and terms with the successful Proposer.

Right of Rejection of Lowest Fee Proposal- The City is under no obligation to award this project/service to the Proposer offering the lowest fee proposal. Evaluation criteria expressed in this RFP solicitation shall be used in the proposal evaluation process. In evaluating proposals, the City may consider the qualifications of the proposers and whether the proposals comply with the prescribed requirements

Non-Compliance- Proposers and/or proposals that do not meet the stated requirements for this Project/scope of work may be considered noncompliant and may be disqualified, unless such noncompliance is waived by the City. During the evaluation process, the City reserves the right to request additional information or clarification from those submitting proposals, and to allow corrections of errors and/or omissions.

Exceptions to Proposal Requirements- Proposers may find instances where they must take exception with certain requirements or specifications of the RFP and PSA. All exceptions shall be clearly identified using the Statement of Compliance- Attachment A, and written explanations shall include the scope of the exceptions, the ramifications of the exceptions for the City, and a description of the advantage to be gained or disadvantages to be incurred by the City as a result of these exceptions.

Determination of Responsiveness and Responsibility- The City shall have sole authority in determining the responsiveness and responsibility of any and all Proposals. For Proposals containing exceptions to specifications and/or requirements, the City shall have sole authority in determining the extent to which exceptions affect the responsiveness and responsibility of any and all Proposals.

Obligation to Award- The City of Healdsburg is not obligated to enter into a Contract or Agreement on the basis of any proposal submitted in response to this RFP. City reserves the right to award multiple contracts for this Project if is deemed most advantageous to the City.

Proposer Reimbursement Prohibition- The City will not pay for any information herein requested, nor are they liable for any costs incurred by any vendors prior to award of a contract or purchase order. The City may require the finalist proposer(s) to provide on-site presentations and demonstrations of the product(s)/service(s) proposed by the proposer(s). All costs associated with the demonstrations or follow- up interviews are the sole obligation of the proposer(s).

Compliance with All Applicable Laws- Proposer declares that it shall comply with all licenses, statutes, ordinances, regulations and requirements of all governmental entities, including federal, state, county or municipal, whether now in force or hereinafter enacted, including, but not limited to, appropriate contractor/consultant/vendor licensing and business licensing.

Inclusive Proposal Pricing - Proposal pricing shall include any and all applicable licenses, insurance coverage, endorsements, bonding and if necessary, any wage compliance deemed necessary to perform the Work or Services as part of the Project described in this RFP. City will not be responsible for reimbursing Contractors for any charges not included in the Proposal pricing that are incurred in securing these requirements.

Subcontractor/Joint - The selected Contractor shall be the Prime Contractor performing the primary functions of the Agreement. If any portion of the Agreement is to be performed by a subcontractor, this must be clearly set forth in the Proposal submittal as to what part(s) is/are to be delegated. The City reserves the right to reject any Proposal wherein use of subcontractors significantly affects the ability of the Proposer to function as the Prime Contractor on the awarded Agreement. The Prime Contractor will at all times be responsible for the acts and errors or omissions of its subcontractors or joint participants and persons directly or indirectly employed by them. Acceptance or rejection of a Proposer's request to use subcontractors is at the sole discretion of the City.

Questions and Clarifications

Any questions regarding the scope of work or business terms should be submitted to Patrick Fuss, P.E., at pfuss@ci.headldsburg.ca.us. All requests for information and answers will be submitted to the proposers that have registered for the RFP. All questions must be received no later than the date indicated in the project Schedule of RFP, above.

Sincerely,

Patrick Fuss, P.E.
Principal Water/Wastewater Engineer
Municipal Utility Department

Attachments:

A. Documents Accompanying the RFP
B. Proposer Registration Form
C. Professional Services Agreement
D. Statement of Compliance

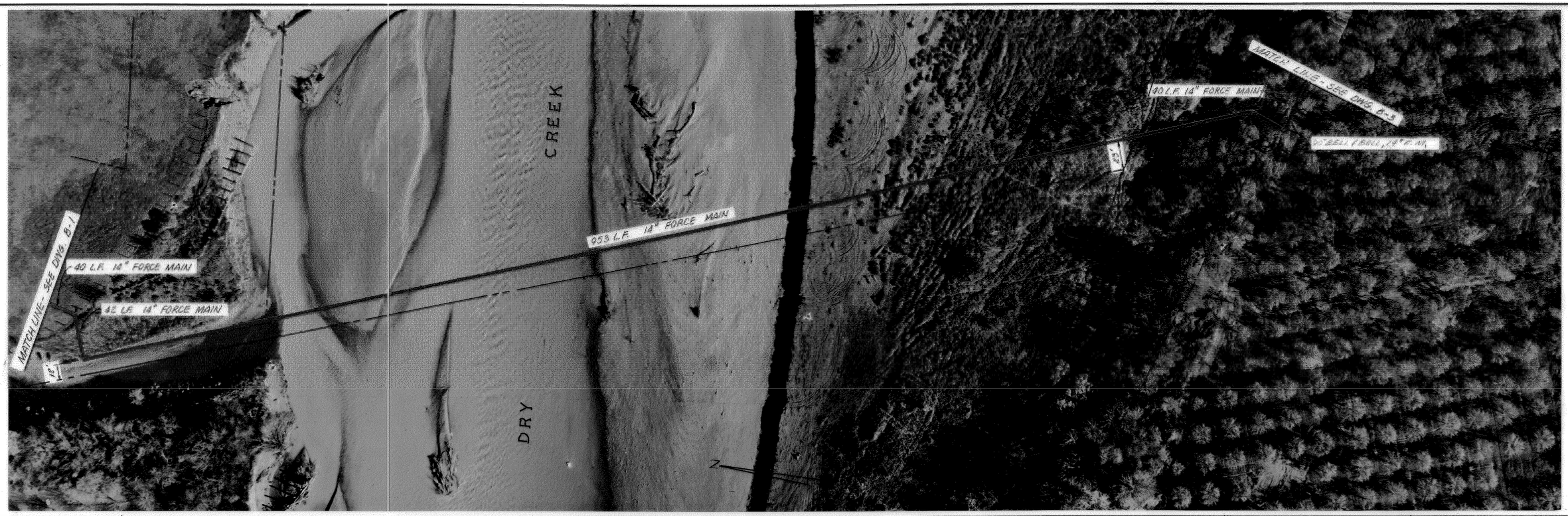
Attachment A Documents Accompanying the RFP

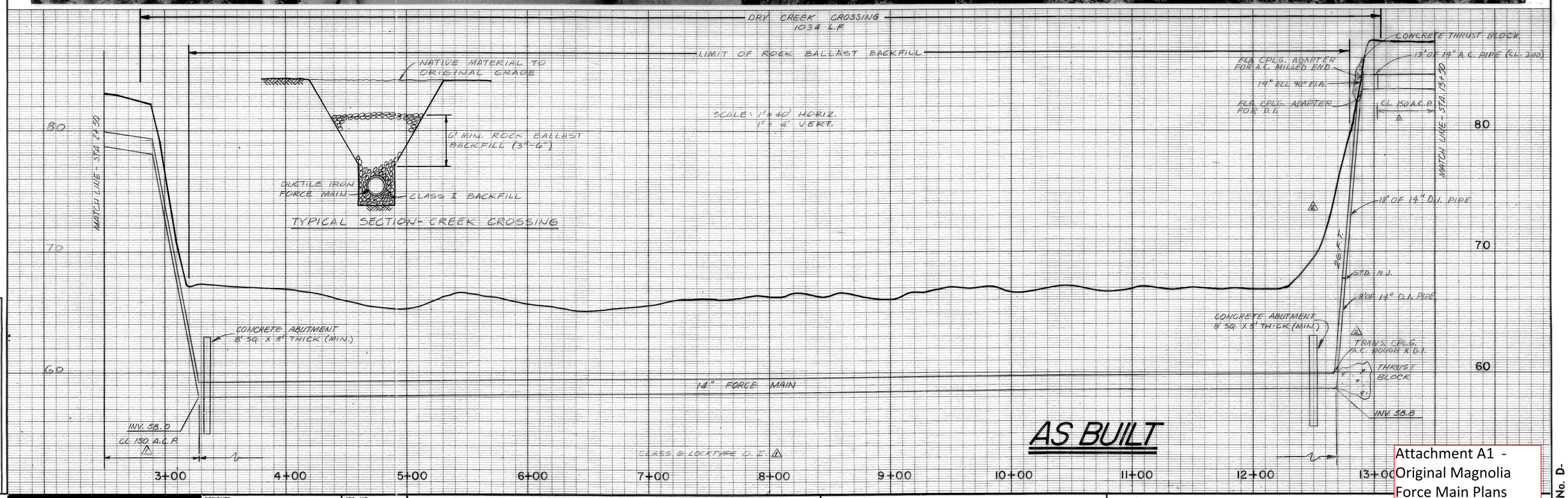
A1 Original Magnolia FM Pipeline Plan and Profile

A2 Photos of Exposed Magnolia FM Pipes

A3 Magnolia FM Scour Analysis

A4 - Magnolia FM Trenchless Relocation Feasibility Investigation





Attachment A1 - Original Magnolia Force Main Plans

NO.	REVISION	BY	DATE
1	AS BUILT	RE	4/72
2	ADDENDUM NO. 3	EM	5/70

YODER/ORLOB ASSOCIATES
CONSULTING ENGINEERS
WALNUT CREEK, CALIFORNIA

DESIGNED M E B
DRAWN D R L
CHECKED E.M.
JOB. NO. 6305.2
DATE MARCH 1970

CITY OF HEALDSBURG, SONOMA COUNTY, CALIFORNIA
APPROVED Project Engineer
APPROVED R.P.E. CIVIL # 7023 For Yoder/Orlob Associates
APPROVED

WATER POLLUTION CONTROL FACILITIES
PROJECT UNIT 2 - SCHEDULE B

SANITARY FORCE MAIN
STA. 2+50 To STA. 13+50

FILE No. D-

File No. CIP1971.02

Attachment A2 - Photo Circa 2014 of Magnolia Force Main Exposed on Dry Creek streambed

DRY CREEK SCOUR ANALYSIS

Prepared for:

The City of Healdsburg

Healdsburg, California

Prepared by:

Northwest Hydraulic Consultants Inc.

Sacramento, CA

08 June 2016

NHC Ref. No. 5001723

Attachment A3 - Cry Creek Scour Analysis at Magnolia Force Mains

Prepared by:

Jenna Paul, M.S., P.E.
Engineer

Reviewed by:
Brad Hall, M.S., P.E. (WA)
Principal

DISCLAIMER

This document has been prepared by Northwest Hydraulic Consultants Inc. in accordance with generally accepted engineering practices and is intended for the exclusive use and benefit of the City of Healdsburg and their authorized representatives for specific application to the Dry Creek Scour Analysis in Healdsburg, California, USA. The contents of this document are not to be relied upon or used, in whole or in part, by or for the benefit of others without specific written authorization from Northwest Hydraulic Consultants Inc.. No other warranty, expressed or implied, is made.

Northwest Hydraulic Consultants Inc. and its officers, directors, employees, and agents assume no responsibility for the reliance upon this document or any of its contents by any parties other than the City of Healdsburg.

CREDITS AND ACKNOWLEDGEMENTS

This work was authorized by contract dated 7 March 2016 between the City of Healdsburg and Northwest Hydraulic Consultants Inc. Patrick Fuss, P.E., Principal Engineer for the City of Healdsburg, was the primary point of contact and provided background information and other reporting on the proposed pipeline relocation. Greg Guensch, P.E. of the Sonoma County Water Agency provided copies of previously completed hydrologic and geomorphic investigations of Dry Creek, as well as copies of HEC-RAS hydraulic models developed for analysis and design of ongoing habitat enhancement and restoration design on Dry Creek.

EXECUTIVE SUMMARY

The City of Healdsburg contracted Northwest Hydraulic Consultants (NHC) to perform a scour assessment for a proposed pipeline below Dry Creek. Possible scour mechanisms include (1) vertical incision of the channel due to a reduction in upstream sediment loading, (2) bed-profile lowering due to the lowered tailwater elevations and a successive head-cutting of the upstream bed, and (3) live bed scour caused by flood events. Previous studies done by Interfluve, a field reconnaissance visit, and common scour methodologies support the following analysis.

Dry Creek, the largest tributary to the Russian River, travels approximately 14 miles from Lake Sonoma to its mouth. Since the mid-19th century, the landform of the Dry Creek Watershed has varied as a result of anthropogenic activities, such as logging and agricultural development. Gravel mining on the Russian River, in the vicinity of Healdsburg, and subsequent placement of the Healdsburg and Coyote dams caused incision of the bed on Dry Creek and its tributaries. To counter this degradation, the U.S. Army Corps of Engineers (USACE) installed grade control structures, while land-owners installed bank stabilization features. With the closure of Warm Springs Dam in 1982, the sediment supply from the upper watershed was reduced, and this was likely another factor contributing to a brief period of incision downstream of the dam. An analysis of U.S. Geological Survey (USGS) stage-discharge records shows that, since construction of the dam, the bed elevation of Dry Creek in the vicinity of proposed pipeline has reached an equilibrium.

Currently, the USACE operates Warm Springs Dam, which releases controlled flows into Dry Creek. The watershed encompasses several smaller tributaries downstream of Warm Springs Dam, yet most are un-gaged creeks. To quantify the change in flow along the reach, Interfluve (2011) conducted flood frequency analyses using available USGS gage data and the Warm Springs Dam Water Control Manual. Results were extrapolated at the mouth of each tributary using relative drainage areas. This analysis provided the estimated inflows to Dry Creek at the 1-yr, 2-yr, 5-yr, 10-yr, 50-yr, and 100-yr flood frequencies.

Using inflows from the hydrologic analysis, Interfluve (2011) prepared a 1D, steady-state HEC-RAS model of Dry Creek, which extended from Warm Springs Dam to the Russian River. NHC truncated this model to lower reach of Dry Creek, just above the Mill Creek tributary. Although the exact location of the proposed crossing is yet to be determined, NHC understands that it will be placed in the vicinity of the existing recycled water pipeline bridge (downstream from the mouth of Mill Creek). As the crossing location has not been finalized, scour results will be presented at three (3) cross-sections, surrounding the expected location. Output from the HEC-RAS model includes in-channel hydraulic depth, velocity, and water surface elevation for the 1-yr, 2-yr, 5-yr, 10-yr, 50-yr, and 100-yr storm frequencies.

Shields Number and critical velocity calculations, supported by the hydraulic computations and bed material properties, indicate that Dry Creek bed material is susceptible to movement during high flow conditions. The competent velocity method and Blench regime approach yielded scoured depths which, subtracted from the water surface elevation, give the expected scoured bed elevation for each flood

event. Both methods provide similar scoured bed elevations, which generally range 34 – 38 feet along the three cross-sections of interest, as a result of the 100-yr event. Computed scoured depths range up to 22 – 27 feet below the existing bed elevation for the 100-year flood event.

NHC recommends placing the pipeline no higher than 34 ft. (NAVD 88) to avoid scour during the 100-yr event. To satisfy these recommendations, excavated or directionally drilled depths reach up to 27 ft. below the existing bed elevation and as much as 55 ft. below the existing floodplain elevation. Should the cost and effort to install this pipeline exceed the City of Healdsburg's expectations, NHC is available to prepare and discuss possible scour protection alternatives. Several scour counter-measures are available, such as the placement of a roughened riffle, which reduces the required depth of the pipeline placement.

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1 INTRODUCTION

The City of Healdsburg plans to install a pipeline under the streambed of Dry Creek. The proposed pipeline is intended to replace an existing pipeline, which was originally placed below the channel bed and has recently become exposed to the channel as a result of scour. To avoid the risk of exposure of the proposed pipeline, the City of Healdsburg contracted Northwest Hydraulic Consultants Inc. (NHC) to assess the crossing for potential scour. In the absence of hydraulic structures, possible scour mechanisms include (1) vertical incision of the bed due to changes in the upstream sediment supply, (2) lowering of the bed profile due to decreased tailwater elevations and the successive head-cutting of the channel bed, and (3) natural scour caused by bed mobilization during high flow events. This analysis considers a variety of approaches including a review of historical USGS stage-discharge records, inspection of the available channel cross-sections, and application of physically and experimentally-based scour methodologies to quantify the expected bed scour for a range of flood events.

2 BACKGROUND

Dry Creek, approximately 14 miles in length, flows from Lake Sonoma to the Russian River in the vicinity of Healdsburg, California. The project site rests between the mouth of Mill Creek and the confluence of Dry Creek with the Russian River, as shown in Figure 1. Although the exact location of the proposed pipeline crossing is unknown, NHC understands that it will be placed near the existing suspended recycled water bridge.

Dry Creek originates from the outfall of Warm Springs Dam, which was built in 1982 and contains Lake Sonoma. A variety of smaller streams, such as Pena Creek, Dutcher Creek, and Mill Creek, contribute additional flows throughout the reach. The cumulative discharge during low flow conditions is monitored by a U.S. Geological Survey (USGS) gage (ID 11465350), which is located downstream of the project site (Figure 1).

Interfluve (2011) notes that since the early 19th century, a variety of anthropogenic activities have influenced the current conditions of Dry Creek. Beginning in the 1850s, vegetation on the floodplain evolved from forests, to grazing lands, to its current state of agricultural fields. As these activities influence the watershed sediment supply and runoff characteristics, this ultimately led to an initial degradation of Dry Creek. Additional channel influences include gravel mining in the Russian River, and the subsequent placement of the Healdsburg and Coyote Dams. The USACE (1987) attributes the incision of Dry Creek with these activities, as they lowered base elevations of the Russian River, and therefore, the mouth of Dry Creek. Degradation of the bed caused by the lowered tailwater elevations traveled upstream through Dry Creek and many of its tributaries, leading to an overall lower base elevation. To mitigate the lowering of the bed profile due the influences of the Russian River, the USACE installed three grade control structures on Dry Creek, while landowners installed bank protection features.

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Legend
- Streams
- Approximate Location of USGS Gage (ID 11465350)

SCALE - 1:100,000
0 5,000 10,000 Feet
N

Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree

Job: 5001723
Date: MAY 2016

FIGURE 1

DRY CREEK SCOUR ANALYSIS

SITE LOCATION

ABC, P:\5001723-Dry_Creek_Scour_Analysis\GIS\2_MXD_Workmaps\Report_Figure_Workmaps\Fig_1_Site_Map_v2.mxd

Finally, in 1982, the USACE constructed Warm Springs Dam, which was implemented, in part, for flood control purposes. The dam ensured a reduction in peak flows during the wet months, but it also provided base flow during the typical dry summer and early fall months. Figure 2 compares the controlled monthly-average flows against pre-dam conditions near the outfall of Warm Springs Dam.

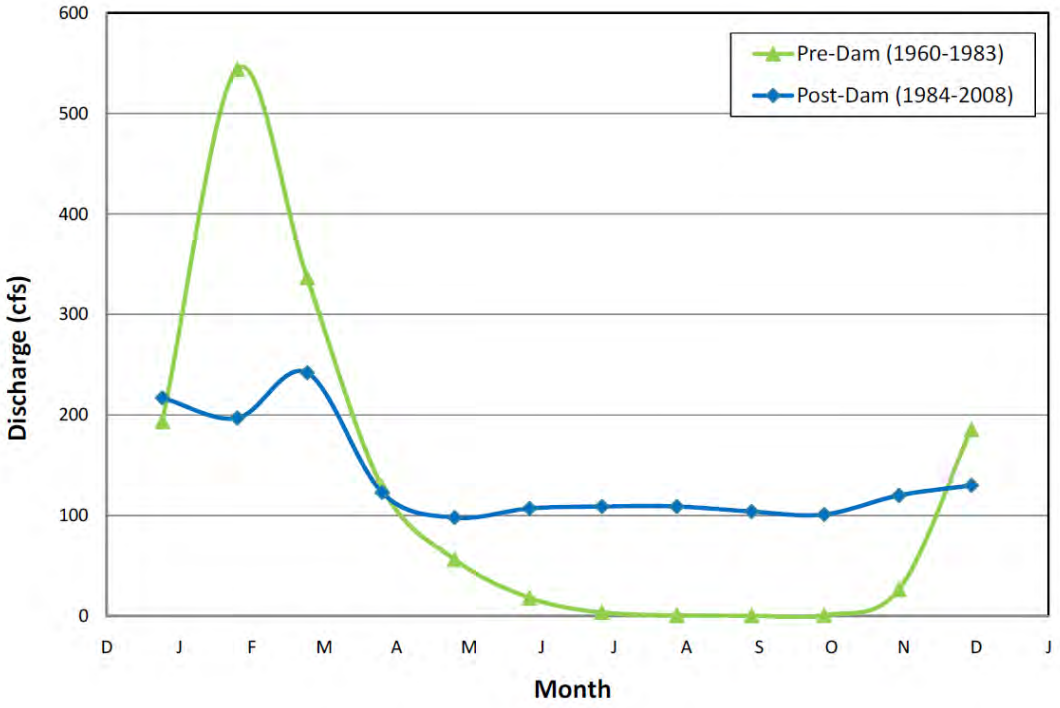

Figure 2. "Comparison of monthly median discharges for pre- and post-dam periods at Yoakim Bridge (USGS No. 11465200)." Dry Creek Current Conditions, Interfluve (2010).

Figure 2 shows that Warm Springs Dam provides typical monthly-average flows near 100 cfs. Not only did the dam reduce peak flows into Dry Creek, but it also reduced the sediment supply to the channel downstream of the dam. As discussed in section 4, this was another factor leading to additional incision along Dry Creek.

3 HYDROLOGY

The Dry Creek Watershed drains an area of 217 sq. mi. (USGS, 2016) and encompasses several, smaller tributaries. The majority of these tributaries provide seasonal inflows to Dry Creek, yet most are un-gaged, and there is no record of their flow contributions. An understanding of the flood frequencies at the mouth of each tributary supports the hydraulic modeling of Dry Creek. Interfluve (2011) estimated these flood frequencies using two (2) methods: (1) a frequency analysis using the Water Control Manual (WCM) for Warm Springs Dam and extrapolating the discharges along Dry Creek based on drainage area

ratios, and (2) determining flood frequencies on gaged creeks and extrapolating these flows to un-gaged creeks based on ratios of subbasin areas. Table 1 lists the flood frequency results from both methods.

Table 1. "Peak flow estimates at locations downstream of Warm Springs Dam. Estimates in columns labeled WCM derived from values included in 1984 Water Control Manual. Estimates in columns labeled Gage Data based on flood frequency analysis of available gage data, and extrapolation to ungaged watersheds. Q1, Q2, Q5, Q10, Q25, Q50 and Q100 refer to peak flood discharges with return intervals of 1, 2, 5, 10, 25, 50, 100 years, respectively." (Interfluve 2011)

Location / Tributary Confluence	Cum. Drainage Area (sq. mi.)	River Mile	Dist. Upstream from Russian River Conf. (ft)	Q1		Q2		Q5		Q10		Q25		Q50		Q100	
				WCM[1] (cfs)	Gage Data (cfs)	WCM[1] (cfs)	Gage Data (cfs)	WCM[1] (cfs)	Gage Data (cfs)	WCM[1] (cfs)	Gage Data (cfs)	WCM[1] (cfs)	Gage Data (cfs)	WCM[1] (cfs)	Gage Data (cfs)	WCM[1] (cfs)	Gage Data (cfs)
Outlet of Warm Springs Dam	130	13.8	72829	1500	400	2500	2450	4000	4300	**6000**	5500	6000	6000	**6000**	6000	**6000**	6000
Schoolhouse Creek	130.8	13.2	69781	1511	431	2522	2500	4033	4436	6022	5668	6039	6270	6056	6297	6100	6300
Fall Creek	133.7	12.1	64002	1551	529	2603	2550	4154	4867	6103	6192	6180	6500	6257	6500	6463	7000
Dutcher Creek	137.2	11.7	61861	1600	644	2700	2600	4300	5366	**6200**	6797	6350	6800	**6500**	7000	**6900**	7500
Vince's Creek	138.1	11.3	59863	1629	676	2737	2650	4341	5508	6219	6971	6428	7000	6619	7500	7058	8000
Pena Creek	160.6	10.9	57573	2358	1059	3655	2790	5369	7000	**6700**	7000	8380	7400	**9600**	8100	**11000**	8600
Canyon Road Creek	162.9	10.3	54265	2434	1137	3758	3025	5507	7339	6846	7412	8580	8056	9833	8821	11291	9223
Grape Creek	171.2	7.2	38042	2707	1392	4127	3795	6004	8444	7371	8743	9302	10152	10673	11127	12342	11214
Crane Creek	176.4	6.2	32840	2878	1559	4359	4301	6316	9174	**7700**	9626	9754	11550	**11200**	12500	**13000**	12700
Kelly Creek	181.2	4.3	22462	3107	1715	4697	4770	6799	9850	**8200**	10445	10490	12846	**12100**	13700	**14100**	14100
Pine Ridge Canyon	183.1	3.2	16717	3485	1782	5144	4974	7336	10147	**8700**	10808	11187	13426	**13000**	14300	**15000**	14700
Mill Creek	209.2	0.7	3480	5371	2222	7610	7092	10569	13682	**12500**	15374	15767	18948	**18000**	20500	**21000**	21103
RR Confluence	217	13.8	72829		2442		7757		14631		16510		20726		22000		22792

[1] **Bold italicized** values represent values as appear in the WCM. All other values in column labeled WCM have been extrapolated or interpolated.

Both frequency estimations provide similar peak flows, and Interfluve adopted the gage-based values in their analysis. To complete the hydrologic analysis, Interfluve also observed the influence of the Russian River on Dry Creek discharges. During the 1.5-yr and 10-yr flood events on the Russian River, stages at the mouth Dry Creek reach 80 ft. and 88.72 ft., respectively (Interfluve 2011). Russian River event stages influence as much as the lower 3 miles of Dry Creek, which encompasses the reach of the existing and proposed pipeline crossings.

4 GEOMORPHOLOGY

4.1 Dry Creek Channel Planform

Prior to the closing of Warm Springs Dam, Dry Creek was subject to significantly higher variation in flow with winter high flows regularly exceeding the now controlled maximum release flow from the dam, to long periods of zero flow within Dry Creek (Interfluve, 2011) (Figure 2). This flow variation led to the development of open, un-vegetated gravel bar surfaces and a dynamic Dry Creek channel that shifted in location during the winter high flow events. Since dam closure, the extreme high flows have been greatly reduced due to flood regulation, and perennial flows released during the spring through fall time period has led to a densely vegetated overbank on Dry Creek. Channel migration rates have reduced to a nearly static planform over most of the Dry Creek channel downstream of Warm Springs Dam,

including the region in the vicinity of the proposed pipeline crossing. Since the Dry Creek channel location is relatively static, the active channel extents can be estimated from aerial photography to define both channel roughness and mobile bed limits for quantifying the hydraulic characteristics and subsequent scour estimates on lower Dry Creek.

4.2 Bed Materials

The Dry Creek channel bed is a gravel bed channel, typical of the streams in this region of Sonoma County. The bed material size characteristics used in this assessment of channel scour were estimated from bed material samples taken by Interfluve (2011) through sampling of both the surface materials on the channel bed as well as subsurface sampling of bed materials below the surface armor layer. Bed material samples gathered in the vicinity of the pipeline crossing show bed material sediments characterized as a mixed grain size gravel bed, with sediment grain sizes varying from sand sized sediments smaller than 2 mm in diameter, to very coarse gravel and small cobble sediment clasts up to 90 mm in diameter. Characteristic grain size sediments, as determined by Interfluve (2011), are a median grain size diameter of approximately 25 mm for the surface material samples, and approximately 11 mm for the subsurface sediments for the samples obtained in the Dry Creek reach near the proposed pipeline crossing. Additional information on subsurface sediment characteristics is available from geotechnical borings taken in the vicinity of the proposed pipeline crossing (GeoEngineers, 2009). Borings RB1 through RB4 generally indicate sandy gravel subsurface materials, similar in characteristic to the subsurface bed material samples obtained by Interfluve (2011). The bore logs also show that this sand-gravel layer occupies the uppermost 43 – 48 ft. of the soil profile, followed by an underlying silt/clay cohesive layer (GeoEngineers, 2009).

4.3 Vertical Stability of Dry Creek

The USGS gage (ID 11465350) provides stages during low-flow conditions on Dry Creek dating back to 1982. This gage is located approximately 900 feet upstream of the mouth of Dry Creek and 1100 feet downstream from the existing and proposed pipeline crossing locations. Measurements of Dry Creek flowrates and corresponding water surface elevations were taken by the USGS to develop a stage-discharge rating curve at the gage location. The measured water surface elevations over time during low flow conditions, without any significant backwater effects from the Russian River, provides information on trends and changes in the channel bed elevation over that time period. Stage and discharge measurements for flows near 80 and 120 cfs (plus or minus 10 cfs) were extracted from the USGS records for the time period since the Warm Springs Dam closure (1982) to the present, and these are plotted in Figure 3. This figure is oftentimes referred to as a specific gage plot, and shows trends in measured stage for a specific flowrate or flowrates over time. The data indicates that channel incision occurred for a period of approximately 10 years following dam closure in 1982. Since the mid 1990's, gage heights for flows of 80 to 120 cfs have stabilized to an elevation of approximately 5 feet as measured by the USGS gage datum. The measurements indicate small variations of stage over time of plus or minus approximately 0.5 to 1 foot, but such variation is to be expected for active alluvial channels such as Dry Creek.

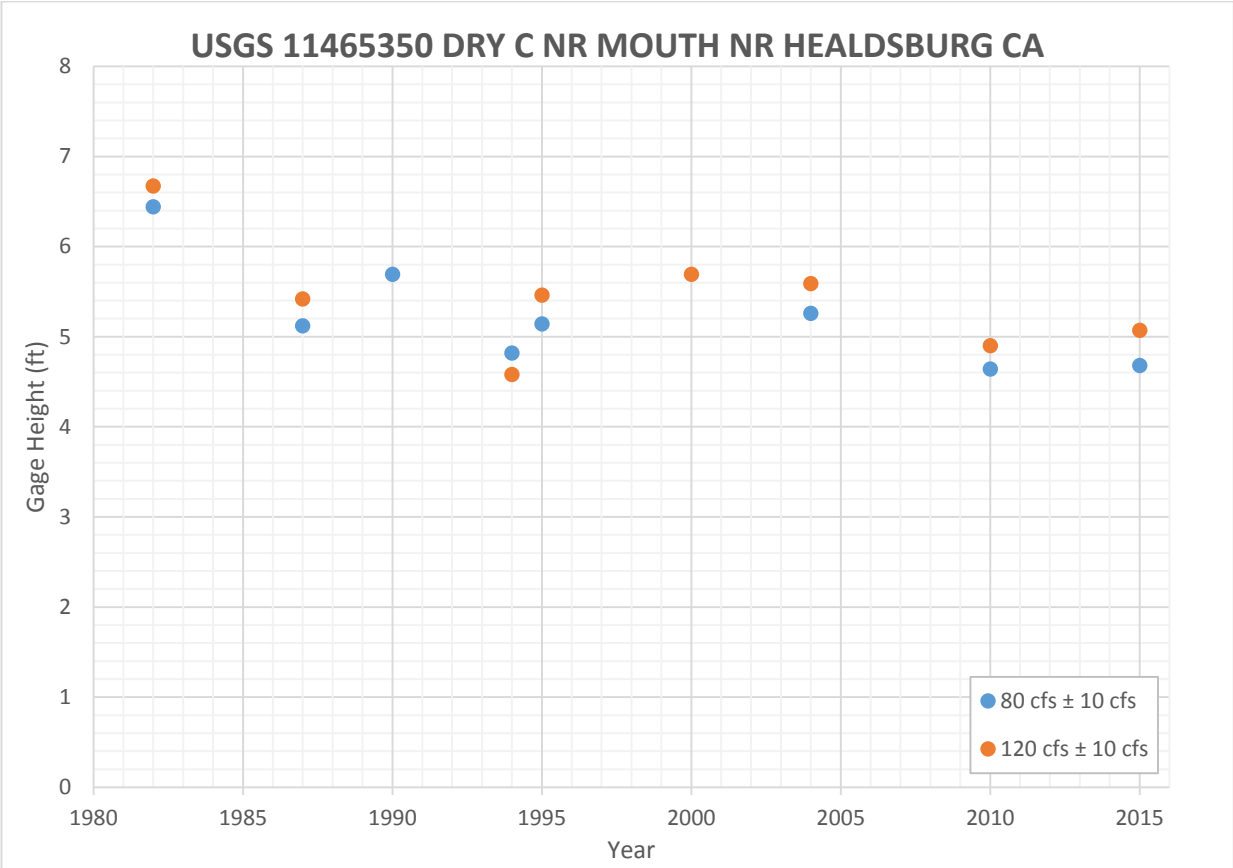

Figure 3. Specific gage plot of Dry Creek.

5 HYDRAULICS

This section describes the hydraulic analysis of Dry Creek, providing a foundation for the scour assessment. Section 5.1 describes the modeling procedures, inputs, and assumptions. Section 5.2 provides the solution of the hydraulic model, in particular, the hydraulic depth and velocity results—which drive the scour process.

5.1 Modeling Procedures

HEC-RAS version 4.1.0 was used to evaluate the hydraulics of Dry Creek. As a part of a comprehensive fish habitat study, Interfluve (2011) assembled and calibrated a 1-D, steady-state HEC-RAS model of Dry Creek. The model extent includes the entire reach from Warm Springs Dam to the mouth of Dry Creek, featuring inflows from major tributaries such as Dutcher Creek, Pena Creek, and Mill Creek. The steady flow component used the inflows from Interfluve's (2011) hydrologic regression analysis of the Dry

Creek watershed, for a variety of established storm frequencies (see Section 3). The downstream boundary conditions observed two (2) possibilities: (1) a case with low flow conditions on the Russian River (i.e., no back water influence), utilizing the normal depth option in HEC-RAS in which the energy slope is specified at the downstream boundary and (2) a case with a 1.5-yr coincident event occurring on the Russian River, utilizing a specified downstream water surface elevation option in HEC-RAS. Elevations in the HEC-RAS model geometry lie in the North American Vertical Datum (NAVD) 1988 datum. Subsequent results shall be reported with respect to the NAVD 1988 datum.

NHC acquired Interfluve's extended HEC-RAS model from the Sonoma County Water Agency (Greg Guench, personal communication, 2016) and truncated it to the lower reach of Dry Creek. The truncated model extends from above Mill Creek to the mouth of Dry Creek. Figure 4 illustrates the modeling extents and the HEC-RAS cross-sections used in this analysis. Modified from Interfluve's original set-up, this model adds cross-section 1498 by interpolating the geometry from the upstream and downstream sections. In this way, the hydraulics could be reported along an approximately 1000-ft stretch (modeling stations 1498 – 2536), centered about the existing recycled water pipeline bridge.

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Legend

- Approximate Location of USGS Gage (ID 11465350)
- HEC-RAS Cross-Sections
- Stream

SCALE - 1:5,000
0 250 500 Feet
N

Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree

Job: 5001723

Date: MAY 2016

FIGURE 4

DRY CREEK SCOUR ANALYSIS

HEC-RAS MODEL CROSS-SECTIONS

ABC, P:\5001723-Dry_Creek_Scour_Analysis\GIS\2_MXD_Workmaps\Report_Figure_Workmaps\Fig_2_Modeling_XS.mxd

This Lower Dry Creek model was improved by merging the existing cross-sections with Sonoma County LiDAR (NASA 2013) on the floodplain. Only a few cross-sections were modified, which eliminated the occurrence of vertical glass walls where topography was missing in the Interfluve HEC-RAS model. The Manning's roughness values from the original model were preserved, as the model was reasonably calibrated to measured flow conditions. Consistent with dense brush and trees observed during NHC's reconnaissance visit on March 23, 2016, the model featured overbank Manning's roughness of 0.12. The model featured Manning's roughness values ranging from 0.032 – 0.04 in the channel, in agreement with what Interfluve (2011) classified as a gravel bed in pebble counts of this reach.

While Interfluve's extended model provides inflows for a range of recurrence intervals, this analysis focuses on larger magnitude flood events that can potentially lead to bed scour at the proposed pipeline crossing. Of particular interest are the 1-yr, 2-yr, 5-yr, 10-yr, 50-yr, and 100-yr flood frequencies. Table 2 lists the flow conditions for these events, in particular, the upstream boundary and lateral inflow conditions.

Table 2. HEC-RAS model boundary conditions and inflows.

RAS Cross-Section	Q_1 (cfs)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)	Q_{50} (cfs)	Q_{100} (cfs)	Description
5799	1,782	4,974	10,147	10,808	14,300	14,700	Upstream Inflows
3488	2,222	7,092	13,682	15,374	20,500	21,103	Mill Creek Tributary
216	2,878	7,757	14,631	16,510	22,000	22,792	Downstream Inflows

This analysis models Dry Creek floods with two possible tailwater downstream boundary conditions. The first scenario assumes low-flow conditions in the Russian River, meaning there is no backwater influence on Dry Creek due to high Russian River stage. A normal depth downstream boundary condition satisfies this scenario. The average bed slope of 0.002 ft./ft. was used as the energy slope in the normal depth boundary condition. The second case utilizes 1.5-yr coincident event on the Russian River, which raises the tailwater elevations on lower Dry Creek. In this case, a water surface elevation of 80 ft. was specified for the downstream boundary condition, corresponding to the 1.5-yr flood event water surface elevation on the Russian River at the mouth of Dry Creek. The 10-yr coincident event on the Russian River resulted in a stage of 88.72 ft. at the mouth of Dry Creek (Interfluve 2011). Due to flood levels that exceeded the floodplain elevations of the available topography, the 10-yr coincident Russian River flood event was not modeled in 1D HEC-RAS as the high backwater stage exceeds the floodplain extent captured by the HEC-RAS cross sections. These high backwater stage conditions on lower Dry Creek are not expected to be of concern for quantifying scour near the proposed pipeline crossing, as the high backwater stage leads to lower energy slopes and lower channel velocities, thus reducing the scour potential compared to conditions of lower or no backwater effects.

5.2 Hydraulic Results

Primary output from the HEC-RAS model includes the water surface elevation, hydraulic depth, and channel and overbank velocities. Figure 5 illustrates the water surface profiles during low-flow conditions on the Russian River (i.e., normal depth boundary condition). Figure 6 provides the same profiles for during the 1.5-yr coincident event on the Russian River.

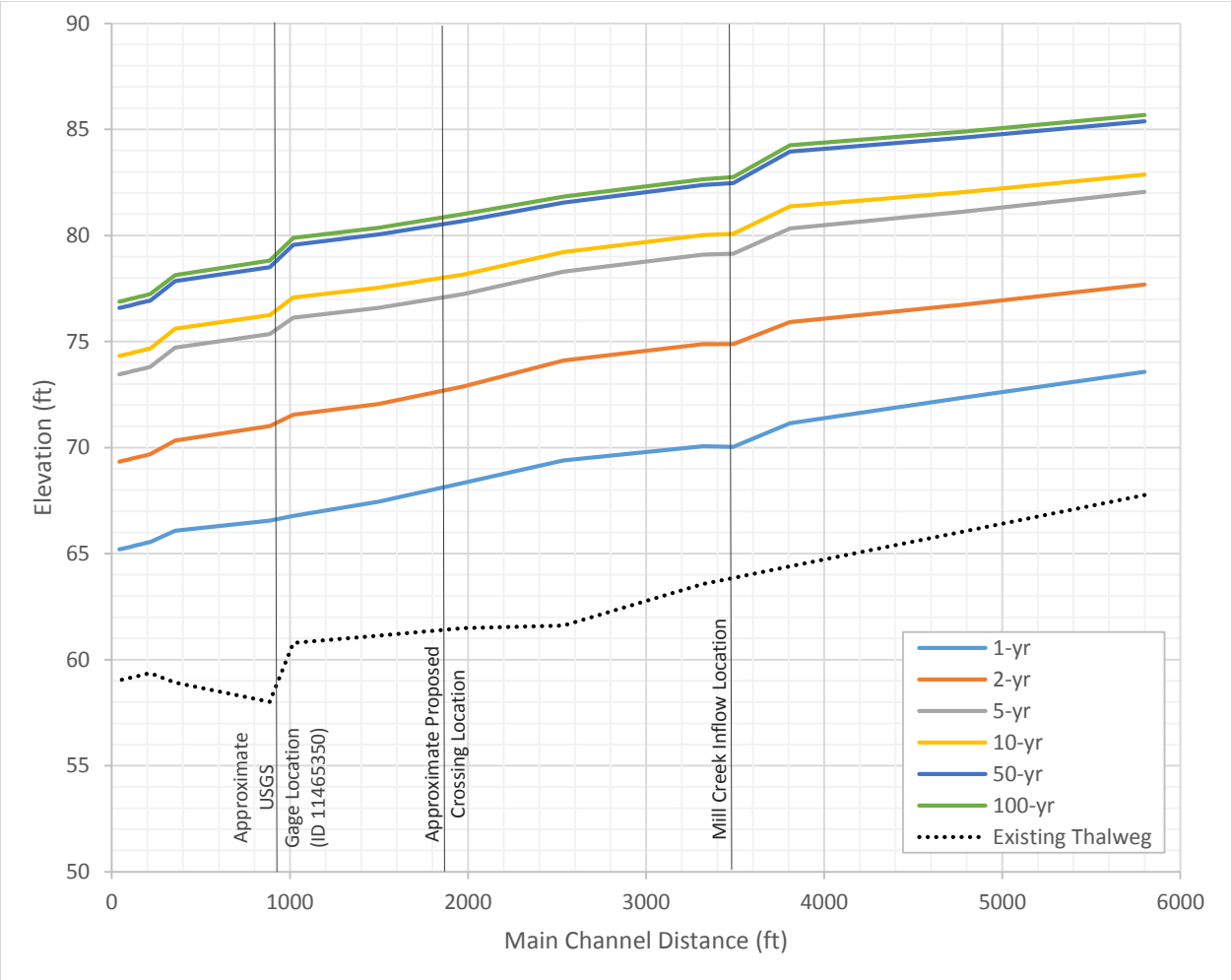

Figure 5. Water surface profiles with low-flow conditions on the Russian River.

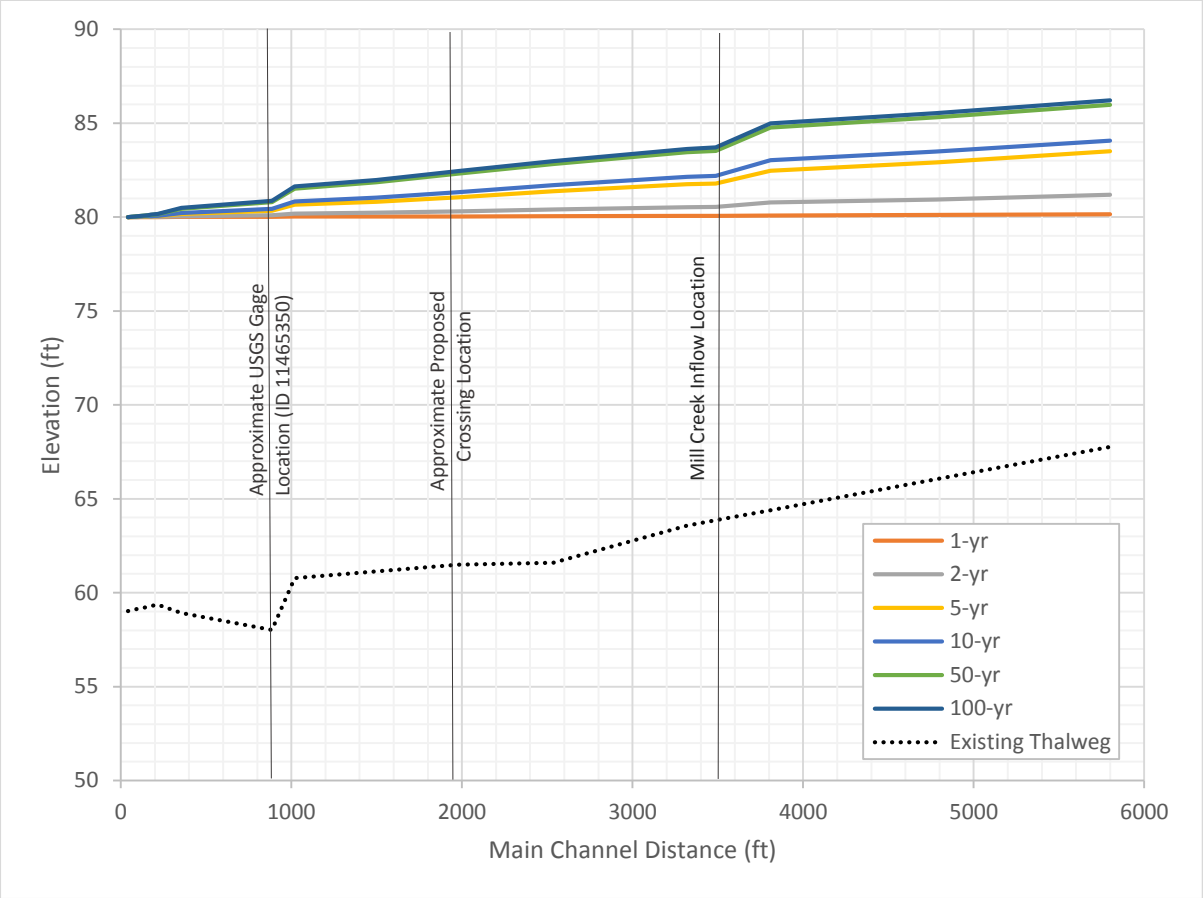

Figure 6. Water surface profiles during 1.5-yr coincident event on the Russian River.

Figure 5 produces water surface profiles nearly parallel to the reach-average bed slope. These profiles result in hydraulic depths ranging from 5 ft. to 19 ft. between cross-section 1498 and cross-section 2536.

The 1.5-yr coincident event on the Russian River (Figure 6) produces significantly higher water surface elevations than the low-flow assumption. Between cross-sections 1498 – 2536, the hydraulic depths range from 17 – 20 ft. Combined with the 1-yr and 2-yr events on Dry Creek, backwater effects from the 1.5-yr Russian River event produces mild water surface gradients (i.e., less than 0.002 ft./ft., the bed slope). Water surface gradients are non-detectible until the 5-yr event on the Russian River.

Similar to the water surface profiles, the different downstream boundary conditions produce different in-channel velocities. Figure 7 presents the modeled in-channel velocities for the Russian River low-flow assumption. Figure 8 provides velocities along the main channel during the 1.5-yr coincident event on the Russian River.

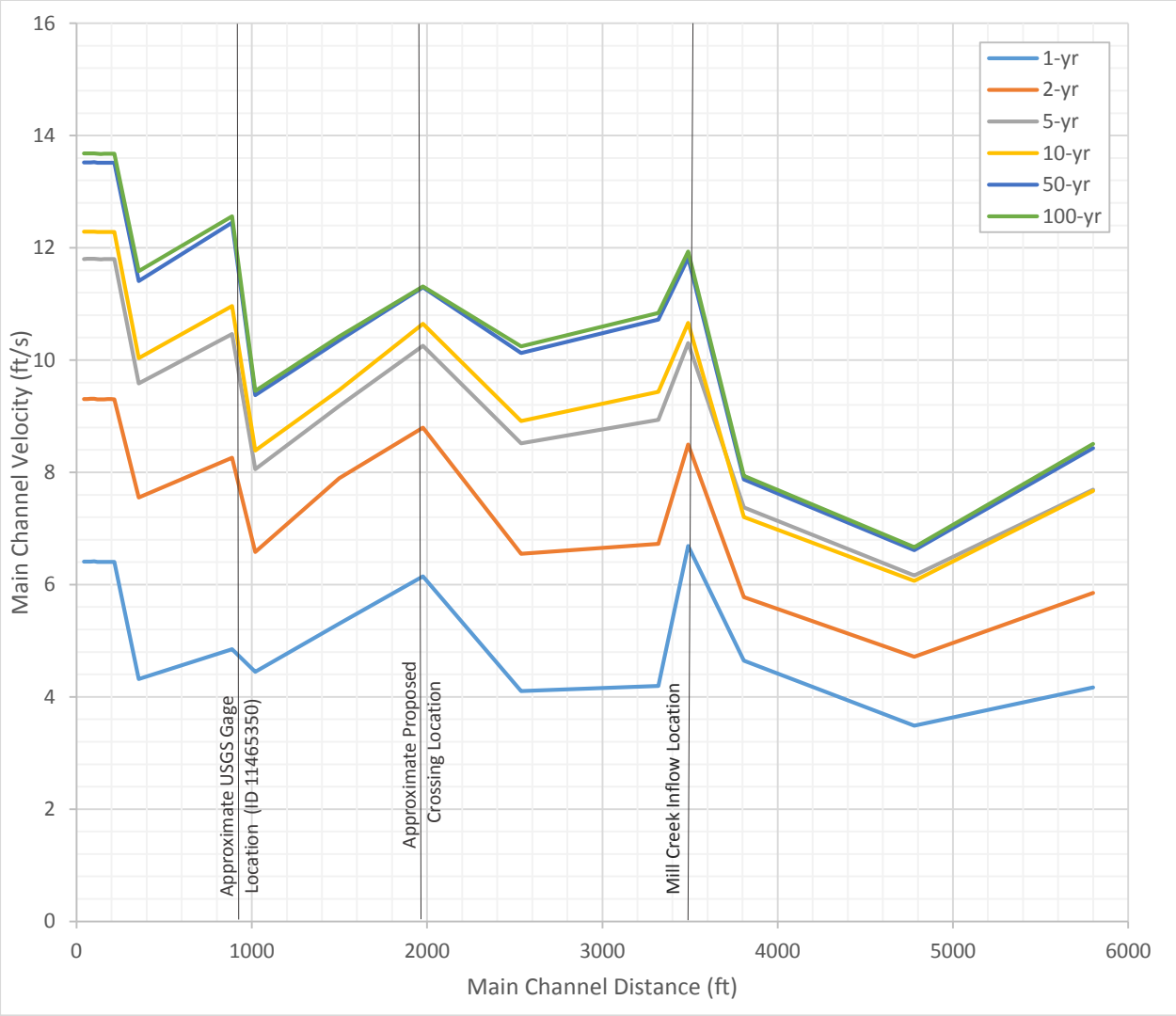

Figure 7. Channel velocity profiles with low-flow conditions on the Russian River.

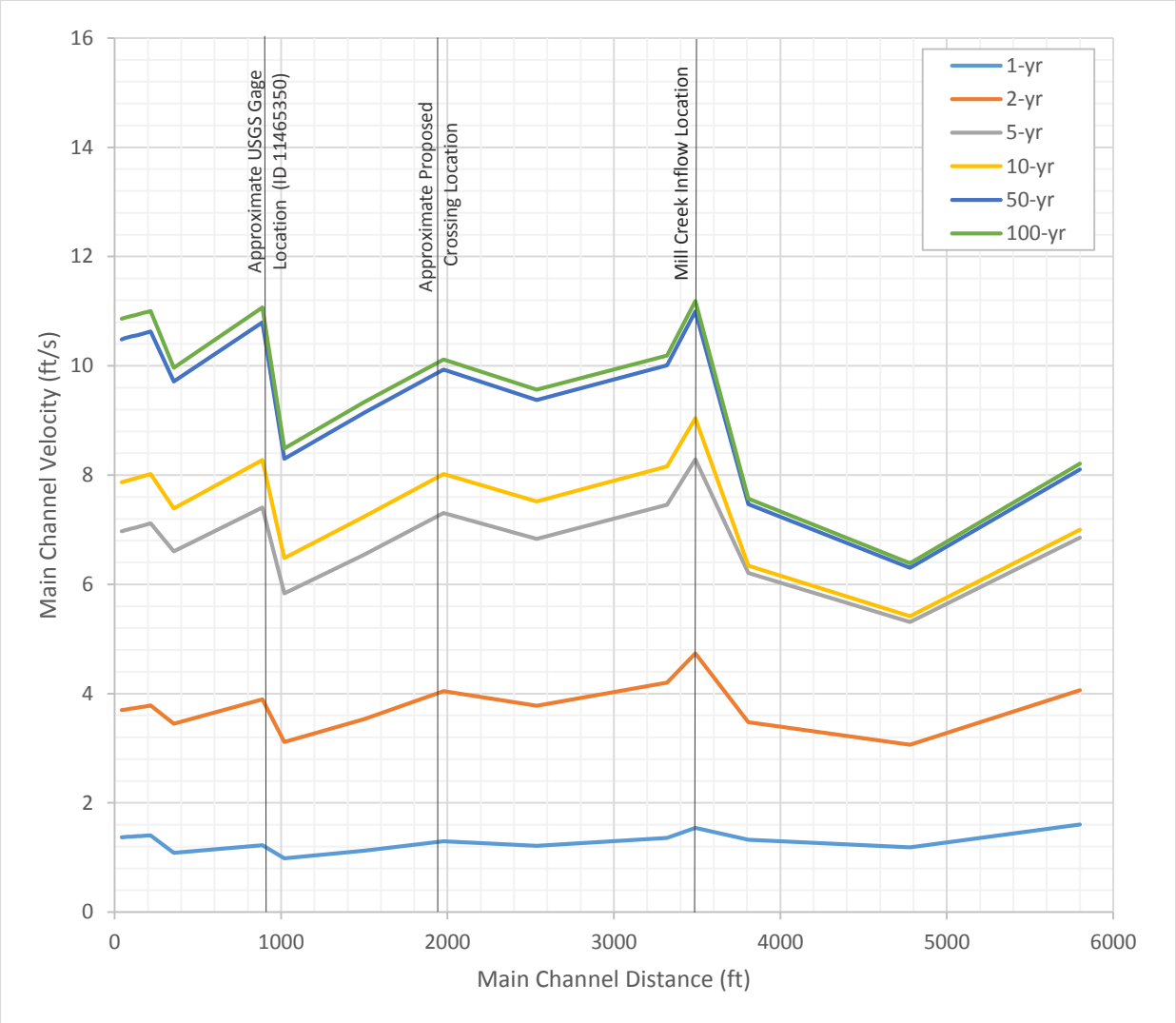

Figure 8. Channel velocity profiles during the 1.5-yr coincident event on the Russian River.

Without the backwater influence from the Russian River, HEC-RAS produces in-channel velocities ranging 4 – 11.3 ft/s between cross-sections 1498 – 2536 for the range of flood events analyzed (Figure 7). Inclusion of the backwater effects on the Russian River produces in-channel velocities ranging 1 – 10 ft/s (Figure 8). During the 1.5-yr coincident event on the Russian River, the 1-yr and 2-yr events on Dry Creek produce velocities that generally fall below 4 ft/s. Figure 7 and Figure 8 show that, in the cross-sections of interest near the proposed pipeline crossing, the highest velocities occur at cross-section 1977.

HEC-RAS can compute the velocity distribution across a cross-section based on a conveyance procedure. Figure 9 presents the velocity distribution of cross-section 1977, during the 100-yr event with low-flow conditions on the Russian River.

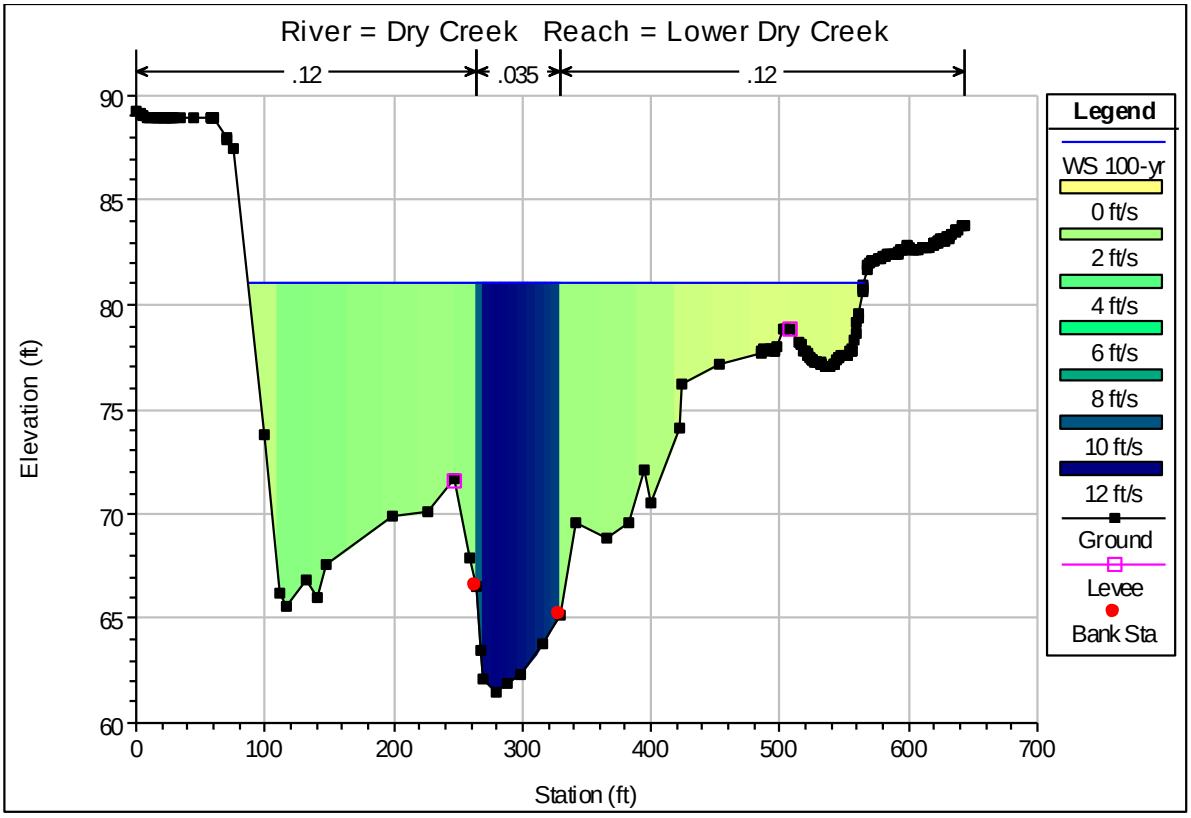

Figure 9. Velocity distribution cross-section 1977.

The velocity distribution indicates that maximum velocities occur in the channel (i.e., between the bank stations), and low velocities occur on the heavily vegetated overbank. The in-channel velocities reach nearly 11.5 ft/s. Right bank and left bank velocities fall below 3 ft/s. As discussed in a successive section (6.2), the overbank velocities are not sufficient to induce significant erosive processes on the vegetated overbank portions of the Dry Creek channel. The following scour analysis focuses in the channel, where the velocities are higher and able to mobilize the channel bed materials.

6 SCOUR ANALYSIS

Scour occurs when moving water erodes the channel bed. Several physical conditions lead to this process such as channel constrictions, meander, changes in sediment supply, and flood events. At the lower reach of Dry Creek, scour may occur through three independent processes: (1) long-term degradation of the stream profile due to reduced sediment loading after the closure of Warm Springs Dam, (2) bed-profile lowering due to an initial lowering of Dry Creek's hydraulic tailwater control and subsequent head-cutting of the channel, and (3) live-bed scour of the channel bed due to high flow events on Dry Creek. As section 4 illustrated, the lower reach of Dry Creek has reached an equilibrium bed elevation profile since dam closure, and therefore scour processes (1) and (2) are not expected to dominate. The following scour analysis focuses on event-driven erosion of the channel bed.

Event-based scour calculation procedures estimate the maximum scoured depth, which is measured from the water surface to the computed elevation of the eroded bed. Such calculations facilitate elevation recommendations for future, underground pipeline installations. This section presents two approaches for determining the erosion potential of Dry Creek, as well as two methodologies for estimating the maximum expected scoured depths. For clarity, this section provides results in terms of scoured bed elevation profiles. Appendix A provides details from the scoured depth calculations.

6.1 Shields Number

The Shields (or Mobility) Number predicts the beginning of bed movement by considering the conditions of the channel. This dimensionless value may be calculated as follows (Transportation Association of Canada [TAC], 2004, p. 70):

$$M_n = \frac{yS}{(s-1)D} \qquad \text{Equation 1}$$

where y = [hydraulic] depth, S = channel bed slope, D = characteristic grain size (D_{50}), and s = the specific gravity of bed material sediments (2.65). For cohesionless gravel channels, $M_n > 0.045$ indicates sufficient conditions for the movement of bed materials (TAC 2004). This parameter shows that the possibility of bed movement increases with depth, and subsequently, flood frequency. Likewise, Equation 1 states that increasing the grain size reduces the erosive potential of the bed. A larger characteristic grain size generally implies heavier bed material particles, which possess more resistance to movement against forces induced by flowing water.

Incorporating the HEC-RAS results from Section 5.2 and the representative grain size of 11 mm, Shields Numbers were calculated for several flood events. Table 3 lists these values near the location of the anticipated pipeline crossing.

Table 3. Shields Numbers for each cross-section.

Event	M_n		
	Cross-section 2536	Cross-section 1977	Cross-section 1498
Q_1	0.22	0.18	0.17
Q_2	0.38	0.33	0.32
Q_5	0.52	0.48	0.47
Q_{10}	0.55	0.51	0.51
Q_{50}	0.63	0.60	0.59
Q_{100}	0.64	0.61	0.60

Clearly, Table 3 presents Mobility Numbers in excess of 0.045, indicating that bed mobility is expected during flood events and bed scour can occur.

6.2 Critical Velocity

Another approach for predicting bed mobility includes calculation of the critical velocity. The critical velocity represents a threshold at which incipient particle motion occurs. As such, when the stream velocity exceeds this critical velocity, movement of the bed material is expected. The following equation estimates this velocity (TAC, 2004, p. 70):

$$V_{critical} = 1.58 g^{0.5} y^{0.1} (s-1)^{0.5} D^{0.4} \qquad \text{Equation 2}$$

where g = gravitational constant, y = [hydraulic] depth, s = relative density, and D = characteristic grain size (D_{50}). Incorporating the D_{50} of the bed material and hydraulic depths modeled in HEC-RAS into the above equation provides estimates of critical velocities for bed mobility at the project location. Table 4 compares the critical velocities and the channel velocities (v_{RAS}) modeled in HEC-RAS.

Table 4. Comparison of critical velocities and modeled velocities.

Event	Cross-section 2536		Cross-section 1977		Cross-section 1498	
	v_{RAS} (ft/s)	$v_{critical}$ (ft/s)	v_{RAS} (ft/s)	$v_{critical}$ (ft/s)	v_{RAS} (ft/s)	$v_{critical}$ (ft/s)
Q_1	4.1	3.5	6.2	3.6	5.3	3.6
Q_2	6.6	3.7	8.8	3.8	7.9	3.8
Q_5	8.5	3.8	10.3	4.0	9.2	4.0
Q_{10}	8.9	3.8	10.6	4.0	9.5	4.0
Q_{50}	10.1	3.8	11.3	4.1	10.4	4.1
Q_{100}	10.2	3.8	11.3	4.1	10.4	4.1

Table 4 shows that in every cross-section, the modeled velocity exceeds the critical velocity. In agreement with the Shields number analysis, the critical velocity indicates that scour can be expected at these cross-sections during flood conditions.

6.3 Competent Velocity Method

The competent-velocity method determines a scoured depth such that the resultant channel velocity is less than the critical velocity for bed mobility. In this method, the hydraulic depth, velocity, and discharge are calculated within the extents of an un-scoured channel. The hydraulic depth is incrementally lowered, effectively increasing the flow area of the channel, until the modeled velocity falls below the critical velocity. The final hydraulic depth (i.e., scoured depth), when subtracted from the water surface elevation, estimates the elevation of the scoured bed.

Figure 10 and Figure 11 present the outcome of the competent velocity method for each flood event for the no backwater condition and the 1.5-yr coincident event on the Russian River, respectively.

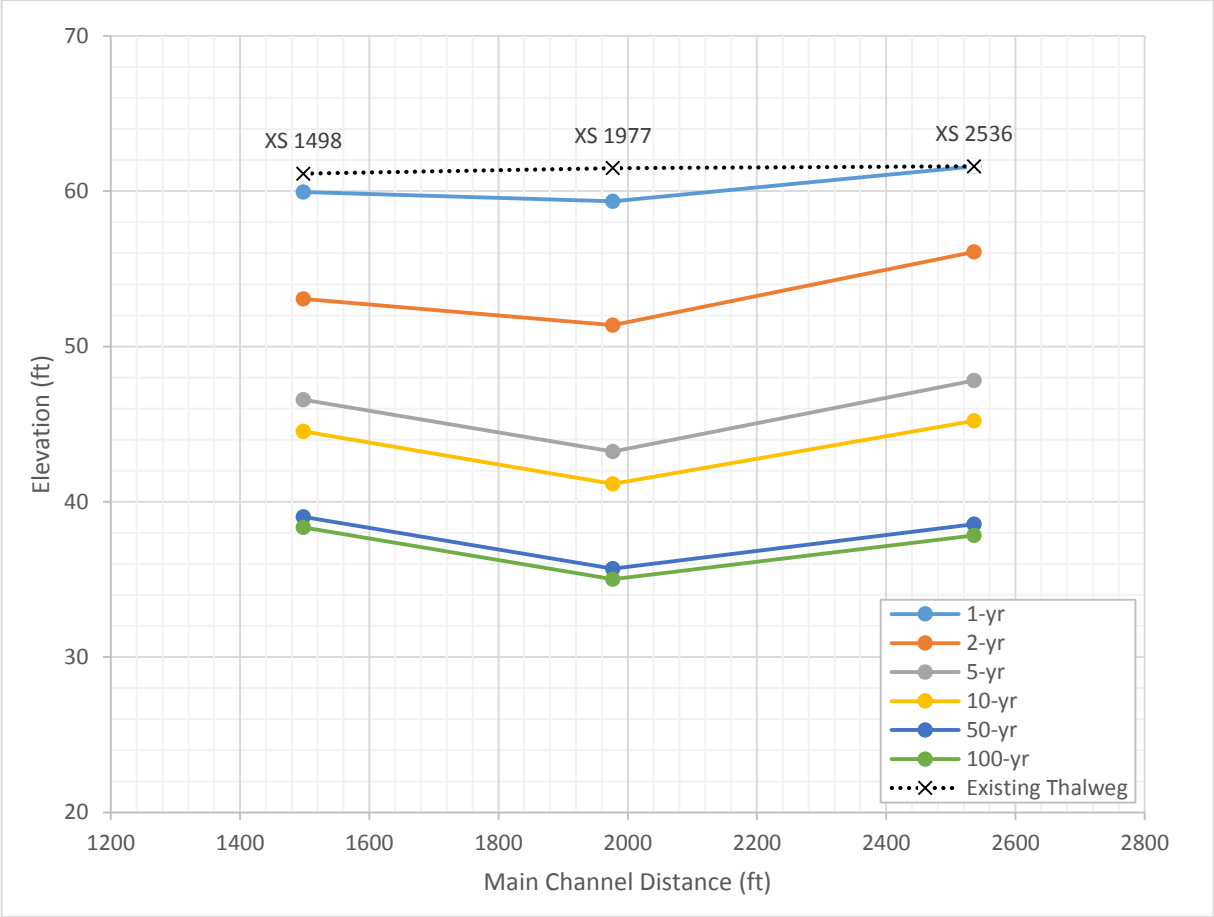

Figure 10. Scoured bed elevations from the competent velocity method (no Russian River backwater condition).

The depth of scour predicted by the competent velocity method approaches 26.5 ft. at cross-section 1977 during the 100-yr event (Figure 10). As a result, the lowest expected (maximum scoured) bed elevation is approximately 35 ft. For each flood event, cross-section 1977 consistently develops the deepest scour depths, and hence lowest scoured bed elevation. Incidentally, the maximum velocities occur at cross-section 1977 (Figure 7), highlighting the influence of velocity on scour potential.

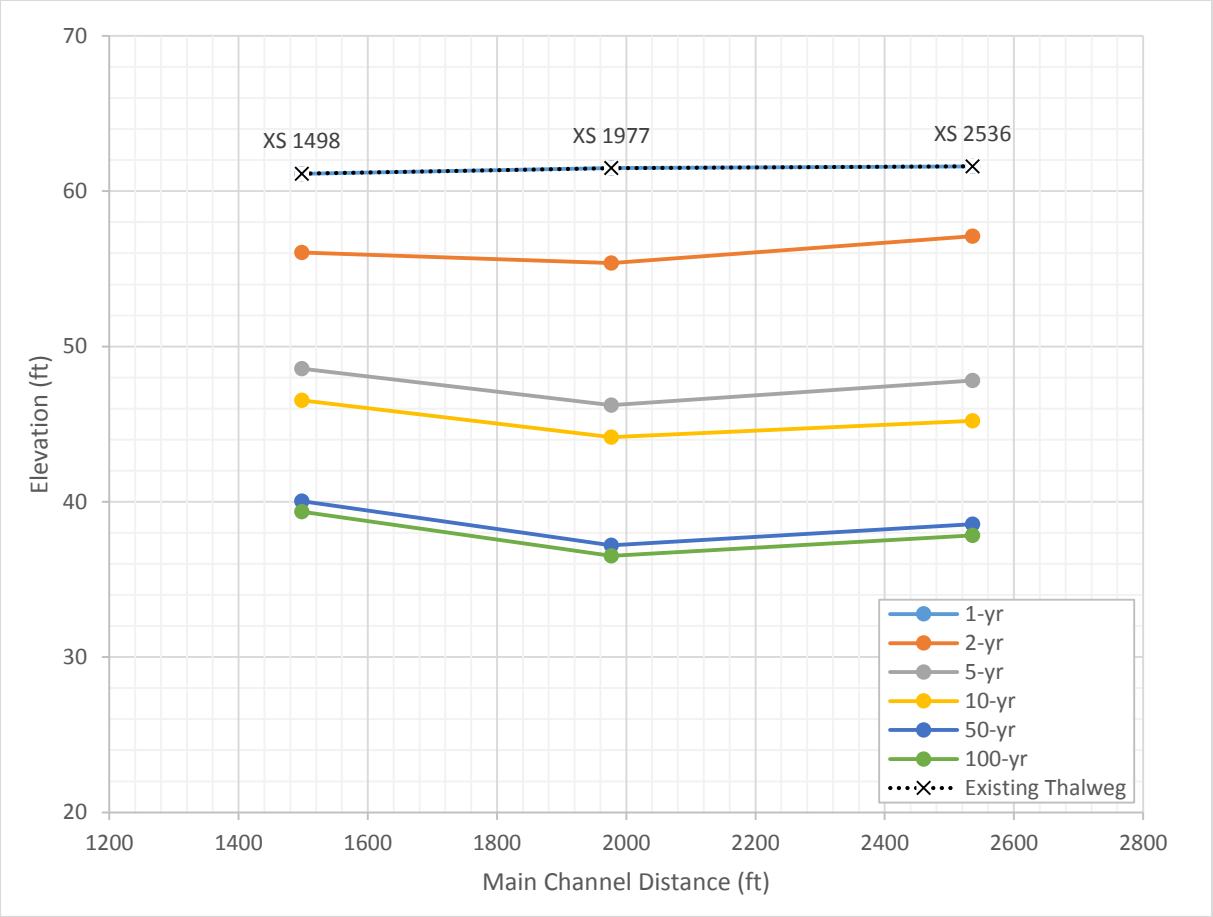

Figure 11. Scoured bed elevations from the competent velocity method (1.5-yr Russian River coincident event).

The competent velocity method estimates that the depth of material scoured from the channel bed approaches 25 ft. at cross-section 1977 during the 100-yr event (Figure 11). As a result, the bed scours to a minimum elevation of 36.5 ft. at this location. Figure 11 shows that no scour occurs during the 1-yr event when the Russian River backwaters into Dry Creek due to a 1.5-yr event. As shown in Figure 8, in-channel velocities fall below 2 ft/s during the 1-yr event, and these velocities are not large enough to initiate movement of the bed materials. Again, the greatest scour depths occur at cross-section 1977, where the largest magnitudes of velocity occur in the reach of interest.

6.4 Blench's Regime Method

Blench's equation determines a regime, or mean, depth of scour. This method is based on the flow in the channel and the grain size. The following equation calculates the regime depth of scour:

$$y_r = \left(\frac{q^2}{F_{b\theta}}\right)^{\frac{1}{3}}$$ Equation 3

where q = discharge per unit width (m^2/s), and $F_{b\theta}$ is a bed factor based on the median grain diameter (D_{50}) . Figure 12 provides an estimate of the bed factor, given the representative grain size.

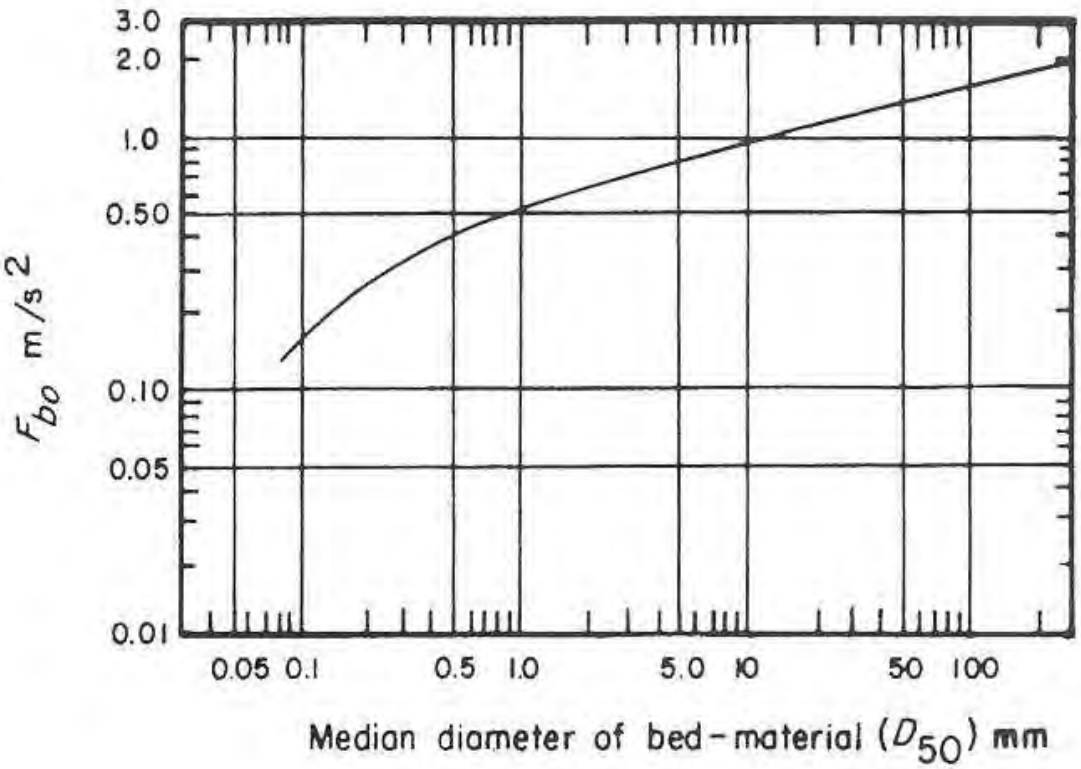

Figure 12. "Blench's $F_{b\theta}$ factor versus bed-material grain size". A Guide to Bridge Hydraulics, p. 91, Transportation Association of Canada (2004).

The scoured depth results from multiplying the regime depth by a factor of safety, Z. The Z-factor depends on the degree of meander in the stream, and it generally ranges 2 ± 0.75. Selection of the Z-multiplier requires inspection of the bends from aerial photography and engineering judgement. Figure 13 and Figure 14 provide profiles of the scoured bed elevations using a Z-value of 2, for the normal depth and 1.5-yr coincident events, respectively.

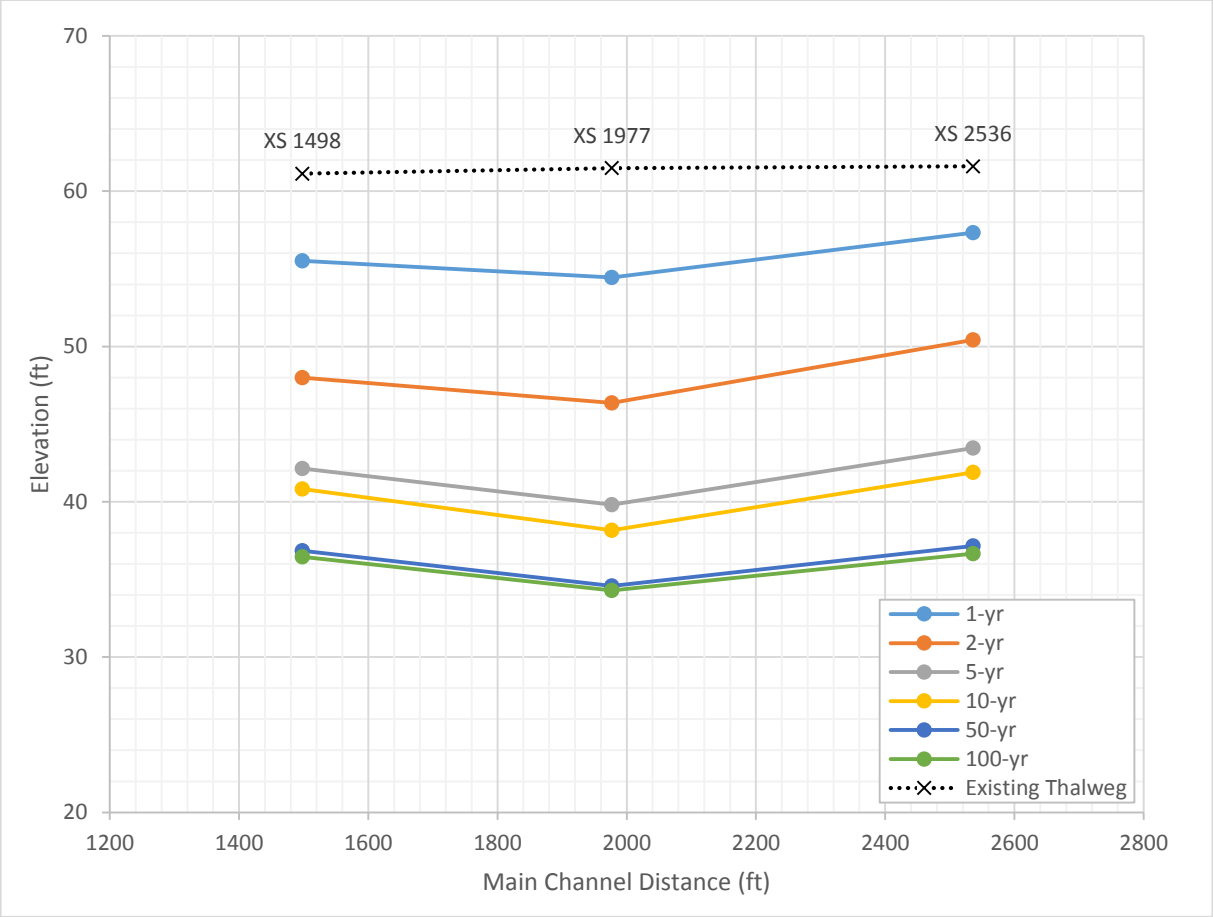

Figure 13. Scoured bed elevations resulting from Blench's regime equation (no Russian River backwater condition).

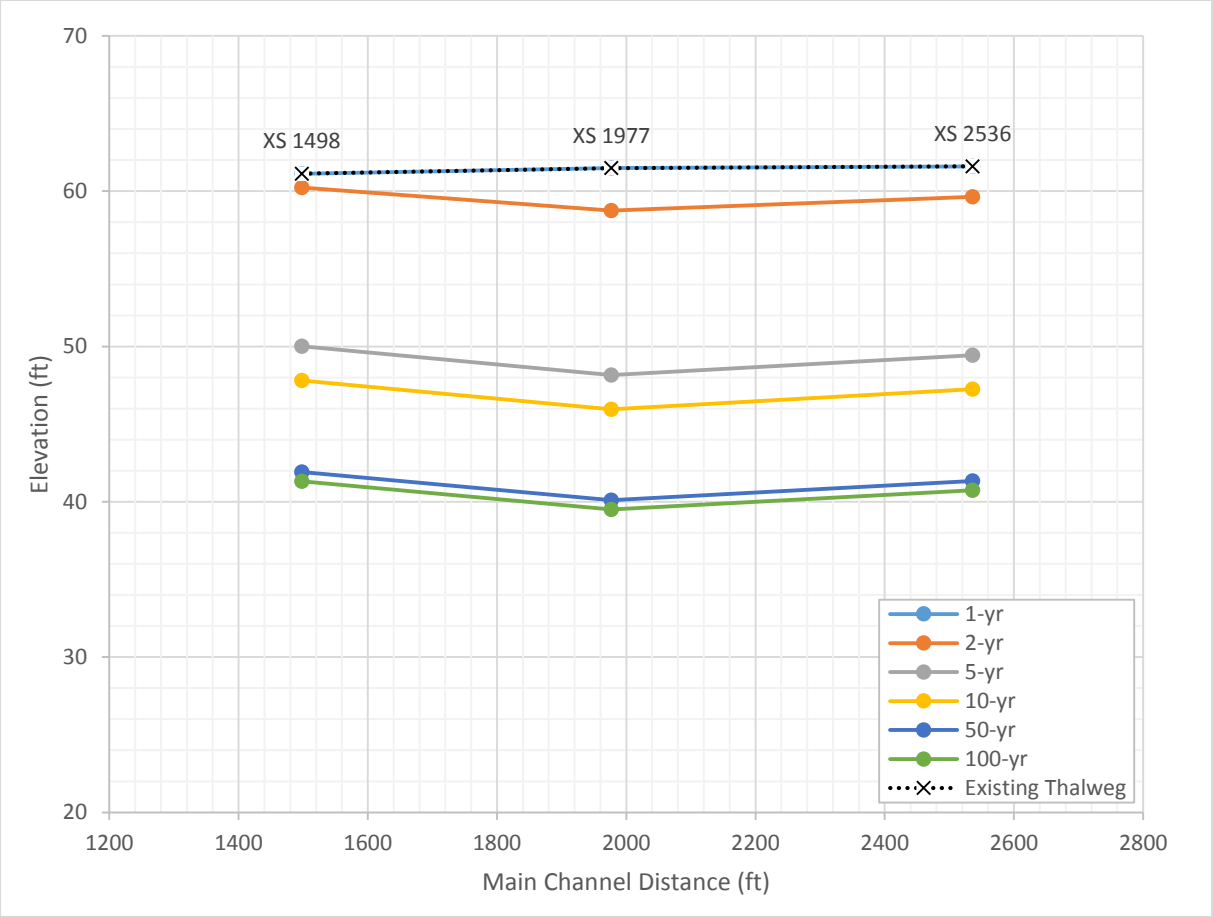

Figure 14. Scoured bed elevations resulting from Blench's regime equation (1.5-yr Russian River coincident event).

The Blench regime equation, paired with normal depth-condition hydraulic output, predict scoured bed elevations ranging 34.3 – 57.3 ft. (Figure 13). Alternatively, paired with the 1.5-yr coincident event hydraulic output, Blench's equation predicts scoured bed elevations ranging 0 – 36.8 ft. (Figure 14). Figure 14 illustrates that no bed erosion occurs during the 1-yr event, and no more than 2.5 ft. of erosion is expected during the 2-yr event. Consistent with the competent velocity approach, cross-section 1977 exhibits the greatest scour depth.

7 SUMMARY AND CONCLUSIONS

In summary, the Shields Number and critical velocity parameter indicate that lower Dry Creek is susceptible to scour for flood frequencies ranging between the 1-yr and the 100-yr events. The two scour methodologies predict similar scoured bed elevations. The competent velocity approach shows that during the 100-yr event, scoured bed elevations range 35 – 38 ft. Blench's regime method predicts

scoured bed elevations in the range of 34 – 37 ft. for the 100-yr event. In both methodologies, the maximum predicted depth of scour is approximately 27 ft. below the existing channel bed. As this depth does not exceed the thickness of the upper sand-gravel layer, the channel is not expected to scour into the underlying clay layer.

The hydraulic analysis illustrates that the low-flow conditions on the Russian River allow for higher channel velocities on Dry Creek, as opposed to the 1.5-yr coincident event, and more significantly influences the depth of scour for lower flood frequencies. Figure 10, 11, 13, and 14 provide a general guide for the pipeline placement, as the scour depth varies along the reach. Once the location of the proposed pipeline has been firmly established, the expected scour elevations can be determined by interpolation between the elevations provided in these figures. In anticipation of the 100-yr event, NHC recommends placement of the crown of the pipeline no higher than elevation 34 ft. (NAVD 1988) through this reach of Dry Creek.

Reaching these recommended elevations requires excavation or directionally drilling approximately 27 feet below the existing bed elevation and materials, or as much as 55 ft. below the overbank. Should this excavation be more costly or laborious than anticipated by the City of Healdsburg, alternative scour countermeasures are available which reduce the required depth of the pipeline placement. One such countermeasure entails the construction of a roughened riffle or similar type structure. These structures require the placement of channel bed slope protection, which feature larger grain sizes and provide resilience to scour during extreme events, while still allowing for upstream and downstream passage of aquatic organisms, and passage of bed material sediments over the roughened riffle. If scour counter-measures are the preferred approach, NHC is available to prepare and discuss possible alternatives.

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APPENDIX A: SCOUR CALCULATIONS

Table 1. Scour calculations with the competent velocity method for the no backwater condition on the Russian River.

Event	Cross-Section 2536								
	Channel Discharge (cfs)	Channel Top Width (ft)	Channel Hydraulic Depth (ft)	Critical Velocity (ft/s)	Channel Velocity (ft/s)	W.S. Elevation (ft)	Scoured Bed Elevation (ft)	Min. Channel Elevation (ft)	Depth of Scour (ft)
Q_1	2,195	81.8	7.5	3.7	3.6	69.4	61.6	61.6	0.0
Q_2	6,029	81.8	18.0	4.1	4.1	74.1	56.1	61.6	5.5
Q_5	10,764	81.8	30.5	4.3	4.3	78.3	47.8	61.6	13.8
Q_{10}	11,940	81.8	34.0	4.3	4.3	79.2	45.2	61.6	16.4
Q_{50}	15,489	81.8	43.0	4.4	4.4	81.6	38.6	61.6	23.1
Q_{100}	15,899	81.8	44.0	4.5	4.4	81.8	37.8	61.6	23.8
Event	Cross-Section 1977								
	Channel Discharge (cfs)	Channel Top Width (ft)	Channel Hydraulic Depth (ft)	Critical Velocity (ft/s)	Channel Velocity (ft/s)	W.S. Elevation (ft)	Scoured Bed Elevation (ft)	Min. Channel Elevation (ft)	Depth of Scour (ft)
Q_1	2,209	66.6	9.0	3.8	3.7	68.3	59.3	61.5	2.2
Q_2	5,821	66.6	21.5	4.1	4.1	72.9	51.4	61.5	10.1
Q_5	9,758	66.6	34.0	4.3	4.3	77.2	43.2	61.5	18.3
Q_{10}	10,785	66.6	37.0	4.4	4.4	78.2	41.2	61.5	20.3
Q_{50}	13,349	66.6	45.0	4.5	4.5	80.7	35.7	61.5	25.8
Q_{100}	13,613	66.6	46.0	4.5	4.4	81.0	35.0	61.5	26.5
Event	Cross-Section 1498								
	Channel Discharge (cfs)	Channel Top Width (ft)	Channel Hydraulic Depth (ft)	Critical Velocity (ft/s)	Channel Velocity (ft/s)	W.S. Elevation (ft)	Scoured Bed Elevation (ft)	Min. Channel Elevation (ft)	Depth of Scour (ft)
Q_1	2,206	83.6	7.5	3.7	3.5	67.5	60.0	61.1	1.2
Q_2	6,323	83.6	19.0	4.1	4.0	72.1	53.1	61.1	8.1
Q_5	10,825	83.6	30.0	4.3	4.3	76.6	46.6	61.1	14.6
Q_{10}	11,917	83.6	33.0	4.3	4.3	77.5	44.5	61.1	16.6
Q_{50}	15,199	83.6	41.0	4.4	4.4	80.0	39.0	61.1	22.1
Q_{100}	15,575	83.6	42.0	4.4	4.4	80.4	38.4	61.1	22.8

Table 2. Scour calculations with the competent velocity method for the 1.5-yr coincident event on the Russian River.

Event	Cross-Section 2536								
	Channel Discharge (cfs)	Channel Top Width (ft)	Channel Hydraulic Depth (ft)	Critical Velocity (ft/s)	Channel Velocity (ft/s)	W.S. Elevation (ft)	Scoured Bed Elevation (ft)	Min. Channel Elevation (ft)	Depth of Scour (ft)
Q_1	1,708	81.8	6.0	3.6	3.5	80.1	61.6	61.6	0.0
Q_2	5,428	81.8	17.0	4.0	3.9	80.4	61.6	61.6	0.0
Q_5	10,357	81.8	30.5	4.3	4.2	81.4	50.9	61.6	10.7
Q_{10}	11,597	81.8	34.0	4.3	4.2	81.7	47.7	61.6	13.9
Q_{50}	15,319	81.8	43.0	4.4	4.4	82.8	39.8	61.6	21.8
Q_{100}	15,747	81.8	44.0	4.5	4.4	83.0	39.0	61.6	22.6
Event	Cross-Section 1977								
	Channel Discharge (cfs)	Channel Top Width (ft)	Channel Hydraulic Depth (ft)	Critical Velocity (ft/s)	Channel Velocity (ft/s)	W.S. Elevation (ft)	Scoured Bed Elevation (ft)	Min. Channel Elevation (ft)	Depth of Scour (ft)
Q_1	1,477	66.6	6.0	3.6	3.7	80.0	61.5	61.5	0.0
Q_2	4,675	66.6	17.5	4.1	4.0	80.3	61.5	61.5	0.0
Q_5	8,814	66.6	31.0	4.3	4.3	81.1	50.1	61.5	11.4
Q_{10}	9,825	66.6	34.0	4.3	4.3	81.3	47.3	61.5	14.2
Q_{50}	12,804	66.6	43.5	4.4	4.4	82.3	38.8	61.5	22.7
Q_{100}	13,144	66.6	44.5	4.5	4.4	82.5	38.0	61.5	23.5
Event	Cross-Section 1498								
	Channel Discharge (cfs)	Channel Top Width (ft)	Channel Hydraulic Depth (ft)	Critical Velocity (ft/s)	Channel Velocity (ft/s)	W.S. Elevation (ft)	Scoured Bed Elevation (ft)	Min. Channel Elevation (ft)	Depth of Scour (ft)
Q_1	1,648	83.6	5.5	3.6	3.6	80.0	61.1	61.1	0.0
Q_2	5,244	83.6	16.0	4.0	3.9	80.2	61.1	61.1	0.0
Q_5	10,030	83.6	28.0	4.3	4.3	80.8	52.8	61.1	8.3
Q_{10}	11,234	83.6	31.0	4.3	4.3	81.0	50.0	61.1	11.1
Q_{50}	14,805	83.6	40.0	4.4	4.4	81.9	41.9	61.1	19.3
Q_{100}	15,213	83.6	41.0	4.4	4.4	82.0	41.0	61.1	20.2

Table 3. Scour calculations for the Blench Regime approach for the no backwater condition on the Russian River.

Event	Cross-Section 2536								
	Channel Discharge (m^3/s)	Channel Top Width (m)	Unit Discharge (m^2/s)	y_r (m)	$Z*y_r$ (ft)	W.S. Elevation (ft)	Scoured Bed Elevation (ft)	Min. Channel Elevation (ft)	Depth of Scour (ft)
Q_1	62	24.9	2.5	1.8	12.1	69.4	57.3	61.6	4.3
Q_2	171	24.9	6.9	3.6	23.7	74.1	50.4	61.6	11.2
Q_5	305	24.9	12.2	5.3	34.8	78.3	43.5	61.6	18.1
Q_{10}	338	24.9	13.6	5.7	37.3	79.2	41.9	61.6	19.7
Q_{50}	439	24.9	17.6	6.8	44.4	81.6	37.2	61.6	24.4
Q_{100}	450	24.9	18.1	6.9	45.2	81.8	36.7	61.6	24.9
Event	Cross-Section 1977								
	Channel Discharge (m^3/s)	Channel Top Width (m)	Unit Discharge (m^2/s)	y_r (m)	$Z*y_r$ (ft)	W.S. Elevation (ft)	Scoured Bed Elevation (ft)	Min. Channel Elevation (ft)	Depth of Scour (ft)
Q_1	63	20.3	3.1	2.1	13.9	68.3	54.4	61.5	7.0
Q_2	165	20.3	8.1	4.0	26.5	72.9	46.4	61.5	15.1
Q_5	276	20.3	13.6	5.7	37.4	77.2	39.8	61.5	21.7
Q_{10}	305	20.3	15.0	6.1	40.0	78.2	38.2	61.5	23.3
Q_{50}	378	20.3	18.6	7.0	46.1	80.7	34.6	61.5	26.9
Q_{100}	385	20.3	19.0	7.1	46.7	81.0	34.3	61.5	27.2
Event	Cross-Section 1498								
	Channel Discharge (m^3/s)	Channel Top Width (m)	Unit Discharge (m^2/s)	y_r (m)	$Z*y_r$ (ft)	W.S. Elevation (ft)	Scoured Bed Elevation (ft)	Min. Channel Elevation (ft)	Depth of Scour (ft)
Q_1	62	25.5	2.5	1.8	11.9	67.5	55.5	61.1	5.6
Q_2	179	25.5	7.0	3.7	24.1	72.1	48.0	61.1	13.1
Q_5	307	25.5	12.0	5.2	34.4	76.6	42.1	61.1	19.0
Q_{10}	337	25.5	13.2	5.6	36.7	77.5	40.8	61.1	20.3
Q_{50}	430	25.5	16.9	6.6	43.2	80.0	36.8	61.1	24.3
Q_{100}	441	25.5	17.3	6.7	43.9	80.4	36.5	61.1	24.7

Note: Blench's regime formula requires input values in metric units.

Table 4. Scour calculations for the Blench Regime approach for the 1.5-yr coincident event on the Russian River.

Event	Cross-Section 2536								
	Channel Discharge (m^3/s)	Channel Top Width (m)	Unit Discharge (m^2/s)	y_r (m)	Z^*y_r (ft)	W.S. Elevation (ft)	Scoured Bed Elevation (ft)	Min. Channel Elevation (ft)	Depth of Scour (ft)
Q_1	48	24.9	1.9	1.6	10.2	80.1	61.6	61.6	0.0
Q_2	154	24.9	6.2	3.4	22.1	80.4	58.3	61.6	3.3
Q_5	293	24.9	11.8	5.2	33.9	81.4	47.4	61.6	14.2
Q_{10}	328	24.9	13.2	5.6	36.6	81.7	45.1	61.6	16.5
Q_{50}	434	24.9	17.4	6.7	44.1	82.8	38.7	61.6	22.9
Q_{100}	446	24.9	17.9	6.8	44.9	83.0	38.1	61.6	23.5
Event	Cross-Section 1977								
	Channel Discharge (m^3/s)	Channel Top Width (m)	Unit Discharge (m^2/s)	y_r (m)	Z^*y_r (ft)	W.S. Elevation (ft)	Scoured Bed Elevation (ft)	Min. Channel Elevation (ft)	Depth of Scour (ft)
Q_1	42	20.3	2.1	1.6	10.6	80.0	61.5	61.5	0.0
Q_2	132	20.3	6.5	3.5	22.9	80.3	57.4	61.5	4.1
Q_5	250	20.3	12.3	5.3	35.0	81.1	46.1	61.5	15.4
Q_{10}	278	20.3	13.7	5.7	37.6	81.3	43.7	61.5	17.7
Q_{50}	363	20.3	17.9	6.8	44.8	82.3	37.5	61.5	24.0
Q_{100}	372	20.3	18.3	7.0	45.6	82.5	36.8	61.5	24.7
Event	Cross-Section 1498								
	Channel Discharge (m^3/s)	Channel Top Width (m)	Unit Discharge (m^2/s)	y_r (m)	Z^*y_r (ft)	W.S. Elevation (ft)	Scoured Bed Elevation (ft)	Min. Channel Elevation (ft)	Depth of Scour (ft)
Q_1	47	25.5	1.8	1.5	9.8	80.0	61.1	61.1	0.0
Q_2	148	25.5	5.8	3.2	21.2	80.2	59.0	61.1	2.1
Q_5	284	25.5	11.1	5.0	32.7	80.8	48.1	61.1	13.0
Q_{10}	318	25.5	12.5	5.4	35.3	81.0	45.7	61.1	15.4
Q_{50}	419	25.5	16.5	6.5	42.4	81.9	39.4	61.1	21.7
Q_{100}	431	25.5	16.9	6.6	43.2	82.0	38.8	61.1	22.4

Note: Blench's regime formula requires input values in metric units.

MILLER PACIFIC ENGINEERING GROUP

Attachment A4 - Magnolia Force Mains Relocation Feasibility Investigation

December 9, 2016
File: 2363.001trans.doc

City of Healdsburg Utilities Department
401 Grove Street
Healdsburg, California 95448-4723

Attn: Mr. Patrick Fuss, PE, Principal Water/Wastewater Engineer

Re: Evaluation of Conceptual Trenchless Crossing at Dry Creek
City of Healdsburg Magnolia Force Main Relocation
Healdsburg, California

Dear Mr. Fuss,

We are pleased to submit our evaluation of conceptual trenchless crossing alternatives for the relocation of the City of Healdsburg's Magnolia Force Main. The project will include relocating two existing 14-inch-diameter force mains that cross Dry Creek from the existing pump station at Magnolia Drive. The City is considering relocating the pipelines with either a bridge-mounted, aerial crossing over the creek or a trenchless undercrossing below the scour zone of the stream bed. The primary purpose of our evaluation is to assess if a trenchless undercrossing of Dry Creek is feasible and cost effective as compared with a bridge-mounted crossing which was prepared previously by others.

We appreciate the opportunity to work with the City of Healdsburg on this project. Please contact us if you have any questions regarding this report.

Very truly yours,
MILLER PACIFIC ENGINEERING GROUP

REGISTERED PROFESSIONAL ENGINEER
RUSSELL C. AREND
No.3031
Exp. 6/30/17
GEOTECHNICAL
STATE OF CALIFORNIA

REGISTERED PROFESSIONAL ENGINEER
SCOTT A. STEPHENS
2398
Exp. 6/30/17
GEOTECHNICAL
STATE OF CALIFORNIA

Rusty Arend
Geotechnical Engineer No. 3031
(Expires 6/30/17)

Scott Stephens
Geotechnical Engineer No. 2398
(Expires 6/30/17)

Memorandum

To:	Patrick Fuss, PE (City of Healdsburg)	Project:	Magnolia Force Main Relocation
From:	Rusty Arend, GE and Scott Stephens, GE	cc:	Melanie Carrido, PE (The Covello Group)
Date:	December 9, 2016	Job No.:	2363.001
Subject:	Evaluation of Conceptual Trenchless Crossing at Dry Creek		

Revision Log

Revision No.	Date	Revision Description
0	November 4, 2016	Draft, Issued for City Review
1	December 9, 2016	Final

1.0 Introduction

In accordance with our Proposal and Fee Estimate dated August 30, 2016, Miller Pacific Engineering Group (MPEG) has completed our evaluation of conceptual trenchless construction alternatives for the proposed relocation of the City of Healdsburg's Magnolia Force Main. The primary purpose of our evaluation is to assess if a trenchless undercrossing of Dry Creek is feasible and cost effective as compared with a bridge-mounted crossing. Issuance of this report completes our Task 2 services outlined in our Proposal. Future services may include supplemental geotechnical exploration and laboratory testing, preliminary trenchless design, and value engineering and cost estimating services.

2.0 Project Description

The project site is located near the existing force main crossing of Dry Creek, just east/southeast of the Magnolia Pump Station and west/southwest of the intersection of Magnolia Drive and Skinner Road in Healdsburg, California. The project will include relocating two existing 14-inch-diameter force mains that cross Dry Creek from the existing pump station. Available drawings indicate the existing force mains consist of ductile iron and asbestos cement pipes that were constructed below the stream bed in the 1970's using open trench methods. One (and possibly both) of the force mains have become exposed on the bottom of the stream leaving them vulnerable to damage. To reduce the risk of damage, the City is considering relocating the pipelines by either an aerial crossing over the creek or a trenchless undercrossing below the scour zone of the stream bed.

As part of a separate project in the vicinity of the existing force main crossings, the City constructed an aerial crossing of Dry Creek for a 12-inch-diameter, polyvinyl chloride (PVC) recycled water pipeline. The crossing consists of a pipeline suspension bridge which was completed several years ago and is currently in service. A similar bridge design has been prepared by GHD in which the existing bridge would be demolished and a new suspension bridge would be constructed to accommodate the two new force mains and the existing recycled water pipeline (GHD, 2014). Some of the components from the existing bridge would be salvaged and re-used for the new crossing. The Engineer's Estimate for the new bridge crossing (prepared in 2014) is reportedly about $2.7 million.

An undercrossing alternative would include relocating the force main below the stream bed using trenchless construction methods. While the crossing length will depend upon the approach that is selected, a minimum length of about 500 feet is anticipated. As part of a previous study, the City conducted a scour analysis of Dry Creek which indicates the maximum predicted depth of scour for a 100-year flood event is 27 feet below the existing stream bed (Northwest Hydraulics Consultants, Inc., 2016). Any undercrossing alternative would be required to extend below this predicted scour depth.

3.0 Site Conditions

3.1 Surface Conditions

As shown in the "Concept-Level" Drawings (Appendix A), the project site is bounded to the north by Magnolia Drive and tilled fields, to the west and south by vineyards, and to the east by a private residence and fields. The West Slough, an intermittent tributary which runs roughly north/south, parallels the northwestern boundary of the site and intersects Dry Creek just west of the crossing location. Surface conditions within the proposed work areas generally consist of grass and low-lying shrubbery whereas the areas adjacent to the creek banks are heavily vegetated with trees and shrubbery.

A topographic survey of portions of the project area was completed as part of the design for the bridge-mounted crossing alternative. Within the proposed project area, the ground surface elevation on the north side of the creek channel is at roughly 86 to 88 feet (NAVD 88) whereas the surface on the south side of the channel is terraced and varies from about 76 to 84 feet. A "riparian corridor" is delineated on the drawings for the bridge alternative with limits on the north and south side of the creek roughly corresponding to contour elevations of 86 feet and 75 feet, respectively. The Dry Creek stream bed elevation is shown at about 67 feet.

Site access is provided to the north side of Dry Creek by Magnolia Drive and to the south side by an unpaved access road. Existing structures include the Magnolia Pump Station and related facilities, the recycled water pipeline suspension bridge, and a small, wooden barn structure. Underground utilities include the two existing sewer force mains and recycled water line which run through their respective easements toward the west end of the site. Overhead power lines parallel Magnolia Drive and the unpaved access road and cross Dry Creek just west of the existing recycled water pipeline bridge. The approximate locations of the existing improvements are shown on the Concept-Level Drawings in Appendix A.

3.2 Geotechnical Conditions

A geotechnical investigation was completed at the project site by DCM/GeoEngineers as part of the design for the recycled water pipeline project (DCM, 2009). The DCM report includes reference subsurface data from previous investigations along with project-specific borings located near the proposed force main crossing. Collectively, available subsurface data within the crossing vicinity includes eleven borings, two test pits, and one well drilling log which were advanced to depths up to about 101.5 feet below ground surface. The borings, well drilling log and laboratory test results from the previous investigations are provided under Appendix B (test pit logs were not included in the geotechnical report). A geotechnical profile illustrating subsurface conditions near the Dry Creek crossing is also presented in Appendix A as Sheets M-1 and H-1 and in Appendix B as Plate II-9.

Anticipated subsurface conditions generally consist of non-cohesive sand and gravel soils over hard, clayey soils. The sand and gravel soils were encountered to approximate depths of 43 to 48 feet on the south side of the creek (approximate elevation of about 35 to 40 feet), and to about 79 feet on the north side of the creek (approximate elevation of about 10 feet). The sand and gravel were generally medium dense to very dense and were classified under the Unified Soil Classification System as silty and clayey sand (SM and SC), well-graded sand and well-graded sand with silt (SW and SW-SM), poorly graded sand and poorly graded sand with silt (SP and SP-SM), well-graded gravel (GW), poorly graded gravel (GP), and poorly graded gravel with silt and sand (GP-GM). Hard, fat clay (CH) was encountered below the sand and gravel to the depths explored. The clayey soils contain varying amounts of gravel, clayey sand, and clayey gravel and exhibited vague evidence of rock fabric, suggesting the material may be very severely to completely weathered, soft bedrock.

3.3 Groundwater

Groundwater is shown on the boring logs ranging from less than 1 foot below ground surface in boring RB-3-69 to about 27 feet below ground surface in borings B-22 and B-23. These water levels correspond to an elevation of about 57 to 65 feet. Based on the available data, DCM recommended a groundwater level corresponding to 9 feet below ground surface for design of temporary dewatering and shoring systems for the recycled water pipeline. This would correspond to an elevation of about 67 to 75 feet on the south side of the creek and about 77 to 79 feet on the north side of the creek. Groundwater levels are expected to change seasonally and correlate with fluctuations in the adjacent Dry Creek.

4.0 Overview of Feasible Trenchless Construction Methods

If a trenchless approach is selected for the creek crossing, the trenchless construction method must be capable of meeting project requirements and must be appropriate for use given the specific conditions that will be encountered during installation. Some of the key constraints that must be considered during planning and design of the trenchless installation are discussed below.

> *Minimum Depth* – The City conducted a scour analysis of Dry Creek which indicates the maximum predicted depth of scour for a 100-year flood event is 27 feet below the existing stream bed (Northwest Hydraulics Consultants, Inc., 2016). MPEG has assumed a minimum depth of 37 feet below the stream bed will be required to account for the maximum predicted scour depth plus

an additional 10 feet of embedment. This would correspond to an elevation of about 30 feet based on the stream channel information from the bridge replacement drawings.

Alignment Length –To minimize impacts to adjacent properties and the need for new easements, the crossing alignment will be located between Magnolia Drive (to the north) and the unpaved access road (to the south). Using these constraints, the maximum alignment plan length is estimated to be about 1,100 feet. Additionally, the crossing will likely need to extend far enough beyond the creek banks to avoid impacting riparian areas. Based upon the extent of the "riparian corridor" shown in the drawings for the pipe bridge alternative, an estimated minimum crossing length of 500 feet is anticipated.

Anticipated Ground Conditions – From available subsurface data, ground conditions are expected to consist of relatively deep deposits of sand and gravel over hard, clayey soils. The sand and gravel are generally classified as non-cohesive and are anticipated to exhibit running behavior above the groundwater table and flowing behavior below the groundwater table. The hard, clayey soils are anticipated to exhibit firm, cohesive behavior during excavation. These ground behaviors are further described in the Tunnelman's Ground Classification System for Soils on Plate A-3 in Appendix B. Considering the crossing will likely be well below the groundwater table, the selected trenchless method should be capable of controlling flowing ground.

Pipe Size and Material – The selected trenchless method must allow for installation of two 14-inch-diameter force main pipelines. While the pipe material has not yet been selected, we understand that high-density polyethylene (HDPE) or fusible PVC materials are being considered.

Considering the constraints described above, trenchless construction methods considered technically feasible are limited to microtunneling and horizontal directional drilling. These methods are discussed in greater detail in the following sections. It should be noted that there are a number of other methods that are commonly used in trenchless installations such as auger boring, guided boring, pipe ramming and pipe jacking using a shield or other open face system. These methods are not considered technically feasible since they are not capable of controlling the flowing ground conditions that are anticipated during excavation. Additionally, the length of the crossing exceeds the typical installation lengths associated with the pipe ramming and guided boring methods.

5.0 Microtunneling

5.1 Overview

Microtunneling for this project would be a two-pass pipe jacking approach in which a steel casing is installed to provide the initial ground support and the force main pipes are then inserted into the casing. The American Society for Civil Engineers Standard 36-15 (ASCE, 2015) defines microtunneling as a trenchless construction method for installing pipelines in which all of the following elements are utilized during construction:

Remote Control – The microtunneling boring machine (MTBM) is operated from a control panel, normally located on the surface. The system simultaneously installs the pipe as the ground is excavated and removed. Personnel entry is not required for routine operation.

Guidance – The guidance system usually consists of a laser beam projected onto a target in the MTBM. With this system, the MTBM is capable of installing gravity sewers or other types of pipelines to the required tolerance for line and grade.

Pipe Jacking – A pipeline is constructed by consecutively pushing pipes and the MTBM through the ground, using a jacking system for thrust.

Continuous Support – Continuous pressure is provided to the face of the excavation to balance groundwater and earth pressures.

Hydraulic jacks, located in the jacking shaft, advance the steel casing into the ground while simultaneously excavating the face using a cutter wheel. The pipe string is advanced by adding casing segments in the jacking shaft until the MTBM reaches the receiving shaft. The MTBM is steered as the casing is advanced by reference to a laser or other guidance system. Lubrication is often added to minimize the force required to advance the casing. After the casing is installed, the annular space between the ground and casing is often contact grouted. Following contact grouting, the product pipes are inserted inside the casing and set to the design grade. The annular space between the casing and installed pipe is then backfilled with cellular grout to complete the installation.

Microtunneling typically utilizes a slurry circulation system which provides two primary functions: (1) in combination with mechanical pressure, the slurry counterbalances the earth and groundwater pressures at the face of the MTBM; (2) the slurry is used to transport spoils to the ground surface for separation and removal. One of the significant advantages of microtunneling is that it can provide continuous, positive support to the tunnel face during excavation, making it a suitable method for handling the anticipated flowing ground conditions.

5.2 Case History

Microtunneling was used to complete an undercrossing of the Russian River as part of the Santa Rosa Geysers Recharge project (Smith, Anderson, and Romero, 2002). We understand the crossing location is just south of the Highway 101 overcrossing of the Russian River, roughly a half mile northeast of the Magnolia Pump Station. The crossing was completed around 2002 and included advancing roughly 700 feet of 60-inch steel casing through alluvial soils consisting of predominantly sand and gravel. Large diameter drilled shaft methods were used to construct the jacking and receiving shafts to depths ranging from about 90 to 100 feet below ground surface. The depths of the shafts were reportedly selected to locate the tunnel in older alluvial soils which were thought to contain fewer cobbles and boulders than the shallower, younger alluvium.

The successful completion of a microtunnel crossing within proximity to the site further suggests that microtunneling is a technically feasible alternative. It should be noted that the total 2002 cost for the

crossing was reportedly $2.8 million with the costs for the shaft and tunneling components equating to $1.6 million and $1.2 million, respectively.

5.3 Shafts

If a microtunnel option is selected, shafts would be required on both sides of the crossing to facilitate launch and retrieval of the MTBM. Shaft design and construction is largely dependent on the available work area, methods used to control groundwater, and the shaft support system. The support system must be designed to resist soil, groundwater, surcharge, and buoyancy loads anticipated during construction and operation. The shaft support would include a base slab or other means of limiting groundwater infiltration into the bottom of the shaft and supporting hydrostatic uplift pressures that develop after shaft unwatering.

Shaft sizes and work area requirements for microtunneling vary depending on the contractor's equipment, means and methods. The size of the launching shaft is generally controlled by the length of the MTBM, the length of individual casing segments, the size of the jacking equipment, the dimensions of the thrust block and shaft seal, and other factors. The receiving shaft is typically smaller and requires enough space for the shaft seal and for exit and retrieval of the MTBM. Circular shaft configurations are often used as they are more structurally efficient and can be constructed without the use of internal bracing.

Groundwater control measures are required so that the shafts are free of standing water and seepage throughout construction. Groundwater control during shaft construction and operation is generally achieved through dewatering to lower the water table or by installing watertight excavation support systems which provide groundwater cut-off. Based upon the anticipated ground conditions and shaft depths, a watertight excavation support system would likely be required. Shaft support systems that are watertight and considered technically feasible for the anticipated ground conditions and shaft depths generally include:

- Secant Piles
- Cutter Soil Mixing
- Drilled Shafts with Liner
- Slurry Walls
- Ground Freezing
- Caissons

Selection and design of the excavation support and groundwater control systems for launching and receiving shafts should be the responsibility of the contractor, subject to the performance requirements established during design.

5.4 Conceptual Alignment and Profile

To provide a basis for evaluating concept-level cost and feasibility of a microtunnel crossing, MPEG has developed a conceptual alignment and profile for a typical microtunneling approach. The conceptual crossing is shown on Figure M-1 of Appendix A and was developed using the following assumptions:

Steel Casing – A 60-inch-diameter steel casing would be installed to accommodate the two new 14-inch force mains. The assumed casing size is based on the need for a larger MTBM which would allow for better handling of cobbles and boulders in the event these materials are encountered. Larger MTBMs are generally capable of providing more torque and thrust and allow for larger aperture openings in the face which facilitates crushing of larger particle sizes.

Alignment Length – In order to avoid the "riparian corridor" shown in the drawings for the pipe bridge alternative, a minimum alignment length of about 500 feet was assumed for the microtunnel crossing.

Microtunnel Crossing Depth - The casing invert would be at about elevation +24 feet to allow for the 37 feet of embedment below the creek bed. Based on available geotechnical data and the assumed depth, the tunnel excavation is anticipated to encounter mixed-face conditions consisting primarily of the sand and gravel soils for the northern portion of the alignment and hard, clayey soils for the southern portion. Alternatively, the crossing depth could be increased to locate the tunnel entirely within the hard, clayey soils. Based on available data, the clayey soils appear to provide a more favorable material for tunnel excavation as the potential for flowing ground and oversized materials (i.e. cobbles and boulders) is generally reduced. The clayey soils also provide a more favorable material with respect to providing water cutoff in the shaft inverts. While a deeper alignment within the clay would generally reduce construction risks, the additional shaft depth would likely add substantial cost. Therefore, the shallower alignment has been selected as a basis for this initial evaluation.

Launching Shaft – Will consist of a circular shaft constructed using secant piles with a working diameter of 30 feet. The jacking shaft will be located on the north side of the creek and will have an estimated depth of 65 feet to the invert slab. The north side of the creek was selected since there appears to be better access and more available space to support the larger shaft and microtunneling equipment and operations.

Receiving Shaft – Will consist of a circular shaft constructed using secant piles with a working diameter of 20 feet. The receiving shaft will be located on the south side of the creek and will have an estimated depth of 60 feet to the invert slab.

Ground Treatment at Portals – Ground treatment will likely be required outside of the shaft to control flowing ground conditions and groundwater inflows during launch and retrieval of the MTBM. The conceptual alignment assumes that jet grouting would be used at the shaft portals to improve the ground in order to facilitate MTBM launch and retrieval.

Product Pipes – The product pipes will consist of two 14-inch-diameter HDPE pipes which are grouted inside of the steel casing. Although not shown on the drawing, risers will be required to bring the pipeline back to grade to tie-in to the existing force main pipelines on both sides of the creek. For the conceptual alignment, it is assumed the risers will be installed and the shaft will be backfilled using the sand and gravel soils removed during excavation. Other alternatives could include backfilling the shafts with flowable fill or leaving the shafts open for future access and supporting the risers with structural bracing.

6.0 Horizontal Directional Drilling

6.1 Overview

Horizontal directional drilling (HDD) is a steerable trenchless method which allows for pipeline installation along a designed directional path using a surface-launched drilling rig. HDD installations are generally completed in three stages: (1) directional drilling of a small diameter pilot hole, (2) enlarging the pilot hole to a diameter that will accommodate the pipeline, and (3) pulling the pipeline back through the enlarged hole. Drilling fluid is used throughout the process primarily to maintain stability of the bore and to transport cuttings to the surface. Various support equipment (e.g. mixing systems, holding tanks, cleaning systems, etc.) is typically configured near the drilling rig to remove cuttings from the drilling fluid so that it can be recirculated.

Prior to starting drilling for the pilot hole, the drill rig is set to the prescribed entry angle and small pits are excavated at the drill entry and exit to contain drilling fluid. The pilot hole is advanced using a steerable drill bit that is selected depending on ground conditions and contractor preferences. The pilot bore is tracked as it advances using various downhole survey methods and/or surface monitoring systems. Once the pilot hole is established, the hole is incrementally enlarged using reaming tools that typically consist of cutters and fluid jets. The size of the reamers and number of reaming passes are generally selected by the contractor depending upon ground conditions.

Following reaming, pullback of the pipeline generally commences as soon as possible to minimize the duration of which the hole is left open. Pullback is typically completed in a single, continuous pull requiring fabrication and laydown of the entire pipe string. Once installed, the new pipeline is connected to the existing lines at the tie-in locations.

6.2 Conceptual Alignment and Profile

Similar to the microtunneling alternative, MPEG has developed a conceptual alignment and profile for a typical HDD approach as a basis for evaluating concept-level cost and feasibility. The conceptual crossing is shown on Figure H-1 of Appendix A and was developed using the following assumptions:

Alignment Length – As discussed previously, the trenchless crossing is constrained to the north by Magnolia Drive and to the south by vineyards. Therefore, a maximum horizontal length of 1,100 feet was assumed for our conceptual layout. In general, an HDD crossing will be much longer than a microtunnel approach primarily due to the need to install conductor casings through the relatively deep sand and gravel and the need to negotiate vertical curves. In order to achieve the

depth and curvature/radius requirements described in the following sections, a horizontal plan length of about 1,050 feet is anticipated for an HDD approach.

Product Pipes – The product pipes will consist of two 14-inch-diameter HDPE pipes which are bundled inside of a single bore. HDPE pipe was selected because it is relatively flexible and allows for easier handling and installation when working within the space constraints described above.

Conductor Casings – Conductor casings will be installed on both sides of the crossing to advance through the gravel and sand and into the underlying hard, cohesive soils. The casings will be 42-inch-diameter with estimated lengths of 290 feet and 170 feet on the north and south side of the creek, respectively. The use of casings will likely require a "drilled intersect" approach in which the pilot bore is established using two drill rigs (one on either side of the creek) which intersect along the bore path beyond the conductor casings. The use of conductor casings in conjunction with a drilled intersect approach is discussed further in Section 6.4.

Entry Angles – Entry angles are typically between 8 and 16 degrees, although steeper angles are used on some large diameter projects (HDD Consortium, 2008). Entry angles of 16 degrees are used to minimize the required length of the conductor casings.

Vertical Curves – The radius of the vertical curves must be minimized to keep the overall plan length to less than 1,100 feet. For HDPE pipelines, the minimum bend radius is generally controlled by the relatively stiff drill rod. A conservative industry guideline indicates the minimum bend radius should be approximately 1,200 times the nominal diameter of the rod (ASTM, 2005). While the rod size will vary based upon the equipment used, larger rigs typically use drill rods with diameters less than about 6-5/8 inches. Therefore, a bend radius of 750 feet is used commensurate with an estimated minimum radius for the larger drill rod diameter.

HDD Crossing Depth – The depth of the crossing is primarily controlled by the need to install conductor casings through the sand and gravel. Using an entry angle of 16 degrees and curve radius of 750 feet, the pipeline invert elevation will be at approximately -27 feet, corresponding to an embedment of about 94 feet below the stream bed.

HDD Work Areas – The HDD work areas must provide enough space for the drill rig, drilling fluid support system, and other materials and equipment required for the drilling operations. It is assumed that 200-foot by 150-foot work areas could be established at the locations shown on Figure H-1 to support the HDD operations.

Pipe Laydown Area - It is assumed that a 15-foot-wide temporary easement could be established within the tilled field north of the site to accommodate fabrication and laydown during pullback ("Alternate A" on Figure H-2). This presumably represents a favorable work area since it avoids tight horizontal curves. Alternatively, the work area for pipe string fabrication could potentially utilize Magnolia Drive or the unpaved access roads adjacent to the vineyard areas ("Alternate B"

and "Alternate C" on Figure H-2, respectively). However, the tighter horizontal curves would generally make pullback more challenging.

6.3 Previous HDD Evaluation

A previous evaluation of a similar HDD crossing was conducted by DCM/GeoEngineers as part of their geotechnical study for the recycled water pipeline. The findings from this study generally indicated that an HDD crossing was technically possible; however, HDD was not considered feasible due to the high risk of failure and exceptionally high costs. The findings from this study appear to have been based on several key components:

- Bore path design based on entry angles of 14 degrees and curve radii of 1,000 feet.
- The northern conductor casing length was calculated to be 350 feet which is longer than what is typically completed for HDD (conductor casings are typically less than 300 feet).
- The plan alignment length was calculated to be longer than 1,100 feet requiring negotiation of construction easements on either side of the crossing.
- The cost and risk associated with an aerial crossing for the recycled water pipeline were reportedly substantially lower than an HDD alternative.

MPEG understands the estimated cost of an aerial crossing for the force main relocation has prompted the City to re-evaluate a potential undercrossing alternative and whether it is cost effective when compared to the proposed bridge design. In this effort, MPEG has re-evaluated an HDD approach using the bore path design depicted on Figure H-1. This design utilizes steeper entry angles and smaller curve radii than what was used in the previous HDD evaluation for the recycled water pipeline. These changes result in a shorter length for the northern conductor casing (about 290 feet) and a shorter overall plan alignment length (about 1,050 feet). While the steeper entry angles and tighter bend radius are generally more challenging to construct, we understand that the proposed values are achievable using typical HDD equipment based upon our discussions with experienced HDD contractors for this project.

6.4 Conductor Casings

As previously discussed by DCM, the relatively high gravel content within the sand and gravel soils will make it difficult to maintain borehole stability, prevent fluid loss into the formation, and remove gravel-sized particles from the borehole. To mitigate these risks, conductor casings will be installed on both sides of the crossing to advance through the gravel and sand and into the underlying hard, cohesive soils. It is anticipated that the casings will be about 42 inches in diameter with estimated lengths of 290 feet and 170 feet on the north and south side of the creek, respectively. The casings are often installed using a pneumatic hammer, similar to installation of horizontal casings by pipe ramming.

While the proposed northern casing installation length is approaching the upper limit of what is typically seen in HDD projects, similar installation lengths have been achieved based on MPEG's discussions with experienced HDD Contractors and review of HDD case histories. Several projects in which similar casing lengths were installed are included in Table 1. Special procedures will likely be required to achieve the proposed casing lengths such as using one or more telescoping casings, procuring a relatively

large pneumatic hammer for the installation, and/or augering to remove soil from inside of the casing during installation.

It is anticipated that the use of casings will require a drilled intersect approach in which the pilot bore is established using two rigs drilling simultaneously from opposite ends of the crossing until they reach a designated target zone. The intersect method was developed following improvements in downhole surveying technology which greatly enhanced the accuracy of downhole steering systems. The steps involved with an intersect are described in greater detail in the Horizontal Directional Drilling Good Practices Guidelines (HDD Consortium, 2008). The method has been employed on numerous bores since it was first used in 2002. Several case histories which document the successful completion of a drilled intersect are also included under Table 1.

Table 1 – Summary of HDD Case Histories with Long Casings and/or Intersects

Reference	Crossing Location	Casing Diameter[1] (inches)	Casing Length (feet)	Drilled Intersect?
Staheli et al (2012)	Ebey Slough (Marysville, WA)	60	240	No
Duyvestyn et al (2013)	Interstate 86/Railroad Crossing (Corning, NY)	42	330	Yes
Michels (2005)	St. Lawrence Seaway (Quebec, Canada)	42/36/20	400	Yes
Chae et al (2008)	Interstate 405 (Bellevue, WA)	48	270	No
Orton (2008)	Columbia River (Vancouver, WA)	30/24	325	No
Lianides (2016)	Lombardi Gulch (Santa Cruz, CA)	Not used		Yes

(1) Multiple values means that a telescoped casing was installed.

7.0 Risk Analysis

A trenchless undercrossing inherently carries more risk than an overcrossing approach due to the fact that trenchless excavations are conducted “sight-unseen” and there are generally more unknowns associated with underground construction. While trenchless construction risks are unavoidable, they can be identified and managed to facilitate successful project completion. Once risks are identified, management generally entails evaluating and either accepting, avoiding, mitigating, or eliminating the risk exposure.

A Risk Register is one tool that is often used to manage risk in trenchless construction. The register identifies potential risks, evaluates probability and impact severity (in terms of cost and schedule), and summarizes strategies for avoiding, mitigating, eliminating or accepting risks. An overview of the process associated with risk register development is summarized as follows:

1. Identify pertinent risks that may occur on the project.
2. Identify the potential causes leading to the occurrence of each risk and the potential consequences.
3. Evaluate each risk by assigning a likelihood of occurrence and impact severity in terms of added cost and schedule delay.
4. Rank the unmitigated risks by multiplying the likelihood and impact severity. Higher risk rankings reflect higher probability of occurrence and/or impact severity.
5. Identify mitigation strategies which can be implemented during design and construction to avoid, eliminate or reduce the risk to the extent possible.
6. Evaluate each risk using the mitigated likelihood of occurrence and impact severity and re-rank the mitigated risks.
7. Risks that cannot be avoided or eliminated are retained and are generally accepted by the Owner or are transferred to another party. From a planning perspective, project contingencies can be estimated for retained risks using the post-mitigation impact severity.

MPEG has prepared a Preliminary Risk Register for the proposed concept level crossings with the primary purpose of identifying and summarizing the key risks associated with an undercrossing using HDD or microtunneling. The Preliminary Risk Registers are presented in Appendix C. The rankings that were assigned to each item were determined using the likelihood and impact severities presented at the top of the respective Risk Register document. In general, items with rankings greater than 12 represent relatively significant risks, whereas items with risk rankings lower than 12 represent lower to more moderate risks. The Risk Register should be considered a living document and we anticipate that it will be further discussed and expanded with additional input from the project team if a trenchless undercrossing option is pursued.

8.0 Trenchless Alternative Costs

Covello has prepared forecasts of probable construction costs for the conceptual HDD and microtunnel crossing alternatives using the alignments and profiles shown on Figures H-1 and M-1. The costs are included as Appendix D and were developed using current material, equipment and manpower costs, and standard industry production rates for the various activities. Input from HDD and microtunneling contractors as well as historical bidding information for similar scope trenchless projects were utilized for feedback and budgetary comparison. Past trenchless projects which were utilized for developing the cost estimates are listed in Appendix E.

The costs provided under Appendix D are for concept-level, budgetary purposes commensurate with the trenchless evaluation stage of this study. These costs are intended for comparison purposes only and include a 25 percent contingency to account for uncertainties associated with the current preliminary stage of project planning.

It should be noted that the probable construction cost for the conceptual microtunnel crossing alternative is estimated to be about $7.7 million, or roughly three times the cost for the Santa Rosa Geysers Recharge project crossing discussed under Section 5.2. The $2.8 million cost for the Geyser crossing is based on

reported values from a technical paper which documents the case history (Smith, Anderson, and Romero, 2002). While detailed cost information for the Geysers project was not available for review, the discrepancy between the reported cost for the Geysers crossing and probable cost for the conceptual microtunnel crossing is likely due to the following:

- Cost escalation and potential differences in the bidding environment that have occurred since the Geysers crossing was completed in 2002.
- A 25 percent contingency is assumed for the conceptual crossing.
- The probable cost for the conceptual crossing includes roughly $0.8 million to account for ground improvement, product pipe installation, annular grouting, completing the tie-ins at both ends of the alignment and backfilling the shafts. It is not clear whether these items are included in the costs presented for the Geyser project.
- The Geysers project included two microtunnel crossings suggesting the reported costs may have benefited from “an economy of scale”.
- The conceptual microtunneling alignment assumes 30- and 20-foot-diameter shafts will be used for the jacking and receiving shafts, respectively. While the shaft diameters for the Geysers project are not known, lower costs would be expected if smaller shaft sizes were utilized.

9.0 Conclusions and Recommendations

Based upon available information, subsurface data and the project constraints discussed herein, technically feasible alternatives for a trenchless undercrossing of Dry Creek include HDD and microtunneling. For the purposes of comparison, the key factors associated with these alternatives are summarized below in Table 2.

Table 2 – Comparison of Key Factors for Trenchless Undercrossing Alternatives

Factor	Microtunnel	Horizontal Directional Drilling
Cost	$7.7 million	$2.7 million
Shafts	Requires jacking and receiving shafts up to about 65-feet-deep.	Not required
Ground Treatment	Required at tunnel portals. May also be used to construct working floor for shafts.	Not required
Temporary Easements	Likely required for work area on south side of crossing.	Likely required for work area on south side of crossing and for pipe fabrication and laydown.
Permanent Easements	Required where pipeline extends beyond current City easements.	Required where pipeline extends beyond current City easements.
Casing	Requires 500 feet of 60-inch casing for microtunnel drive.	Requires about 460 feet of 42-inch casing for conductor casings. Casing may be removed after completion.
Annular Grouting	Required after product pipes are installed.	Required if conductor casings are left in place. If not left in place, casings should be backfilled with sand or similar material to fill the annular space and reduce settlement.
Risers	Risers and shaft backfilling are required to bring pipeline back to surface grade.	Not required.
Additional Geotechnical Data	Will require large diameter borings at shafts and near center of drive to characterize potential cobbles/boulders and lateral extent of mixed face conditions.	Will require minimum of 1 boring on north side of creek to confirm depth of clay and extend to below planned bore depth.
Primary Risk Elements	Challenges associated with shaft construction, mixed face conditions and gravels, cobbles, and boulders.	Potentially longer alignment and longer conductor casings if clay soils on north side of creek are deeper than expected.

If a trenchless undercrossing alternative is pursued, additional information will be required to advance project planning and design. Easements would likely be needed for construction staging areas and where the new alignment extends beyond existing City easements. A detailed topographic survey should be prepared for the entire project area and should show temporary and permanent easements, designated trenchless work areas (for shafts, pipe laydown, etc.), creek banks and high water elevations, existing overhead or underground utilities, any riparian or exclusionary zones that would impact the proposed work, and other pertinent information as required.

Additional geotechnical information would also be necessary to facilitate the design of either trenchless alternative. General recommendations for additional geotechnical investigation for the respective alternatives are provided below. Supplementary requirements for additional geotechnical recommendations can be provided as a separate memorandum if a specific trenchless alternative is pursued.

Microtunnel Alternative – The geologic setting generally consists of alluvial soils which include stream terrace deposits. While not directly observed, these deposits may contain cobbles and boulders which could not be retrieved within the samples or detected by the relatively small diameter borings that were completed to date. Some of the descriptions from available boring logs note the potential for cobbles which further suggest that larger-sized materials may exist. Since gravels, cobbles, and boulders can have a significant impact on tunneling operations, the extent frequency, size distribution, and physical properties of these materials should be determined, particularly within and immediately above and below the tunnel zone. This would require the completion of additional large-diameter borings near the proposed tunneling alignment. Laboratory testing should also be completed primarily to characterize the size distribution and physical properties of the materials and to characterize potentially abrasive materials. For planning purposes, large diameter borings should be completed at each shaft location and on both sides of the creek as close to the channel as possible.

HDD Alternative – The conductor casing and overall HDD lengths shown in the conceptual alignment assume that hard, cohesive soils will be encountered at about 79 feet below ground surface (elevation of about 10 feet) on the north side of the creek. This assumed depth is based on limited geotechnical data gathered from a well drilling log. If the cohesive soils are deeper than expected, the result would be a longer HDD alignment and conductor casing length. Therefore, additional geotechnical investigation should be completed to confirm the depth to the hard clay on the north side of the creek. The investigation should include at least one boring that extends a minimum of 10 feet below the deepest portion of the alignment to obtain geotechnical information throughout the depth of the profile. Additional borings would be beneficial in more accurately characterizing the depth to the clay soils.

10.0 References

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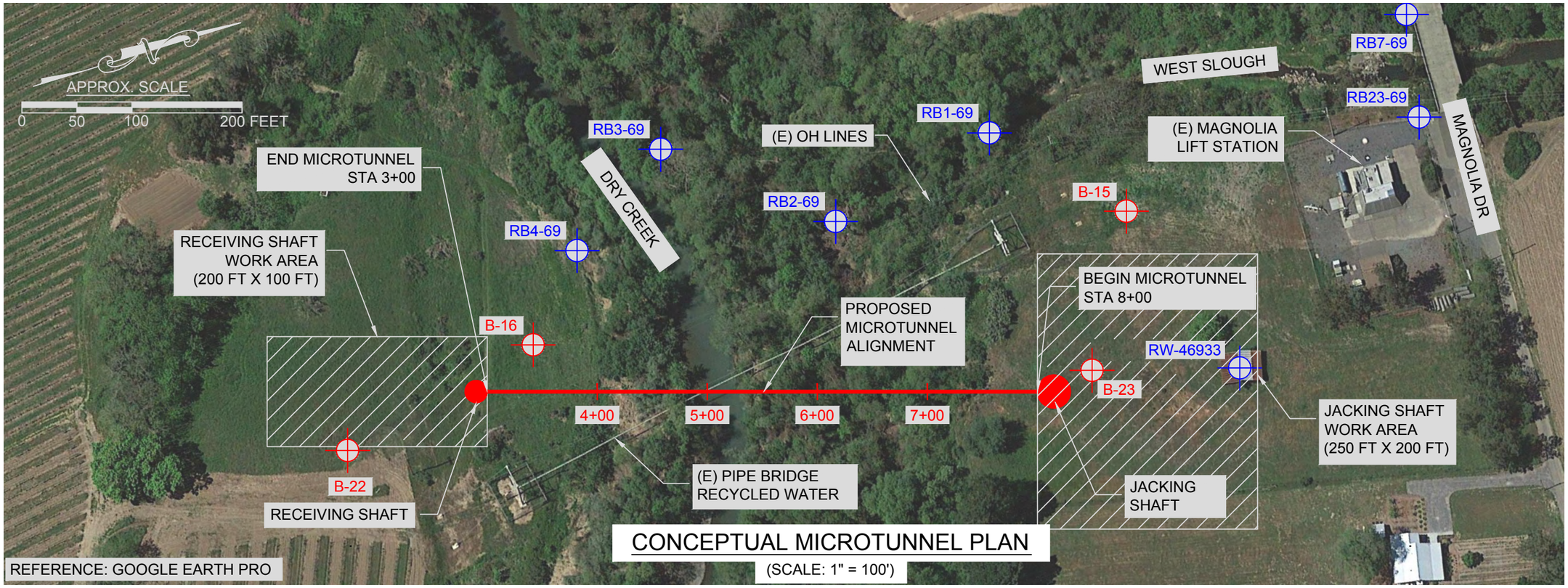
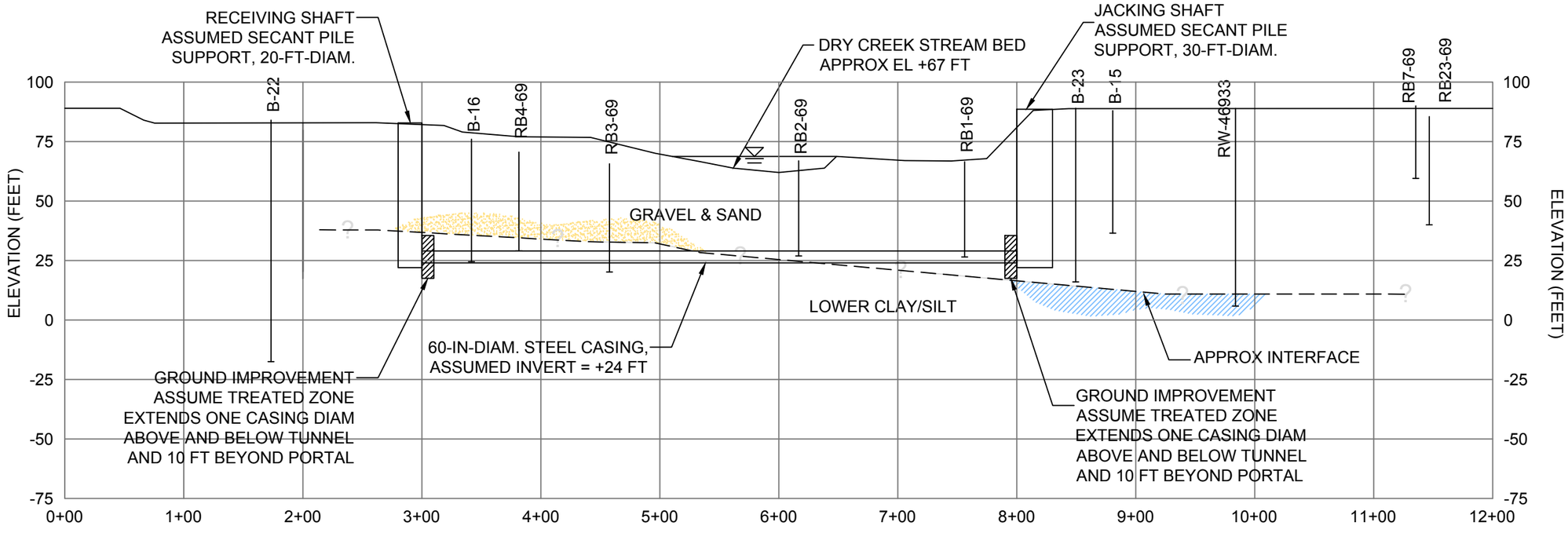
APPENDIX A

“CONCEPT-LEVEL” TRENCHLESS CROSSING DRAWINGS



CONCEPTUAL MICROTUNNEL PLAN

(SCALE: 1" = 100')



CONCEPTUAL MICROTUNNEL PROFILE

(HORIZ. SCALE: 1" = 100', VERT. SCALE: 1" = 50')

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FILE: Conceptual Crossings.dwg

CONCEPTUAL MICROTUNNEL PLAN & PROFILE

Drawn RCA
Checked SAS

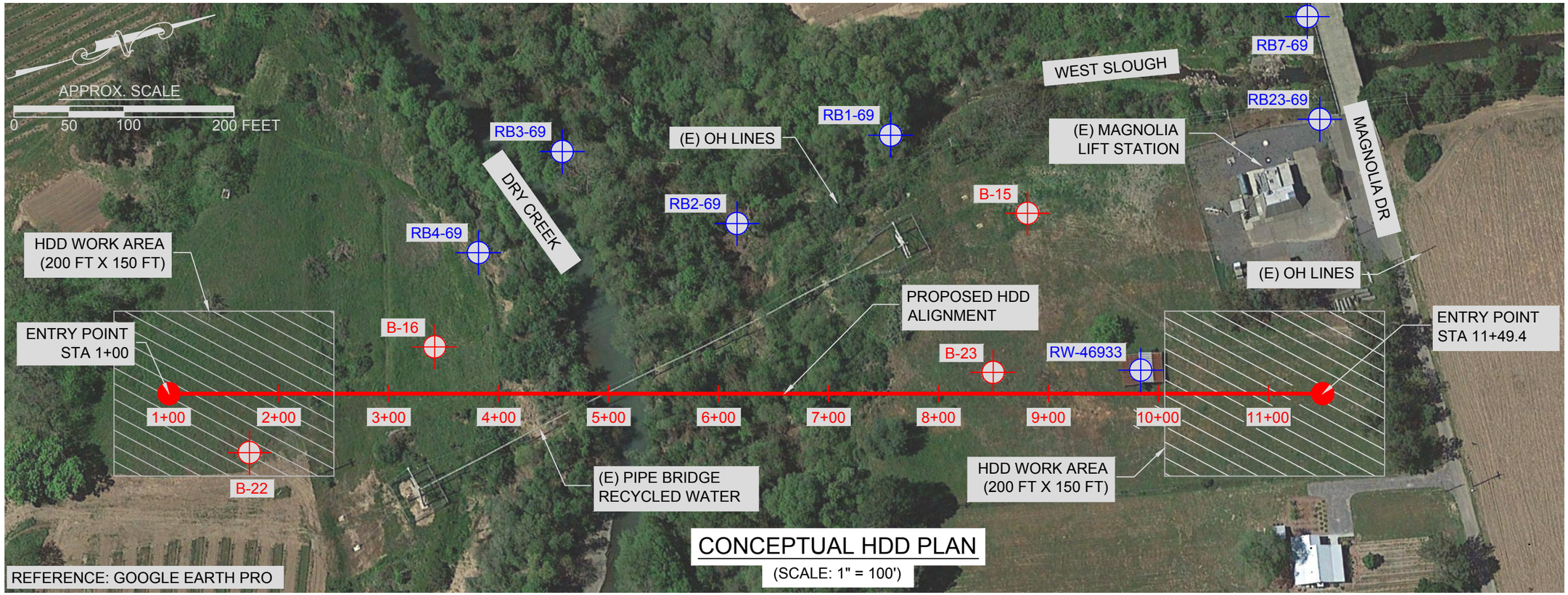
City of Healdsburg
Magnolia Force Main Relocation
Healdsburg, California

Date: 11/1/2016

Project No. 2363.001

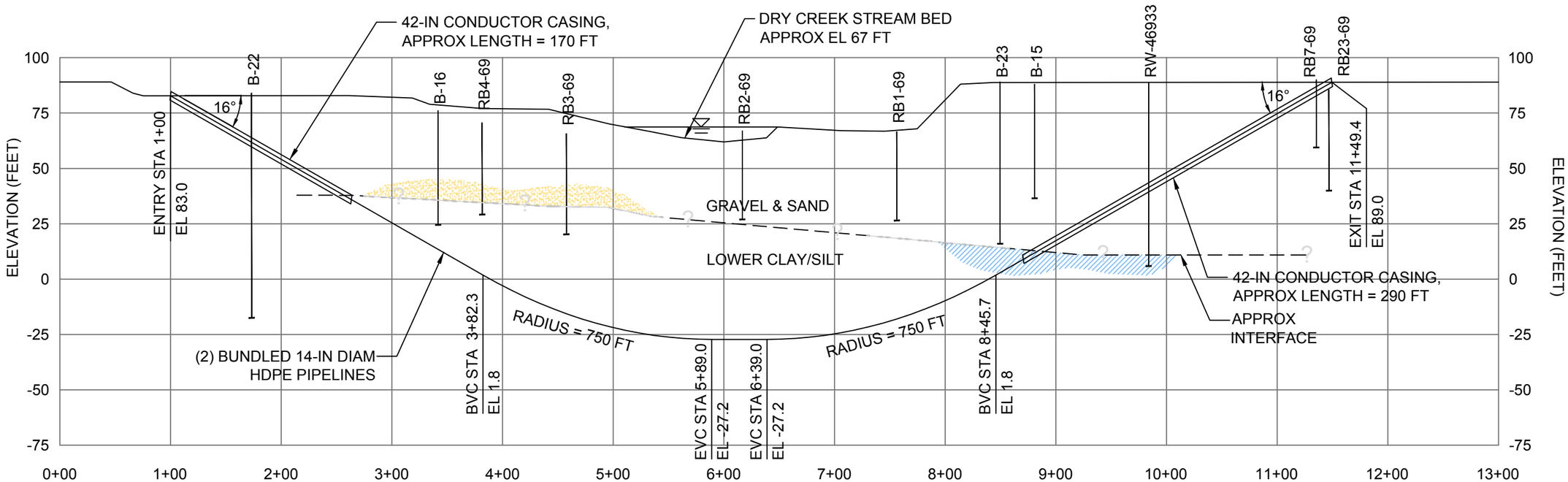
SHEET

M-1



CONCEPTUAL HDD PLAN

(SCALE: 1" = 100')



CONCEPTUAL HDD PROFILE

(HORIZ. SCALE: 1" = 100', VERT. SCALE: 1" = 50')

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CONCEPTUAL HDD PLAN & PROFILE

City of Healdsburg
Magnolia Force Main Relocation
Healdsburg, California

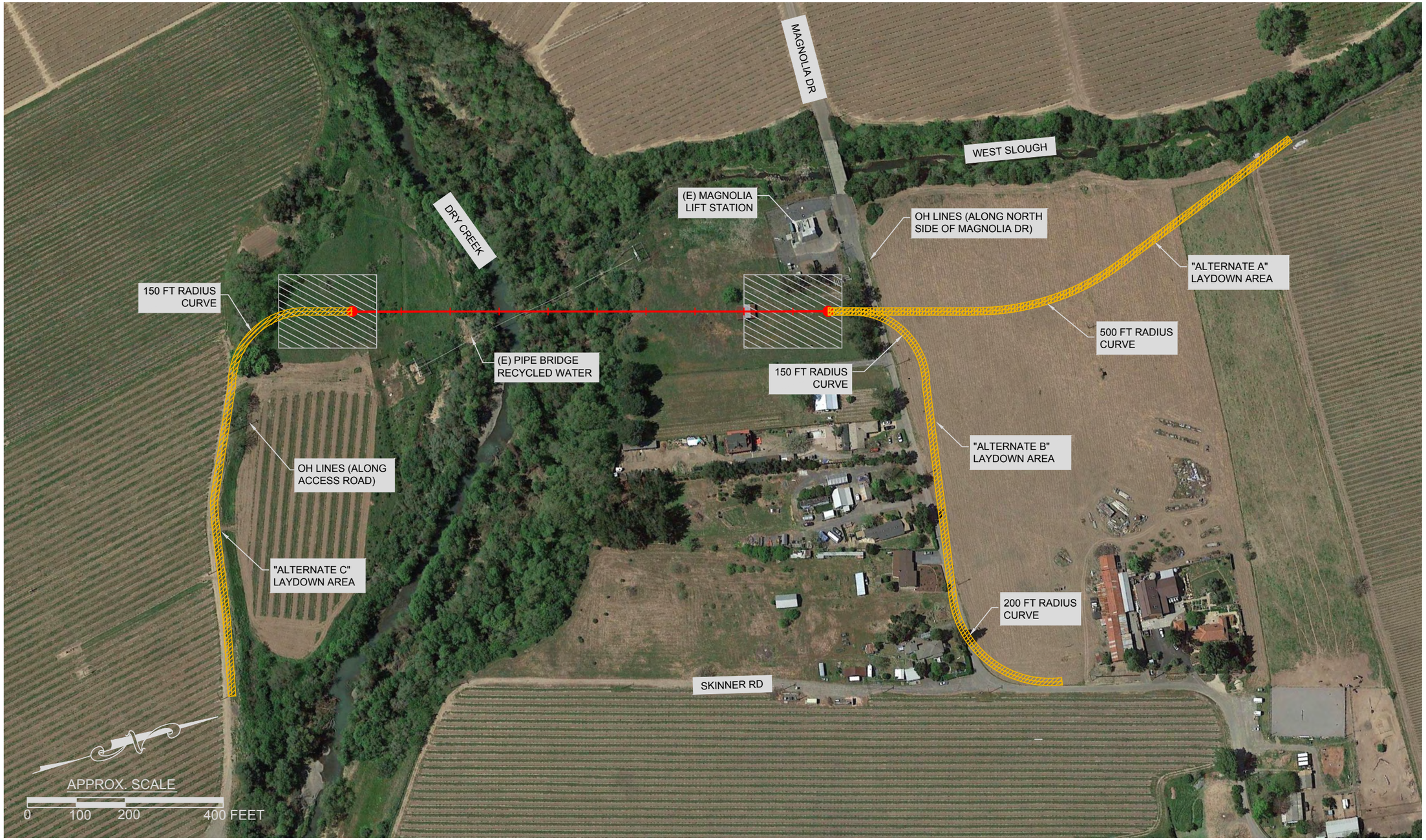
Drawn: RCA
Checked: SAS

Date: 11/1/2016

Project No. 2363.001

SHEET

H-1



CONCEPTUAL PIPE LAYDOWN AREA PLAN

(APPROX. SCALE: 1" = 200')

REFERENCE: GOOGLE EARTH PRO

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CONCEPTUAL HDD PIPE LAYDOWN AREAS

City of Healdsburg
Magnolia Force Main Relocation
Healdsburg, California

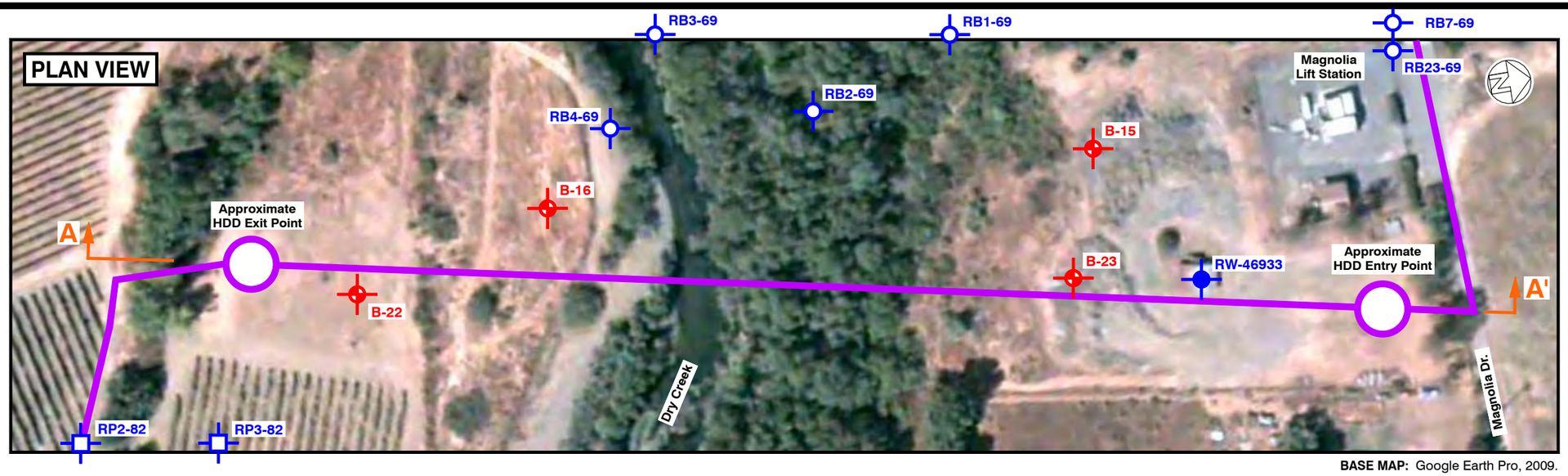
Drawn RCA
Checked SAS

Project No. 2363.001
Date: 11/1/2016

SHEET
H-2

APPENDIX B

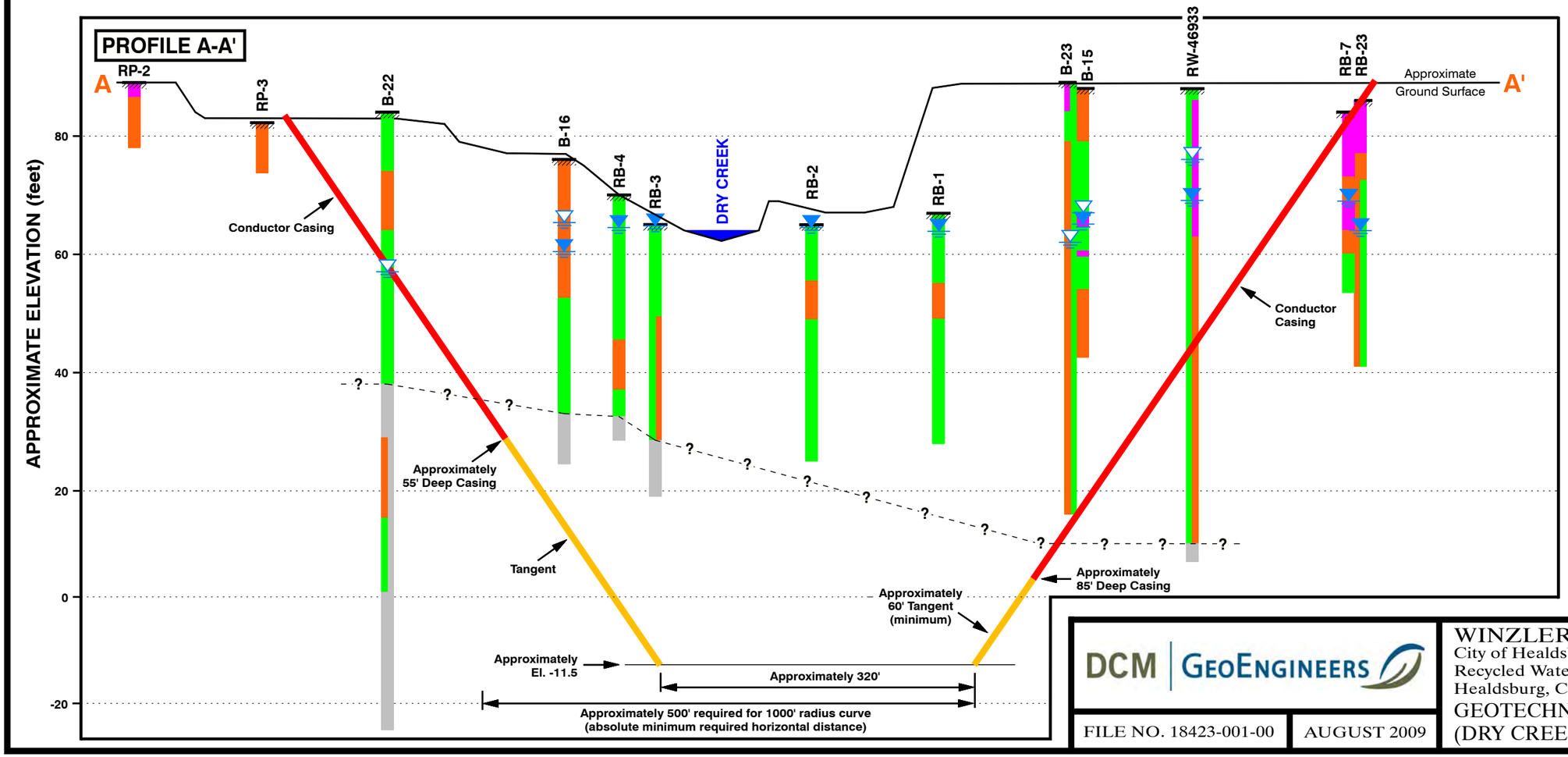
EXISTING GEOTECHNICAL DATA



BASE MAP: Google Earth Pro, 2009.

PLAN LEGEND:

- Approximate project recycled water pipeline alignment
- B-1 — Approximate location and reference number for project geotechnical borings
- RB-1 — Approximate location and reference number for reference geotechnical borings by others
- RW-1 — Approximate location and reference number for reference well drilling log by others
- RP-1 — Approximate location and reference number for reference test pit by others



PROFILE LEGEND:

- **UPPER CLAY/SILT**
  - Predominantly cohesive, firm to raveling behavior
- **SAND**
  - Non-cohesive, raveling to running/flowing behavior
- **GRAVEL**
  - Non-cohesive, running/flowing behavior
- **LOWER CLAY/SILT**
  - Referred to by others as siltstone bedrock
  - Cohesive, firm behavior
- ? - - - ? **ESTIMATED LOWER CLAY/SILT CONTACT**
- **GROUNDWATER**
  - As recorded in project and reference borings
- **GROUND SURFACE AT BORING LOCATION**

APPROXIMATE PLAN/HORIZONTAL SCALE

1 inch equals 120 feet

0 — 30' — 60' — 90' — 120' — 240'

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Healdsburg, California
GEOTECHNICAL PROFILE
(DRY CREEK)

PLATE NO.
II-9
(COLOR PLATE)

TUNNELMAN'S GROUND CLASSIFICATION FOR SOILS

Classification		Behavior	Typical Soil Types
Firm		Heading can be advanced without initial support and final lining can be constructed before ground starts to move.	Loess above water table; hard clay, marl, cemented sand and gravel when not highly overstressed.
Raveling	Slow Raveling Fast Raveling	Chunks or flakes of material begin to drop out of the arch or walls sometime after the ground has been exposed due to loosening or to overstress and "brittle" fracture (ground separates or brakes along distinct surfaces, opposed to squeezing ground). In fast raveling ground, the process starts within a few minutes, otherwise the ground is slow raveling	Residual soils or sand with small amounts of binder may be fast raveling below the water table, slow raveling above. Stiff fissured clays may be slow or fast raveling depending upon degree of overstress.
Squeezing		Ground squeezes or extrudes plastically into tunnel, without visible fracturing or loss of continuity, and without perceptible increase in water content. Ductile, plastic yield and flow due to overstress.	Ground with low frictional strength. Rate of squeeze depends on degree of overstress. Occurs at shallow to medium depth in clay of very soft to medium consistency. Stiff to hard clay under high cover may move in combination of raveling at excavation surface and squeezing at depth behind surface.
Running	Cohesive, running Running	Granular materials without cohesion are unstable at a slope greater than their angle of repose (±30-35). When exposed at steeper slopes they run like granulated sugar or dune sand until the slope flattens to the angle of repose.	Clean, dry granular materials. Apparent cohesion in moist sand, or weak cementation in any granular soil may allow the material to stand for brief period of raveling before it breaks down and runs. Such behavior is cohesive-running.
Flowing		A mixture of soil and water flows into the tunnel like a viscous fluid. The material can enter the tunnel from the invert as well as from the face, crown, and walls, and can flow for great distances, completely filling the tunnel in some cases.	Below the water table in silt, sand, or gravel without enough clay content to give significant cohesion and plasticity. May also occur in highly sensitive clay when such material is disturbed.
Swelling		Ground absorbs water, increases in volume, and expands slowly into the tunnel.	Highly preconsolidated clay with plasticity index in excess of about 30, generally containing significant percentages of montmorillonite.

Reference:

Heuer, R.E., 1974, Important ground parameters in soft ground tunneling, Subsurface exploration for underground excavation and heavy construction, New England College, Henniker, New Hampshire, American Society of Civil Engineers, New York, P. 41-55.

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Recycled Water System Project
Healdsburg, California
TUNNELMAN'S GROUND CLASSIFICATION

PLATE NO.
A-3

LOG OF BORING B-15

LOCATION: North side of Dry Creek approx. 175 ft. behind Magnolia Lift Station. (See Plate I-4)

APPROX. SURFACE ELEVATION: 88 feet

DEPTH feet	SAMPLE NO.	TYPE	PENETRATION RESISTANCE blows/ft.	GROUNDWATER ②	DESCRIPTION ①	MOISTURE	DRY DENSITY lbs./ft.³	LIQUID LIMIT	PLASTICITY INDEX	GRAIN SIZE Gravel (> #4 sieve) %	GRAIN SIZE Sand (#4 to #200 sieve) %	GRAIN SIZE Fines (< #200 sieve) %	UNCONFINED COMPRESSIVE STRENGTH k.s.f.	DIRECT SHEAR Cohesion p.s.f.	DIRECT SHEAR Internal Friction Angle
					CLAYEY SAND (SC) - dark grayish brown - fine to coarse sand - few fine to coarse gravel - moist										
					SILTY SAND (SM) - dark grayish brown - fine to medium sand - moist										
5						12	98								
	1		16		**POORLY GRADED SAND WITH SILT (SP-SM)** - dark grayish brown - fine to medium sand - medium dense - moist	6	96								
10					**WELL-GRADED GRAVEL WITH SAND (GW)** - dark grayish brown - fine to coarse sand and gravel - trace silt and clay - medium dense - moist										
	2		20			4	114								
15															
	3		31			4	120			65	32	3			
					Water level in creek estimated to be 18 feet below ground elevation at boring location.								FINES 2.5% Silt 0.5% Clay		
20															
	4		23			4	114								
	5		14		**SANDY LEAN CLAY WITH GRAVEL (CL)** - dark grayish brown - fine to coarse sand and gravel - stiff - medium plasticity - moist to wet	4									
25					**WELL-GRADED GRAVEL WITH SAND (GW)** - dark grayish brown - dense - fine to coarse sand and gravel - wet										

LOG OF BORING B-15 CONTINUED ON PLATE B-15 (2 OF 2)

NOTES:

① Boring drilled on March 23, 2009. See Appendix A for term definitions and Appendix C for lab test results.

② Groundwater was encountered at a depth of about 19 feet during drilling and measured at 23 feet after well construction was completed 6 hours later. A piezometer well was constructed in this borehole. Equilibrium groundwater depth unknown.

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Recycled Water System Project
Healdsburg, California

LOG OF BORING B-15

PLATE NO.

B-15

(1 of 2)

LOG OF BORING B-15 (continued)

DEPTH feet	SAMPLE NO.	TYPE	PENETRATION RESISTANCE blows/ft.	GROUNDWATER ②	DESCRIPTION ①	MOISTURE	DRY DENSITY lbs./ft.³	LIQUID LIMIT	PLASTICITY INDEX	GRAIN SIZE Gravel (> #4 sieve) %	GRAIN SIZE Sand (#4 to #200 sieve) %	GRAIN SIZE Fines (< #200 sieve) %	UNCONFINED COMPRESSIVE STRENGTH k.s.f.	DIRECT SHEAR Cohesion p.s.f.	DIRECT SHEAR Internal Friction Angle
	6		58		**WELL-GRADED GRAVEL WITH SAND (GW)** - dark grayish brown - dense - fine to coarse sand and gravel - wet	10	130								
	7		39												
					SANDY LEAN CLAY WITH GRAVEL (CL) - dark grayish brown - fine to coarse sand and gravel - hard - medium plasticity - wet										
30	8		58		**WELL-GRADED GRAVEL WITH SAND (GW)** - dark grayish brown - fine to coarse sand and gravel - trace silt and clay - dense - wet	8	137			58	38	4	FINES 3% Silt 1% Clay		
	9		35												
35	10		59		**WELL-GRADED SAND (SW)** - dark gray - dense - fine to coarse sand - wet	6	129								
	11		51		**WELL-GRADED SAND WITH SILT AND GRAVEL (SW-SM)** - dark grayish brown - fine to coarse sand - fine gravels - trace to few silt - trace clay - dense to very dense - wet					36	59	5	FINES 4% Silt 1% Clay		
40	12		71			6	138								
	13		41												
45	14		50/4"			18	106			25	69	6	FINES 5.5% Silt 0.5% Clay		
50	15		65		**POORLY GRADED SAND (SP)** - dark grayish brown - fine to coarse sand - dense - few fine gravel - moist	12	115								

BOTTOM OF BORING AT 51½ FEET

NOTES:

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Recycled Water System Project
Healdsburg, California

LOG OF BORING B-15

PLATE NO.
B-15
(2 of 2)

LOG OF BORING B-16

LOCATION: South side of Dry Creek.
(See Plate I-4)
APPROX. SURFACE ELEVATION: 76 feet

DEPTH feet	SAMPLE NO.	TYPE	PENETRATION RESISTANCE blows/ft.	GROUNDWATER ②	DESCRIPTION ①	MOISTURE	DRY DENSITY lbs./ft.³	LIQUID LIMIT	PLASTICITY INDEX	GRAIN SIZE Gravel (> #4 sieve) %	GRAIN SIZE Sand (#4 to #200 sieve) %	GRAIN SIZE Fines (< #200 sieve) %	UNCONFINED COMPRESSIVE STRENGTH k.s.f.	DIRECT SHEAR Cohesion p.s.f.	DIRECT SHEAR Internal Friction Angle
					CLAYEY SAND (SC) - dark grayish brown - fine to medium sand - trace fine to coarse gravel - moist										
	1				**CLAYEY SAND WITH GRAVEL (SC)** - dark yellowish brown - fine to coarse sand and gravel - medium dense - trace cobbles - moist										
5	2		36			6	107								
	3		23		**WELL-GRADED SAND WITH GRAVEL (SW)** - dark grayish brown - fine to coarse sand and gravel - medium dense - moist										
10	4		33		Water level in creek estimated to be 11½ feet below ground elevation at boring location.	6	111								
	5		26		**WELL-GRADED SAND WITH SILT AND GRAVEL (SW-SM) and POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** - SW-SM is interlayered with thin (<2") layers of SP-SM - dark grayish brown - fine to coarse sand and gravel - trace clay - medium dense - moist										
15	NSR		10												
	7		50			11									
20	8		91			8	125			44	47	9			
	9														
25	10				**POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)** - dark grayish brown - dense - fine to coarse sand and gravel - wet										

Sample 1 ③
Maximum Density = 138.8 pcf
Optimum Moisture = 7.2%

FINES
6% Silt
3% Clay

LOG OF BORING B-16 CONTINUED ON PLATE B-16 (2 OF 2)

NOTES:
① Boring drilled on April 3, 2009. See Appendix A for term definitions and Appendix C for lab test results.
② Groundwater was encountered at a depth of about 10½ feet during drilling and measured at 15½ feet before backfilling 2 hours later. Equilibrium groundwater depth unknown.
③ Sample 1 is a composite of the cuttings from the upper 5 feet of the boring.
④ Sample 12 is a composite of the cuttings from an approximate depth of 30 to 35 feet.

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Recycled Water System Project
Healdsburg, California

LOG OF BORING B-16

PLATE NO.
B-16
(1 of 2)

LOG OF BORING B-16 (continued)

DEPTH feet	SAMPLE NO.	TYPE	PENETRATION RESISTANCE blows/ft.	GROUNDWATER ②	DESCRIPTION ①	MOISTURE	DRY DENSITY lbs./ft.³	LIQUID LIMIT	PLASTICITY INDEX	GRAIN SIZE: Gravel (> #4 sieve) %	GRAIN SIZE: Sand (#4 to #200 sieve) %	GRAIN SIZE: Fines (< #200 sieve) %	UNCONFINED COMPRESSIVE STRENGTH k.s.f.	DIRECT SHEAR: Cohesion p.s.f.	DIRECT SHEAR: Internal Friction Angle
	10		40		**POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)** - dark grayish brown - fine to coarse sand and gravel - dense to very dense - wet	13									
30	11		50			13									
	12									67	24	9			
35	13		73												
40	14		27		- medium dense	15									
45	15		51		**FAT CLAY (CH)** - greenish gray - has vague rock fabric (may be very severely to completely weathered claystone bedrock) - high plasticity fines - gradation indicates mostly silt-sized particles - hard (clay/silt consistency) - very soft (rock hardness) - moist to wet	25				0	2	98			
50	16		89			25		66	35						
					BOTTOM OF BORING AT 51½ FEET										

Sample 12 ④
Corrosion Test
Results on Plate C-7

FINES
6% Silt
3% Clay

FINES
58% Silt
40% Clay

NOTES:

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Recycled Water System Project
Healdsburg, California

LOG OF BORING B-16

PLATE NO.
B-16
(2 of 2)

LOG OF BORING B-22

LOCATION: South side of Dry Creek
(See Plate I-4)
APPROX. SURFACE ELEVATION: 84 feet

DEPTH feet	SAMPLE NO.	TYPE	PENETRATION RESISTANCE blows/ft.	GROUNDWATER ②	DESCRIPTION ①	MOISTURE	DRY DENSITY lbs./ft.³	LIQUID LIMIT	PLASTICITY INDEX	GRAIN SIZE Gravel (>#4 sieve) %	GRAIN SIZE Sand (#4 to #200 sieve) %	GRAIN SIZE Fines (<#200 sieve) %	UNCONFINED COMPRESSIVE STRENGTH k.s.f.	DIRECT SHEAR Cohesion p.s.f.	DIRECT SHEAR Internal Friction Angle
					POORLY GRADED GRAVEL (GP) - generally <1.5 inch rounded gravels - dry										
10					**POORLY GRADED SAND (SP)** - predominantly coarse sand - dry										
20					**POORLY GRADED GRAVEL (GP)** - gravels as large as 2.5 inches observed, but generally <1.5 inch - rounded gravels - variable amounts of sand and fines - dry to wet										
30															
40					- gravels coming up augers clumped together with clay										
50	1	■	50 (4")		**LEAN CLAY WITH SAND (CL)** - dark brown - medium plasticity - hard - moist	11	95								

CONTINUED AT 55 FEET ON SHEET 2 OF 2

NOTES:
① Boring drilled on July 28. See Appendix A for term definitions and Appendix C for lab test results.

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Recycled Water System Project
Healdsburg, California

LOG OF BORING B-22

PLATE NO.
B-22
(1 of 2)

LOG OF BORING B-22 (Continued)

LOCATION: South side of Dry Creek
(See Plate I-4)
APPROX. SURFACE ELEVATION: 84 feet

DEPTH feet	SAMPLE NO.	TYPE	PENETRATION RESISTANCE blows/ft.	GROUNDWATER ②	DESCRIPTION ①	MOISTURE	DRY DENSITY lbs./ft.³	LIQUID LIMIT	PLASTICITY INDEX	GRAIN SIZE Gravel (>#4 sieve) %	GRAIN SIZE Sand (#4 to #200 sieve) %	GRAIN SIZE Fines (<#200 sieve) %	UNCONFINED COMPRESSIVE STRENGTH k.s.f.	DIRECT SHEAR Cohesion p.s.f.	DIRECT SHEAR Internal Friction Angle
					CONTINUED FROM 55 FEET ON SHEET 1 OF 2										
60	2		50 (6")	③	**CLAYEY SAND (SC) to SANDY FAT CLAY (CH)** - dark greenish gray - high plasticity fines - very dense (sand)/hard (clay) - wet	18				10	41	49	FINES 10% Silt 32% Clay		
70	3		50 (4")		**CLAYEY SAND WITH GRAVEL (SC) to CLAYEY GRAVEL (GC)** - dark greenish gray - high plasticity fines - very dense (sand)/hard (clay) - wet - little to no fluid loss noted while drilling through this formation	11				43	44	13	FINES 7% Silt 6% Clay		
	4														
80															
90					**FAT CLAY (CH)** - dark greenish gray - high plasticity - hard - wet										
100	5		58			23		56	27	0	1	99	FINES 40% Silt 59% Clay		
					BOTTOM OF BORING AT 101.5 FEET										

NOTES:
① Boring drilled on July 28. See Appendix A for term definitions and Appendix C for lab test results.
② See groundwater notes on page 1 of 2.
③ Drilling method switched from hollow-stem auger to mud-rotary at 60 feet.

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City of Healdsburg
Recycled Water System Project
Healdsburg, California

LOG OF BORING B-22

PLATE NO.
B-22
(2 of 2)

LOG OF BORING B-23

LOCATION: North side of Dry Creek
(See Plate I-4)
APPROX. SURFACE ELEVATION: 89 feet

DEPTH feet	SAMPLE NO.	TYPE	PENETRATION RESISTANCE blows/ft.	GROUNDWATER ②	DESCRIPTION ①	MOISTURE	DRY DENSITY lbs./ft.³	LIQUID LIMIT	PLASTICITY INDEX	GRAIN SIZE Gravel (> #4 sieve) %	GRAIN SIZE Sand (#4 to #200 sieve) %	GRAIN SIZE Fines (< #200 sieve) %	UNCONFINED COMPRESSIVE STRENGTH k.s.f.	DIRECT SHEAR Cohesion p.s.f.	DIRECT SHEAR Internal Friction Angle
					FILL - SANDY LEAN CLAY WITH GRAVEL (CL) - dark grayish brown - dry - rounded gravels										
					POORLY GRADED GRAVEL (GP) - gravels generally <1 inch - dry - rounded gravels										
10					**POORLY GRADED SAND (SP)** - predominantly coarse sand - few gravels - dry										
20					- clay content increases at approximately 22 feet										
30					**POORLY GRADED GRAVEL (GP)** - gravels generally <1.5 inches - rounded gravels - variable sand content										
40					- gravels coming up augers clumped together with clay										
50					CONTINUED AT 50 FEET ON SHEET 2 OF 2										

NOTES:
① Boring drilled on July 28. See Appendix A for term definitions and Appendix C for lab test results.

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Recycled Water System Project
Healdsburg, California

LOG OF BORING B-23

PLATE NO.
B-23
(1 of 2)

LOG OF BORING B-23 (Continued)

LOCATION: North side of Dry Creek
(See Plate I-4)
APPROX. SURFACE ELEVATION: 89 feet

DEPTH feet	SAMPLE NO.	TYPE	PENETRATION RESISTANCE blows/ft.	GROUNDWATER ②	DESCRIPTION ①	MOISTURE	DRY DENSITY lbs./ft.³	LIQUID LIMIT	PLASTICITY INDEX	GRAIN SIZE Gravel (> #4 sieve) %	GRAIN SIZE Sand (#4 to #200 sieve) %	GRAIN SIZE Fines (< #200 sieve) %	UNCONFINED COMPRESSIVE STRENGTH k.s.f.	DIRECT SHEAR Cohesion p.s.f.	DIRECT SHEAR Internal Friction Angle
					CONTINUED FROM 50 FEET ON SHEET 1 OF 2										
					WELL GRADED SAND WITH GRAVEL (SW)										
	1	■	41		- dark grayish brown - rounded gravels - dense - wet	8	124			32	64	4	**FINES** 2% Silt 2% Clay		
60				③	- significant fluid loss while drilling through this formation										
70															
					BOTTOM OF BORING AT 73 FEET										
80															
90															
100															

NOTES:
① Boring drilled on July 28. See Appendix A for term definitions and Appendix C for lab test results.
② See groundwater notes on page 1 of 2.
③ Drilling method switched from hollow-stem auger to mud-rotary at 60 feet.

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City of Healdsburg
Recycled Water System Project
Healdsburg, California

LOG OF BORING B-23

PLATE NO.
B-23
(2 of 2)

MOORE & TABER · Engineers · Geologists 569-79F

TEST BORING LOG ±5' Rt Sta 4+55± - Force

TYPE 3 inch Rotary ELEVATION 66.5 BORING Nº 1

GWS Elev. 63.5
11-18-69

Depth in Feet	Blows/Foot 350-ft.lb.	Dry Density (lbs/cu.ft)	Sample Size (inches)	Sample Nº
5	15	1.4	1	
10	19	1.4	2	
15	32	1.4	3	
20	24	1.4	4	
25	23	1.4	5	
30	31	1.4	6	
35	39	1.4	7	

Loose to semi-compact brown-gray SANDY fine-coarse GRAVEL with thin SILT layer at 9.0.

Compact brown fine-medium SAND

Compact to dense brown-gray SANDY fine-coarse GRAVEL with some SILT

STRIKE/DIP | RELATIVE COMPACTION | DRY DENSITY (lbs/cu.ft) | MOISTURE (%) | BLOWS/FOOT 350-ft.lb. | SAMPLE SIZE (INCHES) | SAMPLE Nº | DEPTH IN FEET | MATERIAL SYMBOL | UNIFIED SOIL CLASSIFICATION

Logged By SWH Date 11-18-69

REFERENCE: Moore & Taber, 1970, Report of Subsurface and Soils Investigation, Yoder/Orlob Associates, Water Pollution Control Facilities, City of Healdsburg, California.

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FILE NO. 18423-001-00 AUGUST 2009

WINZLER & KELLY

City of Healdsburg
Recycled Water System Project
Healdsburg, California

REFERENCE TEST BORING RB-1-69

PLATE NO.

D-3

MOORE & TABER · Engineers-Geologists 569-79F

TEST BORING LOG ±30' Rt Sta 6+10± - Force

TYPE 3 inch Rotary ELEVATION 65.4 BORING Nº 2

GWS Elev. 64.9
11-19-69

Depth in Feet	Blows/Foot 350-ft. lb.	Sample Size (Inches)	Sample Nº	Description
5	17	1.4	1	Loose to semi-compact brown-gray SANDY fine-coarse GRAVEL
10	17	1.4	2	Semi-compact to compact brown very fine-medium SAND with scattered GRAVEL
15	28	1.4	3	Compact to dense brown-gray SANDY fine-coarse GRAVEL with some SILT
20	30	1.4	4	
25	34	1.4	5	
30	50	1.4	6	
35	130+	1.4	7	Very dense brown weathered SILTY SANDY fine-coarse GRAVEL

Strike Dip | Relative Compaction | Dry Density (lbs/cu.ft.) | Moisture (%) | Material Symbol | Unified Soil Classification

Logged By SWH Date 11-19-69

Figure-1

REFERENCE: Moore & Taber, 1970, Report of Subsurface and Soils Investigation, Yoder/Orlob Associates, Water Pollution Control Facilities, City of Healdsburg, California.

DCM | GEOENGINEERS

WINZLER & KELLY

City of Healdsburg
Recycled Water System Project
Healdsburg, California

REFERENCE TEST BORING RB-2-69

PLATE NO.

D-4

FILE NO. 18423-001-00 AUGUST 2009

MOORE & TABER · Engineers · Geologists

TEST BORING LOG ±210' Lt Sta 6+65± – Force

TYPE 2½" Rotary | ELEVATION 65.7 | BORING Nº 3

G.W.S. Elev. 65.2 11/19/69

Unconfined Compressive Strength (tsf)	Relative Compaction	Dry Density (lbs/cu.ft.)	Moisture (%)	Blows/Foot 350-ft.lb.	Sample Size (inches)	Sample Nº	Depth in Feet	Material Symbol	Unified Soil Classification	Description
							5			Loose to semicompact brown-gray SANDY fine-coarse GRAVEL
				18	1.4	1				
							10			Bottom of Creek 1969
				19	1.4	2				
							15			
				40	1.4	3				Compact & dense gray-brown SANDY fine-coarse GRAVEL with some SILT and layers of SILTY SAND
							20			
				41	1.4	4				
							25			
				43	1.4	5				
							30			
				38	1.4	6				
							35			(Continued)

TYPE 2½" Rotary | ELEVATION 30.7 | BORING Nº 3 Contd.

Unconfined Compressive Strength (tsf)	Relative Compaction	Dry Density (lbs/cu.ft.)	Moisture (%)	Blows/Foot 350-ft.lb.	Sample Size (inches)	Sample Nº	Depth in Feet	Material Symbol	Unified Soil Classification	Description
										(as above)
				31	1.4	7				
							40			Very stiff-very hard tan to gray-blue CLAYEY SILT (weathered SILTSTONE)
3.2		95	24	55	1.4	8				
							45			

Logged By RDM | Date 11/18-19/69

REFERENCE: Moore & Taber, 1970, Report of Subsurface and Soils Investigation, Yoder/Orlob Associates, Water Pollution Control Facilities, City of Healdsburg, California.

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City of Healdsburg
Recycled Water System Project
Healdsburg, California

REFERENCE TEST BORING RB-3-69

PLATE NO.

D-5

FILE NO. 18423-001-00 | AUGUST 2009

MOORE & TABER · Engineers · Geologists

TEST BORING LOG ±120' Rt. Sta 7+80± - Force

TYPE 2½" Rotary | ELEVATION 70.6 | BORING Nº 4

G.W.S. Elev. 65.0 11/20/69

Depth in Feet	Blows/Foot 350-ft.lb.	Sample Size (Inches)	Sample Nº	Description
	8	1.4	1	Loose brown-gray SANDY GRAVEL
10	23	1.4	2	Compact brown-gray SANDY fine-medium GRAVEL with some SILT
15	23	1.4	3	
20	21	1.4	4	
25	27	1.4	5	Compact-dense fine-coarse SAND with scattered GRAVEL
30	41	1.4	6	
35	34	1.4	7	Compact gray-brown SANDY GRAVEL with some SILT
40	38+	BX	8	Hard blue CLAYEY-SILT (weathered SILTSTONE)

Strike Dip | Relative Compaction | Dry Density (lbs/cu.ft.) | Moisture (%) | Material Symbol | Unified Soil Classification

Logged By RDH | Date 11/19-20/69

REFERENCE: Moore & Taber, 1970, Report of Subsurface and Soils Investigation, Yoder/Orlob Associates, Water Pollution Control Facilities, City of Healdsburg, California.

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City of Healdsburg
Recycled Water System Project
Healdsburg, California

REFERENCE TEST BORING RB-4-69

PLATE NO. D-6

FILE NO. 18423-001-00 | AUGUST 2009

56979F

MOORE & TABER · Engineers · Geologists

TEST BORING LOG

±20' Rt Sta 26+00± - Gravity

TYPE 3" Rotary | ELEVATION ±90.0 | BORING Nº 7

Unconfined Compressive Strength (tsf)	RELATIVE COMPACTION	DRY DENSITY (lbs/cu.ft.)	MOISTURE (%)	BLOWS/FOOT 350-ft.lb.	SAMPLE SIZE (INCHES)	SAMPLE Nº	DEPTH IN FEET	MATERIAL SYMBOL	UNIFIED SOIL CLASSIFICATION	
										Brown SILT
							5			
										Brown CLAYEY-SILT
							10			
										Brown SILTY SAND
	G.W.S. Elev. 71.8						15			
	11/24/69									
2.9		101	22	13	1.4	1				Stiff brown CLAYEY SILT
							20			
				24	1.4	2				Compact brown SILTY GRAVELLY fine-coarse SAND
							25			
				60+	1.4	3				Dense brown weathered SILTY SANDY GRAVEL
							30			

Logged By RDM | Date 11/21/69

REFERENCE: Moore & Taber, 1970, Report of Subsurface and Soils Investigation, Yoder/Orlob Associates, Water Pollution Control Facilities, City of Healdsburg, California.

DCM | GEOENGINEERS

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City of Healdsburg
Recycled Water System Project
Healdsburg, California

REFERENCE TEST BORING RB-7-69

PLATE NO.

D-7

FILE NO. 18423-001-00 | AUGUST 2009

MOORE & TABER · Engineers · Geologists

TEST BORING LOG

±55' Rt Sta 0+75± - Gravity

TYPE 4" Auger & 2½" Rotary | ELEVATION 85.5 | BORING Nº 23

Depth	Blows/Foot 150-Lb.	Sample Size (Inches)	Sample Nº	Description
				Brown SILTY CLAYEY SANDY GRAVELLY ROAD FILL
5	10	1.4	1	Soft brown CLAYEY SILT with some ORGANIC MATTER
10	14	1.4	2	Semicompact brown fine-coarse SAND with some fine GRAVEL
15	36	1.4	3	Compact to dense brown-gray fine-coarse SAND and fine-medium GRAVEL with small amount SILT
	G.W.S. Elev. 66.8 2/10/70			
20	29	1.4	4	
	G.W.S. Elev. 63.5 11/26/69			
25	38	1.4	5	
30				(Continued)

TYPE 2½" Rotary | ELEVATION | BORING Nº 23 Contd.

Depth	Blows/Foot 150-Lb.	Sample Size (Inches)	Sample Nº	Description
	28	1.4	6	
35	30	1.4	7	(as above)
40	39	1.4	8	
45				

STRIKE DIP	RELATIVE COMPACTION	DRY DENSITY (lbs/cu ft)	MOISTURE (%)	BLOWS/FOOT 150-Lb.	SAMPLE SIZE (INCHES)	SAMPLE Nº	DEPTH IN FEET	MATERIAL SYMBOL	UNIFIED SOIL CLASSIFICATION

Logged By SWH | Date 11/25-26/69

REFERENCE: Moore & Taber, 1970, Report of Subsurface and Soils Investigation, Yoder/Orlob Associates, Water Pollution Control Facilities, City of Healdsburg, California.

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City of Healdsburg
Recycled Water System Project
Healdsburg, California

REFERENCE TEST BORING RB-23-69

PLATE NO.

D-8

FILE NO. 18423-001-00 | AUGUST 2009

ORIGINAL
File with DWR

CONFIDENTIAL LOG
Water Code Sec. 13752

WATER WELL DRILLERS REPORT

(Sections 7079, 7080, 7081, 7082, Water Code)

THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

Do Not Fill In
No 46933

State Well No.
Other Well No. 9N/9W-33C

(1) OWNER:
Name City of Healdsburg
Address City Hall, Healdsburg, Calif

(2) LOCATION OF WELL:
County Sonoma Owner's Number, if any
Township, Range, and Section
Distance from cities, roads, railroads, etc. Magnolia Ave., Healdsburg
See map on reverse

(3) TYPE OF WORK (check):
New Well ☒ Deepening ☐ Reconditioning ☐ Destroying ☐
If destruction, describe material and procedure in Item 11.

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☐ Municipal ☒
Irrigation ☐ Test Well ☐ Other ☐

(5) EQUIPMENT:
Rotary ☐
Cable ☒
Other ☐

(6) CASING INSTALLED:
STEEL: OTHER:
SINGLE ☒ DOUBLE ☐

From ft.	To ft.	Diam.	Gage or Wall	Diameter of Bore	From ft.	To ft.
0	82	12"	250			

If gravel packed

Size of shoe or wall ring: 12" Size of gravel: none
Describe joint welded

(7) PERFORATIONS OR SCREEN:
Type of perforation or name of screen

From ft.	To ft.	Perf. per row	Rows per ft.	Size in. x in.
62	82	17	14	3/16 x 6

(8) CONSTRUCTION:
Was a surface sanitary seal provided? Yes ☒ No ☐ To what depth 20 ft.
Were any strata sealed against pollution? Yes ☒ No ☐ 12' If yes, note depth of strata
From ft. to ft.
From ft. to ft.
Method of sealing Cement seal

(9) WATER LEVELS:
Depth at which water was first found, if known 12 ft.
Standing level before perforating, if known ft.
Standing level after perforating and developing 19 ft.

(10) WELL TESTS:
Was pump test made? Yes ☒ No ☐ If yes, by whom? Bartley Pump Inc
Yield: 550 gal./min. with 37 ft. drawdown after 24 hrs.
Temperature of water unknown Was a chemical analysis made? Yes ☐ No ☒
Was electric log made of well? Yes ☐ No ☒ If yes, attach copy

(11) WELL LOG:
Total depth 82 ft. Depth of completed well 82 ft.
Formations Describe by color, character, size of material, and structure

ft. to ft.	
0 to 2	gravel
2 to 25	brown clay and gravel
25 to 79	brown sand and gravel
79 to 82	blue cemented gravel

CONFIDENTIAL LOG
Water Code Sec. 13752

Work started 1/13 19 71, Completed 1/29 19 71

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME N. F. Keyt Well Drilling
(Person, firm, or corporation) (Typed or printed)
Address 605 Sierra Ave., Cotati, Calif

[SIGNED] /s/ Vernon Hansen
(Well Driller)

License No. 200068 Dated Oct 18, 19 66

SKETCH LOCATION OF WELL ON REVERSE SIDE

DWR 188 (REV. 9-65)

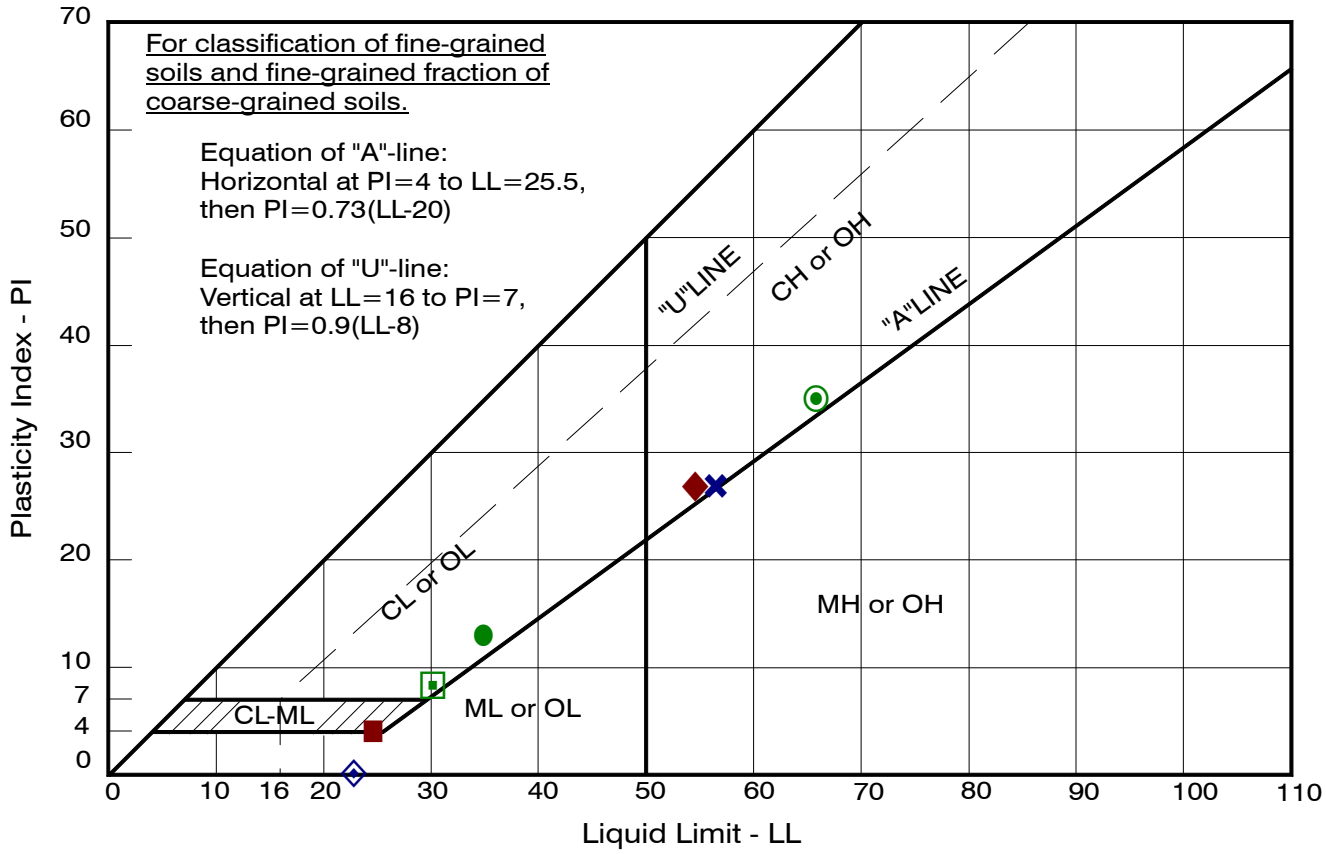
REFERENCE: State of California Department of Water Resources (1966), Well Log No. 46933 (Other Well No. 9N/9W-33C).

DCM | GEOENGINEERS

FILE NO. 18423-001-00 | AUGUST 2009

WINZLER & KELLY
City of Healdsburg
Recycled Water System Project
Healdsburg, California
REFERENCE TEST BORING RB-46933

PLATE NO.
D-9



TEST SYMBOL	BORING SAMPLE NO.	DEPTH (ft)	LIQUID LIMIT - LL	PLASTICITY INDEX - PI	GROUP SYMBOL*
●	B-11-1	3½-4	34	13	CL
◆	B-12-3	4-5½	54	27	CH
■	B-14-3	8½-9	25	4	CL-ML
⊙	B-16-16	50-51½	66	35	CH
◇	B-17-2	4-5½	22	NP	ML
⊡	B-19-2	4-5½	30	8	CL
✖	B-22-5	100-101½	56	27	CH

* Classification of fines < 0.425mm

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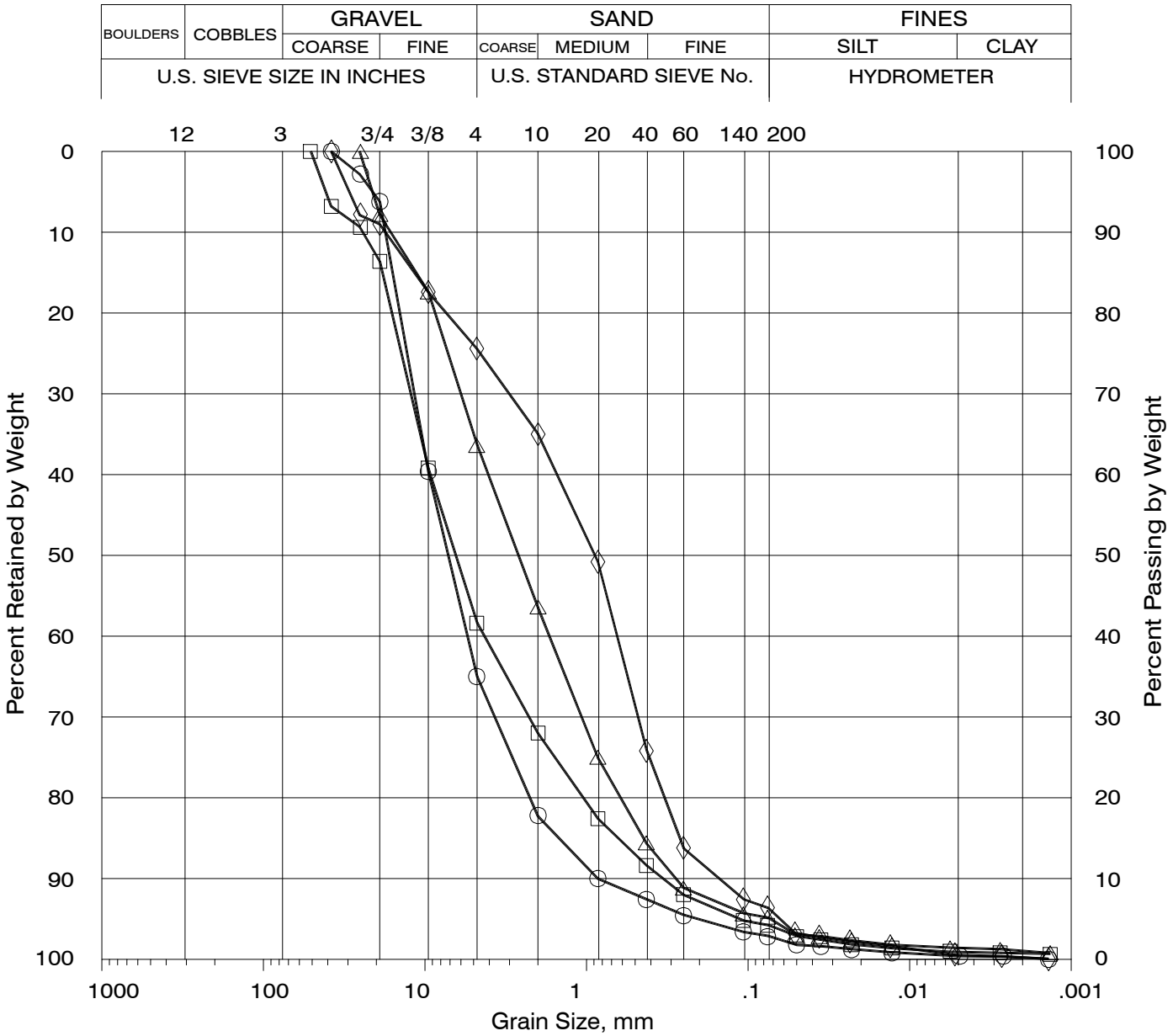
FILE NO. 18423-001-00 | AUGUST 2009

WINZLER & KELLY
City of Healdsburg
Recycled Water System Project
Healdsburg, California

ATTERBERG LIMITS

PLATE NO.
C-1
(2 of 2)



TEST SYMBOL	BORING SAMPLE NO.	DEPTH (feet)	GROUP SYMBOL	DESCRIPTION
○	B-15-3	16-16½	GW	well-graded gravel with sand
□	B-15-8&9	30½-33	GW	well-graded gravel with sand
△	B-15-11	36½-38	SW-SM	well-graded sand with silt and gravel
◊	B-15-14	45½-46	SW-SM	well-graded sand with silt and gravel

NOTE:
The largest particle (grain) size that could have been sampled from our borings by our sample barrels is a function of the inside diameter of the sample barrels used (see Plate A-1). Therefore, there may be larger particles (e.g., coarse gravel, cobbles or boulders) in the soils sampled than reflected on the boring logs and grain size distribution curves provided in this report.

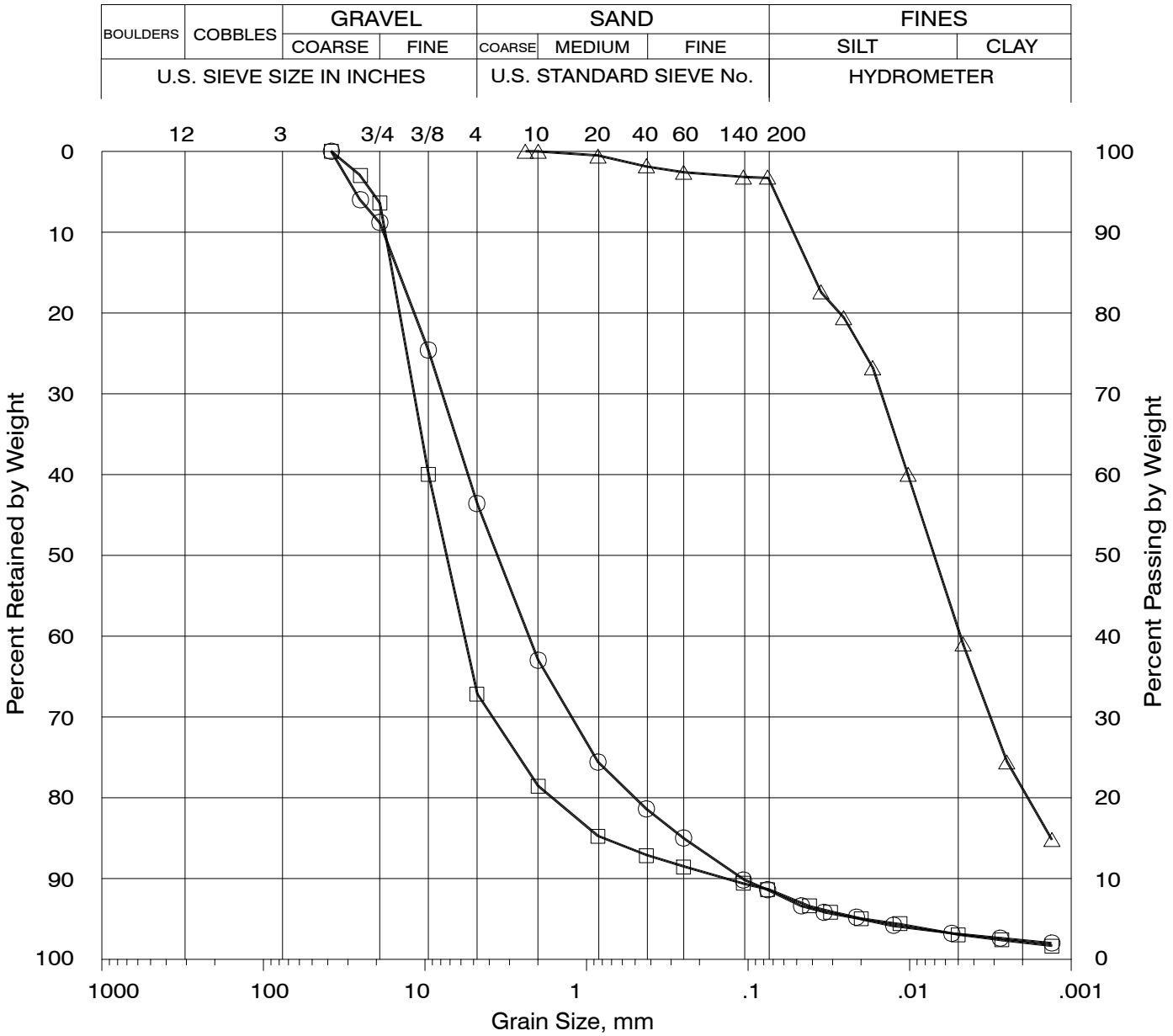
DCM GEOENGINEERS

FILE NO. 18423-001-00 | AUGUST 2009

WINZLER & KELLY
City of Healdsburg
Recycled Water System Project
Healdsburg, California

GRAIN SIZE ANALYSIS

PLATE NO.
C-2
(2 of 5)



TEST SYMBOL	BORING SAMPLE NO.	DEPTH (feet)	GROUP SYMBOL	DESCRIPTION
○	B-16-8	21-21½	SW-SM	well-graded sand with silt and gravel
□	B-16-12	30-35	GP-GM	poorly graded gravel with silt and sand
△	B-16-15	45-46½	CH	fat clay

NOTE:
The largest particle (grain) size that could have been sampled from our borings by our sample barrels is a function of the inside diameter of the sample barrels used (see Plate A-1). Therefore, there may be larger particles (e.g., coarse gravel, cobbles or boulders) in the soils sampled than reflected on the boring logs and grain size distribution curves provided in this report.

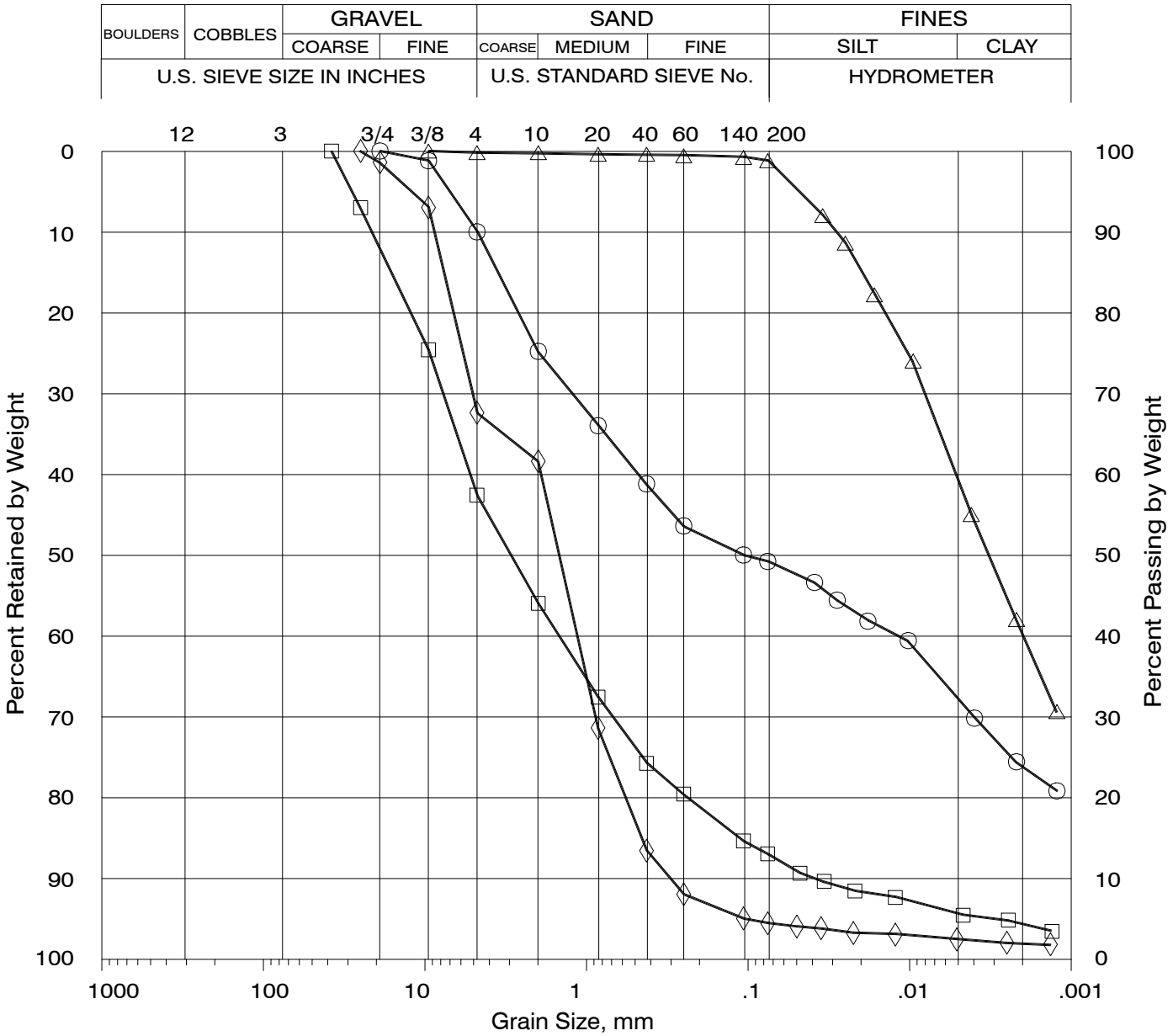
DCM GEOENGINEERS

FILE NO. 18423-001-00 | AUGUST 2009

WINZLER & KELLY
City of Healdsburg
Recycled Water System Project
Healdsburg, California

GRAIN SIZE ANALYSIS

PLATE NO.
C-2
(3 of 5)



TEST SYMBOL	BORING SAMPLE NO.	DEPTH (feet)	GROUP SYMBOL	DESCRIPTION
○	B-22-2	60-61	SC	clayey sand
□	B-22-3	70-71	SC	clayey sand with gravel
△	B-22-5	100-101½	CH	fat clay
◊	B-23-1	56-56½	SW	well-graded sand with gravel

NOTE:
The largest particle (grain) size that could have been sampled from our borings by our sample barrels is a function of the inside diameter of the sample barrels used (see Plate A-1). Therefore, there may be larger particles (e.g., coarse gravel, cobbles or boulders) in the soils sampled than reflected on the boring logs and grain size distribution curves provided in this report.

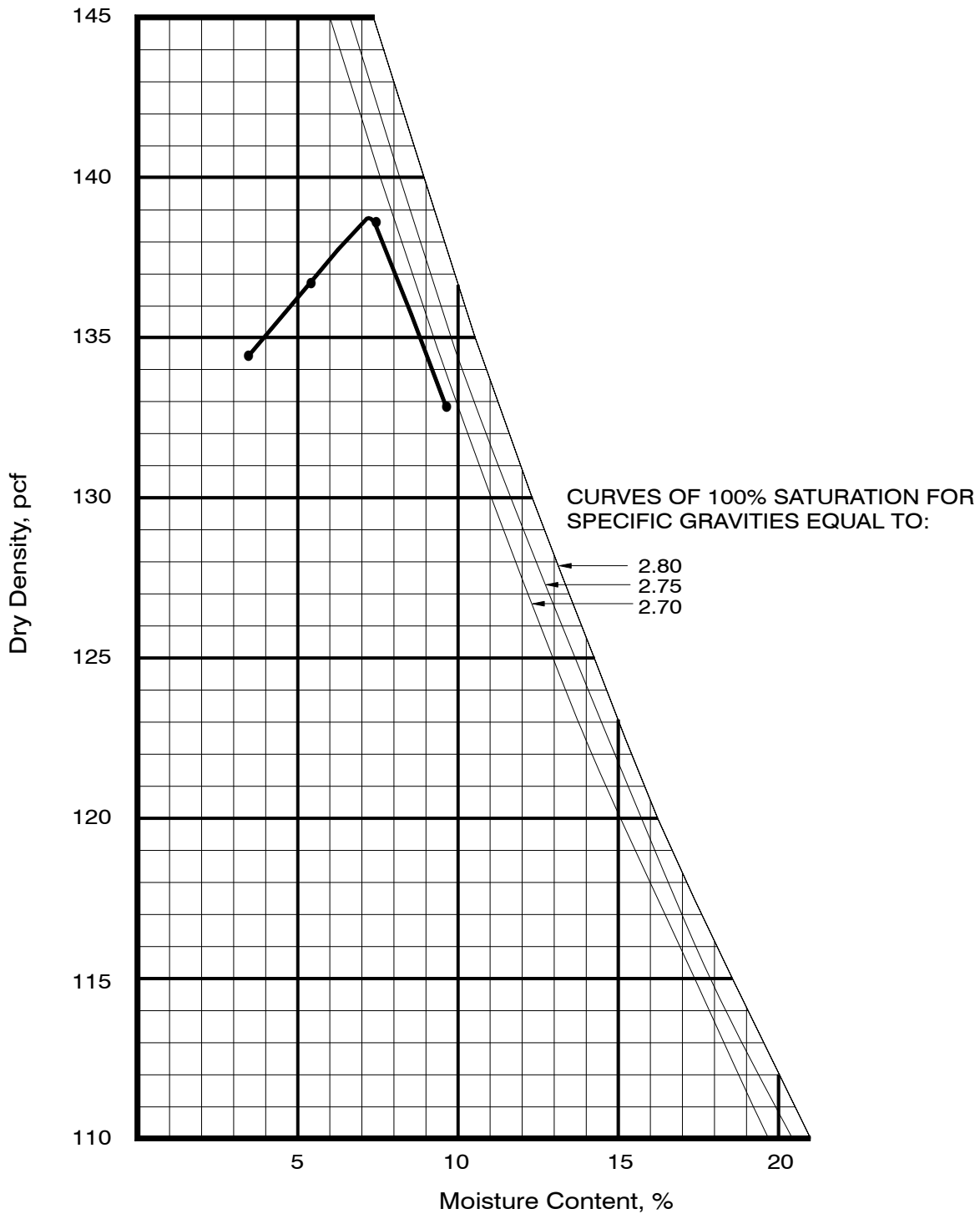
DCM GEOENGINEERS

FILE NO. 18423-001-00 | AUGUST 2009

WINZLER & KELLY
City of Healdsburg
Recycled Water System Project
Healdsburg, California

GRAIN SIZE ANALYSIS

PLATE NO.
C-2
(5 of 5)



TEST SYMBOL	SAMPLE NO.	DESCRIPTION	MAXIMUM DRY DENSITY (pcf)	OPTIMUM MOISTURE CONTENT (%)
●	B-16-1	clayey sand with gravel	138.8	7.2

TEST METHOD A.S.T.M. D1557-07 Procedure

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FILE NO. 18423-001-00 | AUGUST 2009

WINZLER & KELLY
City of Healdsburg
Recycled Water System Project
Healdsburg, California
MOISTURE-DENSITY RELATIONSHIP

PLATE NO.
C-6
(1 of 2)

CORROSION TESTS and RESULTS

SAMPLE NO.	RESISTIVITY saturated (ohm-cm)	REDOX (mV)	pH	SULFATE (mg/kg)	CHLORIDE (mg/kg)
B-5-3	1,900	420	8.2	N.D.	N.D.
B-8-1	4,600	420	6.4	N.D.	N.D.
B-11-3	2,600	420	7.3	N.D.	N.D.
B-16-12	*	410	8.4	N.D.	N.D.
B-19-3	5,400	420	7.3	N.D.	N.D.
Test Method	ASTM G57	ASTM D1498	ASTM D4972	ASTM D4327	ASTM D4327
Detection Limit	-	-	-	15	15

* - Unable to complete resistivity due to limited amount of soil.

Test Notes:

1. The above tests (excluding redox and sulfides) were performed in accordance with the following ASTM Methods:

   a. ASTM G57: STANDARD TEST METHOD FOR FIELD MEASUREMENT OF SOIL RESISTIVITY USING THE WENNER FOUR-ELECTRODE METHOD

   b. ASTM D1498: STANDARD TEST METHOD FOR OXIDATION-REDUCTION POTENTIAL OF WATER

   c. ASTM D4972: TEST METHOD FOR pH OF SOILS

   d. ASTM D4327: STANDARD TEST METHOD FOR ANIONS IN WATER BY CHEMICALLY SUPPRESSED ION CHROMATOGRAPHY

2. Testing provided by Cerco Analytical.

APPENDIX C

PRELIMINARY RISK REGISTERS

Risk Ranking:	Likelihood of Occurrence:	Impact Severity
Score 12 to 25	1 - Very Unlikely (< 10% chance)	1 - Very Low (<$10K or < 1 week)
Score 5 to 11	2 - Unlinkely (10 to 30% chance)	2 - Low ($10K to $50K or 1 to 2 weeks)
Score 1 to 4	3 - Possible (31 to 50% chance)	3 - Moderate ($50K to $100K or 2 to 4 weeks)
	4 - Likely (51 to 80% chance)	4 - High ($100K to $500K or 1 to 3 months)
	5 - Very Likely (> 80% chance)	5 -Very High (>$500K or > 3 months)

HEALDSBURG - MAGNOLIA FORCE MAIN REPLACEMENT PRELIMINARY RISK REGISTER FOR MICROTUNNEL CROSSING ALTERNATIVE

					Unmitigated			Mitigation Measures		Mitigated		
Item No.	Risk Scenario	Potential Cause	Potential Consequence	Impact Type (Cost and/or Schedule)	Likelihood	Impact	Risk Ranking	Design	Construction	Likelihood	Impact	Risk Ranking
1	Cobbles and/or boulders encountered during shaft and/or tunnel construction	Inadequate geotechnical characterization; variable geology	Shaft/tunnel construction more challenging; MTBM impeded or stopped; rescue shaft required	C&S	4	5	20	Complete additional geotechnical exploration including large diameter borings at shafts and near tunnel; specify larger casing/MTBM sizes to allow for larger aperture and more power/torque; prequalify contractors to require experience with anticipated ground conditions; require contingency planning for encountering cobbles/boulders during tunnel and shaft construction; require contingency planning and cost for rescue shaft	Select and operate MTBM with features designed to excavate through cobbly and/or bouldery ground (e.g. larger size; cutterhead designed to deal with anticipated conditions); adjust slurry as required by ground conditions; implement contingency plans as needed; use experienced MTBM operator	3	4	12
2	Mixed face ground conditions encountered during tunnel construction	Inadequate geotechnical characterization; variable geology	Tunnel construciton more challenging; difficult steering resulting in line/grade control issues; flowing conditions in portion of tunnel face leads to overexcavation; MTBM impeded or stopped	C & S	5	3	15	Complete additional geotechnical exploration to characterize extent of mixed face conditions; lower tunnel to avoid mixed face conditions; prequalify contractors to require experience with anticipated ground conditions; require planning and contingencies for encountering mixed face conditions	Select and operate MTBM with features desiged to excavate through mixed face conditions; implement contingency plans as needed; use experienced MTBM operators	5	2	10
3	Damage from settlement	Systemic settlements due to tunnel annular space; poor slurry management; overexcavation due to flowing ground and/or mixed face conditions	Damage to existing improvments (e.g. pipe bridge, recycled water line, force mains, pump station, etc.)	C	3	4	12	Estimate systemic settlements during design and evaluate potential impacts; locate bore path away from existing improvements	Support/underpin existing improvements if risk of damage from settlement is unacceptable; modify slurry as required by ground conditions; use experienced MTBM operator	2	3	6

Risk Ranking:
- Score 12 to 25
- Score 5 to 11
- Score 1 to 4

Likelihood of Occurrence:
1 - Very Unlikely (< 10% chance)
2 - Unlinkely (10 to 30% chance)
3 - Possible (31 to 50% chance)
4 - Likely (51 to 80% chance)
5 - Very Likely (> 80% chance)

Impact Severity
1 - Very Low (<$10K or < 1 week)
2 - Low ($10K to $50K or 1 to 2 weeks)
3 - Moderate ($50K to $100K or 2 to 4 weeks)
4 - High ($100K to $500K or 1 to 3 months)
5 -Very High (>$500K or > 3 months)

HEALDSBURG - MAGNOLIA FORCE MAIN REPLACEMENT PRELIMINARY RISK REGISTER FOR MICROTUNNEL CROSSING ALTERNATIVE

					Unmitigated			Mitigation Measures		Mitigated		
Item No.	Risk Scenario	Potential Cause	Potential Consequence	Impact Type (Cost and/or Schedule)	Likelihood	Impact	Risk Ranking	Design	Construction	Likelihood	Impact	Risk Ranking
4	Obstruction encountered during tunneling	Undocumented well or other man-made improvements extend into tunnel zone	MTBM is impeded or stopped; rescue shaft required	C&S	2	5	10	Thorough review and documentation of all wells and site development documents; require pilot tube probing from shafts to detect potential obstructions; require contingency planning for encountering obstruction	Complete pilot tube probing to detect obstructions prior to MTBM launch; implement contingency plans as needed	1	5	5
5	Hydrofracture/inadvertent return occurs during tunneling	Inadequate ground cover; high drilling fluid pressures; tunneling through highly permeable materials; alignment located near existing borings, wells, or other preferential paths for drilling fluid returns	Loss of slurry pressure and drilling fluid; potential environmental issue if fluid enters creek; stoppages/delays to address and clean up inadvertent returns	C & S	2	3	6	Locate tunnel with adequate depth to prevent inadvertent returns; require contingency plan to address procedures for inadvertent returns; identify and address existing borings, wells, or other preferential paths for drilling fluid returns	Monitor slurry pressure carefully during construction; provide experienced operators; implement contingency plan for inadvertent returns as needed; adjust drilling fluid mix design as required; keep clean up equipment on standby during construction	1	3	3
6	Jacking forces are higher than anticipated	Collapse of annular space; encounter cemented/stiff materials, cobbles/boulders or obstruction	Damage to casing; MTBM is impeded or stopped	C	2	4	8	Require intermediate jacking stations; specify lubrication requirements; specify larger casing/MTBM sizes to allow for higher thrust capacity; require contingency planning for higher than expected jacking forces	Require contractor to submit estimated jacking forces and casing design calculations; monitor jacking forces and adjust means and methods as required; implement good lubrication practices; have intermediate jacking station on site for use as needed; implement contingency plans as needed	1	4	4

Risk Ranking:
- Score 12 to 25
- Score 5 to 11
- Score 1 to 4

Likelihood of Occurrence:
1 - Very Unlikely (< 10% chance)
2 - Unlinkely (10 to 30% chance)
3 - Possible (31 to 50% chance)
4 - Likely (51 to 80% chance)
5 - Very Likely (> 80% chance)

Impact Severity
1 - Very Low (<$10K or < 1 week)
2 - Low ($10K to $50K or 1 to 2 weeks)
3 - Moderate ($50K to $100K or 2 to 4 weeks)
4 - High ($100K to $500K or 1 to 3 months)
5 -Very High (>$500K or > 3 months)

HEALDSBURG - MAGNOLIA FORCE MAIN REPLACEMENT
PRELIMINARY RISK REGISTER FOR
HORIZONTAL DIRECTIONAL DRILLING CROSSING ALTERNATIVE

					Unmitigated			Mitigation Measures		Mitigated		
Item No.	Risk Scenario	Potential Cause	Potential Consequence	Impact Type (Cost and/or Schedule)	Likelihood	Impact	Risk Ranking	Design	Construction	Likelihood	Impact	Risk Ranking
1	Sand and and gravel deeper than anticipated	Inadequate geotechnical characterization; meandering stream/variable geology resulting in changes in depth not detected by geotechncial exploration	Longer overall alignment length and longer conductor casing length required, additional easements required to accommodate longer alignment	C&S	3	4	12	Complete additional geotechnical exploration to characterize depth of sand & gravel on north side of creek	Mitigation measures primarily includes design measures	2	4	8
2	Steering or bore tracking issues during drilling	Inexperienced operators; loose or soft soils that prevent proper steering response; tight curve radius difficult to navigate; interference impedes tracking; use of downhole tools that aren't compatible with ground conditions	Bore deviates from design path; bore extends outside of negotiated easements	C & S	3	3	9	Prequalify operators to ensure adequate experience; require appropriate tracking equipment; require contractor to submit contingency plan addressing correcting line and grade deviations	Use experienced operators; minimize drill rod diameter to accommodate tighter curves; implement bore tracking techniques that ensure higher installation accuracy	2	3	6
3	Conductor casing installation is more difficult than anticipated	Ground conditions are more dense/stiff than anticipated; sand and gravel are deeper than expected requiring longer conductor casings; contractor's equipment is not sufficient to install required casing lengths	Additional cost and time required to rent larger pneumatic hammer during construction; conductor casings cannot be installed through full depth of sand and gravel leading to higher risk of HDD failure	C & S	3	4	12	Prequalify contractors with experience installing casings of similar size in similar ground conditions; specify minimum pneumatic hammer requirements for casing installation; additional geotechnical exploration to characterize depth of sand and gravel	Utilize larger equipment with greater liklihood of success; use telescoped casing approach	2	4	8
4	Loss of circulation of drilling fluid	Unanticipated highly permeable materials (e.g. large gravels, cobbles) beyond conductor casings; void or cavity encountered	Bore hole instability	C	2	4	8	Complete additional geotechnical exploration including boring that extends to bottom of designed bore path; require contingency plans for fluid loss; require experienced operator	Modify drilling fluid to "plug" formation; extend conductor casings further	2	3	6
5	Difficulty transporting gravels or larger particle sizes to surface	High percentage of large gravell or cobbles included in clay soils	Difficulty transporting spoils to surface; larger-sized material collects near low point in bore and makes reaming and pullback more difficult	C	3	3	9	Complete additional geotechnical exploration to characterize frequency and size distribution of larger materials in clay material; require experienced driller	Adjust drilling fluid as required to transport larger particle sizes; complete reaming/swabbing passes as needed to clean hole	2	3	6

Risk Ranking:
- Score 12 to 25
- Score 5 to 11
- Score 1 to 4

Likelihood of Occurrence:
1 - Very Unlikely (< 10% chance)
2 - Unlinkely (10 to 30% chance)
3 - Possible (31 to 50% chance)
4 - Likely (51 to 80% chance)
5 - Very Likely (> 80% chance)

Impact Severity
1 - Very Low (<$10K or < 1 week)
2 - Low ($10K to $50K or 1 to 2 weeks)
3 - Moderate ($50K to $100K or 2 to 4 weeks)
4 - High ($100K to $500K or 1 to 3 months)
5 -Very High (>$500K or > 3 months)

HEALDSBURG - MAGNOLIA FORCE MAIN REPLACEMENT
PRELIMINARY RISK REGISTER FOR
HORIZONTAL DIRECTIONAL DRILLING CROSSING ALTERNATIVE

					Unmitigated			Mitigation Measures		Mitigated		
Item No.	Risk Scenario	Potential Cause	Potential Consequence	Impact Type (Cost and/or Schedule)	Likelihood	Impact	Risk Ranking	Design	Construction	Likelihood	Impact	Risk Ranking
6	Hydrofracture/inadvertent return occurs during pilot hole or reaming	Inadequate ground cover; high drilling fluid pressures; drilling through highly permeable materials; alignment located near existing borings, wells, or other preferential paths for drilling fluid returns	Loss of slurry pressure and drilling fluid; potential environmental issue if fluid enters creek; stoppages/delays to address and clean up inadvertent returns	C & S	2	4	8	Require conductor casings through sand and gravel soils; deepen alignment; use mid-path intersect to reduce pressures during pilot hole drilling; require contingency plan to address procedures for inadvertent returns; identify and address existing borings, wells, or other preferential paths for drilling fluid returns	Monitor slurry pressure carefully during construction; provide experienced drillers/operators; implement contingency plan for inadvertent returns as needed; adjust drilling fluid mix design as required; keep clean up equipment on standby during construction	1	3	3
7	Bore hole collapse	Conductor casing not extended far enough; unanticipated non-cohseive, permeable soils beyond casings cause loss of drilling mud; inadequate drilling fluid pressure	Unable to pass pipe through bore hole; loss or breakage of tools; redrilling of hole required	C & S	3	4	12	Require conductor casing through sand and gravel; complete additional exploration to characterize depth of sand and gravel; minimize the size of the bore hole; require QA/QC procedures for drilling mud.	Use experienced operators; ensure conductor casings are extended to intended depth and correct elevations; perform quality assurance testing on the drilling mud multiple times each day; modify the drilling mud based on the ground conditions	2	4	8
8	Damage from settlement	Systemic settlements due to bore hole annular space; densification of sand/gravel during casing installation or removal	Damage to existing improvments (e.g. pipe bridge, recycled water line, force mains, pump station, etc.)	C	2	4	8	Estimate systemic settlements during design and evaluate potential impacts; locate bore path away from existing improvements	Support/underpin existing improvements if risk of damage from settlement is unacceptable	2	2	4
9	Falure of pipe duing pullback	Inadequate pipe wall thickness; pulling loads are higher than estimated; bore not properly reamed/swabbed	Pipe is damaged or fails requiring repair or reconstruction of pipe string	C & S	2	4	8	Estimate pulling loads for pullback; establish conservative design criteria	Ensure proper reaming and swabbing prior to pullback; adhere to pipe manufacturer's recommendations	1	4	4
10	Failure of drill pipe or downhole tooling	Improper inspection and maintenance; poor operation; ground more abrasive than anticipated; relatively tight curve radius	Drill rod or tooling breaks requiring repair or replacement; downtime and delays retrieving equipment if lost downhole	C & S	2	4	8	Require experienced operators; ensure ground conditions are well characterized; maximize bend radius to extent possible; require contractor to submit documentation of drill pipe inspection	Use new drill steel and tooling; have replacement parts on site/standby during construction; inspect and maintain drill rods and tooling; minimize torque loads by reaming in multiple passes;	1	4	4
11	Damage from vibrations	High vibration levels during driving of conductor casing	Damage to existing improvments (e.g. pipe bridge, recycled water line, force mains, pump station, etc.)	C	2	3	6	Estimate vibration levels and confirm they're acceptable; provide additional setbacks as required	Monitor vibrations during construction and adjust methods as needed	1	2	2

APPENDIX D

FORECAST OF PROBABLE CONSTRUCTION COSTS

FOR CONCEPTUAL TRENCHLESS CROSSINGS

Project: Magnolia Pump Station Force Main Replacement
Location: City of Healdsburg
Owner: City of Healdsburg
Engineer: Miller Pacific
Completion: 140 Calender Days/ $7,500/Day

Trenchless Evaluation - Microtunneling Budget Estimate

Labor Rates	
Plumber	75
Carp:	72
Laborer:	50
Operator:	70
Supt:	90

COVELLO CONSTRUCTION MANAGEMENT PLUS

Date of Esitmate: 12/1/2016
Estimator: Melanie Carrido, Covello

No.	Description	General Contractor Equipment Qty	Unit	Equipment	Qty	Unit	Rate	Cost	Rented Equipment Equipment	Qty.	Unit	Rate	Cost	Material Material	Qty.	Unit	Rate	Cost	Labor Plmb	Carp	Lab	Oper	Supt	Qty.	Unit	Rate	Cost	Subcontractors Sub	Qty.	Unit	Rate	Cost	TOTAL COST	Total Bid Item Cost	Bid Unit Price	Bid Total
1	Mobilization	1	LS																													-	-	383,360	**300,000**	**300,000**
	AP Equip/Phone/Toilet/GL Insur/Supt			Equipment	5	Mos.	2,000	10,000	Toilet/Phone	5	Mos.	500	2,500	GL Insur	1.70%		6,000,000	102,000					1	60	Hour	90	5,400					-	119,900			
	Bond < $500k, Transport,							-	Transport	1	LS	10,000	10,000	Bond < $500	1.20%		500,000	6,000	1					444	Hour	75	33,300					-	49,300			
	Bond > $500k							-	Software	1	LS	2,000	2,000	Bond > $500	0.80%	LS	7,000,000	56,000								-	-					-	58,000			
	Water Truck, Builders Risk							-					-	Bldrs. Risk	0.20%		6,000,000	12,000								-	-					-	12,000			
	Allowance for Contaminated Soil							-					-	Plug	1	LS	10,000	10,000								-	-					-	10,000			
	Hazmat Training & PPE							-					-	Misc.	1	LS	1,500	1,500			1	1		32	Hour	120	3,840					-	5,340			
								-					-					-								-	-					-	-			
								-					-					-								-	-					-	-			
	Survey							-					-					-								-	-	Plug	1	LS	20,000	20,000	20,000			
	Temporary Fence (800 LF) and Gates (3 Each)							-					-					-								-	-	Plug	1	LS	15,000	15,000	15,000			
	Errosion Control							-					-					-								-	-					-	-			
	Silt Fence (1,900 LF)							-					-	Plug	1,900	LF	3	5,700			2	1		40	Hour	170	6,800					-	12,500			
	Fiber Rolls (920 LF)							-					-	Plug	920	LF	4	3,680			2			24	Hour	100	2,400					-	6,080			
	Entrance Stabilization (1 Each)			Loader	1	Day	500	500					-	Plug	1	Each	2,000	2,000			2	1		8	Hour	170	1,360					-	3,860			
	Hydroseeding							-					-					-								-	-	Plug	1	LS	2,500	2,500	2,500			
	Dust Control			Water Truck	3	Mos.	1,000	3,000					-					-			1			40	Hour	50	2,000					-	5,000			
	Concrete Washout (2 Each)			Loader	1	Day	500	500					-	Plug	2	Each	750	1,500			1	1		8	Hour	120	960					-	2,960			
								-					-					-								-	-					-	-			
	Clear and Grub							-					-	Misc.	1	LS	400	400			2			16	Hour	100	1,600					-	2,000			
	Remove Trees (9 Each)							-					-					-								-	-	Pro Tree Care	1	LS	7,040	7,040	7,040			
	Trim Trees (6 Each)							-					-					-								-	-	Pro Tree Care	1	LS	1,680	1,680	1,680			
	Trim Trees for HDD Drill Rig							-					-					-								-	-	Plug	1	LS	2,000	2,000	2,000			
	Tree Protection Fencing (200 LF)							-					-					-								-	-	Plug	200	LF	16	3,200	3,200			
	AC Paving to Repair Magnolia Road							-					-					-								-	-	Plug	1	LS	25,000	25,000	25,000			
	Restore Landscaping							-					-					-								-	-	Plug	1	LS	20,000	20,000	20,000			
2	Micro Tunnel Shaft Installation	125	LF					-					-					-									-					-	-	2,598,380	**26,000.00**	**3,250,000**
2A	Shaft Construction (Jack & Receiving)																												1	LS	2,375,000	2,375,000	2,375,000		-	
	Excavation (Entry Shaft/Exit Shaft Prep)			Large. Excav, Ld	18	Days	1,600	28,800					-					-			1	2		80	Hour	190	15,200					-	44,000			
	Assume 30' Diameter x 65' Deep (Jacking Shaft)																																			
	Assume 20' Diameter x 60' Deep (Receiving Shaft)																																			
	Staging Area Prep for Drill Rig Operations			Sm. Excav, Ldr	4	Days	1,000	4,000					-					-			2	2		32	Hour	240	7,680					-	11,680			
	Offhaul Spoils (2400 CY = 1700 CY + 700 CY)			Loader	30	Days	500	15,000	10 Wheeler	480	Hour	95	45,600					-				1		80	Hour	70	5,600					-	66,200			
2B	Shaft Stabilization - Ground Improvements																											Grnd Imp	1	LS	100,000	100,000	100,000			
	HDPE Liner for Spoils							-					-	Plug	1	LS	1,500	1,500								-	-					-	1,500			
3	Micro Tunnel Installation	500	LF																															1,789,240	**4,125.00**	**2,062,500**
	MicroTunnel Installation			Large Excavator	4	Days	1,600	6,400					-					-								-	-		1	LS	1,750,000	1,750,000	1,756,400			
	HDPE 14" Pipe			Large Excavator	2	Days	1,600	3,200					-	SDR 11	25	LF	1,000	25,000			3	2		16		290	4,640					-	32,840		-	
4	Open Trench - SS Main Pipe to Pump Station	400	LF					-					-														-					-	-	121,990	**420.00**	**168,000**
	Potholing			Backhoe	2	Days	400	800					-					-			1	1		16	Hour	120	1,920					-	2,720			
								-	10 Wheeler	24	Hours	95	2,280					-								-	-					-	2,280			
	(D) Dig Trench (1st Run) Assuming 200 LF			Excavator	5	Days	1,200	6,000					-	Shoring	200	LF	50	10,000			1	1		200	LF	12	2,400					-	18,400			
				Loader	5	Days	500	2,500					-					-			1	1		40	Hour	120	4,800					-	7,300			
	(L) Lay 14" Pipe (1st run)			Excavator	5	Days	1,200	6,000					-					-									-					-	6,000			
								-					-	14" PVC	200	LF	55	11,000			3	2		16	Hour	290	4,640					-	15,640			
								-					-	Fittings	12	Each	500	6,000									-					-	6,000			
								-					-	Misc.	1	LS	250	250									-					-	250			
	(B) Backfill 14" Pipe Trench			Excvator	3	Day	1,200	3,600					-	Sand	3	TN	8	20			2	1		12	Hour	170	2,040					-	5,660			
				Loader	3	Day	500	1,500					-	Native BF	15	TN	13	195			1	1		6	Hour	120	720					-	2,415			
				Jumping Jack	2	Day	50	100					-	Eng Fill	5	TN	25	125								-	-					-	225			
	(D) Dig Trench (2nd Run) Assuming 200 LF			Excavator	5	Days	1,200	6,000					-	Shoring	200	LF	6	1,200			1	1		200	LF	10	2,000					-	9,200			
				Loader	5	Days	500	2,500					-					-			1	1		40	Hour	120	4,800					-	7,300			
								-					-					-								-	-					-	-			
	(L) Lay 14" Pipe (2nd run)			Excavator	2	Days	1,200	2,400					-	14" PVC	200	LF	55	11,000			3	2		16	Hour	290	4,640					-	18,040			
								-					-	Fittings	12	Each	500	6,000								-	-					-	6,000			
	Hydrostatic Testing			Truck	2	Days	50	100					-	Misc.	1	LS	2,000	2,000			2	1	1	16	Hour	260	4,160					-	6,260			
	(B) Backfill 14" Pipe Trench (2nd Run)			Excvator	3	Day	1,200	3,600					-	Sand	3	TN	8	20			2	1		12	Hour	170	2,040					-	5,660			
				Loader	3	Day	500	1,500					-	Native BF	15	TN	13	195			1	1		6	Hour	120	720					-	2,415			
				Jumping Jack	2	Day	50	100					-	Eng Fill	5	TN	25	125							Hour	-	-					-	225			

No.	Description	General Contractor Equipment							Rented Equipment					Material					Labor									Subcontractors					TOTAL COST	Total Item Cost	Bid Unit Price	Bid Total
		Qty	Unit	Equipment	Qty.	Unit	Rate	Cost	Equipment	Qty.	Unit	Rate	Cost	Material	Qty.	Unit	Rate	Cost	Plmb	Carp	Lab	Oper	Supt	Qty.	Unit	Rate	Cost	Sub	Qty.	Unit	Rate	Cost					
5	TIE-IN CONNECTIONS (North Side)	1	LS					-					-					-								-	-					-	-	177,700	200,000	200,000
5A	Excavate for Tie-In Connection at Pump STA			Excavator	3	Day	1,200	3,600	10 Wheerl	24	Hrs	95	2,280					-								-	-					-	5,880			
	Potholing			Loader	3	Day	500	1,500					-	Shoring	2	Week	10,000	20,000			2	2	1	24	Hour	330	7,920					-	29,420			
	Set Shoring			Crane	3	Days	2,500	7,500					-	Rental				-			1	1		8	Hour	120	960					-	8,460			
	Dewatering							-					-	10 HP	1	LS	200	200			1			12	Hour	50	600					-	800			
								-					-					-							Hour	-	-					-	-			
	Tie-In Connection			Excavator	4	Day	1,200	4,800					-	14" PVC	40	LF	55	2,200	1		2	1	1	32	Hour	335	10,720					-	17,720			
				Plug	1	Day	500	500					-	Fittings	1	LS	3,500	3,500							Hour	-	-					-	4,000			
	Thrust Blocks													Conc	2	CY	500	1,000			1	1		4	Hour	120	480						1,480			
	Backfill			Excavator	3	Day	1,200	3,600																													
				Loader	3	Day	500	1,500						Native BF	100	TN	13	1,300			2	2		24	Hour	240	5,760						8,560			
														Eng Fill	50	TN	25	1,250																			
	Remove Shoring			Excavator	2	Day	1,200	2,400	Transport	8	Hrs	95	760								2	1		16	Hour	170	2,720						5,880			
5B	Off-Set Connection to HDPE Carrier Pipe																																				
	14" HDPE (1st Run)			Excavator	4	Day	1,200	4,800	10Ton Crane	8	Hr	500	4,000	Fittings	4	EA	500	2,000	2		2	1	1	32	Hour	410	13,120						23,920			
	14" HDPE (2nd Run)			Excavator	4	Day	1,200	4,800	10Ton Crane	8	Hr	500	4,000	Fittings	4	EA	500	2,000	2		2	1	1	32	Hour	410	13,120						23,920			
	Thrust Blocks													Conc	5	CY	500	2,500			1	1		8	Hour	120	960						3,460			
	Backfill			Excavator	10	Day	1,200	12,000						Native	1,000	TN	13	13,000			2	2		80	Hour	240	19,200						44,200			
6	Open Trench - South Side New SS Main Pipe	200	LF					-					-					-								-	-					-	-	81,376	420	84,000
	Potholing			Backhoe	1	Days	600	600	10 Wheeler	12	Hours	95	1,140					-			1	1		16	Hour	120	1,920					-	3,660			
6A	(D) Dig Trench (1st Run) Assume 100 LF			Excavator	3	Days	1,200	3,600					-	Shoring	100	LF	50	5,000			1	1		100	LF	12	1,200					-	9,800			
				Loader	3	Days	500	1,500					-					-			1	1		24	Hour	120	2,880					-	4,380			
	(L) Lay 14" Pipe (1st run)			Excavator	3	Days	1,200	3,600					-					-									-					-	3,600			
								-					-	14" PVC	100	LF	55	5,500			3	2		16	Hour	290	4,640					-	10,140			
								-					-	Fittings	6	Each	500	3,000									-					-	3,000			
								-					-	Misc.	1	LS	250	250									-					-	250			
	(B) Backfill 14" Pipe Trench			Excvator	2	Day	1,200	2,400					-	Sand	1	TN	8	8			2	1		16	Hour	170	2,720					-	5,128			
				Loader	2	Day	500	1,000					-	Native BF	7	TN	13	91			1	1		16	Hour	120	1,920					-	3,011			
				Jumping Jack	1	Day	50	50					-	Eng Fill	3	TN	25	63									-					-	113			
6B	(D) Dig Trench (2nd Run) (Assuming 100 LF)			Excavator	3	Days	1,200	3,600				3,000	-	Shoring	100	LF	6	600			1	1		100	LF	12	1,200	Plug				-	5,400			
				Loader	3	Days	500	1,500					-					-			1	1		24	Hour	120	2,880					-	4,380			
	(L) Lay 14" Pipe (2nd run)			Excavator	3	Days	1,200	3,600				500	-					-									-					-	3,600			
								-					-	14" PVC	100	LF	55	5,500			3	2		16	Hour	290	4,640					-	10,140			
	Hydrostatic Testing			Truck	2	Days	50	100					-	Misc.	1	LS	2,000	2,000			2	1	1	16	Hour	260	4,160					-	6,260			
								-					-	Misc.	1	LS	250	250									-					-	250			
	(B) Backfill 14" Pipe Trench			Excvator	2	Day	1,200	2,400					-	Sand	1	TN	8	8			2	1		16	Hour	170	2,720					-	5,128			
				Loader	2	Day	500	1,000					-	Native BF	7	TN	13	91			1	1		16	Hour	120	1,920					-	3,011			
				Jumping Jack	1	Day	50	50					-	Eng Fill	3	TN	25	75									-					-	125			
7	TIE-IN CONNECTIONS (South Side)	1	LS					-					-					-								-	-					-	-	191,030	200,000	200,000
7A	Excavate for Tie-In Connection to Existing SS Lines			Excavator	3	Day	1,200	3,600					-					-			2	2	1	24	Hour	330	7,920					-	11,520			
	Potholing			Loader	3	Day	500	1,500	10 Wheerl	24	Hrs	95	2,280	Shoring	2	Week	10,000	20,000				1	1	8	Hour	160	1,280					-	25,060			
	Set Shoring			Crane	3	Days	2,500	7,500					-	Rental				-							Hour	-	-					-	7,500			
	Dewatering							-					-	10 HP	1	LS	200	200			1			12	Hour	50	600					-	800			
								-					-					-									-					-	-			
	Tie-In Connection			Excavator	4	Day	1,200	4,800					-	14" PVC	40	LF	55	2,200			3	1	1	32	Hour	310	9,920					-	16,920			
				Plug	1	Day	500	500					-	Fittings	1	LS	3,500	3,500								-	-					-	4,000			
								-					-					-								-	-					-	-			
	Thrust Blocks							-					-	Conc	2	CY	500	1,000			1	1		4	Hour	120	480					-	1,480			
								-					-					-								-	-					-	-			
	Backfill			Excavator	3	Day	1,200	3,600					-	Native BF	100	TN	13	1,300			2	2		24	Hour	240	5,760					-	10,660			
				Loader	3	Day	500	1,500					-	Eng Fill	50	TN	25	1,250								-	-					-	2,750			
								-					-					-								-	-					-	-			
	Remove Shoring			Excavator	3	Days	1,200	3,600					-					-			2	1	1	24	Hour	260	6,240					-	9,840			
7B	Off-Set Connection to HDPE Carrier Pipe																																				
	14" HDPE (1st Run)			Excavator	4	Day	1,200	4,800	10Ton Crane	8	Hr	500	4,000	Fittings	4	EA	500	2,000	2		2	1	1	32	Hour	410	13,120						23,920			
	14" HDPE (2nd Run)			Excavator	4	Day	1,200	4,800	10Ton Crane	8	Hr	500	4,000	Fittings	4	EA	500	2,000	2		2	1	1	32	Hour	410	13,120						23,920			
	Thrust Blocks													Conc	5	CY	500	2,500			1	1		8	Hour	120	960						3,460			
	Backfill			Excavator	10	Day	1,200	12,000						Native	1,800	TN	10	18,000			2	2		80	Hour	240	19,200						49,200			
								-					-					-									-					-	-			-
8	Restoration/Demob	1	LS	Plug				10,000					-	Plug	1	LS		5,000			2	1		16	Hour	##	2,720	Hydroseed	1	LS	7,500	7,500	25,220	25,220	30,000	30,000
								-					-					-								-	-					-	-			
	Totals							238,300	323,140				84,840					405,746								-	315,340					4,328,920	5,368,296	5,368,296		6,294,500
																												15% (Contractor Mark-Up)					805,244	15.0%		
																												Microtunneling Bid Estimate					6,173,540			
																												MicroTunneling Budget with 25% Estimate Contingency					7,716,925			

COVELLO
CONSTRUCTION MANAGEMENT PLUS

Project: Magnolia Pump Station Force Main Replacement
Location: City of Healdsburg
Owner: City of Healdsburg
Engineer: Miller Pacific
Completion: 80 Calender Days/ $7,500/Day

Trenchless Evaluation - HDD Budget Estimate

Labor Rates	
Plumber	75.00
Carp:	72.00
Laborer:	50.00
Operator:	70.00
Supt:	90.00

Date of Estimate: 12/1/2016
Bid Estimator: Melanie Carrido, Covello

No.	Description	Qty	Unit	General Contr. Equipment	Qty.	Unit	Rate	Cost	Rented Equipment Equipment	Qty.	Unit	Rate	Cost	Material Material	Qty.	Unit	Rate	Cost	Labor Plmb	Carp	Lab	Oper	Supt	Qty.	Unit	Rate	Cost	Subcontractors Sub	Qty.	Unit	Rate	Cost	TOTAL COST	Total Bid Item Cost	Bid Unit Price	Bid Total
1	Mobilization	1	LS																													-	-	249,140	**105,000**	**105,000**
	AP Equip/Phone/Toilet/GL Insur/Supt			Equipment	3	Mos.	2,000	6,000	Toilet/Phone	3	Mos.	500	1,500	GL Insur	1.70%		3,000,000	51,000					1	20	Hour	90	1,800					-	60,300			
	Bond < $500k, Transport,							-	Transport	1	LS	10,000	10,000	Bond < $500	1.20%		500,000	6,000	1					16	Hour	75	1,200					-	17,200			
	Bond > $500k							-	Software	1	LS	2,000	2,000	Bond > $500	0.80%	LS	2,700,000	21,600								-	-					-	23,600			
	Water Truck, Builders Risk							-					-	Bldrs. Risk	0.20%		3,000,000	6,000								-	-					-	6,000			
	Allowance for Contaminated Soil							-					-	Plug	1	LS	10,000	10,000								-	-					-	10,000			
	Hazmat Training & PPE							-					-	Misc.	1	LS	1,500	1,500			1	1		16	Hour	120	1,920					-	3,420			
								-					-					-								-	-					-	-			
								-					-					-								-	-					-	-			
	Survey							-					-					-								-	-	Plug	1	LS	20,000	20,000	20,000			
	Temporary Fence (800 LF) and Gates (3 Each)							-					-					-								-	-	Plug	1	LS	15,000	15,000	15,000			
	Errosion Control							-					-					-								-	-					-	-			
	Silt Fence (1,900 LF)							-					-	Plug	1,900	LF	3	5,700			2	1		40	Hour	170	6,800					-	12,500			
	Fiber Rolls (920 LF)							-					-	Plug	920	LF	4	3,680			2			24	Hour	100	2,400					-	6,080			
	Entrance Stabilization (1 Each)			Loader	1	Day	400	400					-	Plug	1	Each	2,000	2,000			2	1		8	Hour	170	1,360					-	3,760			
	Hydroseeding							-					-					-								-	-	Plug	1	LS	2,500	2,500	2,500			
	Dust Control			Water Truck	3	Mos.	1,000	3,000					-					-			1			40	Hour	50	2,000					-	5,000			
	Concrete Washout (2 Each)			Loader	1	Day	400	400					-	Plug	2	Each	750	1,500			1	1		8	Hour	120	960					-	2,860			
								-					-					-								-	-					-	-			
	Clear and Grub							-					-	Misc.	1	LS	400	400			2			16	Hour	100	1,600					-	2,000			
	Remove Trees (9 Each)							-					-					-								-	-	Pro Tree Care	1	LS	7,040	7,040	7,040			
	Trim Trees (6 Each)							-					-					-								-	-	Pro Tree Care	1	LS	1,680	1,680	1,680			
	Trim Trees for HDD Drill Rig							-					-					-								-	-	Plug	1	LS	2,000	2,000	2,000			
	Tree Protection Fencing (200 LF)							-					-					-								-	-	Plug	200	LF	16	3,200	3,200			
	AC Paving to Repair Magnolia Road							-					-					-								-	-	Plug	1	LS	25,000	25,000	25,000			
	Restore Landscaping							-					-					-								-	-	Plug	1	LS	20,000	20,000	20,000			
2	HDD Installation	1,100	LF					-					-					-								-	-					-		1,130,640	**1,450**	**1,595,000**
	Excavation (Entry Pit/Exit Pit Prep)			Sm. Excav, Ldr	2	Days	1,500	3,000	10 Wheeler	8	Hour	95	760					-			1	1		16	Hour	120	1,920					-	5,680			
	Staging Area Prep for Drill Rig Operations			Sm. Excav, Ldr	4	Days	1,500	6,000					-					-			2	2		16	Hour	240	3,840					-	9,840			
	Offhaul Spoils (200 CY)			Loader	3	Days	500	1,500	10 Wheeler	24	Hour	95	2,280					-				1		24	Hour	70	1,680					-	5,460			
	HDPE Liner for Spoils							-					-	Plug	1	LS	1,500	1,500								-	-					-	1,500			
	HDD Installation			Loader	5	Days	500	2,500	10 Wheeler	8	Hours	95	760					-								-	-	HDD Budget	1	LS	1,104,900	1,104,900	1,108,160			
3	Open Trench Pipe Installation at Pump Station	800	LF					-					-														-					-		154,700	**230**	**184,000**
	Potholing			Backhoe	2	Days	400	800					-					-			1	1		16	Hour	120	1,920					-	2,720			
								-	10 Wheeler	4	Hours	95	380					-								-	-					-	380			
	(D) Dig Trench (1st Run) (Assume 400 ft)			Excavator	4	Days	1,200	4,800					-	Shoring	400	LF	6	2,400			1	1		400	LF	12	4,800					-	12,000			
				Loader	4	Days	500	2,000					-					-			1	1		16	Hour	120	1,920					-	3,920			
	(L) Lay 14" Pipe (1st run)			Excavator	4	Days	1,200	4,800					-					-									-					-	4,800			
								-					-	14" PVC	400	LF	55	22,000			3	2		32	Hour	290	9,280					-	31,280			
								-					-	Fittings	25	Each	500	12,500									-					-	12,500			
								-					-	Misc.	1	LS	250	250									-					-	250			
	(B) Backfill 14" Pipe Trench			Excvator	3	Day	1,200	3,600					-	Sand	5	TN	8	40			2	1		24	Hour	170	4,080					-	7,720			
				Loader	3	Day	500	1,500					-	Native BF	30	TN	13	390			1	1		12	Hour	120	1,440					-	3,330			
				Jumping Jack	3	Day	50	150					-	Eng Fill	10	TN	25	250								-	-					-	400			
	(D) Dig Trench (2nd Run) (Assume 400 ft)			Excavator	4	Days	1,200	4,800					-	Shoring	400	LF	6	2,400			1	1		400	LF	10	4,000					-	11,200			
				Loader	4	Days	500	2,000					-					-			1	1		16	Hour	120	1,920					-	3,920			
	(L) Lay 14" Pipe (2nd run)			Excavator	4	Days	1,200	4,800					-	14" PVC	400	LF	55	22,000			3	2		32	Hour	290	9,280					-	36,080			
					4			-					-	Fittings	25	Each	500	12,500								-	-					-	12,500			
								-					-	Misc.	1	LS	250	250								-	-					-	250			
	(B) Backfill 14" Pipe Trench (2nd Run)			Excvator	3	Day	1,200	3,600					-	Sand	5	TN	8	40			2	1		24	Hour	170	4,080					-	7,720			
				Loader	3	Day	500	1,500					-	Native BF	30	TN	13	390			1	1		12	Hour	120	1,440					-	3,330			
				Jumping Jack	3	Day	50	150					-	Eng Fill	10	TN	25	250							Hour	-	-					-	400			
4	TIE-IN CONNECTION (North Side)	1	LS					-					-					-								-	-					-	-	112,950	**130,000**	**130,000**
4A	Excavate for Tie-In Connection at Pump STA			Excavator	3	Day	1,200	3,600					-					-								-	-					-	3,600			
				Loader	3	Day	500	1,500	10 Wheerl	24	Hrs	95	2,280	Shoring	2	Week	10,000	20,000			2	2	1	24	Hour	330	7,920					-	31,700			
	Set Shoring			Crane	3	Days	2,500	7,500					-	Rental				-								-	-					-	7,500			
	Dewatering							-					-	10 HP	1	LS	200	200			1			12	Hour	50	600					-	800			

No.	Description	Qty	Unit	General Contr					Rented Equipment					Material					Labor									Subcontractors					TOTAL COST	Total Item Cost	Bid Unit Price	Bid Total
				Equipment	Qty.	Unit	Rate	Cost	Equipment	Qty.	Unit	Rate	Cost	Material	Qty.	Unit	Rate	Cost	Plmb	Carp	Lab	Oper	Supt	Qty.	Unit	Rate	Cost	Sub	Qty.	Unit	Rate	Cost				
4A	Excavate for Tie-In at Pump STA (Cont)																																				
	Tie-In Connection			Excavator	4	Day	1,200	4,800					-	14" PVC	40	LF	55	2,200			3	1	1	32	Hour	310	9,920					-	16,920			
				Plug	1	Day	500	500					-	Fittings	1	LS	3,500	3,500							Hour	-	-					-	4,000			
	Thrust Blocks													Conc	2	CY	500	1,000			1	1		4	Hour	120	480									
	Remove Shoring			Excavator	3	Days	1,200	3,600					-					-			2	1	1	24	Hour	260	6,240					-	9,840			
				Crane	1	Days	2,500	2,500					-					-			1	1		24	Hour	120	2,880					-	5,380			
	Backfill			Excavator	3	Day	1,200	3,600					-	Native BF	100	TN	13	1,300			2	2		24	Hour	240	5,760					-	10,660			
				Loader	3	Day	500	1,500					-	Eng Fill	50	TN	25	1,250								-	-					-	2,750			
4B	Off-Set Connection at HDPE Carrier Pipe																																				
	14" HDPE (1st Run)			Excavator	2	Days	1,200	2,400						Fittings	4	EA	500	2,000	1		2	1		16	Hour	245	3,920						8,320			
	14" HDPE (1st Run)			Excavator	2	Days	1,200	2,400						Fittings	4	EA	500	2,000	1		2	1		16	Hour	245	3,920						8,320			
	Thrust Blocks													Concrete	1	CY	500	500									-						500			
	Backfill			Excavator	1	Days	1,200	1,200						Native	1	CY	500	500			1	1		8	Hour	120	960						2,660			
5	Open Trench - South Side New SS Main	400	LF										-																				-	84,396	**230**	**92,000**
	Potholing			Backhoe	2	Days	400	800	10 Wheeler	8	Hours	95	760					-			1	1		32	Hour	120	3,840					-	5,400			
								-					-					-									-					-	-			
5A	(D) Dig Trench (1st Run) (Assume 200 LF)			Excavator	2	Days	1,200	2,400					-	Shoring	200	LF	10	2,000			1	1		200	LF	12	2,400					-	6,800			
				Loader	2	Days	500	1,000					-					-			1	1		16	Hour	120	1,920					-	2,920			
	(L) Lay 14" Pipe (1st run)			Excavator	2	Days	1,200	2,400					-					-									-					-	2,400			
								-					-	14" PVC	200	LF	55	11,000			3	2		16	Hour	290	4,640					-	15,640			
								-					-	Fittings	12	Each	500	6,000									-					-	6,000			
								-					-	Misc.	1	LS	250	250									-					-	250			
	(B) Backfill 14" Pipe Trench			Excvator	2	Day	1,200	2,400					-	Sand	5	TN	8	40			2	1		16	Hour	170	2,720					-	5,160			
				Loader	2	Day	500	1,000					-	Native BF	15	TN	13	195			1	1		16	Hour	120	1,920					-	3,115			
				Jumping Jack	2	Day	50	100					-	Eng Fill	10	TN	25	250									-					-	350			
								-					-													-	-					-	-			
								-					-					-								-	-					-	-			
5B	(D) Dig Trench (2nd Run) (Assuming 200 LF)			Excavator	2	Days	1,200	2,400				3,000	-	Shoring	200	LF	6	1,200			1	1		200	LF	12	2,400	Plug				-	6,000			
				Loader	2	Days	500	1,000					-					-			1	1		8	Hour	120	960					-	1,960			
	(L) Lay 14" Pipe (2nd run)			Excavator	2	Days	1,200	2,400				500	-					-									-					-	2,400			
								-					-	14" PVC	200	LF	55	11,000			3	2		8	Hour	290	2,320					-	13,320			
								-					-	Fittings	12	Each	500	6,000									-					-	6,000			
								-					-	Misc.	1	LS	500	500									-					-	500			
	(B) Backfill 14" Pipe Trench			Excvator	2	Day	1,200	2,400					-	Sand	2	TN	8	16			2	1		8	Hour	170	1,360					-	3,776			
				Loader	2	Day	500	1,000					-	Native BF	15	TN	13	195			1	1		8	Hour	120	960					-	2,155			
				Jumping Jack	2	Day	50	100					-	Eng Fill	6	TN	25	150									-					-	250			
6	TIE-IN CONNECTION (South Side)	1	LS					-					-					-														-		114,910	**135,000**	**135,000**
6A	Excavate for Tie-In Connection on South Side			Excavator	3	Day	1,200	3,600					-					-			2	2	1	24	Hour	330	7,920					-	11,520			
				Loader	3	Day	500	1,500	10 Wheerl	24	Hrs	95	2,280	Shoring	2	Week	10,000	20,000							Hour	-	-					-	23,780			
	Set Shoring			Crane	3	Days	2,500	7,500					-	Rental				-							Hour	-	-					-	7,500			
	Dewatering							-					-	10 HP	1	LS	200	200			1			12	Hour	50	600					-	800			
								-					-					-									-					-	-			
	Tie-In Connection to Existing Lines			Excavator	4	Day	1,200	4,800					-	14" PVC	40	LF	55	2,200			3	1	1	32	Hour	310	9,920					-	16,920			
				Plug	1	Day	500	500					-	Fittings	1	LS	3,500	3,500								-	-					-	4,000			
								-					-					-								-	-					-	-			
	Thrust Blocks							-					-	Conc	2	CY	500	1,000			1	1		8	Hour	120	960					-	1,960			
								-					-					-								-	-					-	-			
	Backfill			Excavator	3	Day	1,200	3,600					-	Native BF	100	TN	13	1,300			2	2		24	Hour	240	5,760					-	10,660			
				Loader	3	Day	500	1,500					-	Eng Fill	50	TN	25	1,250								-	-					-	2,750			
								-					-					-								-	-					-	-			
	Remove Shoring			Excavator	3	Days	1,200	3,600					-					-			2	1	1	24	Hour	260	6,240					-	9,840			
				Crane	1	Days	2,500	2,500					-					-			1	1		24	Hour	120	2,880					-	5,380			
								-					-					-									-					-	-			
6B	Off-Set Connection at HDPE Carrier Pipe																																				
	14" HDPE (1st Run)			Excavator	2	Days	1,200	2,400						Fittings	4	EA	500	2,000	1		2	1		16	Hour	245	3,920						8,320			
	14" HDPE (2nd Run)			Excavator	2	Days	1,200	2,400						Fittings	4	EA	500	2,000	1		2	1		16	Hour	245	3,920						8,320			
	Thrust Blocks													Concrete	1	CY	500	500									-						500			
	Backfill			Excavator	1	Days	1,200	1,200						Native	1	CY	500	500			1	1		8	Hour	120	960						2,660			
7	Restoration/Demob	1	LS	Plug				10,000					-	Plug	1	LS		5,000			2	1		16	Hour	170	2,720	Hydroseed	1	LS	7,500	7,500	25,220	20,220	**26,000**	**26,000**
								-					-					-								-	-					-	-			
	Totals							156,900	179,900				23,000					299,236								-	185,480					1,208,820	1,871,956	1,866,956		2,267,000
																												15% (Contractor Markup)					280,795	15.0%		
																												HDD Bid Estimate					2,152,749			
																												HDD Budget with 25% Estimate Contingency					2,690,937			

COVELLO
CONSTRUCTION MANAGEMENT PLUS

Appendix E - Trenchless Budget Estimate References

Microtunneling Projects

Owner: City of Santa Rosa
Project: Santa Rosa Geysers Recharge Project
Bid Date: circa 2000

Owner: Santa Cruz County Sanitation District
Project: Park Avenue and Wesley Street Sewer Replacement Project
Bid Date: October 2012

Owner: Silicon Valley Clean Water formerly South Bayside System Authority
Project: 48" Force Main Reliability Improvement Project Unit 1
Bid Date: April 2013

HDD Projects

Owner: City of Santa Cruz
Project: Lombardi Gulch Emergency Repair Project
Bid Date: October 2015

Owner: Livermore-Amador Valley Water Management Agency, (LAVWMA)
Project: Western Terminus Project 2010-01
Bid Date: October 2010

Owner: Novato Sanitary District
Project: Novato Sanitary District Wastewater Facility Upgrade – Contract A.2
Ignacio Conveyance Force Main
Bid Date: April 2007

Attachment B - Proposer Registration Form

To: Prospective Proposer

CITY OF HEALDSBURG

ATTACHMENT B - PROPOSAL REGISTRATION FORM

Project: **– City of Healdsburg –Magnolia Force Mains Relocation Design**

Date to be submitted by: January 13, 2017

All Proposers intending to submit proposals must immediately complete this form and fax it to the City of Healdsburg, Patrick Fuss, Project Manager

Proposers failing to comply with this requirement will not receive addendums that might be issued which could affect the proposal being submitted.

FAX TO: 707-431-3181
Or email to pfuss@ci.healdsburg.ca.us
Please follow up transmission of the document with a telephone call to 707-217-3218

Firm/Company Name	
Address	
City and State	
Phone	
Fax	
Email	
Contact Person (Name & Title)	
Date	

Attachment C – City of Healdsburg Professional Services Agreement

CITY OF HEALDSBURG
PROFESSIONAL SERVICES AGREEMENT

This Agreement is made and entered into this _____ day of _____, 2016, by and between the City of Healdsburg, a California Municipal Corporation, 401 Grove Street, Healdsburg, California, 95448, hereinafter referred to as "City," and _____, hereinafter referred to as "Consultant."

RECITALS

WHEREAS, the City has determined that it requires the following professional services from Consultant:_____
_____; and

WHEREAS, Consultant represents and warrants that it is fully qualified to perform such professional services by virtue of specialized experience and training, education and expertise of its principals and employees. Consultant further represents that it is willing to accept responsibility for performing such services in accordance with the terms and conditions set forth in this Agreement; and

WHEREAS, the legislative body of the City on _____ by Resolution No. _____ authorized execution of this Agreement on behalf of the City in accordance with the City Municipal Code and/or other applicable law. [Delete section if not applicable]

NOW, THEREFORE**,** City and Consultant, for the consideration hereinafter described, mutually agree as follows:

1. DESCRIPTION OF SERVICES OR SCOPE OF WORK

The services to be performed under this Agreement (the "Services") are as follows:_____
_____. The Services are further described in Consultant's proposal (the "Proposal"), which is attached to and made a part of this Agreement as Exhibit A.

2. TERM

The Agreement term will commence on date of execution and expire on _____ unless the Agreement term is amended or the Agreement is terminated in accordance with its terms.

3. PAYMENT TERMS AND NOT TO EXCEED AMOUNT

A. City agrees to pay Consultant for Services that are actually performed in accordance with this Agreement. To be eligible for payment, Consultant invoices must be submitted not more often than monthly to City and list the Services performed and the amounts to be paid according to the cost categories and prices in the Proposal. Invoices from Consultant shall be clearly marked with Consultant's name, project name, an itemized description of services rendered during the period covered by the invoice, and City's project account number, if applicable. Invoices shall also contain the total number of hours of work performed under the Agreement by the Consultant and each employee, agent, and subcontractor of Consultant performing services hereunder. When the total number of hours of work by Consultant and any individual employee, agent or subcontractor of Consultant reaches or exceeds 800 hours, a separate notice shall be provided which shall include an estimate of the time necessary to complete the work described in Exhibit A.

B. In no event will City's obligation to pay the Consultant under this Agreement exceed $_____, (the "Not to Exceed Amount"), unless this Agreement is first modified in accordance with its terms. Where the Proposal provides for compensation on a time and materials basis, Consultant must maintain adequate records to permit inspection and audit of Consultant's time and material charges under this Agreement. Consultant will make such records available to City during normal business hours upon reasonable notice. In accordance with California Government Code Section 8546.7, if the Not to Exceed Amount exceeds TEN THOUSAND DOLLARS ($10,000.00), this Agreement and the Consultant's books and records related to this Agreement shall be subject to the examination and audit of the State Auditor, at the request of City or as part of any audit of the City, for a period of three (3) years after final payment under the Agreement.

4. TIME OF COMPLETION

Consultant must commence performance of the Services upon receipt of written direction to proceed from City. Consultant shall devote such time to the performance of services pursuant to this Agreement as may be reasonably necessary to meet the standards of performance provided in Section 7 below and to satisfy Consultant's obligations hereunder. Consultant will complete the Services in accordance with this Agreement by _____ (the "Time of Completion"). The Time of Completion may only be modified by an amendment of the Agreement in accordance with its terms.

5. INDEPENDENT CONTRACTOR

Consultant and City agree that the Consultant will perform the Services as an independent contractor and not as an employee or agent of the City. Persons employed or utilized by Consultant in the performance of the Services will not be employees or agents of the City. Consultant is solely responsible for the payment of employment taxes incurred under this Agreement and any similar federal or state taxes.

6. SUBCONTRACTING

Consultant may subcontract portions of the Services upon the prior written approval of the City. The Consultant will be solely responsible for payment for such subcontract services. No contractual relationship will exist between any such subcontractors of the Consultant and the City.

7. STANDARD OF PERFORMANCE

A. Consultant will perform the Services in the manner and according to the standards observed by a competent practitioner of the profession in which Consultant is engaged in the geographical area in which Consultant practices its profession and will prepare all work products required by this Agreement in accordance with those standards. Consultant will comply with all federal, state and local laws and regulations applicable to performance of the Services, including, but not limited to, the California Building Code, the Americans with Disabilities Act, any copyright, patent or trademark law, and any air pollution control law(s) or regulation(s). Consultant's failure to comply with any law(s) or regulation(s) applicable to the performance of the work hereunder shall constitute a breach of contract.

B. Consultant shall assign only competent personnel to perform services pursuant to this agreement. In the event that City, in its sole discretion, at any time during the term of this Agreement, desires the reassignment of any such persons, Consultant shall, immediately upon receiving notice from the city of such desire of City, reassign such person or persons.

8. OTHER GOVERNMENTAL REGULATIONS

To the extent that this Agreement may be funded by fiscal assistance from another governmental entity, Consultant and any subcontractors shall comply with all applicable rules and regulations to which City is bound by the terms of such fiscal assistance program.

9. USE OF RECYCLED PRODUCTS

Consultant shall endeavor to prepare and submit all reports, written studies, and other printed material on recycled paper to the extent it is available at equal or less cost than virgin paper.

10. INDEMNITY

To the maximum extent permitted by law, Consultant shall, at its own expense, indemnify, defend with counsel acceptable to the City, (which acceptance will not be unreasonably withheld), and hold harmless City and its officers, officials, employees, agents and volunteers ("Indemnitees") from and against any and all liability, loss, damage, claims, suits, actions, arbitration proceedings, administrative proceedings, regulatory proceedings, civil penalties and fines, expenses and costs (including, without limitation, claims expenses, attorney's fees and costs and fees of litigation) (collectively, "Liability") of every nature, whether actual, alleged or threatened, arising out of or in connection with the Services or Consultant's failure to comply with any of the terms of this Agreement, regardless of any fault or alleged fault of the Indemnitees.

The Consultant's obligation to indemnify, defend and hold harmless under this provision shall not be excused because of the Consultant's inability to evaluate Liability, or because the Consultant evaluates Liability and determines that the Consultant is not or may not be liable. The Consultant must respond within 30 calendar days to any tender for defense and indemnity by the City, unless the time for responding is extended by an authorized representative of the City in writing. If the Consultant fails to accept tender of defense and indemnity within 30 calendar days, in addition to any other remedies authorized by law, so much of the money due or that may become due the Consultant under this Agreement as shall reasonably be considered necessary by the City, may be retained by the City until disposition has been made of the matter subject to tender, or until the Consultant accepts the tender, whichever occurs first.

The Consultant waives any and all rights to express or implied indemnity against the Indemnitees concerning any Liability of the Consultant arising out of or in connection with the Services or Consultant's failure to comply with any of the terms of this Agreement .

Notwithstanding the foregoing, to the extent this Agreement is a "construction contract" as defined by California Civil Code § 2783, as may be amended from time to time, Consultant's duty to indemnify under this provision shall not apply when to do so would be prohibited by California Civil Code § 2782, as may be amended from time to time.

Notwithstanding the foregoing, to the extent that the Services include design professional services subject to Cal. Civil Code § 2782.8, as amended from time to time, Consultant's duty to indemnify shall only be to the maximum extent permitted by Civil Code § 2782.8.

In the event that Consultant or any employee, agent, or subcontractor of Consultant providing services under this Agreement is determined by a court of competent jurisdiction or the California Public Employees Retirement System (PERS) to be eligible for enrollment in PERS as an employee of City, Consultant shall indemnify, defend, and hold harmless City for the payment of any employee and/or employer contributions for PERS benefits on behalf of Consultant or its employees, agents, or subcontractors, as well as for the payment of any penalties and interest on such contributions, which would otherwise be the responsibility of City.

The defense and indemnification obligations of this Agreement are undertaken in addition to, and shall not in any way be limited by, the insurance obligations contained in this Agreement.
Consultant/Subcontractor's responsibility for such defense and indemnity obligations shall survive the termination or completion of this Agreement for the full period of time allowed by law.

11. INSURANCE

a. All required insurance must be provided in the form of "occurrence"-type policies underwritten by admitted insurers in the State of California with a rating of A or better from the current year Best Rating Guide. All policies must be issued at the expense of the Consultant and must be maintained at the Consultant's expense throughout the performance of the Work. Consultant shall maintain insurance as required by this contract to the fullest amount allowed by law.

b. The limits of the Commercial General Liability (including bodily injury, personal injury and property damage) insurance shall be:

$2,000,000 per occurrence
$2,000,000 aggregate

c. If the work to be performed involves vehicles or vehicular equipment, the Automobile insurance limit shall be:

$2,000,000 per accident for bodily injury and property damage

Automobile coverage should be at least as broad as Insurance Services Automobile Liability form CA 0001 Code 1 ("any auto"). No endorsement may be attached limiting the coverage. If coverage provided is anything less than 'any auto' additional information, such as schedule of covered autos or proof of personal auto liability coverage, may be required by the City.

d. Worker's Compensation Insurance. Proof of Workers Compensation and Employers Liability insurance as required by any applicable law, regulation or statute, including the provisions of Division IV of the Labor Code of the State of California, and any act or acts amending it. Worker's compensation insurance must be for Statutory Limits and must cover the full liability of the Consultant. The Consultant's Employer's Liability Insurance must be in an amount no less than $1,000,000.00 per occurrence. The workers' compensation policy must be endorsed with a waiver of subrogation. The insurance company, in its endorsement, must agree to waive all rights of subrogation against the City, its officers, officials, employees, agents and volunteers for losses paid under the terms of such policy.

e. Umbrella/Excess Policy. The limits of insurance required under this Contract may be satisfied by a combination of primary and umbrella or excess Insurance. Any umbrella or excess insurance shall contain or be endorsed to contain a provision that such coverage shall also apply on a primary and non-contributory basis for the benefit of City (if agreed to in a written contract or agreement) before the City's own insurance or self-insurance shall be called upon to protect it as a named insured.

f. If applicable, the Consultant, at its own cost and expense, must maintain for the period covered by this Agreement professional liability insurance in an amount not less than ONE MILLION DOLLARS ($1,000,000) covering errors and omissions. Any deductible or self-insured retention under the required professional liability insurance may not exceed $150,000 per claim.

g. The City's Risk Manager may increase or decrease the insurance requirements and limits set forth in those cases in which he/she determines that special circumstances justify such an increase or decrease.

h. Both the General Liability and Auto endorsements must add the City, its officials, officers, employees, agents and volunteers as an additional insured ("Additional Insured"). The Additional Insured coverage under the Consultant's general liability policy shall be "primary and non-contributory" and Consultant's coverage will not seek contribution from the City's insurance or self-insurance and shall be at least as broad as CG 20 01 04 13.

i. It shall be a requirement under this Agreement that any available insurance proceeds broader than or in excess of the specified minimum insurance coverage requirements and/or limits shall be available to the Additional Insured. Furthermore, the requirements for coverage and limits shall be (1) the minimum coverage and limits specified in this Agreement; or (2) the broader coverage and maximum limits of coverage of any insurance policy or proceeds available to the name insured; whichever greater.

j. The Consultant shall provide the City with a 30 day written notice of any reduction or cancellation of such insurance required to be furnished by the Consultant and include a severability of interest clause acceptable to the City and if requested by the City.

k. If an Umbrella or Excess Policy is used to satisfy the requirements, than an email or language stating such on the certificate must be provided from the insurance carrier/broker and that Umbrella/Excess Policy 'follows form' or is 'continuous' to the General liability and/ Auto liability policy in addition to the required endorsement.

l. Examples of City approved insurance forms are included in this PSA package. If the Consultant's insurance carrier chooses to use forms other than the City's approved forms, such forms shall be subject to the approval of the City. If the Consultant provides policy pages instead of an endorsement the insurance agent/broker will be asked to sign, initial and date all applicable sections of the policy that meet the City's insurance requirements.

m. All self-insured retentions (SIR) must be disclosed to City for approval and shall not reduce the limits of liability. Policies containing any self-insured retention (SIR) provision shall provide or be endorsed to provide that the SIR may be satisfied by either the named insured or the City. The City reserves the right to obtain a full certified copy of any insurance policy and endorsements. Failure to exercise this right shall not constitute a waiver of right exercise later.

n. Subcontractors

i. Consultant agrees to include with all subcontractors in their subcontract the same requirements and provisions of this contract including the indemnity and insurance requirements to the extent they apply to the scope of the Subcontractor's work. Consultant shall require all sub-contractors to provide a valid certificate of insurance and the required endorsements included in the Contract prior to commencement of any work and Consultant will provide proof of compliance, upon request, to the City.

ii. Any Subcontractor hired by the Consultant agrees to be bound to the Consultant and the City in the same manner and to the same extent as Consultant is bound to the City under the Contract. Subcontractor further agrees to include the same requirements and provisions of this Contract, including the indemnity and insurance requirements, with any Subcontractor to the extent they apply to the scope of the Subcontractor's work. A copy of the contract indemnity and insurance provisions will be furnished to the Subcontractor upon request

12. NON-DISCRIMINATION

During the performance of this Agreement, Consultant will not discriminate against any employee of the Consultant or applicant for employment because of race, religion, creed, color, national origin, age, physical or mental handicap or disability, medical condition, marital status, sex, or sexual orientation. Consultant will take affirmative action to ensure that applicants are employed and that employees are treated during employment without regard to their race, religion, creed, color, national origin, age, physical or mental handicap or disability, medical condition, marital status, sex, or sexual orientation.

13. LICENSES AND PERMITS

A. BUSINESS LICENSE

Before the City will issue a notice to proceed with the Services, to the extent the business license requirements of the Healdsburg Municipal Code apply, Consultant and any subcontractors subject to the requirements must acquire at their sole expense a business license from City in accordance with the Code. Such licenses must be kept valid throughout the Agreement term.

B. OTHER LICENSES AND PERMITS

Consultant represents and warrants to City that Consultant and its employees, agents, and any subcontractors have all licenses, permits, qualifications, and approvals of whatsoever nature that are legally required to practice in their respective professions. Consultant expressly represents and warrants to City that Consultant and its employees, agents, and any subcontractors shall, at their sole cost and expense, keep in effect at all times during the term of this Agreement any licenses, permits, and approvals that are legally required to practice their respective professions.

14. OWNERSHIP OF WORK PRODUCTS AND TREATMENT OF DOCUMENTS

All plans, specifications, reports, designs and other documents prepared by Consultant pursuant to this Agreement shall be and remain the property of the City. Any modification or reuse of such documents by the City without Consultant's prior written consent will be at the City's sole risk. Except as may be otherwise required by law, Consultant will disclose no data, plans, specifications, reports or other documents pertaining to the Services without the prior written consent of the City.

15. ALTERNATIVE DISPUTE RESOLUTION

If any dispute arises between the parties that cannot be settled after engaging in good faith negotiations, City and Consultant agree to resolve the dispute in accordance with the following:

A. Each party shall designate a senior management or executive level representative to negotiate any dispute.

B. The representatives shall attempt, through good faith negotiations, to resolve the dispute by any means within their authority.

C. If the issue remains unresolved after ten (10) days of good faith negotiations, the parties shall attempt to resolve the disagreement by negotiation between legal counsel. If the above process fails, the parties shall resolve any remaining disputes through mediation to expedite the resolution of the dispute.

D. The mediation process shall provide for the selection within 15 days of both parties of a disinterested third person as mediator, shall be commenced within 30 day, and shall be concluded within 15 days from the commencement of the mediation.

E. The parties shall equally bear the costs of any third party in any alternative dispute resolution process.

F. The alternative dispute resolution process is a material condition to this Agreement and must be exhausted as an administrative remedy prior to either Party initiating legal action. This alternative dispute

resolution process is not intended to, nor shall be construed to, change the time periods for filing claims or action specified by Government Code section 900, et seq.

16. TERMINATION AND REMEDIES

A. City may terminate this Agreement for convenience by giving at least 10 days' written notice to Consultant specifying the termination effective date. Upon receipt of such notice, Consultant may continue performance of the Services through the date of termination. City shall pay Consultant for all Services actually performed in accordance with this Agreement through the termination effective date. City, however, may condition payment of such compensation upon Consultant delivering to City any and all documents provided to or prepared by Consultant, and any and all documents provided to or prepared by City for Consultant, in connection with this Agreement. Such material may consist of photographs, computer software, video and audio tapes and other materials.

B. If Consultant materially breaches any term of this Agreement, in addition to any other remedies the City may have at law or equity, the City may:

1. Terminate the Agreement by notice to the Consultant specifying the termination effective date;

2. Retain, and/or recover from the Consultant at no additional cost to the City, the plans, specification, drawings, reports and other design documents and work products prepared by Consultant, whether or not completed;

3. Complete the unfinished Services itself or have the unfinished Services completed, and/or;

4. Charge Consultant, or deduct from monies that may be due or become due the Consultant under this Agreement, the difference between the cost of completing the unfinished Services pursuant to this Agreement and the amount that would otherwise be due Consultant had Consultant completed the Services in accordance with this Agreement.

17. BINDING EFFECT AND ASSIGNMENT PROHIBITION

This Agreement is binding upon City, Consultant, and their successors. Except as otherwise provided herein, neither City nor Consultant may assign, sublet or transfer its interest in this Agreement or any part thereof without the prior written consent of the other, and any purported assignment without such consent will be void.

18. REPRESENTATIVES

A. City representative for purposes of this Agreement will be _____. Consultant representative for purposes of this Agreement will be _____. The parties' designated representative will be the primary contact person regarding the performance of the Services. The parties intend that their designated representatives will cooperate in all matters regarding this Agreement and in such a manner so as to achieve performance of the Services in a timely and expeditious fashion. Consultant shall not substitute or replace primary representative without approval of the City.

B. Notices:

Any written notice to Consultant shall be sent to:

_____

_____

_____

Any written notice to City shall be sent to:

_____
City of Healdsburg
401 Grove Street
Healdsburg, CA 95448

19. INTEGRATION AND AMENDMENT

This Agreement represents the entire and integrated agreement between City and Consultant and supersedes all prior negotiations, representations or agreements, whether written or oral. If a discrepancy, disagreement, ambiguity, inconsistency or difference in interpretation of terms arises as to terms or provisions of this Agreement and any Exhibit(s) attached to this Agreement, this Agreement shall control and shall be deemed to reflect the intent of the Parties with respect to the subject matter hereof. This Agreement may only be amended by a writing signed by a representative authorized to bind the Consultant and a representative authorized to bind the City.

20. CONFLICT OF INTEREST PROHIBITION

City and Consultant will comply with the requirements of the City's Conflict of Interest Code adopted pursuant to the provisions of California Government Code Section 87300 and following, the Political Reform Act (California Government Code Section 81000 and following), the regulations promulgated by the Fair Political Practices Commission (Title 2, Section 18110 and following of the California Code of Regulations), California Government Code Section 1090 and following, and any other ethics laws applicable to the performance of the Services and/or this Agreement. Consultant may be required to file with the City Clerk a completed Form 700 before commencing performance of the Services unless the City Clerk determines that completion of a Form 700 is not required, pursuant to the City's Conflict of Interest Code. Form 700 forms are available from the City Clerk.

The Consultant may not perform Services for any other person or entity that, pursuant to any applicable law or regulation, would result in a conflict of interest or would otherwise be prohibited with respect to the Consultant's obligations pursuant to this Agreement. The Consultant agrees to cooperate fully with the City and to provide any necessary and appropriate information requested by the City or any authorized representative concerning potential conflicts of interest or prohibitions concerning the Consultant's obligations pursuant to this Agreement.

Consultant may not employ any City official, officer or employee in the performance of the Services, nor may any official, officer or employee of the City have any financial interest in this Agreement that would violate California Government Code Section 1090 and following. Consultant hereby warrants that it is not now, nor has it been in the previous twelve (12) months, an employee, agent, appointee, or official of the City. If Consultant was an employee, agent, appointee, or official of the City in the previous twelve months, Consultant warrants that it did not participate in any manner in the forming of this Agreement. Consultant understands that, if this Agreement is made in violation of Government Code Section 1090 and following, the entire Agreement is void and Consultant will not be entitled to any compensation for Consultant's performance of the Services, including reimbursement of expenses, and Consultant will be required to reimburse the City for any sums paid to the Consultant under this Agreement. Consultant understands that, in addition to the foregoing, penalties for violating Government Code Section 1090 may include criminal prosecution and disqualification from holding public office in the State of California.

Any violation by the Consultant of the requirements of this provision will constitute a material breach of this Agreement, and the City reserves all its rights and remedies at law and equity concerning any such violations.

21. APPLICABLE LAW AND VENUE

The laws of the State of California shall govern the rights, obligations, duties and liabilities of the parties to this Agreement and the interpretation of this Agreement. Any action or proceeding that is initiated or undertaken to enforce or interpret any provision, performance, obligation or covenant set forth in this Agreement shall be brought in a state court in Sonoma County.

22. RECOVERY OF ATTORNEY'S FEES

If a party to this Agreement brings any action, including an action for declaratory relief, to enforce or interpret any term of this Agreement, the prevailing party will be entitled to reasonable attorneys' fees in addition to any other relief to which that party may be entitled. The court may set such fees in the same action or in a separate action brought for that purpose.

23. SEVERABILITY

If a court of competent jurisdiction finds or rules that any provision of this Agreement is invalid, void, or unenforceable, the provisions of this Agreement not so adjudged will remain in full force and effect. The invalidity in whole or in part of any provision of this Agreement shall not void or affect the validity of any other provision of this Agreement.

24. COUNTERPARTS

This Agreement may be executed in multiple counterparts, each of which shall be an original and all of which together shall constitute one agreement.

City

By: _____
David Mickaelian, City Manager

By: _____
Heather Ippoliti, Assistant City Manager/
Risk Manager

ATTEST:

By: _____
Maria Curiel, City Clerk

CONSULTANT

By: _____

APPROVED AS TO FORM:

By: _____
Samantha Zutler, City Attorney

Exhibits: Exhibit A – Consultant's Proposal

2252829.1

Attachment D – Statement of Compliance Form

CITY OF HEALDSBURG

ATTACHMENT D - STATEMENT OF COMPLIANCE FORM

Instructions: Each proposal must be accompanied by a signed Statement of Compliance. The Proposer must sign one, and only one of the declarations stated below and remit as part of your Proposal as Attachment A.

No Exceptions.

The undersigned declares that the Proposal submitted by (Name of Firm/Company) ____to provide the services as described in the RFP was prepared in strict compliance with the instructions, conditions, and terms listed in the RFP, Scope of Services and (PSA) with no exceptions taken.

Signature:_______________________________ Date:__________________________________

Printed Name and Title: ____

- -

Exceptions.

By signing below, the Proposer acknowledges that the Proposal submitted by (Name of Firm/Company) ____has been prepared in consideration of and with exception to some of the terms of the RFP, Scope of Services and (PSA). By signing below, the Proposer declares that the Proposal includes a statement that identifies each item to which the Proposer is taking exception or is recommending change, includes the suggested rewording of the contractual obligations or suggested change in the RFP, and identifies the reasons for submitting the proposed exception or change. The City reserves the right to reject any declarations that are not accompanied with the required documentation as described above.

Signature:_______________________________ Date:__________________________________

Printed Name and Title: ____

[Attach a separate sheet(s) detailing each exception being taken]