NORTH COAST RESOURCE PARTNERSHIP

2018/19 IRWM Project Application

The North Coast Resource Partnership (NCRP) 2018/19 Project Application Instructions and additional information can be found at the NCRP 2018/19 Project Solicitation webpage (https://northcoastresourcepartnership.org/proposition-1-irwm-round-1-implementation-funding-solicitation/). Please fill out grey text boxes and select all the check boxes that apply to the project. Application responses should be clear, brief and succinct.

Project Applications will be accepted until 5:00 pm, ~~March 8, 2019~~ March 15, 2019. It is important to save the application file with a distinct file name that references the project name. When the application is complete, please email to kgledhill@westcoastwatershed.com

If you have questions, need additional information or proposal development assistance please contact:

- Katherine Gledhill at kgledhill@westcoastwatershed.com or 707.795.1235
- Tribal Projects: Sherri Norris, NCRP Tribal Coordinator at sherri@cieaweb.org or 510.848.2043

Project Name: Ranney Collector 2 Rehabilitation Project

A. ORGANIZATION INFORMATION

1. **Organization Name: Humboldt Bay Municipal Water District**

2. **Contact Name/Title**
   Name: John Friedenbach
   Title: General Manager
   Email: friedenbach@hbmwd.com
   Phone Number (include area code): (707) 443-5018

3. **Organization Address (City, County, State, Zip Code):**
   Eureka, Humboldt County, CA, 95501

4. **Organization Type**
   ☒ Public agency

☐ Non-profit organization
☐ Public utility
☐ Federally recognized Indian Tribe
☐ California State Indian Tribe listed on the Native American Heritage Commission's California Tribal Consultation List
☐ Mutual water company
☐ Other:

5. **Authorized Representative** (if different from the contact name)
Name: Pat Kaspari
Title: District Engineer
Email: pat.kaspari@ghd.com
Phone Number (include area code): (707) 443-8326

6. **Has the organization implemented similar projects in the past?** ☒ yes ☐ no
Briefly describe these previous projects.
The District has implemented a systematic approach to our Ranney Collector rehabilitations. Over the course of two decades, we have assessed the condition of all 4 of the Collectors; developed an approach for economical and successful rehabilitation. Rehabilitation of Collector 3 was intiated in 2012 and completed in 2015. Rehabilitation of Collector 1 was initiated in 2016 and will be completed in 2019.

7. **List all projects the organization is submitting to the North Coast Resource Partnership for the 2018/19 Project Solicitation in order of priority.**
The proposed project, Ranney Collector 2 Rehabilitation Project, will be the only submittal.

8. **Organization Information Notes:**

B. ELIGIBILITY

1. **North Coast Resource Partnership and North Coast IRWM Objectives**

GOAL 1: INTRAREGIONAL COOPERATION & ADAPTIVE MANAGEMENT
☒ Objective 1 - Respect local autonomy and local knowledge in Plan and project development and implementation
☒ Objective 2 - Provide an ongoing framework for inclusive, efficient intraregional cooperation and effective, accountable NCIRWMP project implementation
☐ Objective 3 - Integrate Traditional Ecological Knowledge in collaboration with Tribes to incorporate these practices into North Coast Projects and Plans

GOAL 2: ECONOMIC VITALITY
☒ Objective 4 - Ensure that economically disadvantaged communities are supported and that project implementation enhances the economic vitality of disadvantaged communities by improving built and natural infrastructure systems and promoting adequate housing
☐ Objective 5 - Conserve and improve the economic benefits of North Coast Region working landscapes and natural areas

GOAL 3: ECOSYSTEM CONSERVATION AND ENHANCEMENT

☒ Objective 6 – Conserve, enhance, and restore watersheds and aquatic ecosystems, including functions, habitats, and elements that support biological diversity

☒ Objective 7 - Enhance salmonid populations by conserving, enhancing, and restoring required habitats and watershed processes

GOAL 4: BENEFICIAL USES OF WATER

☒ Objective 8 - Ensure water supply reliability and quality for municipal, domestic, agricultural, Tribal, and recreational uses while minimizing impacts to sensitive resources

☒ Objective 9 - Improve drinking water quality and water related infrastructure to protect public health, with a focus on economically disadvantaged communities

☒ Objective 10 - Protect groundwater resources from over-drafting and contamination

GOAL 5: CLIMATE ADAPTATION & ENERGY INDEPENDENCE

☒ Objective 11 - Address climate change effects, impacts, vulnerabilities, and strategies for local and regional sectors to improve air and water quality and promote public health

☒ Objective 12 - Promote local energy independence, water/ energy use efficiency, GHG emission reduction, and jobs creation

GOAL 6: PUBLIC SAFETY

☐ Objective 13 - Improve flood protection and reduce flood risk in support of public safety

2. **Does the project have a minimum 15-year useful life?**

   ☒ yes ☐ no

   If no, explain how it is consistent with Government Code 16727.

3. **Other Eligibility Requirements and Documentation**

   CALIFORNIA GROUNDWATER MANAGEMENT SUSTAINABILITY COMPLIANCE

   a) Does the project that directly affect groundwater levels or quality?

      ☒ yes ☐ no

   b) If Yes, will the organization be able to provide compliance documentation outlined in the instructions, to include in the NCRP Regional Project Application should the project be selected as a Priority Project?

      ☒ yes ☐ no

   CASGEM COMPLIANCE

   a) Does the project overlie a medium or high groundwater basin as prioritized by DWR?

      ☐ yes ☒ no

   b) If Yes, list the groundwater basin and CASGEM priority: Mad River Basin. Rated Very Low.
   c) If Yes, please specify the name of the organization that is the designated monitoring entity:
   d) If there is no monitoring entity, please indicate whether the project is wholly located in an economically disadvantaged community.

      ☒ yes ☐ no

URBAN WATER MANAGEMENT PLAN

a) Is the organization required to file an Urban Water Management Plan (UWMP)?
   ☒ yes ☐ no
b) If Yes, list the date the UWMP was approved by DWR: 2017
c) Is the UWMP in compliance with AB 1420 requirements?
   ☒ yes ☐ no
d) Does the urban water supplier meet the water meter requirements of CWC 525?
   ☒ yes ☐ no
c) If Yes, will the organization be able to provide compliance documentation outlined in the instructions, to include in the NCRP Regional Project Application should the project be selected as a Priority Project?
   ☒ yes ☐ no

AGRICULTURAL WATER MANAGEMENT PLAN

a) Is the organization – or any organization that will receive funding from the project – required to file an Agricultural Water Management Plan (AWMP)?
   ☐ yes ☒ no
b) If Yes, list date the AWMP was approved by DWR:
c) Does the agricultural water supplier(s) meet the requirements in CWC Part 2.55 Division 6?
   ☐ yes ☐ no

SURFACE WATER DIVERSION REPORTS

a) Is the organization required to file surface water diversion reports per the requirements in CWC Part 5.1 Division 2?
   ☒ yes ☐ no
d) If Yes, will the organization be able to provide SWRCB verification documentation outlined in the instructions, to include in the NCRP Regional Project Application should the project be selected as a Priority Project?
   ☒ yes ☐ no

STORM WATER MANAGEMENT PLAN

a) Is the project a stormwater and/or dry weather runoff capture project?
   ☐ yes ☒ no
b) If yes, does the project benefit a Disadvantaged Community with a population of 20,000 or less?
   ☐ yes ☐ no
e) If No, will the organization be able to provide documentation that the project is included in a Stormwater Resource Plan that has been incorporated into the North Coast IRWM Plan, should the project be selected as a Priority Project?
   ☐ yes ☐ no

C. GENERAL PROJECT INFORMATION

1. Project Name: Ranney Collector 2 Rehabilitation Project

2. Eligible Project Type under 2018/19 IRWM Grant Solicitation

- ☐ Water reuse and recycling for non-potable reuse and direct and indirect potable reuse
- ☒ Water-use efficiency and water conservation
- ☐ Local and regional surface and underground water storage, including groundwater aquifer cleanup or recharge projects
- ☒ Regional water conveyance facilities that improve integration of separate water systems
- ☒ Watershed protection, restoration, and management projects, including projects that reduce the risk of wildfire or improve water supply reliability
- ☐ Stormwater resource management projects to reduce, manage, treat, or capture rainwater or stormwater
- ☐ Stormwater resource management projects that provide multiple benefits such as water quality, water supply, flood control, or open space
- ☐ Decision support tools that evaluate the benefits and costs of multi-benefit stormwater projects
- ☐ Stormwater resource management projects to implement a stormwater resource plan
- ☐ Conjunctive use of surface and groundwater storage facilities
- ☒ Decision support tools to model regional water management strategies to account for climate change and other changes in regional demand and supply projections
- ☐ Improvement of water quality, including drinking water treatment and distribution, groundwater and aquifer remediation, matching water quality to water use, wastewater treatment, water pollution prevention, and management of urban and agricultural runoff
- ☒ Regional projects or programs as defined by the IRWM Planning Act (Water Code §10537)
- ☐ Other:

3. Project Abstract

Ranney Collector rehabilitation consists of replacing laterals that project out into the aquifer. Once the new flow rates are determined, then new engergy efficient pumps and motors are sized to efficiently and cost effectively pump the water. Once the pump and motors are sized, then new electrical controls, circuitry and station 12kV transformer are installed to efficiently operate the new system. Original pumps, motors, electrical circuitry and transformer were install in 1960.

4. Project Description

HBMWD supplies wholesale treated groundwater to 88,000 people through 7 municipal agencies, and serves water to numerous other industrial and public entities in the region. HBMWD obtains water from 4 Ranney Collectors installed along the banks of the Mad River. The Collectors are large concrete caissons that extend from the surface to 80-100 ft below grade. Laterals, 1-ft steel well screens, are projected horizontally from the caissons into the surrounding aquifer and direct the water to the Collector. The water is then pumped from the Collector through the treatment and distribution system. For the past 50+ years the Collectors have been maintained and upgraded; however, they are nearing the end of their useful life and need to be rehabilitated. Investigations have shown that some of the laterals have collapsed and all of them have calcium and iron oxide deposits on the lateral screens that reduce their capacity. HBMWD is working on a phased rehabilitation of each collector and replacement of all the laterals in all of the collector wells and has successfully completed rehabilitation on Collectors 1 and 3.

This project focuses on the next phase which is rehabilitation of Collector 2. The rehabilitation process begins with replacement of the laterals. For Collector 2, three or four new stainless steel laterals will be projected from the existing caisson. Cores will be cut through the sides of the existing caisson so the new laterals can be projected out horizontally into the surrounding aquifer. The new laterals will be spiral wound, stainless steel well screens, with a much larger ratio of open space per foot of screen than the existing lateral screens. This will reduce the flow velocities in the subsurface, thereby reducing the associated turbidity of the water and the energy and cost to treat the turbidity. Given the greater capacity and lower flow velocities, the drawdown in the collector will be reduced. This will reduce the energy required to pump the water from the caisson through the treatment and distribution system, thereby reducing energy consumption and greenhouse gas (GHG) emissions. HBMWD provides groundwater recharge to the aquafers below the collectors by releasing water from Ruth Lake. In addition to assuring water supply reliability for the regional water system, this project will maintain beneficial flows for salmonids throughout approximately 75 miles of the Mad River below Ruth Lake.

The Project protects and enhances drinking water quality, and is the most cost-effective, environmentally sensitive method of ensuring a reliable, drought resilient, high quality drinking water supply for the region in and around Humboldt Bay for approximately 2/3rds of the County's population. 88% of the county's population in HBMWD's service area are Disadvanctaged Communities based on the DAC tracts, block groups, and places methodology computations.

5. Specific Project Goals/Objectives

Goal 1: Provide reliable supply of high quality drinking water to HBMWD customers
Goal 1 Objective: Rehabilitate Collector infrastructure components that are 50+ yrs old.
Goal 1 Objective: Continue to implement the phased rehabilitation of Collector system.
Goal 1 Objective: Provide adequate water supply with minimal environmental impact.
Goal 1 Objective: Reduce energy consumption and GHG emissions via new efficient pumps/motors.

Goal 2: Reduce impacts to water quality.
Goal 2 Objective: Reduce the influence of the collectors on water quality by increasing the area from which water is extracted, thus reducing the localized impacts to the aquafer recharge areas.
Goal 2 Objective: Develop an extraction pumping schedule which results in the least impact to the recharge area with the greatest production.
Goal 2 Objective: Reduce: turbidity in raw water; energy consumption & cost, and GHG emissions associated with pumping and treating turbidity.
Goal 2 Objective:

Goal 3: During rehabilitation, minimize impacts to the surrounding environment and river channel
Goal 3 Objective: Contain construction activities to the existing confines of Collector 2, eliminating additional work in the river channel.
Goal 3 Objective: Implementation of a Storm Water Pollution Prevention Plan for the Project.
Goal 3 Objective:

Additional Goals & Objectives (List)
Improve energy efficiency of the regional water system.
Increase access to a larger recharge area thus reducing water draw down in the well which results in reduced energy required to pump water to the regional treatment system.
Provide additional flexibility in the timing of pumping, allowing for pumping during off-peak hours at a reduced cost to the water ratepayers.
Maintain the status quo for releases from Ruth Lake, sustaining the carrying capacity and cold water refugia for juvenile salmonid rearing in the Mad River.
Provide the most cost-effective alternative for maintaining a reliable water supply for 2/3rds of Humboldt County's population, 88% of which are DAC for the next 50 years.

6. **Describe how the project addresses the North Coast Resource Partnership and North Coast IRWM Plan Goals and Objectives selected**.
   The Project addresses objectives of the NCRP and NCIRWMP goals by:
   Conserving native salmonid populations in the Mad River through flow releases from Ruth Lake.
   Enhancing drinking wate quality by increasing the area of the lateral screens and decreasing flow velocities and associated turbidity.
   Most cost effective regional approach for ensuring adequate water supply and drought resiliency.
   Addressing environmental justice issues by controlling the cost burden to the customers, many of whom are disadvantaged communities.

7. **Describe the need for the project**.
   The Project will replace critical aging infrastructure that is of regional importance to assure water supply and drought resiliency while decreasing GHG emissions. The system design and operation recharge groundwater in the process of providing a reliable drinking water source for nearly two-thrids of Humboldt County's population. Maintaining the regional water supply infrastructure is essential for its operation for the next 50 years.

8. **List the impaired water bodies (303d listing) that the project benefits:**
   This Project benefits the Mad River, which is listed in the 2006 Clean Water Act Section 303(d) list of Water Quality Limited Segments. With the improved production capacity of Collector 2, flow releases from Ruth Lake will be maintained with related benefit of lower temperature refugia locations in upper section of the Mad River.

9. **Will this project mitigate an existing or potential Cease and Desist Order or other regulatory compliance enforcement action?** ☐ yes ☒ no
   If so, please describe?

10. **Describe the population served by this project.**
    The Humboldt County population served by the HBMWD regional water system is approximately 88,000 residents in and around the Humboldt Bay area, 88% of which are DAC.

11. **Does the project provide direct water-related benefits to a project area comprised of Disadvantaged Communities or Economically Distressed Communities?**
    - ☐ Entirely
    - ☒ Partially
    - ☐ No

    List the Disadvantaged Community(s) (DAC)
    Eureka, Arcata, Manila, Freshwater, Bayside, Samoa, Humboldt Hill, Fields Landing, Indianola, McKinleyville, Fieldbrook, and Blue Lake.

12. **Does the project provide direct water-related benefits to a project area comprised of Severely Disadvantaged Communities (SDAC)?**
    - ☐ Entirely
    - ☒ Partially
    - ☐ No

List the Severely Disadvantaged Community(s)
Eureka, Samoa, Manila, Arcata, McKinleyville, Sunny Brae.

13. **Does the project provide direct water-related benefits to a Tribe or Tribes**?
    - ☐ Entirely
    - ☒ Partially
    - ☐ No

    List the Tribal Community(s)
    Blue Lake Rancheria. See grant support letter included with grant application.
    If yes, please provide evidence of support from each Tribe listed as receiving these benefits.

14. **If the project provides benefits to a DAC, EDA or Tribe, explain the water-related need of the DAC, EDA or Tribe and how the project will address the described need.**
    The water related need is human consumption of drinking water at a reasonable cost. The HBMWD regional water system satisfies that basic human need. Funding for this project lessens the capital cost to rehabilitate the HBMWD regional water system while simultaneously reducing operating costs via improved energy efficiency. Lower capital costs reduces the burden of water rate increase to all of the disadvantaged communities and tribe served by HBMWD.

15. **Does the project address and/or adapt to the effects of climate change? Does the project address the climate change vulnerabilities in the North Coast region?** ☒ yes ☐ no
    If yes, please explain.
    New laterals, pumps & motors, and electrical systems will increase the inflow rate at the Collector which decreases the drawdown, increases pump efficiency and decreases energy consumption and corresponding GHG emissions. The increased surface area of lateral's screens reduces velocities of water flowing into the screens and will reduce accociated turbidity. This will reduce energy consumption & GHG emissions associated with treatment of the water for turbidity.

16. **Describe how the project contributes to regional water self-reliance.**
    HBMWD was able to provide water supply to meet the normal demands of all 7 municipal customers even during the height of the recent California drought years. The location of Ruth Lake at the top of the Mad River watershed helps ensure that it will fill, as it did during every year of the recent drought. Calculations show that the system will provide over 4 years of regional supply under drought conditions. The new laterals will be projected out farther than the existing laterals and will have more uniform screen openings. Consequently, they will draw from a greater aquaifer area, resulting in less overall drawdown in the aquifer. The installation of new laterals will ensure a reliable water supply for the lifetime of the new laterals.

17. **Describe how the project benefits salmonids, other endangered/threatened species and sensitive habitats.**
    With improved production capacity of Collector 2, flow releases from Ruth Lake will be maintained resulting in lower temperature refugia locations in upper section of Mad River thereby conserving native salmonid populations.

18. **Describe local and/or political support for this project.**
    Local communities who will benefit from this project include: Cities of: Arcata, Blue Lake, Eureka; CSD's of: Fieldbrook-Glendale, Humboldt, Manila, McKinelyville.Tribal beneficiary - Blue Lake Rancheria. US Coast Guard. Also see attached letters of support.

19. List all collaborating partners and agencies and nature of collaboration.
HBMWD has existing formal agreements with our wholesale customers: Cities of: Arcata, Eureka, and Blue Lake; and Humboldt, McKinleyville, Fieldbrook-Glendale, and Manila Community Services Districts with regards to providing water and performing infrastructure upgrade and rehabilitation projects such as the Collector 2 rehabilitation. HBMWD meets with these agencies on a monthly basis to collaborate on upcoming and on-going projects, and issues of mutual interest. The Collector 2 rehabilitation project has been included in these discussions. HBMWD coordinates routinely with the State Water Resources Control Board regarding our operations. See attached letters of support evidencing other collaborations.

20. Is this project part or a phase of a larger project? ☒ yes ☐ no
Are there similar efforts being made by other groups? ☐ yes ☐ no
If so, please describe?
This Project is in HBMWD Capital Improvement plan which spans 50 years into the future. HBMWD has achieved several milestones including lateral and caisson assessments, attempted rehab (not replacement which is current project) of existing Collector 2 laterals (failed), development of groundwater model to assess potential lateral locations and yield, and the successful rehabilitation of Collectors 1 and 3. This Project is the next critical step in our comprehensive measured approach in our CIP.

21. Describe the kind of notification, outreach and collaboration that has been done with the County(ies) and/or Tribes within the proposed project impact area, including the source and receiving watersheds, if applicable.
HBMWD frequently collaborates with Humboldt and Trinity Counties on land use, environmental, and economic issues. See attached support letter from Economic Development. HBMWD's collaboration with our 7 municipal customers occurs monthly. HBMWD has worked closely with Tribes on many infrastructure projects. See attached support letter from Blue Lake Rancheria.

22. Describe how the project provides a benefit that meets at least one of the Statewide Priorities as defined in the 2018 IRWM Grant Program Guidelines and Tribal priorities as defined by the NCRP?
The Project meets Action #1-increase water sector energy efficiency and GHG reduction capacity with installation of new laterals and energy efficient modern pumps & motors.
The Project meets Action #2-increase Regional Self-Reliance through the delivery of water through HBMWD's regional system with 7 municipal agencies while reducing capital costs and individual rates to DAC's within our service area.
The Project meets Action #4-continue protecting and restoring the resiliency of our ecosystems to support fish and wildlife population through maintaining releases from Ruth Lake sustaining the carrying capacity and cold water refugia for juvenile salmonid rearing in the Mad River while enhancing water flows in this stream system.
The Project meets Action #5-effectively manage water resources through hydrologic conditions to reduce impact of shortages and secures a more reliable water supply and consequently improves drought preparedness.

23. Project Information Notes:

D. PROJECT LOCATION

1. **Describe the location of the project**
   Geographical Information
   Latitude: 40 54' 27.1656"
   Longitude: -124 2" 53.433"

2. **Site Address (if relevant):**

3. **Does the applicant have legal access rights, easements, or other access capabilities to the property to implement the project?**
   ☒ Yes If yes, please describe
   ☐ No If No, please provide a clear and concise narrative with a schedule, to obtain necessary access.
   ☐ NA If NA, please describe why physical access to a property is not needed.
   HBMWD owns the property where the Project is located

4. **Project Location Notes:**

E. PROJECT TASKS, BUDGET AND SCHEDULE

1. **Projected Project Start Date:** 7/1/20
   Anticipated Project End Date: 12/31/23

2. **Will CEQA be completed within 6 months of Final Award?**
   ☐ Yes State Clearinghouse Number:
   ☒ NA, Project is exempt from CEQA
   ☐ NA, Not a Project under CEQA
   ☐ NA, Project benefits entirely to DAC, EDA or Tribe, or is a Tribal local sponsor. [Projects providing a water-related benefit entirely to DACs, EDAs, or Tribes, or projects implemented by Tribes are exempt from this requirement].
   ☐ No

3. **Please complete the CEQA Information Table below**
   Indicate which CEQA steps are currently complete and for those that are not complete, provide the estimated date for completion.

CEQA STEP	COMPLETE? (y/n)	ESTIMATED DATE TO COMPLETE
Initial Study	N	
Notice & invitation to consult sent to Tribes per AB52	N	
Notice of Preparation	N	
Draft EIR/MND/ND	N	

CEQA STEP	COMPLETE? (y/n)	ESTIMATED DATE TO COMPLETE
Public Review	N	
Final EIR/MND/ND	N	
Adoption of Final EIR/MND/ND	N	
Notice of Determination	N	
N/A - not a CEQA Project		

If additional explanation or justification of the timeline is needed or why the project does not require CEQA, please describe.
Project will be a CEQA Categorical Exemption form and process.

4. **Will all permits necessary to begin construction be acquired within 6 months of Final Award?**
   ☒ Yes
   ☐ NA, Project benefits entirely to DAC, EDA, Tribe, or is a Tribal local sponsor
   ☐ No

5. **PERMIT ACQUISITION PLAN**

Type of Permit	Permitting Agency	Date Acquired or Anticipated
Grading Permit	County of Humboldt	7/1/20
1600 Permit	CDFW	7/1/20
404	Army Corps	7/1/20
401	RWQCB	7/1/20

For permits not acquired: describe actions taken to date and issues that may delay acquisition of permit.

6. **Describe the financial need for the project**.
   From the early 1960's until 1999, HBMWD had long-term contracts with 2 large industrial consumers (pulp mills) on the Samoa Peninsula.Water rates they paid funded 75% of HBMWD's operational costs. Mills closed in 2009 resulting in a large rate increase to the domestic water consumers. These rates pay for the continued operation of HBMWD's regional system, but are not sufficient to fund fully large capital projects such as the Collector Rehabilitations.

7. **Is the project budget scalable?** ☒ yes ☐ no
   Describe how a scaled budget would impact the overall project.
   The entire project needs to be completed to render it effective. However, if more match is required, HBMWD could potentially adjust our match amount to address the needs and limitations of the NCRP.

8. **Describe the basis for the costs used to derive the project budget according to each budget category.**
   Administration costs were estimated by analyzing those required for rehabilitations of Collectors 1 and 3. All of the tasks that will be required for the Planning/Design/Engineering category were required for the Collectors 1 and 3 projects. Consequently, these actual costs were used as the basis for determining Collector 2. Construction costs were determined from unit cost bid information for the Collectors 1 and 3 projects.

9. **Provide a narrative on cost considerations including alternative project costs.**
HBMWD has analyzed alternative methods to rehabilitate the collector laterals. These alternatives were unsuccessful. The only means to efficiently and cost effectively rehabilitate the collectors is to begin with replacing the laterals. We have past experience with the rehabilitations of Collectors 1 and 3 that prove our current methodology is successful and results in proven benefits to the environment, energy efficiency, reduction of GHG emissions while maintaining reasonable water rates.

10. **List the sources of non-state matching funds, amounts and indicate their status**.

HBMWD general fund which is supported by wholesale water contracts with our 7 municipal agencies. Current general fund reserve balance is $2.085M. Our reserves are augmented annually by $300K.

11. **List the sources and amount of state matching funds.**

N/A

12. **Cost Share Waiver Requested (DAC or EDA)?** ☒ yes ☐ no
Cost Share Waiver Justification: Describe what percentage of the proposed project area encompasses a DAC/EDA, how the community meets the definition of a DAC/EDA, and the water-related need of the DAC/EDA that the project addresses. In order to receive a cost share waiver, the applicant must demonstrate that the project will provide benefits that address a water-related need of a DAC/EDA.
88% using the Tracts, Block Groups and Places methodology. The American Community Survey Median Houlsehold Income for 2016 was appended to the Census Place GIS data and provided via the Division of Integrated Regional Water Management's DAC Mapping Tool was utilized. HBMWD is a regional drinking water provider to 88,000 residents of Humboldt County in the Humboldt Bay area. The computed DAC's reside within our District's boundaries. See attached DAC areas map depicted within district boundary.

13. **Major Tasks, Schedule and Budget for NCRP 2018 IRWM Project Solicitation**
Please complete MS Excel table available at https://northcoastresourcepartnership.org/proposition-1-irwm-round-1-implementation-funding-solicitation/; see instructions for submitting the required excel document with the application materials.

14. **Project Tasks, Budget and Schedule Notes:**

F. PROJECT BENEFITS & JUSTIFICATION

1. **Does the proposed project provide physical benefits to multiple IRWM regions or funding area(s)?**
☐ yes ☒ no
If Yes, provide a description of the impacts to the various regions.

2. **Provide a narrative for project justification. Include any other information that supports the justification for this project, including how the project can achieve the claimed level of benefits. List**

any studies, plans, designs or engineering reports completed for the project. *Please see the instructions for more information about submitting these documents with the final application.*
The Project benefits include: increased water supply reliability; increased groundwater recharge; avoided electrical costs; improved water quality; fishery improvement; decreased operational & maintenance costs; GHD emission reductions; stabalized water rates for DAC's. These results are proven in the 2015 Collector 3 Capstone Report prepared by GHD.
Studies, plans, reports include:
1996 - Inspection Report for Collector 1, Aqua Video Engineering
2003 - Ranney Collector Rehabilitation Feasibility Report, Winzler & Kelly
2006 - Inspection Report Collector Wells 1,1A,3,4, Collector Wells International, Inc.
2006 - Humboldt Bay Municipal Wter District Groundwater Study, Winzler & Kelly
2006 - Pump Station 2 Evaluation Final Report, Winzler & Kelly
2008 - HBMWD Ranney Collector Final Evaluation Report, Winzler & Kelly
2012 - HBMWD Ranney Collector 3 Lateral Installation Final Report, GHD & Reynolds, Inc.
2015 - HBMWD Collector 3 Capstone Report, GHD

3. **Does the project address a contaminant listed in AB 1249 (nitrate, arsenic, perchlorate, or hexavalent chromium)?** ☐ yes ☒ no
   If yes, provide a description of how the project helps address the contamination.

4. **Does the project provide safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes consistent with AB 685?** ☒ yes ☐ no
   If Yes, please describe.
   The Project would provide safe, clean and affordable water for human consumption. The project preserves and enhances the high quality water delivery system for the Humboldt Bay region which includes DAC's. The projected life of a rehabilitated Collector is 50 years. Consequently, the Project ensures water resource allocation and efficient use for the benefit of present and future generations.

5. **Does the project employ new or innovative technologies or practices, including decision support tools that support the integration of multiple jurisdictions, including, but not limited to, water supply, flood control, land use, and sanitation?** ☐ yes ☒ no
   If Yes, please describe.

6. **For each of the Potential Benefits that the project claims complete the following table to describe an estimate of the benefits expected to result from the proposed project.** [*See the NCRP Project Application Instructions, Potential Project Benefits Worksheet and background information to help complete the table. The NCRP Project Application, Attachment B includes additional guidance, source materials and examples from North Coast projects*.]

PROJECT BENEFITS TABLE

Potential Benefits Description	Physical Amt of Benefit	Physical Units	Est. Economic Value per year	Economic Units
Water Supply				
Increased groundwater recharge	10%	percent increase	Unknown	Not monetized
Increased water supply reliability	Approx 36,000	# of households	$10,050,000/year	$23/household/month
Avoided electric costs	Energy savings	Kw	$16,800	$/year
Water Quality				
Maintain lower water temperatures	Fish habitat improve	degrees C or F	Unknown	Not monetized
Additional Water Quality Projects Avoided	------------	Avoiced Projects	$5 million	---------
Avoided water treatment costs	$1800/year	Dollars	------------	$/year
Other Ecosystem Service Benefits				
Fishery Improvement	75 miles	Miles of river	Unknown	--------
Aquatic habitat Improvement	75 miles	Miles of river	Unknown	--------
Other Benefits				
Carbon emmissions reductions	37.4 tons per yr	CO2E per year - tons	$560/yr	$15 per ton of CO2E
Decreased operation & maintenance costs		impacted laterals	$40,000	

7. Project Justification & Technical Basis Notes:

1. Approx 88,000 customers divided by ave household size for Humboldt Co. (2.39) equals 36,820 multiplied by $23 (suggested econmic unit per household per month) equals $846,862 per month or $10,162,344 per year.

2. Project will improve groundwater quality by spreading out grandwater production and recharge areas. New laterals will be placed in currently underutilized protion of the Holocen quaifer. The draw-down impacts will be mitigated by increasing surface water releases from Ruth Lake to recharge areas. The overall groundwater quality will be increased because groundwater flow per area is reduced by increasing the total production area.

3. Energy savings are realize by reduced pumping dut to higher water levels in the collector. Assumes $10 per million gallongs pumped multiplied by 6 mgd, multiplied by 280 days per year, equaling $16,800. Basis is savings realized after Collector 3 rehabilitation.

4. The Project benefits the Mad River by reducing terperature impairment. Improved production capacity in Collector 2 maintains existing flow releases along 75 miles of river from Ruth Lake to the Project site.

5. $5 million savings based on the avoided costs to expand the HBMWD Turbidity Reduction Facility.

6. Assumes an increase in turbidity/treatment costs of approx. 10% resulting from failed laterals. Cost = 5 gallons of Alum/day multiplied by $2/gallon multiplied by 180 days/year = $1,800/year.

7. The Project will conserve & enhance native salmonid populations by protecting their habitat, water quality and watershed processes. The Project will sustain and create more carrying capacity and cold water refugia for juvenile salmonid rearing.

8. $40,000 physical benefit assumption based on an old lateral collapsing and remvoing gravel from Collector with a dive crew. Improved prodcution capacity of Collector 2; additional flow released from Ruth Lake, increased flows to 75 miles of Mad River which has historically gone dry during summer, all substantially improve the river aquatic and riparian habitat.

9. Modern pumps/motors/electrical system will reduce emission from electricity use. The Project reduces cost burden on ratepayers or regional water system while maintaining high quality, energy efficient system. Using assumptions in note 3 above, and cost of$0.10 per kWh, energy reduction would be 168 MWh per year. Assuming a CO2E emission factor of 445 lbs per MWh (Climate Registry website) results in an emission reduction of 37.4 tons of CO2E per year. Assuming a cost of $15 per ton of CO2E results in an economic value of $561 per year.

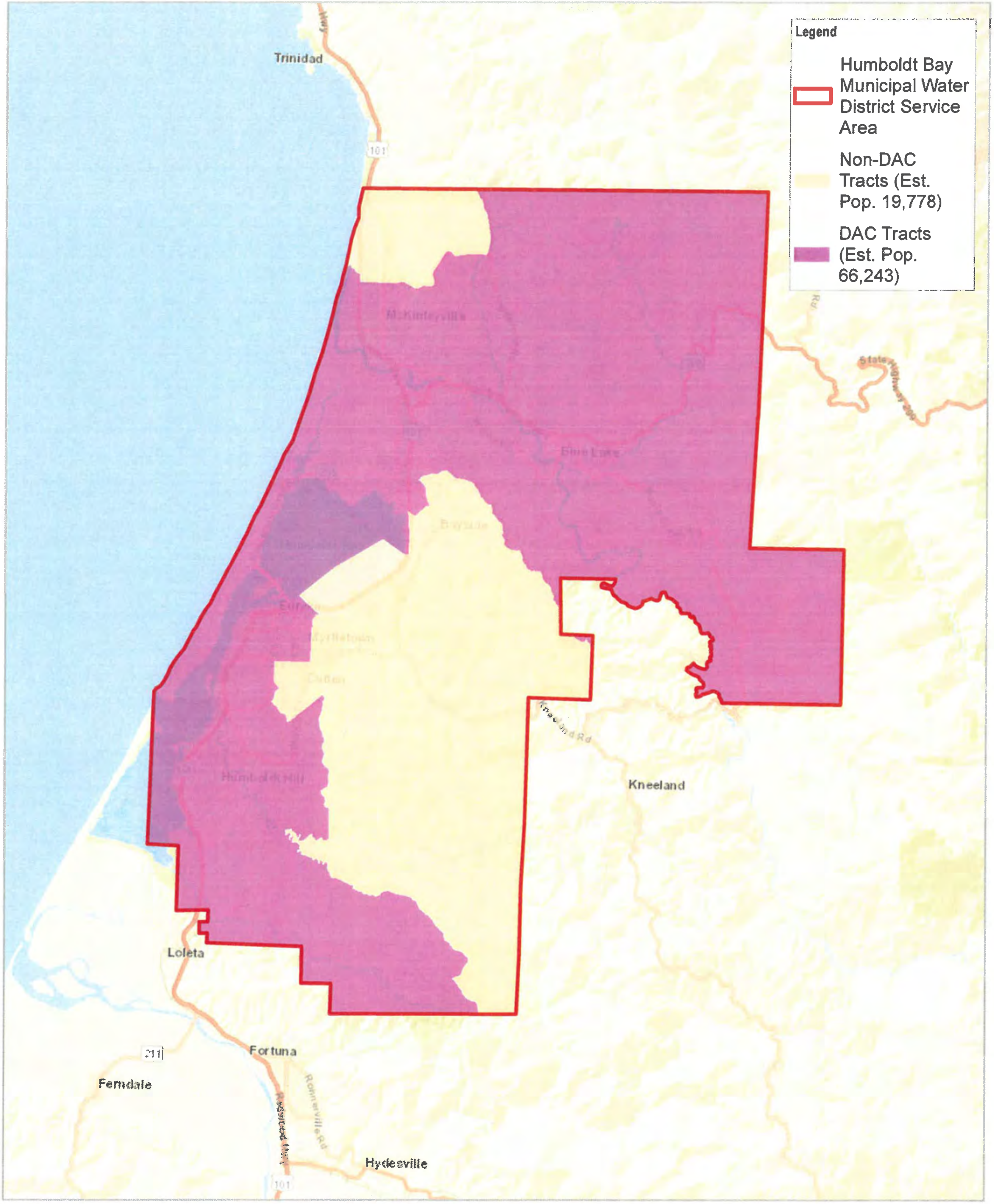
Major Tasks, Schedule and Budget for North Coast Resource Partnership 2018/19 IRWM Project Solicitation

Project Name: Ranney Collector 2 Rehabilitation Project
Organization Name: Humboldt Bay Municipal Water District

Task #	Major Tasks	Task Description	Major Deliverables	Current Stage of Completion	IRWM Task Budget	Non-State Match	Total Task Budget	Start Date	Completion Date
A	**Category (a): Direct Project Administration**								
1	Administration	In cooperation with the County of Humboldt sign a sub-grantee agreement for work to be completed on this project. Develop invoices with support documentation. Provide audited financial statements and other deliverables as required.	Invoices, audited financial statements and other deliverables as required.	0%	$0.00	$10,000.00	$10,000.00	5/1/20	12/31/23
2	Monitoring Plan	Develop Monitoring Plan to include goals and measurable objectives.	Final Monitoring Plan	0%	$0.00	$35,000.00	$35,000.00	11/1/23	12/31/26
3	Labor Compliance Program	Execute service agreement with Labor Compliance Program company.	Submission of Labor Compliance Program	0%	$0.00	$21,000.00	$21,000.00	7/1/20	12/31/23
4	Reporting	Develop monthly reports describing work completed, challenges, and strategies for reaching remaining project objectives. Develop Final Report.	Quarterly and Final Reports	0%	$0.00	$26,000.00	$26,000.00	6/1/20	12/31/23
B	**Category (b): Land Purchase/Easement**								
1	N/A	HBMWD owns all of the land where the project will take place.	N/A	100%	$0.00	$0.00	$0.00		
C	**Category (c): Planning/Design/Engineering/Environmental Documentation**								
1	Final Design /Plans	Develop a set of plans and specifications to the 100% complete level. 100% plans and specifications will be supplied to all interested parties for review and comment.	100% Plans and Specifications		$25,000.00	$25,000.00	$50,000.00	10/1/20	12/31/20
2	Environmental Documentation: CEQA *	Prepare Categorical Exemption and all relevant CEQA documents as per CEQA Guidelines.	CEQA Document	0%	$5,000.00	$5,000.00	$10,000.00	5/1/20	7/1/20
3	CDFW 1600 Permit	Streambed Alteration Agreement	Permit or Waiver	0%	$5,000.00	$5,000.00	$10,000.00	5/1/20	7/1/20
4	Humboldt County Grading Permit		Permit		$4,500.00	$4,500.00	$9,000.00	5/1/20	7/1/20
5	Water Board/NPDES Permits	Either a Low Threat Discharge Permit or NPDES Permit from Regional Board.	Permit	0%	$2,000.00	$2,000.00	$4,000.00	5/1/20	7/1/20
6	Purchase and Install (8) Valves on Existing Laterals			0%	$57,500.00	$57,500.00	$115,000.00	7/1/20	10/15/20
7	Geophysical Assessment	Install geophones to map bedrock locations & assess subsurface geology.	Geophysical Report	0%	$0.00	$105,000.00	$105,000.00	7/1/20	9/1/20
8	Feasibility Study	Includes modeling, lateral location recommendations and development water disposal plan.	Final Feasibility Report with Cost Estimates and Preliminary Design.	0%	$0.00	$60,000.00	$60,000.00	9/1/20	10/15/20
D	**Category (d): Construction/Implementation**								
1	Construction/Implementation Contracting	Develop advertisement for bids and contract documents; conduct pre-bid contractors meeting; perform evaluation of bids; award contract.	Summary of Bids and Contract Award	0%	$7,500.00	$7,500.00	$15,000.00	2/1/21	6/1/21
2	Mobilization and Site Preparation			0%	$208,000.00	$206,500.00	$414,500.00	6/1/21	7/1/21
3	Initial Performance Tests	Assess flow in existing laterals and total flow drawdown to establish baseline.	Initial Test Result Report	0%	$13,000.00	$13,000.00	$26,000.00	7/1/21	7/31/21
4	Dewatering & Control of Water			0%	$144,000.00	$144,000.00	$288,000.00	7/1/21	10/15/21
5	Furnish, Install, & Develop 12" Diameter Type 304 Stainless Steel Laterals			0%	$46,000.00	$1,229,750.00	$1,275,750.00	7/1/21	10/15/21
6	Furnish and Install (4) 12" Diameter Steel Gate Valves on New Laterals			0%	$82,500.00	$9,000.00	$91,500.00	9/1/21	10/15/21
7	Install New Transformer	Includes transformer and electrical switchboard, main and wiring.			$0.00	$175,000.00	$175,000.00	7/1/23	8/31/23
8	Replace Pumps & Motors	Includes two 400 hp pumps and motors.			$0.00	$595,000.00	$595,000.00	7/1/22	10/15/22

Project Name: Ranney Collector 2 Rehabilitation Project
Organization Name: Humboldt Bay Municipal Water District

Task #	Major Tasks	Task Description	Major Deliverables	Current Stage of Completion	IRWM Task Budget	Non-State Match	Total Task Budget	Start Date	Completion Date
9	Project Signage			0%	$0.00	$2,000.00	$2,000.00	7/1/20	12/31/23
10	Project Close Out, Inspection & Demobilization	Inspect project components and establish that work is complete. Verify that all project components have been installed and are functioning as specified will be conducted as part of construction inspection and project closeout. Conduct project completion photo monitoring. Prepare record drawings.	As-Built and Record Drawings; Project completion site photos	0%	$0.00	$100,000.00	$100,000.00	11/1/23	12/31/23
11	Project Performance Monitoring	The performance of the project will be monitored in accordance to the Monitoring Plan using the following measurement tools and methods: Providing ongoing submittals of plans and specifications prior to construction; Providing contractors bids; Providing ongoing construction monitoring memos during construction of the project; Performing pre- and post- construction tests that include gathering data with respect to production capacity, drawdown, and turbidity, and submitting associated reports; Preparing and submitting a final project report.	Project Performance Monitoring Report	0%	$0.00	$98,000.00	$98,000.00	12/1/23	12/31/26
12	Construction Administration	Complete tasks necessary to administer construction contract. Keep daily records of construction activities, inspection, and progress. Conduct project construction photo-monitoring.	Construction Management Logs; Completed construction administration tasks documented in monthly progress reports.	0%	$0.00	$170,000.00	$170,000.00	7/1/20	10/15/23
	Total North Coast Resource Partnership 2018/19 IRWM Grant Request				**$600,000.00**	**$3,105,750.00**	**$3,705,750.00**		
	Is Requested Budget scalable by 25%? If yes, indicate scaled totals; if no delete budget amount provided.				**$450,000.00**	**$2,329,312.50**	**$2,779,312.50**		
	Is Requested Budget scalable by 50%? If yes, indicate scaled totals; if no delete budget amount provided.					**$1,552,875.00**	**$1,852,875.00**		



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Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California I FIPS 0401 Feet

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Humboldt Bay Municipal Water District
Prop 1 Grant Assistance

2016 Disadvantage Community Data By Tract

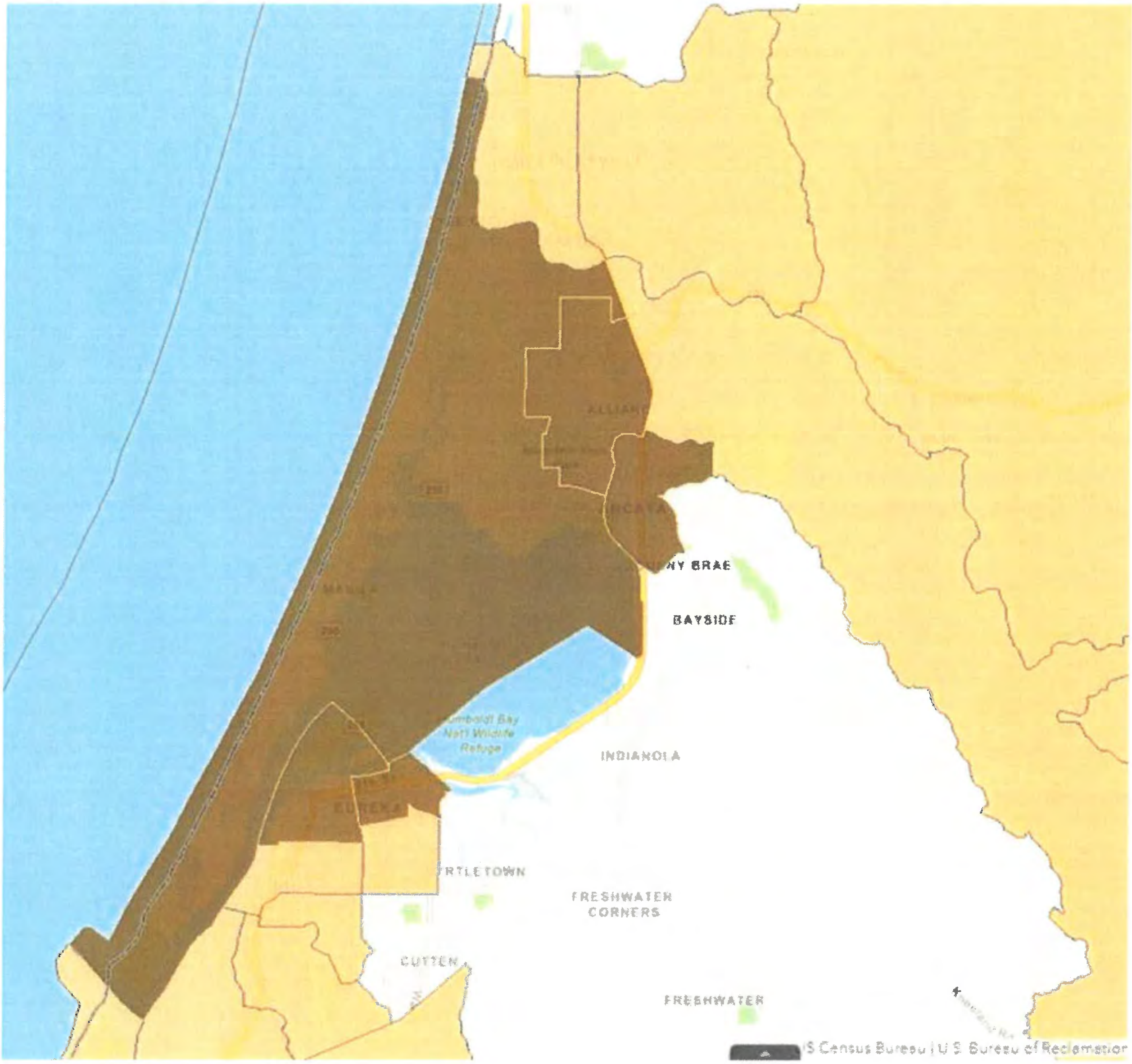
Project No. **11189854**
Revision No. **-**
Date **March 2019**

FIGURE 1

G:\111\11189854 HBMWD-IRWM Prop1 Grant Assist\08-GIS\Maps\Deliverables\11189854_01_DACByTract.mxd
Print date: 28 Feb 2019 - 14:56

Data source: Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community. Created by: ashows

SEVERLY DISADVANTAGED COMMUNITIES
WITHIN HBMWD district boundaries



BLUE LAKE RANCHERIA
P.O. Box 428
Blue Lake, CA 95525

Office: (707) 668-5101
Fax: (707) 668-4272

www.bluelakerancheria-nsn.gov

March 14, 2019

North Coast Resource Partnership
c/o Humboldt Bay Municipal Water District
PO Box 95
Eureka, CA 95502-0095
Via email to: friedenbach@hbmwd.com

RE: Blue Lake Rancheria Support for HBMWD Grant Proposal for Ranney Collector 2 Project

Dear North Coast Resource Partnership Grant Review Team,

The Blue Lake Rancheria, a federally recognized tribal government (BLR), supports the North Coast Resource Partnership (NCRP) grant proposal from the Humboldt Bay Municipal Water District (HBMWD) to rehabilitate one of its Ranney Collectors.

The HBMWD has a proven record of successful rehabilitation projects of this kind, resulting in cost-savings and significant success in the operation of its drinking water system that serves a large rural region, including BLR. HBMWD supplies drinking water to approximately 88,000 people in the Humboldt Bay area via seven municipal agencies. Any constrictions of HBMWD's water supply or water quality would impact the entire service area. BLR believes it is wise and necessary planning to replace aging water infrastructure before it becomes a problem (with far greater expense) and this proposed project achieves this goal. A timely and well-planned project as proposed by HBMWD will be more cost-effective and certainly have less impact than an emergency/crisis situation and response.

The Ranney Collectors are a critical component of HBMWD's water system in that they collect water far below the river bottom, which is of superior quality than direct diversion from the river. This indirect withdrawal is much more protective of aquatic life in the Mad River than a surface diversion, but it requires ongoing investment and maintenance. The rehabilitation of the Ranney Collector laterals will also reduce potential impacts to aquatic species by reducing the localized 'velocity pull' created by the water withdrawal. New intake screens and repaired lateral lines will increase the effective surface area for water intake and therefore reduce the force of the current created by the water withdrawals. This project will replace the old and deteriorated laterals, screens, pumps, motors, and electrical equipment for Ranney Collector 2.

BLR fully supports this project and any level of grant funding that NCRP can provide. These refurbishments help ensure the reliability and high quality of HBMWD's water supply for the foreseeable future and is beneficial to aquatic life in the Mad River. HBMWD's prior work to refurbish and extend the life of this collection system has been exceptional, winning regional engineering project awards. Working in and below the river bed will require careful minimization and mitigation efforts to protect environmental resources from short term construction impacts, however, as noted above, the HBMWD has conducted these exact tasks before on other Collectors without incident.

This project has co-benefits in terms of preserving a rare and effective drinking water system in the main stem of a river, and protecting the necessary instream flows in the Mad River dedicated for that purpose. Preserving instream flows in the Mad River is a well-established BLR priority for water quality and to protect endangered and threatened species in this watershed, which is also BLR's aboriginal territory.

BLR asks for your support and funding of this HBMWD grant application. Please contact Jana Ganion with questions, or for more information at jganion@bluelakerancheria-nsn.gov and/or (707) 668-5101 x1044.

Sincerely,

Arla Ramsey

Arla Ramsey
Vice Chairperson

COUNTY ADMINISTRATIVE OFFICE
Economic Development
COUNTY OF HUMBOLDT
520 E Street, Eureka, CA 95501
Telephone (707) 445-7745 Fax (707) 445-7219
https://humboldtgov.org/

John Friedenbach
General Manager
Humboldt Bay Municipal Water District
PO BOX 95
Eureka, CA 95502-0095

March, 11th 2019

Subject: HBMWD Lateral Rehabilitation Project

This office is aware that the Humboldt Bay Municipal Water District (HBMWD) has applied for grant assistance to renovate an existing collector, and that this project will entail replacement and refurbishment of old and deteriorated infrastructure including, but not limited to, the replacement of laterals, pumps and motors.

The County of Humboldt Economic Development department strongly supports initiatives and endeavors which strengthen local infrastructure, especially those that are aligned with the County of Humboldt's Comprehensive Economic Development Strategy (CEDS).

The HBMWD's proposed project, in particular, will enhance the feasibility of certain development projects that are already under consideration for the Samoa Peninsula,

Should you have any questions feel free to reach out to me.

Regards,

Scott Adair
Director of Economic Development
County of Humboldt
sadair@co.humboldt.ca.us
707-475-4800 (Direct line)

HUMBOLDT BAYKEEPER®

March 13, 2019

North Coast Resource Partnership
c/o Humboldt Bay Municipal Water District
PO Box 95
Eureka, CA 95502-0095

Dear North Coast Resource Partnership,

On behalf of Humboldt Baykeeper, I am writing in support of the Humboldt Bay Municipal Water District (HBMWD) application for Prop. 1 financial assistance to renovate one of its Ranney collectors. Humboldt Baykeeper works to safeguard our coastal resources for the health, enjoyment, and economic strength of the Humboldt Bay community, and is a member of the California Coastkeeper Alliance and the international Waterkeeper Alliance.

The proposed project will replace old and deteriorated laterals, pumps and motors, and electrical equipment for Ranney Collector 2. We fully support this project since it will help ensure the reliability and high quality of drinking water supplies for approximately 88,000 people in the Humboldt Bay area. It will also lower energy costs related to pumping and will benefit aquatic species and their habitat. Upgrading or replacing aging infrastructure before it becomes a problem is good public policy, and the proposed project achieves this. We urge the NCRP to prioritize funding for this project.

Sincerely,

Jennifer Kalt

Jennifer Kalt, Director
jkalt@humboldtbaykeeper.org

Mailing Address: 600 F Street, Suite 3 #810
Office: 415 I Street, Arcata, CA 95521
(707) 499-3678
www.humboldtbaykeeper.org

WATERKEEPER® ALLIANCE MEMBER

March 12, 2019

North Coast Resource Partnership
c/o Humboldt Bay Municipal Water District
PO Box 95
Eureka, CA 95502-0095

RE: Support for HBMWD Grant Proposal for Collector 2 Project

Dear NCRP grant review team,

The Mad River Alliance (MRA) supports the NCRP grant proposal from the Humboldt Bay Municipal Water District (HBMWD) to rehabilitate one of its Ranney Collectors. These Collectors are the component of the HBMWD system that withdraw water from below the Mad River. This project will replace the old and deteriorated laterals, screens, pumps, motors, and electrical equipment for the Ranney Collector 2. MRA fully supports this project and any level of grant funding that NCRP can provide. This will help ensure the reliability and high quality of HBMWD's water supply for the foreseeable future and is beneficial to aquatic life in the Mad River.

Mad River Alliance is a community driven group working to protect clean local water and the ecological integrity of the Mad River watershed for the benefit of its human and natural communities. MRA believes this project will help maintain the critical water infrastructure operated by HBMWD and will reduce the potential impacts of these withdrawals on aquatic species.

HBMWD supplies drinking water to approximately 88,000 people in the Humboldt Bay area via seven municipal agencies. Any shortcomings with HBMWD's water supply or water quality would affect the entire service area. MRA believes it is prudent planning for water systems to upgrade or replace their aging infrastructure before it becomes a problem and the proposed project achieves this goal.

The Ranney Collectors are a critical component of HBMWD's water system in that they collect water far below the river bottom, which is of superior quality than direct diversion from the river. This indirect withdrawal is much more protective of aquatic life in the Mad River than a surface diversion, but it requires ongoing investment and maintenance. The rehabilitation of the Ranney Collector laterals will also reduce potential impacts to aquatic species by reducing the localized 'velocity pull' created by the water withdrawal. New intake screens and repaired lateral lines will increase the effective surface area for water intake and therefore reduce the force of the current created by the water withdrawals.

Working in and below the river bed will require careful minimization and mitigation efforts to protect environmental resources from short term construction impacts. MRA is confident that the many parties involved in the public permitting process, and HBMWD's well demonstrated interest and commitment to protecting the resources of the Mad River, will result in a project that minimizes these impacts and has net benefits to the community, the Mad River, and all its inhabitants. A timely and well-planned project as proposed by HBMWD will certainly have less impacts than an emergency crisis response to problems with this critical component of Humboldt County's drinking water infrastructure.

MRA urges your support and funding of this HBMWD grant application. If you have any questions, please feel free to contact me at 707-498-4937 or dan@madriveralliance.org.

Sincerely,

Daniel Berman
Executive Director
Mad River Alliance
www.madriveralliance.org

ENGINEERING
INSPECTIONS

AQUA VIDEO ENGINEERING

Underwater Video
Water Tanks • Marinas • Etc.
Tank Cleaning & Inspection

INSPECTION REPORT
FOR
HUMBOLDT BAY MUNICIPAL WATER DISTRICT
COLLECTOR #1 RAINEY COLLECTOR
INSPECTED ON SEPTEMBER 10, 1996
AQUA VIDEO ENGINEERING

LICENSED ARCHITECT
JAY V. HYDE
C11529
REN 8/31/97
STATE OF CALIFORNIA

P.O. Box 86 • Carmichael, California 95609 • (916) 483-9066
FAX (916) 483-9075

AQUA VIDEO
ENGINEERING
INSPECTIONS

AQUA VIDEO ENGINEERING

Underwater Video
Water Tanks • Marinas • Etc.
Tank Cleaning & Inspection

Humboldt Bay Municipal Water District
P.O.Box 95
Eureka, California 95501

ATTN: Dale Stoveland

On September 10, 1996 Aqua Video Engineering conducted a visual inspection of concrete lined Rainey Collector interior.

Name:	Collector #1
Dimensions:	Diameter: 12', Depth: 78'
Construction:	Cast-in-place concrete
Date Constructed:	1966
Last Inspection:	

PART 1. CONDITION OF COLLECTOR STRUCTURE

1.1 **SIDEWALL:** The uncoated concrete side wall is in good condition. There are approximately two dozen spalled areas (apparently caused by internal impacts to the side walls, not from expansion within the concrete structure). In addition two dozen 1" diameter corrosion cells were observed at the exposed ends of form ties near the 30' depth; there are a dozen 12" long hairline cracks leaching white mineral salts adjacent to these form tie holes and the siphon. One wood block insert was observed. [Photographs #1 through 4,19 through 36, 39 through 42, 51]

1.2 **BOTTOM**: approximately 60% of the bottom of this reservoir was covered with rock, gravel, concrete chips, and construction refuse. The debris did not allow for complete inspection of the bottom.

The portions of the bottom which could be inspected revealed that the rough finished concrete is in good condition: no cracks, spalls, rust spots, or other imperfections were observed. [Photographs #5 through 7, 18, 52]

1.3 **ROOF STRUCTURE:** The roof structure appeared to be structurally sound.

The uncoated concrete is in good condition: no cracks, spalls, rust spots, or other imperfections were observed. [Photographs #8, 9]

P.O. Box 86 • Carmichael, California 95609 • (916) 483-9066
FAX (916) 483-9075

PART 2: ACCESS

2.1 **ACCESS HATCH:** The 60" diameter Access Hatch with galvanized steel curb and cover is structurally sound and in good condition. Small amounts of corrosion were observed on the bolts, washers, and nuts. [Photographs #10, 11]

2.2 **INTERIOR LADDER**: the galvanized steel Interior Ladder is structurally sound and in good condition. It is equipped with a safety climb device. The upper 20% of the ladder was above the normal water line and had a few patches of corrosion, below the water line the ladder was heavily encrusted with corrosion products. The degree of corrosion could not be determined from this visual inspection. [Photographs #11 through 18]

PART 3: APPURTENANCES

3.1 **COLLECTOR LATERALS:** The main collector is fitted with 12 collector laterals (identified clockwise from the interior ladder as "A" through "L"). Each lateral is fitted with a gate valve that is operated from the top via valve extension lines attached to the side of the main collector. The valves appeared functional at the time of inspection. The ends of the collectors, the valves, and the metal hydraulic lines were all encrusted with corrosion products and nodules. [Photographs #4, 19 through 40]

3.2 **SIPHON:** A 36" diameter siphon pipe sends water to Pump Station #1. It exits through the side wall and elbows down to a flared bell. The coating on the exterior of the pipe and the end of the bell has failed and there are numerous 1" to 2" individual rust nodules on the pipe and bell. As far as it could be observed, the coating on the interior of the pipe is in good condition with a few small (1/4" diameter) corrosion cells observed at holidays and other coating imperfections. [Photographs #41 through 46]

3.3 **OVERFLOW:** The 6" diameter overflow is structurally sound and in good condition. The pipe is wrapped with an asphalt saturated paper and fabric. The paper has been damaged and is peeling off at the top and bottom flange allowing surface corrosion to occur. The diver/Inspector was informed that this structure may not be operational. [Photographs #47 through 50]

PART 4. CONCLUSIONS AND RECOMMENDATIONS:

4.1 **CONCRETE CONDITION:** The concrete side wall is in good condition and no corrective action is required.

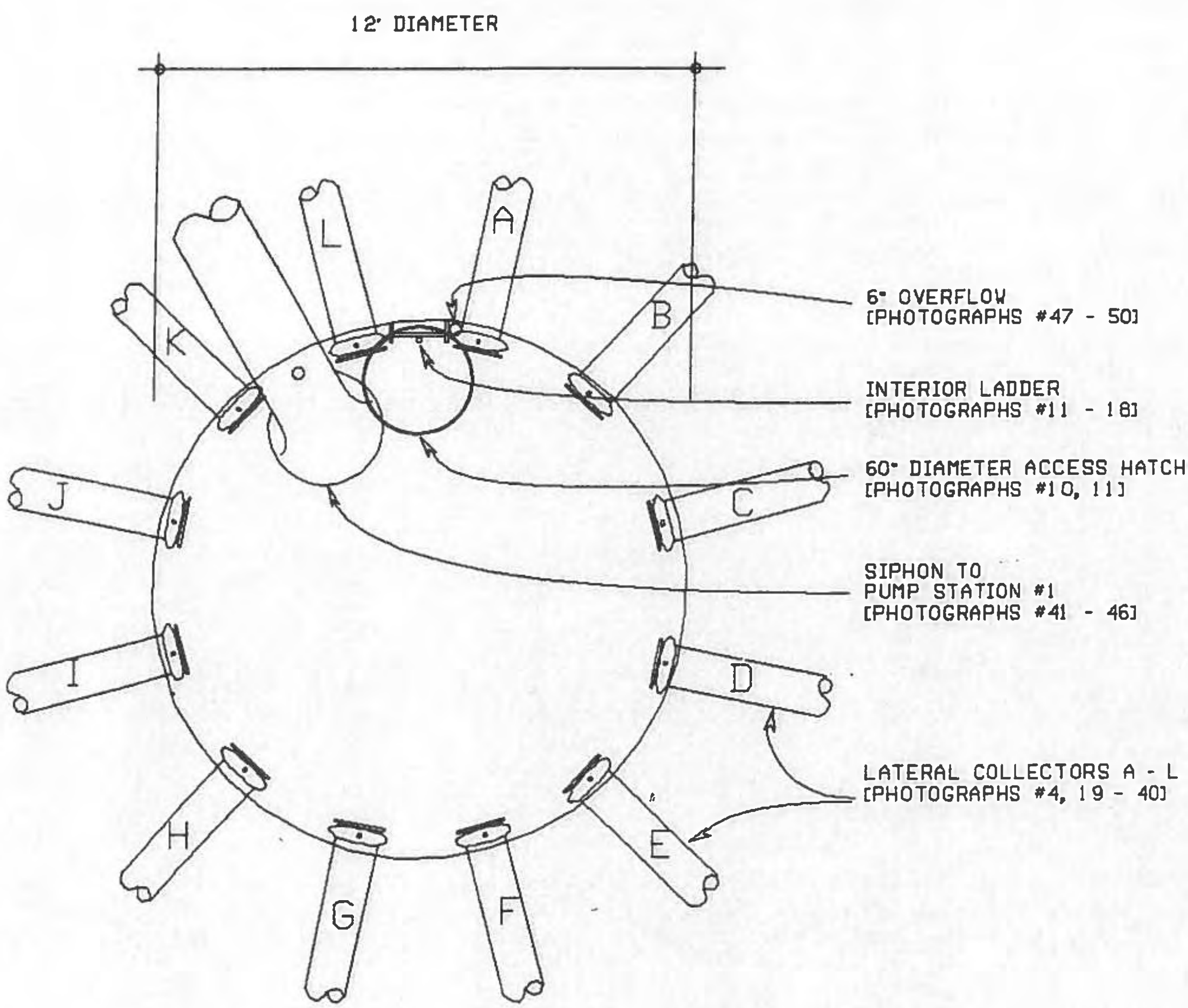
4.2 **METAL COMPONENTS:** The metal components below the water line that have not been recoated are heavily encrusted with corrosion products. The degree of corrosion could not be determined from this visual inspection but it is obvious that there is some metal loss occurring. At this point the structural integrity is not compromised and these features should be monitored if not scheduled to be recoated.

Submitted,

Jay V. Hyde

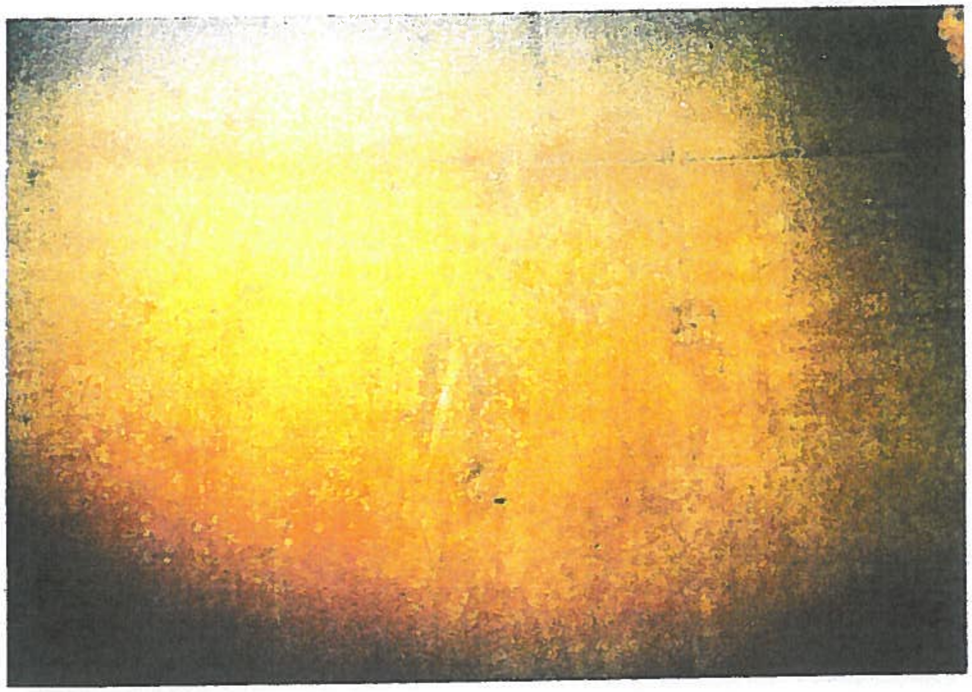
Jay V. Hyde

JVH/ms

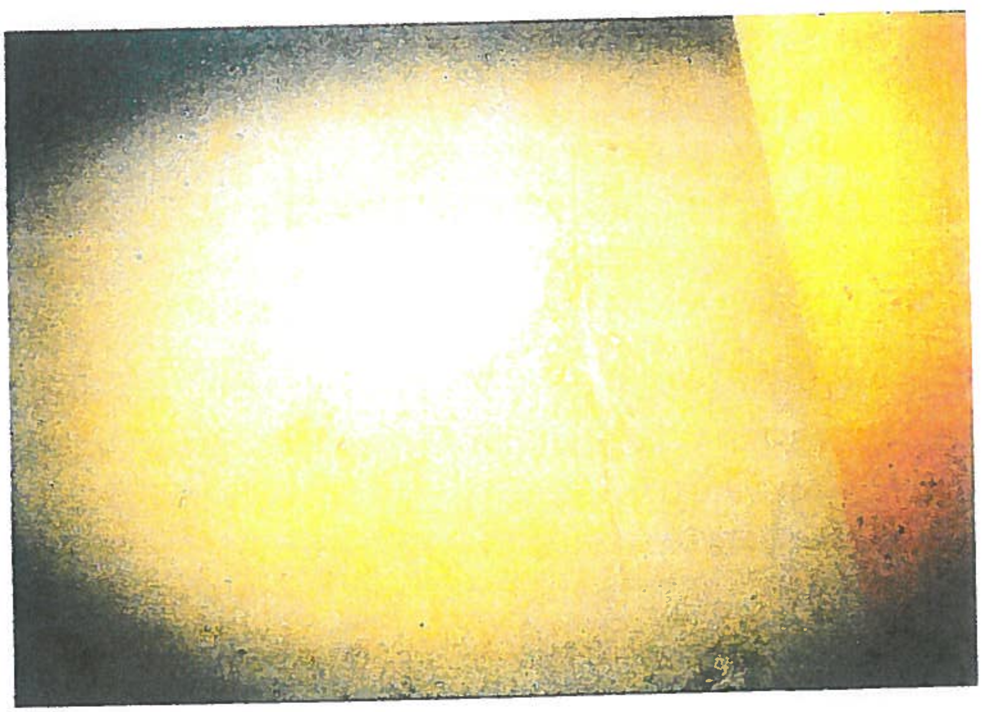


HUMBOLDT BAY
MUNICIPAL WATER DISTRICT
COLLECTOR #1

NOT TO SCALE

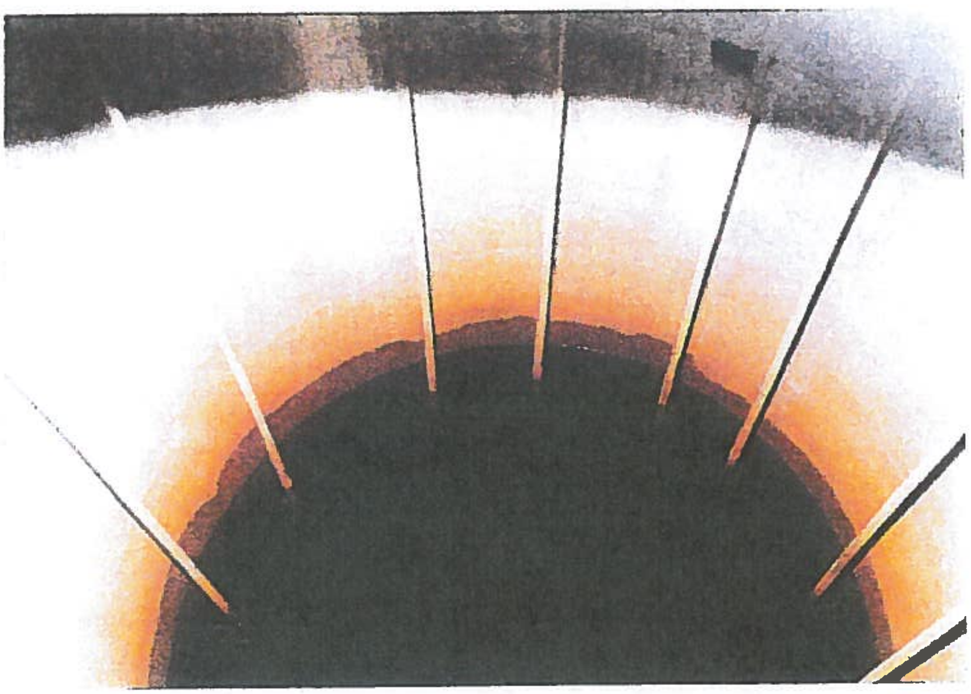


PHOTOGRAPH #1: SIDE WALL



PHOTOGRAPH #2: SIDE WALL NEAR OVERFLOW

PHOTOGRAPH #3: SIDE WALL - FORM TIE HOLE

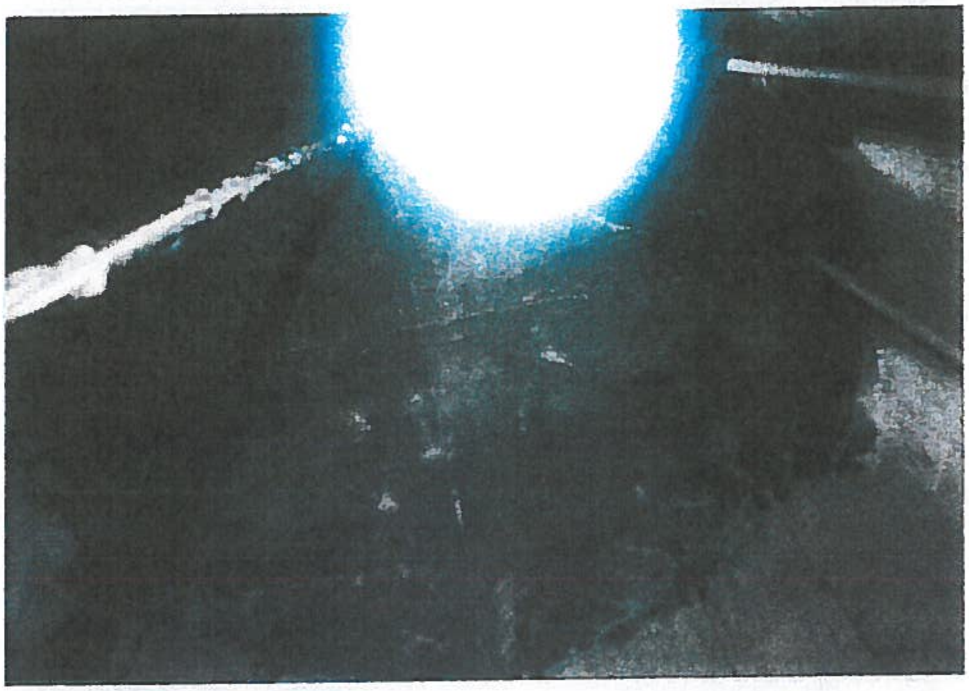


PHOTOGRAPH #4: SIDE WALL - VALVE OPERATOR SHAFTS

PHOTOGRAPH #5: BOTTOM DEBRIS, LADDER

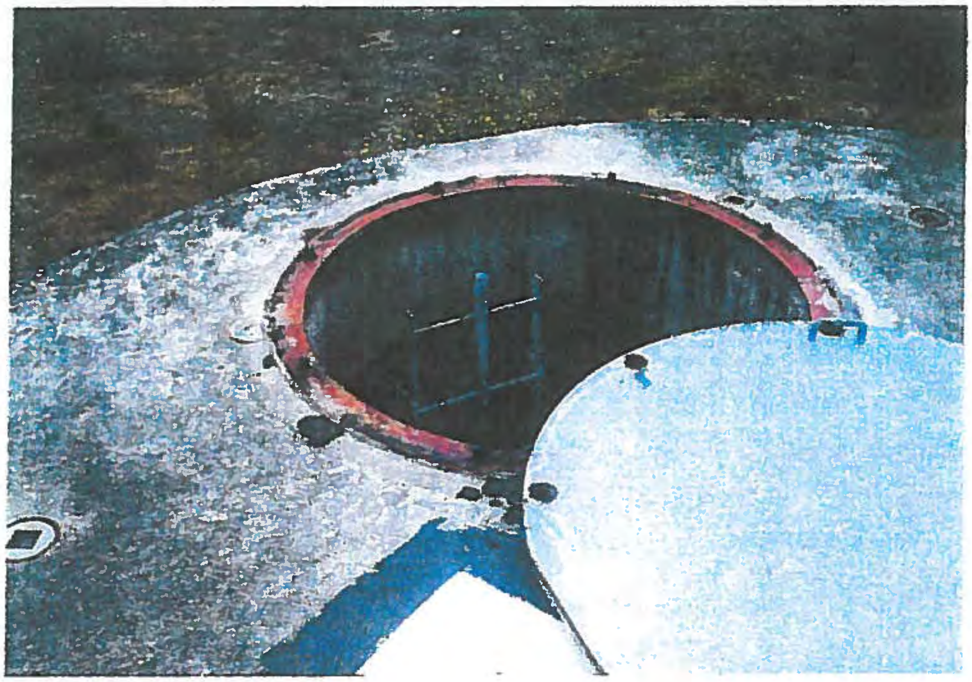
PHOTOGRAPH #6: BOTTOM DEBRIS

PHOTOGRAPH #7: BOTTOM CONDITION AND DEBRIS

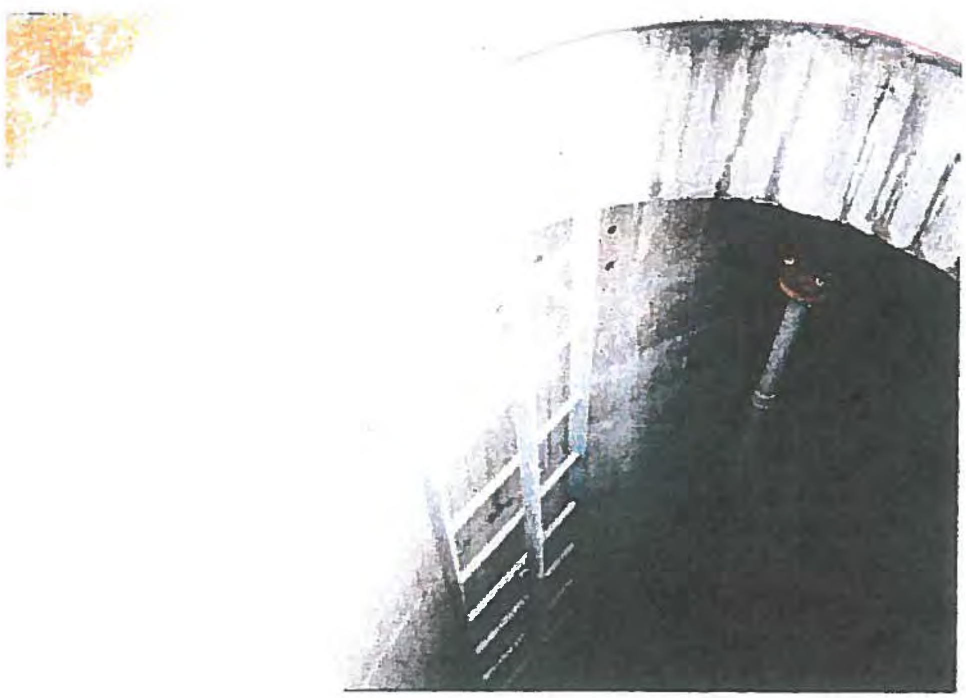


PHOTOGRAPH #8: ROOF STRUCTURE, VALVE LINES

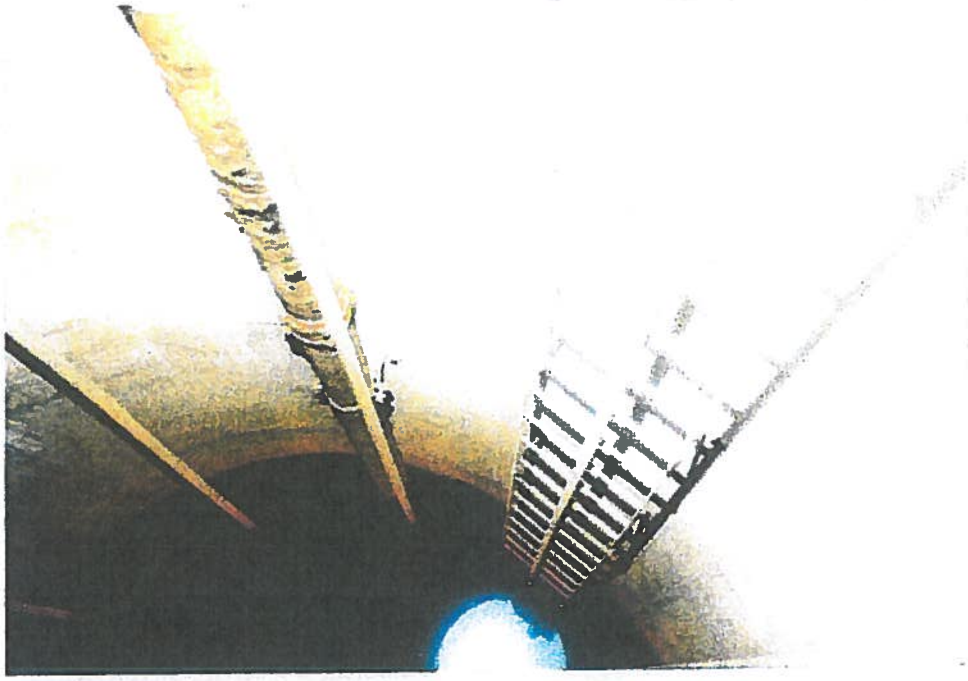
PHOTOGRAPH #9: ROOF STRUCTURE, VALVE LINES



PHOTOGRAPH #10: ACCESS HATCH, INTERIOR LADDER

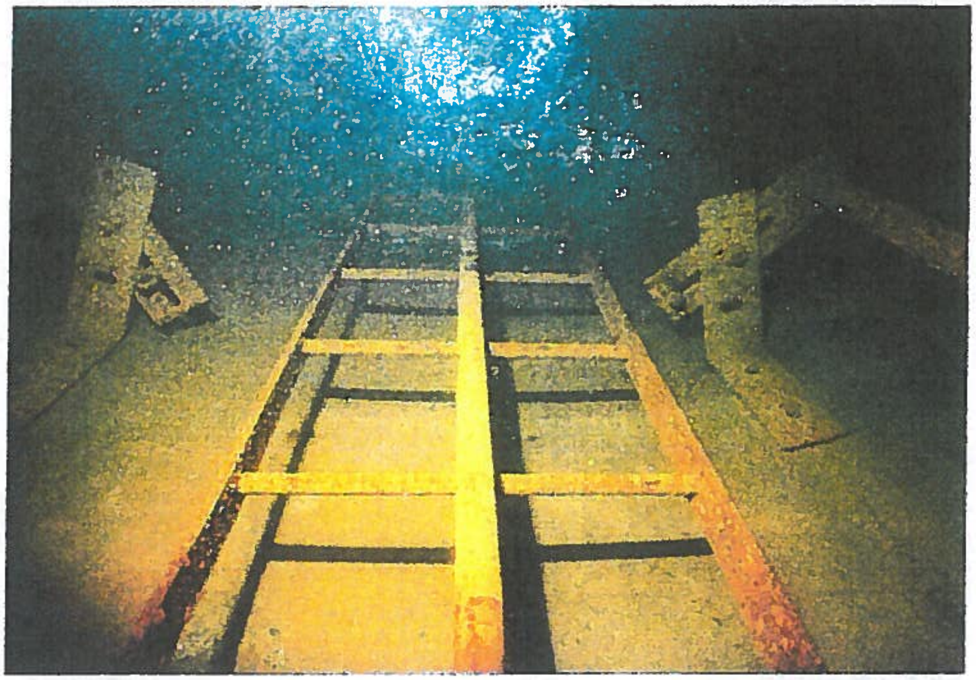


PHOTOGRAPH #11: ACCESS HATCH, INTERIOR LADDER



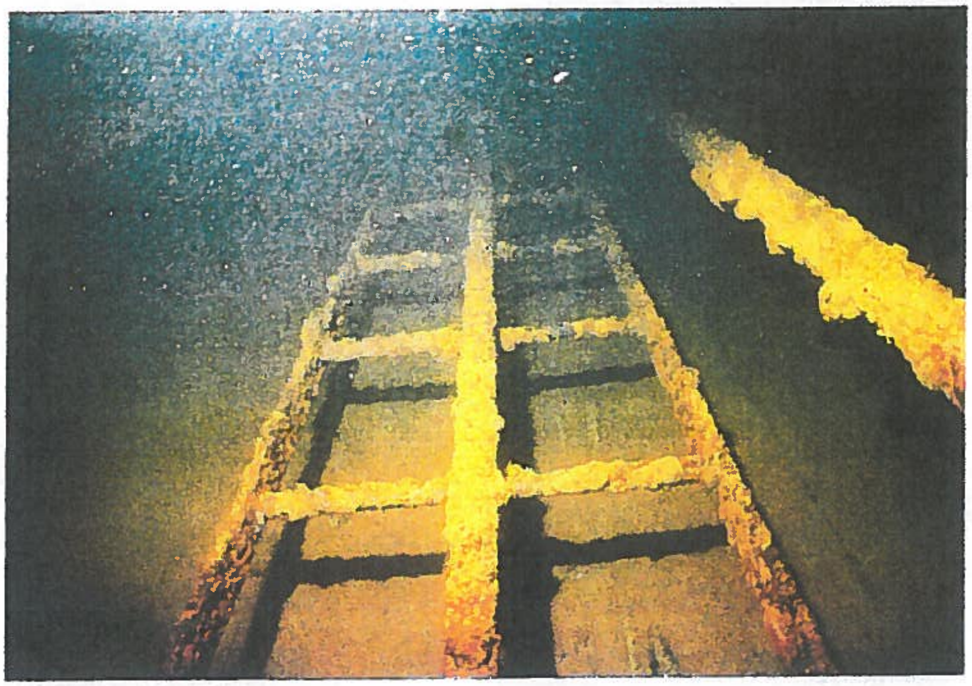
PHOTOGRAPH #12: INTERIOR LADDER. OVERFLOW PIPE

PHOTOGRAPH #13: INTERIOR LADDER

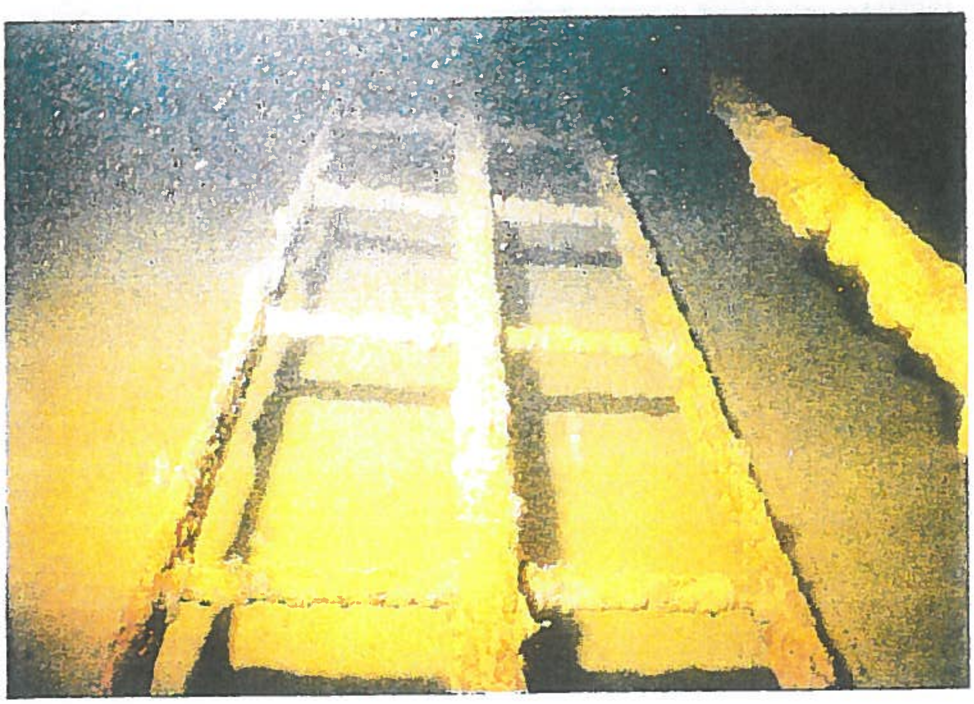


PHOTOGRAPH #14: INTERIOR LADDER, VALVE STEM BRACES

PHOTOGRAPH #15: INTERIOR LADDER



PHOTOGRAPH #16: INTERIOR LADDER



PHOTOGRAPH #17: INTERIOR LADDER

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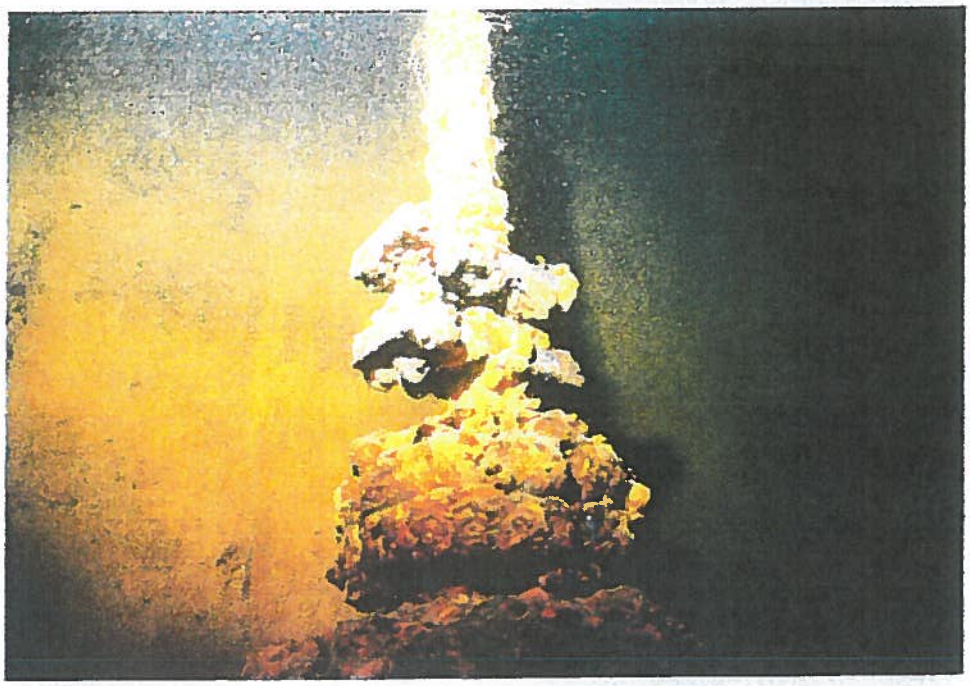
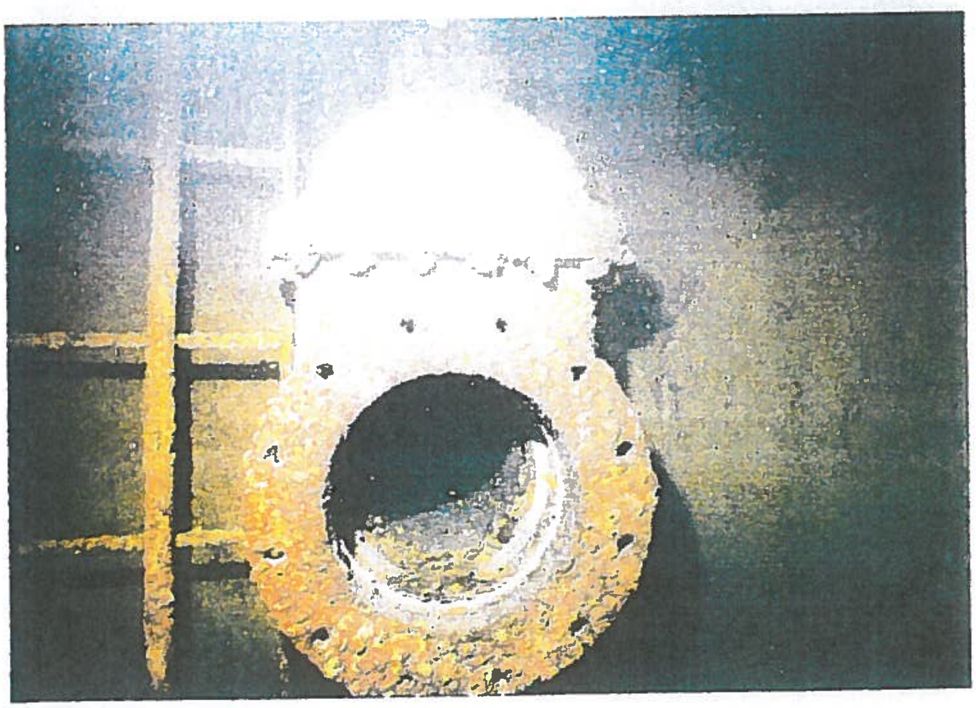


PHOTOGRAPH #19: LATERAL COLLECTOR A - TOP OF VALVE



PHOTOGRAPH #20: LATERAL COLLECTOR A

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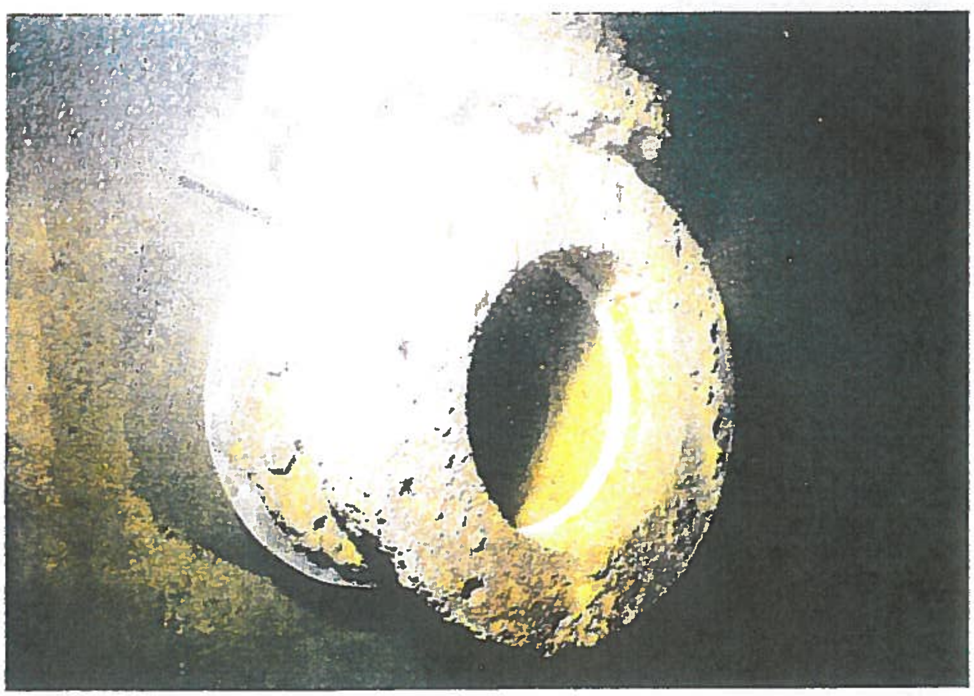

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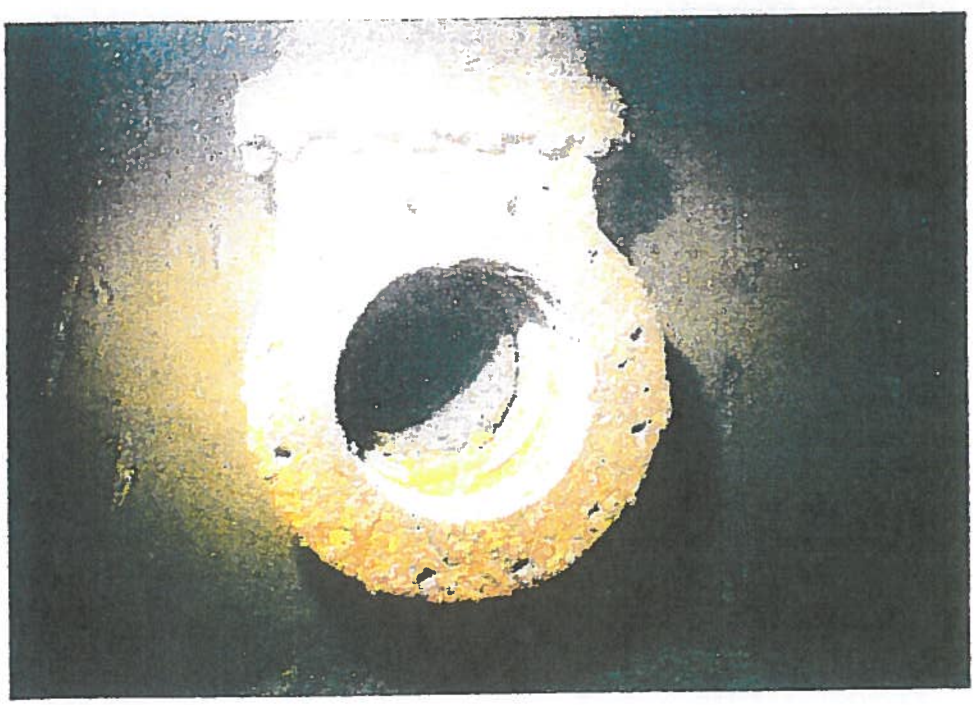

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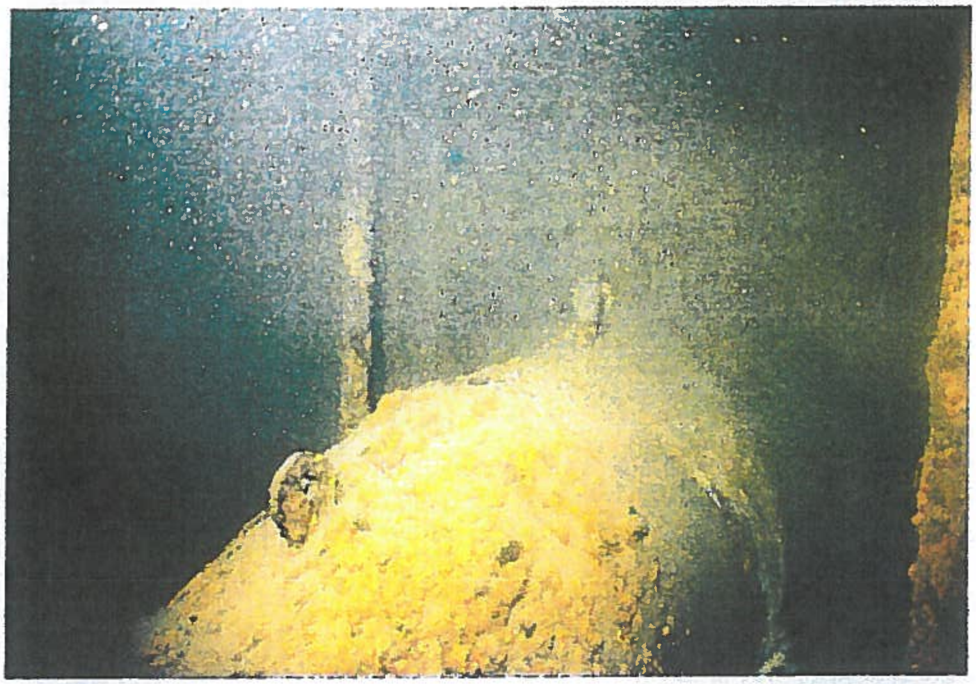
PHOTOGRAPH #42: SIPHON TO SIDE WALL



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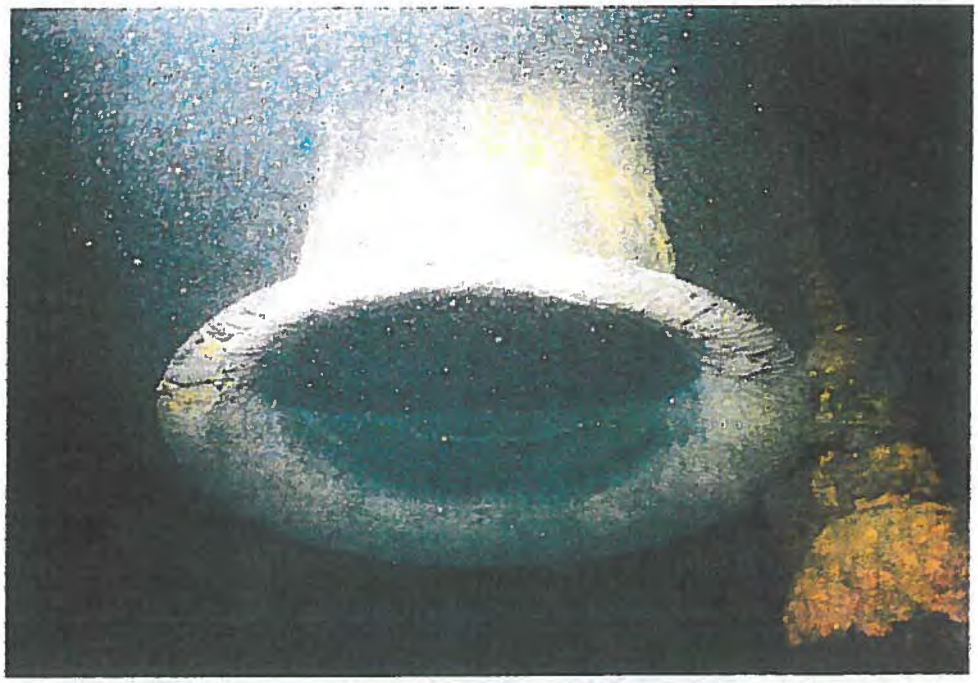
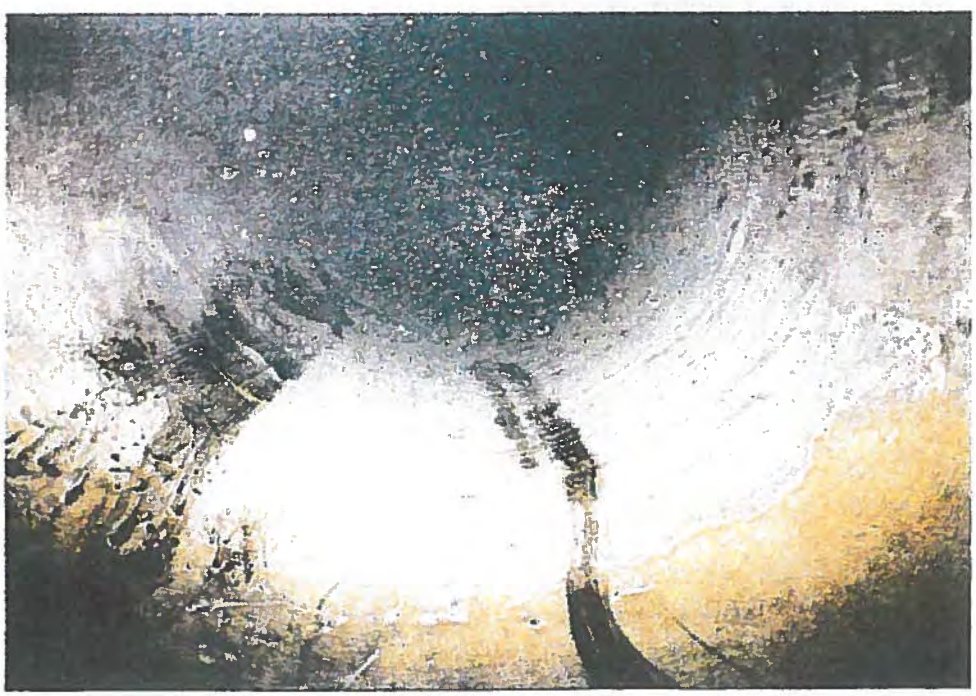


PHOTOGRAPH #45: BELL AT END OF SIPHON



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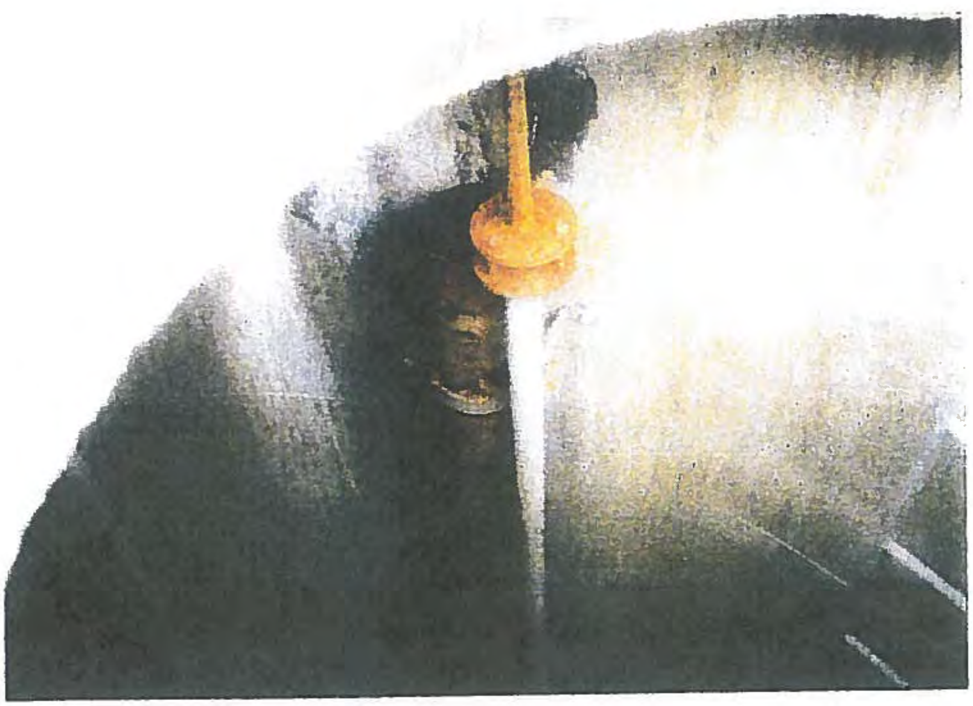
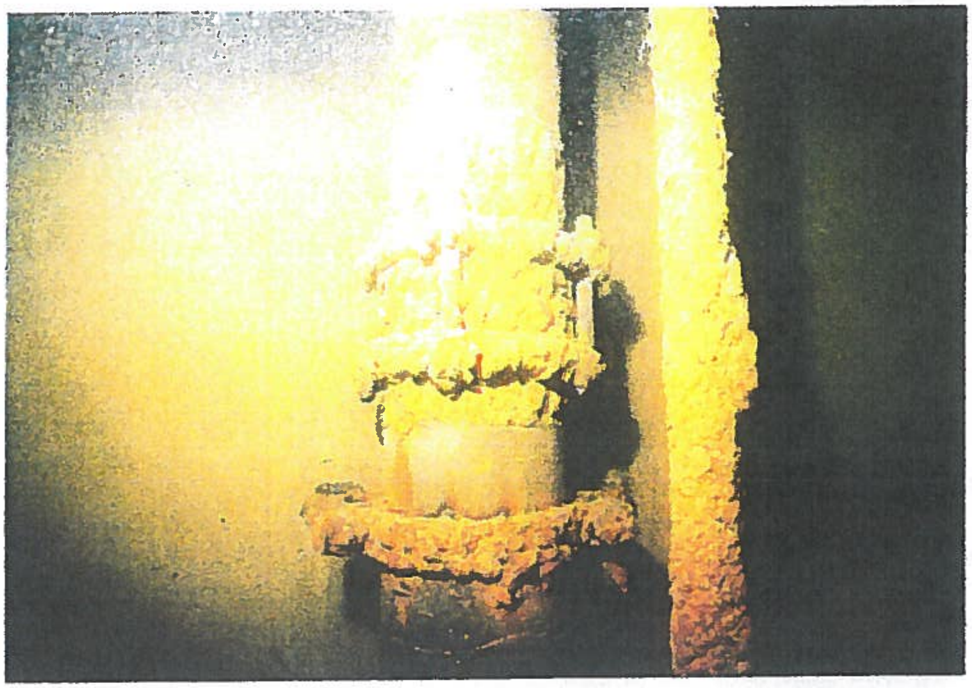


PHOTOGRAPH #48: TOP OF OVERFLOW



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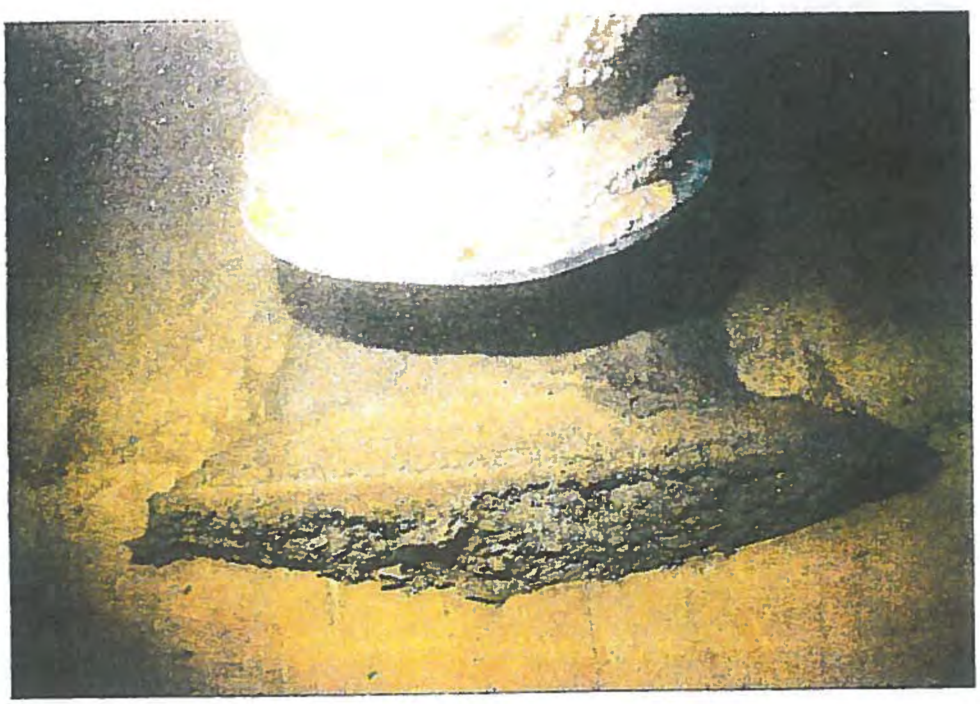

PHOTOGRAPH #52: CONCRETE OVERPOUR ON BOTTOM

Ref: 02-1055-06010

December 8, 2003

Ms. Carol Rische
Humboldt Bay Municipal Water District
P.O. Box 95
Eureka, CA 95502

Re: Ranney Collector Rehabilitation Feasibility Report
Agreement No. 52 – CPE – 6

Dear Carol:

Per the above referenced Agreement we are pleased to submit the following letter report regarding rehabilitation of the District's Ranney Collectors. Per the Scope of Work the services are:

1. Identify and contact agencies which have had rehabilitation of existing laterals, or have installed new laterals on Ranney Collectors to determine what their experience was and how the collector performed before and after restoration work was completed.
2. Based on the findings in Reynolds, Inc. report "Inspection and Pump Test of Ranney Well No. 2 (PS2), February 2003" and the information obtained for activity 1 (above), evaluate and provide a summary of long-term supply alternatives (e.g., rehabilitate or replace Ranney laterals vs. other supply alternatives).
3. Provide a brief summary of the permit and other regulatory requirements for the various options.

In addition to the above outlined scope of work a copy of the Reynolds, Inc. report "Inspection and Pump Test of Ranney Well No. 2 (PS2), February 2003" was forwarded at the request of the District to Henry Hunt from Collector Wells International in order to obtain a second opinion regarding the condition of PS2. Collector Wells International is a company that formed when the Ranney Methods Corporation was bought and taken over by Reynolds, Inc. Subsequent to their review of the report Henry Hunt has provided an opinion in a letter of findings based on Reynolds, Inc. testing and report and has met with the District on two occasions to discuss the District's facilities and interpretation of the data and video tape of PS2. Collector Wells International has thus far provided this service at no charge to the District. A discussion of their opinion is contained in this report.

Summary of Agencies with Recent Rehabilitation Work

Eleven water suppliers who have recently had rehabilitation work performed on their Ranney Collector wells were contacted to ascertain how their experience was with the rehabilitation work, how the wells performed before and after restoration work, which rehabilitation companies performed the services and how they felt overall about the work that was performed.

Work performed included cleaning and rehabilitation of existing well caissons and laterals, installation of new perforated or stainless steel wire-wrapped laterals, and construction of new collector wells. The majority of work performed on existing collector wells involved either inspection and cleaning or a combination of inspection, cleaning and installation of new laterals. In some cases cleaning of laterals was completed as routine maintenance that the owners scheduled every 5-10 years.

Methods of cleaning laterals have changed over the last 20 years. Past cleaning methods included chemical processes, sand blasting and air blasting. Presently, high-pressure rotary-jet methods are normally used. These methods reportedly are rapid (laterals cleaned at a rate of about 1 foot/minute) and effective. Cleaning of Ranney Collector wells typically involves the following steps:

1. Video inspection (flow tested if requested)
2. Initial suction shoveling to remove heavy debris from the caisson
3. High-pressure rotary-jet cleaning of laterals (up to 20,000 psi)
4. Second suction shoveling to remove any additional debris
5. Final inspection and video (flow tested if requested)

Based on our research we were able to identify three companies in the U.S. that currently provide collector well cleaning and rehabilitation services. The companies are Reynolds, Inc., who performed the Inspection and Pump Test of Ranney Well No. 2, Collector Wells International (CWI), located in Columbus, Ohio, and LiquiVision Technology located in Klamath Falls, Oregon. CWI provides the same services as Reynolds, Inc., (i.e., rehabilitation, lateral replacement, construction of new collector wells), and are Reynolds' primary competitor. LiquiVision Technology is a professional diving company which specializes in services for water districts and municipal suppliers of water. LiquiVision's Ranney Collector well services are limited primarily to cleaning, videoing and pump testing.

Each of the three companies provided us with a list of references. A total of thirteen water suppliers were contacted to ascertain their experiences and how their collectors performed before and after the work was performed. All water suppliers who have used the cleaning and rehabilitation services of these companies were satisfied with the work performed and the cost of the service. Most water suppliers stated that they would hire the same company to perform future services, while a few said they would put the work out to bid. It is our opinion that the work should be bid based on a performance specification in order to receive a competitive cost. In each case, collector well production was always found to increase after cleaning services were performed; however the duration of the increase depended on conditions such as water quality and aquifer substrate. Quantitatively the owners didn't provide us with a firm value on how well the production improved, but some stated that production returned to the rate that the wells produced when initially installed. Corrosive water sources or waters high in iron, manganese or other minerals were found to contribute to rapid decreases in well production and lateral degradation. Fortunately, the Mad River water does not contain these constituents or characteristics in high enough concentrations that are detrimental to the laterals. Inspections often found large mineral deposits and bacterial colonies throughout the caissons and laterals. Additionally, wells installed in aquifers with fine bed material tended to clog relatively quickly (within a few years) after cleaning, and required more frequent cleanings. Although the rehab work performed by the three companies is very similar, the cost for the work was variable. Costs may be dependent on the company performing the services, well location, required permits, and extent of cleaning. The cost for cleaning services for one well and laterals, which includes inspection, jet-rotary cleaning and pump testing, ranged from \$17,000 - \$400,000. Although this is a wide price range for nearly the same type of work, varying circumstances, location, number of laterals, permitting, access and other site and location specific issues cause the cost to vary greatly.

Reynolds, Inc. reports an expected cost to clean PS2 in the range of \$140,000 - \$175,000. We specifically addressed the cost for cleaning of PS2 with Henry Hunt of CWI after his review of the collector and the report and video tape generated by the Reynolds, Inc. report. After his review he reports that cleaning of the laterals would be in the neighborhood of \$110,000. Included with this report is Figure 1 which shows a plan view of PS2 and the length of the laterals as reported by Reynolds, Inc. As you know, several of the laterals have sand lines in them that were abandoned in place during the original construction of the well. Figure 1 shows these laterals and the length at which the sand lines are located in the laterals. The typical cleaning procedure as outlined above is based on being able to completely access the interior of the laterals. The presence of the sand lines makes this not feasible in the three laterals as shown on Figure 1. It is possible to make an attempt to cut and remove the sand lines prior to the cleaning process. Because it is unknown why the sand lines were not originally removed it is not known whether it is possible to remove the sand lines through cutting and pulling. This operation could be done on a time and materials basis with known techniques that have been successful to remove lost sand lines but with no guarantee. It is estimated that this could cost \$12,000 - \$15,000 to attempt to remove the sand lines if done in conjunction with the cleaning operation. Based on the above reported costs it is estimated that cleaning and attempted removal of the sand lines could cost in the range of \$120,000 - \$180,000.

Many water suppliers who were contacted also had new laterals installed in their collector wells. Virtually all newly installed laterals were the stainless steel wire-wound type, replacing the older slotted steel type similar to the laterals installed in the District's collectors. New lateral installation services typically include all the services for a well cleaning described above in addition to the lateral installation. Most of the recent lateral installations contained a total of 300-700 feet of new laterals (typically 3 or 4 new laterals). Water suppliers with new lateral installations observed significant increases in production and in some cases original well production levels were restored. The costs for the installation of new laterals with cleaning were between $300,000 and $1,800,000. This, again, is a wide price range for the same services, most new lateral installation services for one well were between $300,000 and $500,000. As with cleaning services, costs are dependent on the company performing the services, well location, required permits, and subsurface conditions encountered during the installation.

Of the water suppliers contacted, only one recently had a new Ranney Collector well constructed. CWI designed and constructed the well. The depth of the caisson was about 40 feet, and the cost of the new well was about $700,000. This is the reported cost which seems low for a new well and to have it outfitted with power and pumps. We estimate that construction of a new collector on the Mad River would cost in the $1.5 – $2.0 million range and total project costs including design and permitting would exceed $2.0 million. We have provided a list of the owners contacted and a summary of the work performed as an attachment to this letter. We have also generated a table with a summary of the contacts and costs of the projects for comparison.

Long Term Supply Design Alternatives

The District's long term domestic supply alternatives are based on continued use of the Ranney Collectors with wintertime treatment as required by the Turbidity Reduction Facility and direct delivery of water from the collectors to customers during the summer.

Needed changes in long term supply capability are dependent on changes in demand on a daily basis. Currently annual peak day demand (summer) is approximately 15 MGD with a peak hourly demand of 16.55 MGD. The District's Ranney Collectors as a system can provide a known sustained demand of 17.1 MGD with three pumps running. Four pumps running can generate 20.2 MGD, but it is not known if this capacity can be sustained due to physical system test constraints, i.e. there is no where to pump the excess water to test the sustainability of 20.2 MGD. Prior tests performed on the composite collector system indicated interference between collectors after sustained pumping, indicating aquifer drawdown issues.

If demand remains relatively constant, long term supply capability is simply dependant on maintenance and continued operation of the existing Ranney collectors. If demand rises and exceeds the current known capability of the system, increased supply alternatives will need to be evaluated and eventually implemented. Possible alternatives to increase supply capabilities include improvement of existing production efficiency and/or added storage to offset hourly and daily peaks. Discussion has also been held about conversion of the TRF to surface water treatment and utilization of Pump Station 6 to supply increased demand. These alternatives are discussed below.

Based on the information provided by Reynolds, Inc. report “Inspection and Pump Test of Ranney Well No. 2 (PS2), February 2003” and other information gathered indicate that several possible alternatives are available to rehabilitate, repair or upgrade the existing Ranney Collectors and laterals. The alternatives may result in increased efficiency and collector life and should allow the continued use of the existing wells and related infrastructure. While each of the alternatives provided has technical merit, the cost of each varies along with environmental considerations and the expected benefit. Therefore the preferred alternative should be chosen based on a balance of the desired end result, environmental impacts, and availability of funds.

The following preliminary alternatives are listed in order of estimated implementation costs.

1) Rehabilitate Existing Collector and Laterals

Rehabilitation of the existing collectors and laterals addresses the primary objective of potentially increasing efficiency and collector life in a cost-effective manner. Work would include preliminary video inspections of the wells and laterals, preliminary pump tests to establish initial well production and drawdown, jet-rotary cleaning of the well caissons and laterals, final pump tests to determine efficiency gains resulting from cleaning operations, and final video inspections of wells and laterals. If failed or failing laterals are encountered they could be taken out of service by closing the end valve on the lateral in the caisson if operable. If the valves are not operable new valves would need to be installed in order to isolate the lateral from the caisson. Although implementation of this alternative could potentially result in an immediate increase in collector efficiency, it does not address issues of long-term productivity and collector life, or lost well capacity through failed or failing laterals. Cleaning should primarily be considered a maintenance activity.

Opinion of the laterals conditions in PS2 varied widely between Reynolds, Inc. and CWI. As reported by Scott Riegert of Reynolds, Inc., rehab by cleaning is risky due to the collector’s age. He indicates that based on the age and condition of the laterals there is significant risk that the stress of the cleaning operation may cause further failure of laterals that are producing water or maybe render the well inoperable. He goes on to state that rehabilitation is risky, unpredictable and not long term and the District should expect to see the well’s capacity drop off very quickly over the next few years. Although the video from the inspection and pump test activities show the laterals to be generally in good condition, he reports that he has seen this before but upon further inspection and cleaning the metal in the laterals is relatively thin and deteriorates rapidly after rotary cleaning.

Henry Hunt of CWI also indicates that they feel the well and laterals appear to be in good condition, both structurally and operationally, and reports they do not see any evidence of screen thinning or corrosion. Based on these observations he indicates that the screen appears to be of suitable thickness to perform adequately. He also states that cleaning of the well screens and redevelopment of the aquifer surrounding the screens would help in better showing the condition of the screens, but feels based on the videotape this would show that the well screens are in good condition. In our conversations with Henry Hunt he has indicated that he feels the laterals have suitable thickness to continue to operate into the future for some time. Of course he can't guarantee that the laterals will operate indefinitely, but contrary to Reynolds, Inc. opinion, he did feel that he wouldn't be surprised if the District received at least another 20 years of service from the laterals based on their current condition.

2) Installation of New Laterals at New Locations

This alternative addresses the primary objective of increasing long-term production and collector life. Installation of new laterals will add useful life to the collectors that cleaning rehabilitation as described above won't. Increased well efficiency and production may be an added benefit by the addition of new laterals. Work for this alternative would include those items described in Alternative No.1 with modifications and additional elements as described below.

Although both Reynolds, Inc., and CWI both install laterals, the techniques implemented by each firm may be different. Neither company would completely divulge their process, but it can be surmised it is similar. Locations for new laterals in the caisson are chosen based on existing well data and locations of existing laterals. The caisson is pumped down and the existing lateral valved and flanged so the work can be performed in a "dry" area. A hole is bored in the caisson wall and packing is used so that a steel casing can be projected into the substrate. Material is removed with a sand line in front of the steel casing and the casing is jacked forward using the back wall of the caisson as a buttress. After the casing is projected to the desired length or it meets refusal, the sand line is removed and a stainless steel wire wrapped lateral is inserted inside the casing. After the lateral has been projected the casing is removed and substrate collapses around the new lateral and a new valve is installed in the caisson on the end of the lateral.

This is a relatively new method for installation of laterals. Previously the slotted steel lateral (similar to the District's laterals) was jacked in directly with the bore head and sand line attached. The sand line was then removed and in some instances left in place as is the case with several of the laterals in PS2. The primary benefit of the new installation process is that the substrate material can be examined by a hydrogeologist during installation of the casing in order to optimize the slot size of the lateral. Previously the slot size was predetermined and installed prior to knowing the actual size and specific type of strata of the aquifer at the depth of installation.

3) Convert Turbidity Reduction Facility to a Surface Water Treatment Plant

Although it may be required in the future to convert the TRF to a surface water treatment plant due to changing regulations and operate continuously, the TRF was designed and operates based on credit for filtration through the gravel in the river. Because of the credit for filtration through the gravels, conversion to a surface water treatment plant would require significant redesign and upgrades to the system and major capital outlay to allow treatment of surface water pumped from the fore bay of Pump Station 6. For the purpose of this study, this is not considered a cost effective feasible alternative.

4) Construct New Collector Wells

This alternative addresses the primary objective of increasing long-term production and collector life. Work for this alternative would require selecting a new site(s) for one or more new collector wells, completing collector well design, permitting, and constructing the new well(s) and connecting it with the existing system. As discussed previously construction of a new well would likely cost in excess of $2.0 million including design and permitting. The existing system and Ranney Collectors have been maintained well and are in good condition. Because these functioning wells can be rehabilitated, It is our opinion that it is more cost effective to complete rehabilitation of existing wells than to consider trying to permit and build a new well.

The District would have to complete the CEQA process and obtain permits for construction of a new well from Fish & Game, National Marine Fisheries, Northcoast Regional Water Quality Control Board and the U.S. Army Corps of Engineers. The State Lands Commission should also be contacted. Because of the many agencies involved and the location of the work is in the Mad River, the permitting process could generate a project with many conditions based on the fact there are wells in place that can be used and/or rehabilitated.

Permit and Other Regulatory Requirements

Rehabilitation of the laterals by cleaning and flushing may require further consultation with Fish & Game, National Marine Fisheries and the U.S. Army Corps of Engineers. Currently, the five-year Streambed Alteration Agreement with Fish & Game and the annual Army Corps permits will be supported by documentation prepared on behalf of the District. The documentation includes the HBMWD Negative Declaration for Maintenance of Facilities in the Mad River and the HBMWD Habitat Conservation Plan which has been adopted. These documents both refer to construction of a berm adjacent to collectors to allow for the occasional flushing of the collectors for maintenance. Rehabilitation of the collectors for cleaning purposes may require a larger bermed area (up to 200 by 200 feet square) for percolation of water used in the cleaning operation that may not be covered by the language contained in the referenced documents. We would recommend placement of a percolation pond for rehabilitation of PS2 in the park area adjacent to the collector out of the limits of the river, and recommend consultation with Fish &

Game to determine whether this area would be considered within the river and would require an additional or modification to the existing streambed alteration permit. Location of percolation ponds for rehabilitation of the other collectors would have to be on a case by case basis based on their location with consultation with the agencies. Work for cleaning purposes would be required to be completed between June 1 and October 15 as is required under current permits.

Installation of new laterals may require further CEQA revisions due to the "drilling" in the gravel bed. We recommend that as these alternatives are further developed and a long term solution is chosen, agencies be contacted in order to discuss possible construction activities to determine any further permit requirements that they may deem necessary.

Conclusions and Recommendations

The long term use, condition and maintenance of the existing Ranney Collectors is of significant importance to the District. The collectors represent the foundation of the District's domestic water supply and must be maintained and rehabilitated so that they remain in use another 40 or 50 years. To date, the District has experienced a reasonable and useful life from the collectors and with good planning and maintenance should be able to operate the collectors for an extended time in the future.

In the course of this study we have spoken with the two companies that perform the type of work to clean and rehabilitate the Ranney Collectors or build new wells. We have had several meetings with them to discuss the District's system and obtained differing opinions regarding the condition of PS2 based on the Reynolds, Inc. report. It is our opinion that the District complete the following:

1. Assemble bid documents to clean and rehabilitate PS2. Put the rehabilitation out to bid and include as a bid requirement that the company performing the work has the capability to install new laterals if required.
2. Following completion of item 1 above, TV inspect all of the laterals in each collector to catalogue the condition of each lateral within the individual collectors. This may not need to be completed immediately but could be a planned event in the next 5 years assuming the cleaning of PS2 is successful.
3. Clean and rehabilitate the remaining collectors based on the inspections and existing condition of the collectors.
4. There is no doubt that at sometime in the relatively near future some or all of the collectors will have to have new laterals projected. It cannot be expected that the existing laterals will last another 40 years. No reasonable combination of storage and/or minor upgrades to the TRF can replace the Ranney Collectors and their long term use to provide water to the system. Therefore, it will be necessary to install new laterals at sometime in the future following a condition survey and cleaning as outlined above.

The above approach will allow the District to make a step-by-step approach to rehabilitating the collectors. It is important to adequately understand the existing condition of the laterals in the collectors. Reynolds, Inc., reports that cleaning of the laterals is risky based on the age of the collectors. However, CWI's opinion is that the laterals appear to be in generally good shape and should be fine after cleaning and rehabilitation. Regardless, after cleaning the laterals true condition will be exposed and the District will have a clear picture as to the condition of PS2 and likely a good idea of the condition of the remaining collectors due to similar installation conditions. It is not feasible to make this determination without some of the above outlined efforts being undertaken. However, in the future it will be necessary for the District to begin a program to eventually project new laterals in order to extend the life of the collectors.

Based on reported costs from our contacts it is likely that cleaning rehabilitation as presented would cost in the neighborhood of \$120,000-\$180,000 per collector. Reynolds, Inc., reported a likely cost of \$140,000 - \$170,000 for cleaning, but based on our research, estimates of cost from CWI and putting the rehabilitation out to bid should make the cost a little less. New laterals would likely cost a minimum of \$500,000 per collector, but these costs and an approach can be refined further in order to develop a long term plan and installation strategy.

Please do not hesitate to call me if you have any questions or comments.

Sincerely,
WINZLER & KELLY

Alex Culick, P.E.
Senior Project Manger

tc

Enclosure

c: Barry Van Sickle

INSPECTION REPORT
COLLECTOR WELLS
1A, 1, 3 and 4

Prepared For:

Humboldt Bay Municipal Water District Eureka, California

Prepared By:

Collector Wells International, Inc. A Layne Christensen Company

Columbus, Ohio
January 2007

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1.0 INTRODUCTION

Collector Wells International, Inc. (CWI), a Layne Christensen Company, recently completed inspections of the Humboldt Bay Municipal Water District (District) Collector Wells (Pump Stations) 1A, 1, 3 and 4. The work was conducted the as authorized by Professional Services Agreement No. 52-RCE-1 dated October 11, 2006, in accordance with the CWI proposal dated October 10, 2006.

1.1 BACKGROUND

The District has six (6) collector wells (1, 1A, 2, 3, 4 and 5) located along the Mad River in Arcata, California (Figures 1 and 2). The District designates Collector Wells 1 through 5 as pumping stations (PS) with their respective numbers (e.g. PS1 for Collector Well 1). Construction of Collector Wells 1, 2, 3 and 4 was begun in 1961 and performance testing was conducted in 1962. Collector Well 5 is not currently in service. Collector Well 1 is connected to Collector Well 1A by a siphon line, and there are no pumps installed in Collector Well 1A. Nearly all of laterals in Collector Well 1 are plugged or have the valves closed, so effectively, the water pumped from Collector Well 1 is derived almost entirely from Collector Well 1A.

Each Collector Well consists of a reinforced concrete caisson with an inner diameter of 13 feet and an outer diameter of 16 feet (Ranney, 1962). The Collectors vary in the numbers and lengths of laterals installed. A summary of the available information on the collector wells is presented in Table 1, and the original construction diagrams for Collectors 1, 3 and 4 are presented in Appendix A. The laterals in the wells were constructed with 12-inch OD, punch-slotted steel well screen with 3/8-inch by 1-1/16-inch rectangular slots.

During an inspection of Collector Well 2 (PS2) (Reynolds, Inc., 2003), and during subsequent maintenance on this collector well (CWI, 2005), it was determined that several of the laterals have substantial upward deflections and there are sand lines that had been left in place in some of the laterals from the original construction. The deflection of the laterals and the presence of the sand lines prohibit access to the laterals for maintenance. Because of the age of the collector wells, and the condition of some of the laterals in Collector Well 2, it was considered prudent to ascertain the condition of Collector Wells 1, 1A, 3 and 4 in order to plan for future water supply and maintenance needs.

In April 2006, a test boring was drilled adjacent to Collector Well 3 and a short-term pumping test was conducted in this boring. This work was directed by Winzler & Kelly Consulting Engineers of Eureka, California to evaluate the feasibility of the installation of additional laterals in Collector Well 3. An assessment of the results of the drilling and testing of this boring are included in this report.

1.2 REPORT ORGANIZATION

Section 1.0 – Introduction – presents the purpose, background and limitations of the project.

Section 2.0 – Collector Well Inspection Procedures – presents the field procedures used to conduct the inspections.

Section 3.0 – Collector Well Conditions and Inspection Results – presents a summary of the current conditions of the collector wells and the results of the inspections.

Section 4.0 – Collector Well 3 Test Drilling Activities – presents a summary of the drilling and testing activities and interpretation of the results

Section 5.0 – Summary and Recommendations – presents a summary of the findings and recommendations for maintenance and improvements in the collector wells.

Section 6.0 – References cited in the report

1.3 LIMITATIONS

This report was prepared for the exclusive use of the Humboldt Bay Municipal Water District for the specific applications and the purposes specified in the report. Conclusions reached in this report are based upon the objective data available to us at the time of forming our opinions and the accuracy of the report depends upon the accuracy of these data. Every effort is made to evaluate the information by the methods generally recognized to constitute accepted standard practices for ground water investigations at the time of rendering the report and the conclusions reached therein to represent our opinions. The company cannot be responsible for actual conditions proved to be materially at variance with the data collected or supplied to us, upon which our opinions are based.

2.0 COLLECTOR WELL INSPECTION PROCEDURES

The inspections of Collector Wells 1, 1A, 3 and 4 were conducted by a professional diver and support crew experienced in collector well inspections including a CWI hydrogeologist. Diving services were provided by MM Diving of Crescent City, California. The inspections were conducted from October 17 through October 20, 2006 and included the following tasks:

1. Placement of temporary screens over each of the operating pumps in each well and the siphon line in Collector Well 1A during the inspection for protection of the diver and equipment.
2. Video inspection of each caisson to determine an accurate count and condition of the control valves and laterals screens in each collector well.
3. Video inspection of each accessible lateral to observe the condition of the lateral well screen, presence and location of sand lines, degree of mineral precipitation on the screens, and accumulation of sand, silt and sediment in each lateral.
4. Measurement of the flow and temperature for each lateral under pumping conditions.
5. Video inspection of the siphon line between Collector Wells 1 and 1A.
6. Preparation of a report detailing procedures, findings and recommendations.

During the inspections, the hydrogeologist measured water levels in the collector well caissons and accessible adjacent monitoring wells using an electric water level meter. Water levels were obtained in the wells with the pumps turned on to reflect the normal operating conditions for the wells, and static water levels were obtained before the pumps were turned on when possible. For the period during which the well inspections were conducted, the District provided CWI with caisson water level records for Collector Wells 1, 2, 3 and 4; river level records; and total production values from their Supervisory Control And Data Acquisition (SCADA) system. River level data were also obtained from the US Geological Survey (USGS) Mad River gage station number 11481000 that is located approximately 2000 feet downstream of the water treatment plant.

The hydrogeologist also inspected above-water conditions in the caisson and in the pump house where the pumps and motors are installed. The diver inspected the underwater portion of the well including such features as: the lateral control valves, caisson walls, the bottom of the caisson and the pump column and intake area. The diver also inspected the inside of the lateral screens in the section nearest the caisson in order to observe the amount and type of encrustation present, and to estimate the structural condition of the screens.

The diver assisted with measurements of the relative rate of flow and water temperature from each accessible lateral utilizing a specially-designed hand-held flow meter/temperature sensor. These measurements were used to determine the relative productivity of the individual laterals. During the flow measurements, the District operated only the well being inspected. This allowed determination of the total pumping rate from the collector well at the time of the flow measurements.

A color video camera was inserted into each accessible lateral to visually inspect the lateral screen to its full accessible length. The camera used was a static camera system that was projected into the laterals using a length of flexible high-density polyethylene (HDPE) pipe. MM Diving provided the camera system. This camera was also used to inspect the siphon line between Collector Well 1A and Collector Well 1. DVD format copies of the videos taken during the inspections are provided with this report.

Water samples were collected from Collector Wells 1A, 3 and 4 and from the river, and these samples were submitted to a laboratory for chemical screening analysis of inorganic constituents, metals and volatile organic chemicals. In Collector Well 1A, the diver collected the water samples in the caisson. Because none of the laterals are open in Collector Well 1 and the water in the well is derived from Collector Well 1A via the siphon line, no water samples were collected from this well. In Collector Wells 3 and 4, the water samples were collected from the taps in the well pump houses after allowing the water lines to purge for several minutes. The water quality analyses are for informational purposes only and are not intended for regulatory compliance.

The findings, conclusions and recommendations have been compiled in this report, prepared and reviewed by our technical personnel. This report includes analysis of the pumping data, observations and results from the inspection, water quality analyses and recommendations for activities.

3.0 COLLECTOR WELL CONDITIONS AND INSPECTION RESULTS

This section presents a brief description of the as-built design of each of the collector wells that were inspected along with a summary of the inspection results. Drawings of the construction details for Collector Wells 1, 3 and 4 from the performance testing report (Ranney, 1962) are presented in Appendix A, and a summary of information on the collector wells is presented in Table 1. Water level data collected during the inspections by CWI are presented in Appendix B.

3.1 COLLECTOR WELL 1A INSPECTION RESULTS

The inspection of Collector Well 1A was conducted on October 17, 2006. Collector Well 1A is located about 700 feet northeast of the water treatment plant and about 200 feet east southeast of Collector Well 1 (PS1). There are no pumps installed in Collector Well 1A and no pump house. The well is connected to Collector Well 1 by a siphon pipe line. Pumping of Collector Well 1 draws water from Collector Well 1A through this siphon line.

Only limited information on the construction details and no information on performance testing of Collector Well 1A was available at the time of the inspection or report preparation. The measured depth from the top of the top slab to the caisson floor was 72.7 feet at the access hatch. There are two tiers of laterals in the well, with the centerline of the lower tier about 3 feet above the caisson floor, and the centerline of the upper tier about 8 feet above the caisson floor. There are six laterals in each tier. The laterals in both tiers are roughly equally spaced around the perimeter of the caisson with the upper tier staggered from the lower tier so that horizontal position of each upper tier lateral is about halfway between the horizontal positions of two of the lower tier laterals. Based on the distances that the diver was able to advance the video camera in the laterals, it appears that they are all about 61 to 62 feet in length. Each lateral is equipped with a valve and there is a valve stem on each valve that leads to the top of the caisson top slab.

A summary of the visual and video inspection observations in Collector Well 1A is presented in Table 3. A summary of the diver's observations during the inspections is presented in Appendix C. Photographs and still images from the video inspection of Collector Well 1A are presented in Appendix D. Visual inspection showed no apparent problems with the caisson or valves. There is about 6-inches to 1 foot of loose sand and gravel and probably some small chunks of concrete on the caisson floor. The lower end of the ladder from the access hatch is loose from the caisson wall.

The siphon line leading to Collector Well 1 is located just to the left of the ladder leading from the access hatch. The siphon line consists of a 30-inch (approximate) diameter pipe. The siphon line has a 90-degree elbow where it comes through the caisson wall and about 20 feet of vertical pipe leading down to a belled opening. The opening is about 11 feet above the caisson floor.

Video inspection of the laterals showed that the interiors of the lateral screens are generally coated with black and reddish-colored bacterial and/or mineral deposits. These deposits appear to be less than ½-inch to more than 1-inch thick. In portions of the laterals the deposits are thick enough so that the screen slot openings are not visible. The diver was able to advance the camera to the end of all of the laterals except the fourth lateral from the right of the ladder in the lower tier (designated as A4 in the tables). This lateral was partially blocked by what appeared to be sand and gravel at about 55 feet from the caisson wall. There were no obvious problems with the integrity of the other laterals in Collector Well 1A, however, the deposits coating the inside of the laterals prevented observation of the well screen material. No sharp deviations or deflections from horizontal in the lateral orientations were observed, although there could be gradual deviations. There are no sand lines remaining in the any of the laterals in Collector Well 1A, nor were sand lines observed remaining in the laterals in Collector Wells 3 and 4. This is further indication that there are no significant deviations from horizontal in the lateral orientations.

During the inspection, water levels were obtained using an electric water level meter in the Collector Well 1A caisson and the closest monitoring well MW-1. These water levels and water levels provided by the District from their SCADA system for their river intake and Collector Well 1 and also for the USGS river gage are depicted in the hydrographs in Figure 3. A summary of water level data and pumping rates during the inspection are presented in Table 2. As indicated in Table 2, the average pumping rate from Collector Well 1 during the inspection was 6.3 million gallons per day (MGD) or about 4350 gallons per minute (gpm). Because most of the lateral valves in Collector Well 1 are closed or the laterals are plugged, the majority of the water pumped from Collector Well 1 is obtained from Collector Well 1A through the siphon line. After 3.6 hours of pumping during the inspection, there was an observed drawdown in Collector Well 1A of 12.3 feet giving an observed specific capacity of approximately 350 gallons per minute per foot of drawdown (gpm/ft) assuming all of the water pumped was from Collector Well 1A.

Lateral flow and temperature measurements conducted in Collector Well 1A are summarized in Table 4. The results indicate that the flow from the individual laterals ranges from a minimum of about 2% of the total flow to a maximum of about 16% of the total flow. The combined flow from the lower tier makes up about 58% of the total and the combined flow from the upper tier makes up about 42% of the total. The water temperature from the individual laterals ranged from about 61° to about 65° F.

3.2 COLLECTOR WELL 1 (PS1) INSPECTION RESULTS

The inspection of Collector Well 1 (PS1) was conducted on October 18, 2006. Collector Well 1 is located about 600 feet northeast of the water treatment plant. There are three pumps installed in Collector Well 1, designated 1-2, 1-3 and 1-4. Pumping of Collector 1 draws water from Collector Well 1A through the siphon line between the two wells.

A diagram showing the construction details for Collector Well 1 is presented in Appendix A, however, the number and orientation of the laterals observed during the inspection do not completely correspond to this diagram. There are two tiers of laterals in the well, with the centerline of the lower tier about 3 feet above the caisson floor, and the centerline of the upper tier about 10 feet above the caisson floor. However, there are six (6) laterals (counting a 24-inch diameter corrugated pipe through the caisson wall) in the lower tier instead of the three shown on the drawing. There are seven (7) laterals in the upper tier as indicated on the construction diagram, however, the orientation of these laterals as described by the divers does not seem to conform to the orientation indicated on the construction diagram.

A summary of the inspection observations in Collector Well 1 is presented in Table 5. A summary of the diver's observations during the inspections is presented in Appendix C. Photographs and still images from the video inspection of Collector Well 1 are presented in Appendix E.

Visual inspection showed no apparent problems with the caisson, pump house, pumps and pump columns. The housekeeping in the pump house is generally very good. There is a large amount of debris on the floor of the caisson including scrap metal, wood, sand and gravel and chunks of concrete. There is what appears to be a 6-inch or 8-inch diameter stilling pipe just to the left of the access ladder. This pipe is corroded through in one spot and is just barely attached to the caisson wall. The siphon line leading to Collector Well 1 is located to the right of the ladder leading from the access hatch. The siphon line has a 90-degree elbow where it comes through the caisson wall and about 20 feet of vertical pipe leading down to a belled opening. The opening is about 10 feet above the caisson floor.

All of the laterals in Collector Well 1 are either plugged, capped or have the valves closed or nearly closed. Consequently no video inspection of the insides of the laterals was conducted, their conditions were not ascertained, and no flow tests were performed. Numbering clockwise from the right of the ladder, in the lower tier, laterals A1 and A2 have no valves and are plugged with wood. Lateral A3 does not have a valve and is capped with a metal cap that has a pipe fitting in the center of the cap and another on top of the cap. There is a 24-inch diameter corrugated pipe extending through the caisson wall that is identified as A4 in Table 4. This pipe is plugged with wood. Lateral A5 has two valves fitted together in parallel on the end of the flange, with the outer valve closed. The valve on lateral A6 is partially opened about 1 inch, and there was very strong flow of water from this lateral. In the upper tier, the valve on lateral B1 is partially opened about 1/4-inch, and there was some flow from this lateral. The valves on laterals B2 through B5 are closed. The valve on lateral B6 is closed, but the diver indicated that there was a slight amount of flow leaking through the valve seal. The valve on lateral B7 is cracked open and has a small amount of flow coming through it.

During the inspection, water levels were obtained using an electric water level meter in the Collector Well 1 caisson, a 12-inch diameter vertical well located 104 feet west of the west side of Collector Well 1 and in monitoring well MW-1. These water levels and water levels provided by the District from their SCADA system for their river intake and Collector Well 1 and also for the USGS river gage are depicted in the hydrographs in Figure 4. A summary of water level data and pumping rates during the inspection are presented in Table 2. As indicated in Figure 4 and Table 2, the average pumping rate from Collector Well 1 during the inspection was 5.6 MGD or about 3900 gpm with pump 1-2 running. After 1.7 hours of pumping during the inspection, the water level in Collector Well 1 decreased 12.0 feet below the static level. Because most of the lateral valves in Collector Well 1 are closed or the laterals are plugged, the majority of the water pumped from Collector Well 1 is obtained from Collector Well 1A through the siphon line, and consequently the specific capacity of Collector Well 1 could not be established during the inspection.

During the inspection of Collector Well 1, a video inspection of the siphon line between Collector Well 1 and Collector Well 1A was conducted. The diver was able to advance the camera up the siphon 170 feet from Collector Well 1 toward Collector Well 1A. At this point, the friction on the HDPE pipe prevented further advance of the camera. The measured distance from the closest side of the outside of the Collector Well 1 caisson to the closest side of the outside of the Collector Well 1A caisson is about 186 feet. As seen from the video camera, the inside of the siphon pipe has a relatively uniform thin coating of gray and reddish-colored deposits. The camera appeared to scrape this coating loose, so it is apparently relatively soft. There were no apparent obstructions in the siphon pipe or obvious problems observed. However, the end of the HDPE pipe on which the camera was attached flexed so that the camera pointed at a slight angle as it was advanced, and the full diameter of the pipe cannot be observed in the video.

3.3 <u>COLLECTOR WELL 3 (PS3) INSPECTION RESULTS</u>

The inspection of Collector Well 3 (PS3) was conducted on October 19, 2006. Collector Well 3 is located about 3600 feet east southeast of the water treatment plant on the north side of the Mad River. There are two pumps installed in Collector Well 3, designated 3-1 and 3-2.

A diagram showing the construction details for Collector Well 3 is presented in Appendix A. The number and orientation of the laterals observed during the inspection do appear to correspond to this diagram. There are two tiers of laterals in the well, with the centerline of the lower tier about 3 feet above the caisson floor, and the centerline of the upper tier about 4 feet above the caisson floor. There are a total of five (5) laterals in the well with four (4) laterals in the lower tier and one (1) lateral in the upper tier.

A summary of the inspection observations in Collector Well 3 is presented in Table 6. A summary of the diver's observations during the inspections is presented in Appendix C. Photographs and still images from the video inspection of Collector Well 3 are presented in Appendix F.

Visual inspection showed no apparent problems with the caisson, pump house, pumps and pump columns. The housekeeping in the pump house is generally very good. The floor of the caisson is relatively free of debris. There is a t-shaped I-beam assembly in Collector Well 3 about 20 feet below the static water level (approximate elevation 15 feet) that is attached to the wall at two points and suspended by a cable on the free end. Also in this well, there is a valve port in the side of the caisson that might be for a surface water intake. The top of this port is at an elevation of approximately 20 feet, and the valve is capped off. The lateral valves in Collector Well 3 have long-stemmed actuator assemblies, and all but the valve on lateral A3 have a cable attached to the actuator that leads up to the intermediate floor. Also, there are pipes leading to the bottom of the caisson that are attached to what appears to be some type of venturi lift system.

Video inspection of the laterals in Collector Well 3 showed that the interiors of the lateral screens are generally coated with gray and reddish-colored bacterial and/or mineral deposits. These deposits generally appear to be less than ½-inch thick. The screen slot openings are generally visible in most of the laterals, but the deposits coating the inside of the laterals prevented observation of the well screen material. The diver was able to advance the camera to the end of all of the laterals except the A3 and A5. There is a 90-degree elbow on the end of lateral A3 that points downward. The valve on this lateral is opened only about 1 to 1-1/2 inches so no video inspection of the interior of lateral A3 could be conducted. The diver observed that there is flow from the lateral. Lateral A3 is the only lateral in Collector Well 3 that does not have a cable attached to the valve actuator. Lateral A5 was partially blocked by what appeared to be sand and gravel at about 58 feet and 62 feet from the caisson wall. The camera could not be advanced beyond 62 feet, whereas the reported length of lateral A5 is 68 feet. No sharp deviations or deflections from horizontal in the lateral orientations were observed, although there could be gradual deviations. There are no sand lines remaining in the Collector Well 3 laterals that were videoed, which is further indication that there are no significant deviations from horizontal in the lateral orientations.

During the inspection, water levels were obtained using an electric water level meter in an 8-inch diameter vertical well located 39 feet west of the west side of the Collector Well 3 caisson. These water levels and water levels provided by the District for the river intake and Collector Well 3 and also for the USGS river gage are depicted in the hydrographs in Figure 5. Because of pump lubricating oil floating on the surface of the water in the Collector Well 3 caisson, water level measurements could not be accurately made in the caisson with the electric water level meter during the inspection. There is also a monitoring well located about 200 feet to the east of Collector Well 3, but water levels were not monitored in this well during the inspection. A summary of water level data and pumping rates during the inspection are presented in Table 2. As indicated in Table 2, the average pumping rate from Collector Well 3 during the inspection was 4.8 MGD or about 3330 gpm with pump 3-1 running. After 2 hours of pumping during the inspection, there was an observed drawdown in Collector Well 3 of 13.4 feet. This gives an apparent specific capacity of 250 gpm/ft. The 1962 performance testing results indicate an apparent specific capacity of about 250 gpm/ft after 2 hours of pumping, but the reported pumping rate for the performance test was 10.2 to 10.4 MGD (Ranney, 1962). Given that valve is not fully opened on the lateral that is reported to be the longest, the performance of the well is quite good considering its age.

Lateral flow and temperature measurements conducted in Collector Well 3 are summarized in Table 7. The results indicate that the flow from the individual laterals ranges from a minimum of about 18% of the total flow in lateral B2 to a maximum of about 36% of the total flow in lateral

A2. This assumes that all of the flow is from laterals A2, A4, A5 and B2. With the valve on lateral A3 partially open, there is some flow from this lateral. However, because the flow estimates are based on water velocity measurements, it is difficult to quantify the amount of flow from the lateral with the valve partially opened. The water temperature from the individual laterals ranged from about 61° to about 63° F.

3.4 <u>COLLECTOR WELL 4 (PS4) INSPECTION RESULTS</u>

Collector Well 4 (PS4) is located about 4500 feet east southeast of the water treatment plant on the south side of the Mad River. There are two pumps installed in Collector Well 4, designated 4-1 and 4-2.

A diagram showing the construction details for Collector Well 4 is presented in Appendix A. The number and orientation of the laterals observed during the inspection do appear to correspond to this diagram. There is a single tier of laterals in the well, with the centerline of the laterals about 3 feet above the caisson floor.

A summary of the inspection observations in Collector Well 4 is presented in Table 8. A summary of the diver's observations during the inspections is presented in Appendix C. Photographs and still images from the video inspection of Collector Well 4 are presented in Appendix G.

Visual inspection of Collector Well 4 showed no apparent problems with the caisson, pump house, pumps and pump columns. The housekeeping in the pump house is generally very good. There is 2 to 8 inches of loose sand and gravel on the caisson floor. There is a t-shaped I-beam assembly in Collector Well 4 similar to the one in Collector Well 3. However the I-beam assembly in Collector Well 4 is lying in the bottom of the caisson with one end resting on the valve actuator of lateral A2, one end against the side of valve actuator on lateral A6 and the third end resting on the caisson floor. Similar to the one observed in Collector Well 3, there is a valve port in the side of the caisson well that might be for a surface water intake. This port is at approximately 35 feet below the intermediate floor and is located above a position between laterals A1 and A2. The valve on the port is capped. The lateral valves in Collector 4 have long-stemmed actuator assemblies, and all have a cable attached to the actuator that leads up to the intermediate floor. There are pipes leading to the bottom of the caisson that are attached to what appears to be some type of venturi lift system similar to the one in Collector Well 3. The lower end of the ladder is loose from the caisson wall.

Video inspection of the laterals showed that the interiors of the lateral screens are generally coated with gray-colored bacterial and/or mineral deposits. These deposits generally appear to be less than ½-inch to more than 1-inch thick. The deposits coating the inside of the laterals prevented observation of the well screen material. The diver was able to advance the camera to the end of all of the laterals except the A1 and A3. The valve on lateral A1 is opened about 40%, and the valve on lateral A3 is opened only about 1 inch so the camera could not be inserted into either of these laterals. No sharp deviations or deflections from horizontal in the lateral orientations were observed, although there could be gradual deviations. There are no sand lines remaining in the Collector Well 4 laterals that were videoed, which is further indication that there are no significant deviations from horizontal in the lateral orientations.

In lateral A2 there are relatively uniform gray deposits on the screen that are greater than 1/2 inches thick. The thickness of these deposits generally increases away from the caisson. The screen slot openings are generally not visible in this lateral. Some of the deposits are loose and silty especially past 30 feet from the caisson. The camera appeared to reach the end of lateral A2 at 68 feet from caisson but visibility was poor. There are similar deposits in lateral A4, and especially past 40 feet from the caisson, some of the deposits are loose and silty. The camera was advanced to 108 feet from caisson in lateral A4, but visibility was lost at 100 feet because of silty material being stirred up by the camera. The deposits on the screen in lateral A5 are generally less than 1/2 inch thick, and the slot openings are generally visible. The deposits on the screen in lateral A6 are generally more than 1/2 inch thick, and the slot openings are generally not visible.

During the inspection, water levels were obtained using an electric water level meter in the Collector Well 4 caisson. These water levels and water levels provided by the District for their river intake and Collector Well 4 and also for the USGS river gage are depicted in the hydrographs in Figure 6. There are no monitoring wells adjacent to Collector Well 4. A summary of water level data and pumping rates during the inspection are presented in Table 2. The average pumping rate from Collector Well 4 during the inspection was 6.0 MGD or about 4180 gpm with pump 4-1 running. After 2 hours of pumping during the inspection, there was an observed drawdown in Collector Well 4 of 13.4 feet. This gives an apparent specific capacity of 310 gpm/ft. The 1962 performance testing results indicate an apparent specific capacity of about 450 gpm/ft at the end of the test with the reported pumping rate of 11.7 MGD (Ranney, 1962). Even without all of the lateral vales open the performance of the well is quite good considering its age, but there may have been some reduction in the capacity due to the accumulation of deposits in the laterals.

Lateral flow and temperature measurements conducted in Collector Well 4 are summarized in Table 9. The results indicate that the flow from the individual laterals ranges from a minimum of about 1% of the total flow in lateral A6 (which is 35 feet long) to a maximum of about 43% of the total flow in lateral A2. This assumes that all of the flow is from laterals A2, A4, A5 and A6. With the valves on lateral A1 and A3 partially open, there is some flow from these laterals. However, because the flow estimates are based on water velocity measurements, it is difficult to quantify the amount of flow from these laterals with the valves partially opened. The water temperature from the individual laterals ranged from about 60° to about 61° F.

3.5 <u>WATER QUALITY RESULTS</u>

3.5.1 <u>INSPECTION SAMPLING RESULTS</u>

Water samples were collected from Collector Wells 1A, 3, 4 and the Mad River during the inspection activities. The samples from Collector Wells 3 and 4 were collected from the taps in the pump houses after flushing the lines for several minutes. The sample from Collector Well 1A was collected in the caisson by the diver. No sample was obtained from Collector Well 1 because most of the laterals are plugged or the valves are closed. The water samples were submitted to National Testing Laboratories, Ltd., of Ypsilanti, Michigan for analysis for selected metals, inorganic and indicator parameters and volatile organic compounds. The WaterCheck analyses from National Testing Laboratories are conducted for information/screening purposes and are not intended for regulatory compliance. The laboratory methods are not necessarily those that would be used by a certified lab for public water supply analysis. A summary of the results is presented in Table 10 and the laboratory reports are presented in Appendix H.

The water quality results from Wells 1A, 3 and 4 are indicate that in general the water quality from the wells is similar to the water quality of the river. The hardness levels ranged from 83 to 89 milligrams per liter (mg/l) as $CaCO_3$. The total dissolved solids values ranged from 91 to 100 mg/l. The iron concentrations ranged from 0.041 mg/l in the sample from Collector Well 3 to 0.34 mg/l in the sample from Collector Well 4. The iron concentration in Collector Well 4 (0.34 mg/l) slightly exceeds the secondary maximum contaminant level (SMCL) for this constituent, which is 0.30 mg/l. The manganese in Collector Well 4 at 0.072 mg/l also exceeds the SMCL for this constituent (0.050 mg/l). Secondary maximum contaminant levels are generally based on aesthetic concerns and are not based on health affects.

Lead was reported in the samples from Collector Wells 3 and 4 at concentrations of 0.058 mg/l and 0.010 mg/l, respectively. The maximum contaminant level for (MCL) for lead in drinking water is 0.015 mg/l. Lead was less than the detection level of 0.002 mg/l in the sample from Well 1A. As the analytical methods used for these samples were not intended for regulatory compliance, these results should not be interpreted to mean that the discharge water from Collector Wells 3 and 4 exceeds drinking water limits. When the laboratory results were received following the inspection activities, it was recommended to the District to conduct additional testing of the lead concentrations in the raw water supplied from these Collector Wells 3 and 4.

3.5.2 FOLLOW-UP SAMPLING RESULTS

As recommended, the District obtained additional water samples from Collector Well 3 (PS3) and Collector Well 4 (PS4) on December 20, 2006. The samples were submitted North Coast Laboratories, Ltd., a certified laboratory, and analyzed for lead. Additionally, the sample from Collector Well 4 was analyzed for manganese. These results are also included in Table 10 and Appendix H. As indicated, the re-sampling results did not detect lead above the detection level (0.001 mg/l) in the samples from either Collector Well 3 or Collector Well 4. The manganese result from the re-sample of Collector Well 4 was 0.013 mg/l, which is substantially lower than the manganese result for this well from the inspection sample (0.072 mg/l) and is below the SMCL for manganese (0.050 mg/l). It is possible that the detection of lead in the inspection sample from Collector Well 3 and the detection of lead and elevated manganese in the inspection sample from Collector Well 4 were the result of constituents present in the taps and pipes used to obtain the samples from these wells. Because the re-sample analyses were conducted by a certified laboratory using drinking water methods, while the inspection samples were conducted by a non-certified laboratory using screening techniques, the re-sample results are considered more representative of the raw water quality of Collector Wells 3 and 4 than are the inspection sample results.

4.0 COLLECTOR WELL 3 TEST DRILLING ACTIVITIES

As part of an evaluation of the potential to increase the yield of Collector Well 3, test drilling activities were conducted adjacent to the well in April 2006. The drilling activities were conducted under the direction of Winzler & Kelly, Consulting Engineers of Eureka, California. A boring, designated B-1, was drilled at a location sixty (60) feet north of the Collector Well 3 caisson. The boring was drilled using rotasonic methods to a total depth of 88 feet. After the boring was drilled, a temporary well was installed, and a short-term multiple-rate step test was performed. Information on the drilling and testing results are presented in Appendix I.

The drilling results indicate that the upper 11 feet of materials is comprised of fill and relatively fine-grained sediments. Below 11 feet, the materials generally consist of sand and gravel in varying proportions. The interval from 60 to 88 feet was reportedly comprised of 20 to 30 percent sand and 60 to 70 percent gravel. The upper portion of this interval from 60 to 70 feet reportedly contained 5 to 20 percent silt and/or clay, while the lower portion of the interval from 70 to 88 feet had little or no fines. The centerlines of the existing laterals in Collector Well 3 are at depths of approximately 73 to 74 feet, and the caisson floor is at a depth of approximately 77 feet. Consequently, if new laterals were to be installed in the well, they would need to be installed above the existing laterals, and the interval from 60 to 70 feet is the optimum zone for the installation of new laterals based on the drilling results, considering available drawdown, aquifer materials and permeability.

For the step pumping test conducted by Winzler & Kelly in boring B-1 adjacent to the Collector Well 3 the temporary well was screened from depths of 60 to 70 feet. The observed specific capacity values at the end of each step of: 86.4, 58.9, 47.6 and 32.9 gpm/ft, at reported pumping rates of 19, 33, 50 and 71 gpm. The transmissivity of the aquifer can be estimated from specific capacity values using the following equation (Driscoll, 1986):

$$T = 1500 * Q/s$$

Where: T = transmissivity, gallons per day per foot (gpd/ft)
Q/s = specific capacity, gallons per minute per foot (gpm/ft)

This approximation assumes a fully efficient, fully penetrating well.

For the first step of the pumping test for which the specific capacity was 86.4 gpm/ft the above approximation would give a transmissivity of about 130,000 gpd/ft. The large decrease in the specific capacity with increasing pumping rates is an indication that the test well was not 100% efficient. Also the short well screen length relative to the aquifer thickness would result in partial penetration effects.

In order to estimate the transmissivity of the aquifer, the specific capacity data from the interval tests were adjusted for well loss and the effects of partial penetration effects using an equation by Kozeny (Driscoll, 1986), such that:

$$T = \frac{1500 \cdot Q/s}{X \cdot E}$$

$$X = L \cdot \left[1 + 7 \cdot \sqrt{\frac{r}{2 \cdot b \cdot L}} \cdot \cos\left(\frac{\pi \cdot L}{2}\right)\right]$$

Where:	r	= well radius, in feet
	b	= aquifer thickness, feet
	L	= well screen length as a fraction of aquifer thickness
	E	= efficiency, obtained from analysis of the step test

Analysis of the step test data using the Bruin and Hudson (1955) method gives a well efficiency of approximately 73% during the first step. Using this result would give a specific capacity of 119 gpm/ft if the well was fully efficient, and this would indicate a transmissivity of about 178,000 gpd/ft with the above approximation.

The temporary well used for the step test was screened at depths from 60 to 70 feet. The static water level was 18.7 feet below the ground surface. Assuming that the bottom of the boring (88 feet) is the base of the aquifer, the 10-foot screened length is 14% of the aquifer thickness (69.3 feet). Using these values in the Kozeny equation gives a partial penetration correction factor of 0.23. However, when this factor is applied to the previous transmissivity value the result is a transmissivity of about 760,000, which is unrealistically high. This is likely due to stratification in the aquifer, which could cause the Kozeny equation to overestimate the partial penetration effects. The step test results indicate that the aquifer transmissivity is probably at least 180,000 gpd/ft. Due to partial penetration effects, the value is probably higher, but it is difficult to quantify these effects. The testing in the vicinity of the collector wells in 1960 (Ranney, 1960) gave reported values of transmissivity of 98,300, 172,000 and 227,000 gpd/ft. The step test results indicate that the transmissivity adjacent to Collector Well 3 is probably near the upper end of this range.

Using these testing results, an estimate the yield of Collector Well 3 can be calculated if additional laterals were installed. The theoretical drawdown under steady-state pumping conditions in a collector well near a stream in an unconfined aquifer is calculated using the following equation developed by Hantush and Papadopulos (1962):

$$s_{cs} \geq \left(\frac{Q}{2\pi K b}\right) \mathrm{Ln}\left(\frac{\Gamma^{\Gamma}}{\varepsilon^{\varepsilon}}\left(\frac{\left(\frac{b}{\pi r_w}\right)^2}{2\left(1 - \cos\frac{\pi}{b}\left(2z_i + r_w\right)\right)}\right)^{\frac{b}{4l}}\right)$$

where:

s_{cs}	= Drawdown in collector well, ft
Q	= Yield of collector, gal/day
K	= Hydraulic Conductivity, gal/day/ft^2
b	= Saturated thickness of aquifer, ft
Γ	= $(2\,(a - r_c))/l$
a	= Effective distance to a line of recharge, ft
l	= Average length of laterals, ft
r_c	= Radius of collector caisson, ft
ε	= $(2a - r_c - l)/l$
r_w	= Effective radius of each lateral, ft
z_i	= Depth of lateral below static water level, ft

Using a variation of the above equation, the potential yield of Collector Well 3 was estimated using the following assumptions:

Grade Elevation 46 ft, msl

Top of Aquifer Elevation	27.3 ft, msl
Base of Aquifer	-37.4 ft, msl
Centerline of Laterals	-16.0 ft, msl
Inside Diameter of Caisson	13 ft
Static Water Level	27.3 ft, msl
Hydraulic Conductivity	2900 gpd/ft^2
Saturated Aquifer Thickness	69 ft
Recommended Minimum Pumping Level	-6 ft, msl
Radius of Laterals	0.5 ft
Design distance to line source of recharge	400 ft
Average Lateral Length	150 ft
Number of Laterals	5

These assumptions consider the installation of five (5) new laterals at a depth of 62 feet (elevation –16.0 feet, assuming grade at 46 feet). This would put the laterals in the cleanest sand and gravel interval observed between the depths of 60 to 70 feet in boring B-1. It was assumed that these new laterals could be projected to an average length of 150 feet. For the purposes of estimating the collector well yield, the effective distance to the recharge boundary represented by the river was set at 400 feet. This value was chosen to give a conservative estimate of the potential collector well yield. The effective distance to the source of recharge may vary seasonally with changes in river level, water temperature and streambed conditions. To ensure that the full length of all of the laterals remains below the water level, the recommended minimum pumping level in the collector caisson is specified as 10 feet above the centerline of the laterals.

Using the above equation and assumptions, it is calculated that Collector Well 3 would have a sustained yield of up to 8,100 gpm (11.6 MGD). This assumes all of the production from the new laterals and does not take into account additional potential yield from the existing laterals. Actual yields would depend on how well the aquifer conditions match the assumed conditions, and would vary with changes in river level and ground water temperature. Also, it may be difficult to project the laterals to an average length of 150 feet due to the aquifer characteristics.

5.0 SUMMARY AND RECOMMENDATIONS

Collector Wells International, Inc., recently completed inspections of the Humboldt Bay Municipal Water District Collector Wells (Pump Stations) 1A, 1, 3 and 4. The inspections of these wells included visual inspection by a diver, video inspection of the accessible portions of the laterals, lateral flow and temperature analysis and the collection of water samples from Collector Wells 1A, 3 and 4.

5.1 SUMMARY

The inspections of Collector Wells 1A, 1, 3 and 4 were conducted from October 17 to October 20, 2006. In general the above ground condition of the collector wells was found to be good, and the housekeeping practices in the pump houses to be very good.

Collector Well 1A was found to be generally in good condition. There are bacterial/mineral deposits on the lateral screens, but it appeared that all but one of the twelve laterals are open for their entire length. The apparent specific capacity of this well during the inspection was 350 gpm/ft. No sharp deviations or deflections from horizontal in the lateral orientations were observed, although there could be gradual deviations. There are no sand lines remaining in the any of the laterals in Collector Well 1A, nor were sand lines observed remaining in the laterals in Collector Wells 3 and 4. This is further indication that there are no significant deviations from horizontal in the lateral orientations.

There were no apparent problems observed with the Collector Well 1 caisson, pump house, pumps and pump columns. There is a large amount of debris on the floor of the caisson including scrap metal, wood, sand and gravel and chunks of concrete. There is what appears to be a stilling pipe just to the left of the access ladder that is corroded through in one spot and is just barely attached to the caisson wall. All of the laterals in Collector Well 1 are either plugged, capped or have the valves closed or nearly closed. Consequently no video inspection of the insides of the laterals was conducted, and no flow measurements were conducted.

In the lower tier of laterals in Collector Well 1, two of the laterals have no valves and are plugged with wood. One lateral does not have a valve and has a metal cap over the flange. One lateral has two valves fitted together on the end of the flange, the outer of which is closed. The valve on one lower tier lateral is partially opened about 1 inch, and there was very strong flow of water from this lateral. There is also a 24-inch diameter corrugated pipe extending through the caisson wall that is plugged with wood. In the upper tier, the valve one lateral is partially opened about 1/4-inch, and there was some flow from this lateral; the valve on another lateral is cracked open and has a small amount of flow coming through it; and the valve one lateral is closed, but the diver indicated that there was a slight amount of flow leaking through the valve seal. The valves on the other four upper tier laterals are closed and do not appear to be leaking.

During the inspection of Collector Well 1, a video inspection of the siphon line between Collector Well 1 and Collector Well 1A was conducted. The diver was able to advance the camera up the siphon 170 feet from Collector Well 1 toward Collector Well 1A. There were no apparent obstructions in the siphon pipe or obvious problems observed.

Visual inspection of Collector Well 3 showed no apparent problems with the caisson, pump house, pumps and pump columns. The floor of the caisson is relatively free of debris. There is a t-shaped I-beam assembly about 20 feet below the static water level that is attached to the wall at two points and suspended by a cable on the free end. The interiors of the lateral screens in Collector Well 3 are generally coated with gray and reddish-colored bacterial and/or mineral deposits. The diver was able to advance the camera to the end of three of the five laterals. There is a 90° elbow on the end of lateral A3, and the valve is opened only about 1 to 1-1/2 inches. Lateral A5 is partially blocked by what appeared to be sand and gravel at about 58 feet and 62 feet from the caisson wall, and the camera could not be advanced beyond 62 feet, whereas the reported length of this lateral is 68 feet. The apparent specific capacity of this well during the inspection was 250 gpm/ft.

The inspection of Collector Well 4 showed no apparent problems with the caisson, pump house, pumps and pump columns. There is 2 to 8 inches of loose sand and gravel on the caisson floor. There is a t-shaped I-beam assembly in Collector Well 4 similar to the one in that is suspended in

Collector Well 3. However the I-beam assembly in Collector Well 4 is lying in the bottom of the caisson with end resting on the valves of two of the laterals. The interiors of the lateral screens are generally coated with gray-colored bacterial/mineral deposits. The diver was able to advance the camera to the end of all but two of the six laterals in Collector Well 4. The valve on lateral A1 is opened about 40%, and the valve on lateral A3 is opened only about 1 inch so the camera could not be inserted into either of these laterals. In laterals A2 and A4 some of the deposits on the screens are loose and silty. The camera was advanced to 108 feet from caisson in lateral A4, but visibility was lost at 100 feet because of silty material being stirred up by the camera. The apparent specific capacity of this well during the inspection was 310 gpm/ft.

The water quality results are generally good, and the quality of water from the wells is similar to the river water quality. The total dissolved solids and hardness values are low and the iron concentrations are relatively low. Lead was reported in the samples collected during the inspection from Collector Wells 3 and 4 at concentrations of 0.058 mg/l and 0.010 mg/l, respectively. Lead was less than the detection level of 0.002 mg/l in the sample from Well 1A. The analytical methods used for the inspection samples were not intended for regulatory compliance. After receiving the inspection sampling results, the District obtained additional water samples from Collector Wells 3 and 4 on December 20, 2006, and these samples were analyzed for lead by a certified laboratory. The re-sampling results did <u>not</u> detect lead above the detection level (0.001 mg/l) in the samples from either Collector Well 3 or Collector Well 4.

An evaluation of the test drilling conducted adjacent to Collector Well 3 showed that below a depth of 11 feet, the materials generally consist of sand and gravel in varying proportions. The interval from 60 to 88 feet was reportedly comprised of 20 to 30 percent sand and 60 to 70 percent gravel. The centerlines of the existing laterals in Collector Well 3 are at depths of approximately 73 to 74 feet, and the caisson floor is at a depth of approximately 77 feet. Consequently, if new laterals were to be installed in the well, they would need to be installed above the existing laterals, and the interval from 60 to 70 feet is the optimum zone for the installation of new laterals based on the drilling results. Based in part on the results of the short-term pumping test conducted in the boring adjacent to Collector Well 3, preliminary estimates show that the well could yield at least 8100 gpm (11.6 MGD) with the addition of five new laterals installed at a depth of 62 feet below grade.

5.2 RECOMMENDATIONS

There does not appear to be any pressing maintenance requirements for Collector Well 1A. There are deposits in the lateral screens that could be removed by cleaning and redevelopment. However, the observed specific capacity of Collector Well 1A during the inspection was relatively high, and it is possible that redevelopment of the well would not significantly improve its performance.

If it is desired to continue to operate Collector Well 1 with the laterals closed, it might be advisable to more permanently seal the laterals. The wooden plugs in some of the lower tier laterals and the 24-inch diameter pipe are showing evidence of decay. For safety reasons, the corroded stilling pipe next to the access ladder would need to be removed prior to any maintenance work in this well. It is advisable that the debris be cleared from the floor of the caisson also.

A slight improvement of the performance of Collector Well 3 might be made by fully opening the valve on lateral A3. A more substantial increase in yield could be made by the installation of new laterals in the interval from depths of 60 to 70 feet below ground surface. A more detailed pumping test using the collector well and the adjacent observation wells may be necessary to more fully evaluate the potential yield of additional laterals. It is understood that Winzler & Kelly has developed a computer-based ground water flow model for the District's well field. This model could also be used to help estimate the maximum potential yield of Collector Well 3, and the affect that additional pumping from Collector Well 3 could have on the performance of the other collector wells. If new laterals were installed in Collector Well 3, the existing laterals could be cleaned and redeveloped at the same time. Any maintenance work on Collector Well 3 would require the removal of the I-beam assembly that is suspended in the caisson. If this I-beam assembly was intended to secure the pump columns, such as to prevent damage during a seismic event, it might be prudent to replace this assembly. It is also recommended that the pump lubricating oil observed floating on the water inside Collector Well 3 be removed.

An improvement in the performance of Collector Well 4 could be made by fully opening the valves on laterals A1 and A3. There are deposits in the lateral screens that could be removed by cleaning and redevelopment. The observed specific capacity of Collector Well 4 during the inspection was lower than the reported specific capacity from the 1962 performance testing. Some of this apparent reduction in specific capacity could simply be the result of the lateral valves not being fully opened. However, redevelopment of the well would likely improve its performance. Any maintenance work on Collector Well 4 would require the removal of the I-beam assembly that in the bottom of the caisson. If this I-beam assembly was intended to secure the pump columns, such as to prevent damage during a seismic event, it might be prudent to replace this assembly.

The condition of Collector Well 5 (PS5) is unknown at this time. Because the pumps were previously removed, CWI was unable to conduct a meaningful inspection and flow evaluation during the recent inspection activities. It is recommended that a temporary pump be installed to facilitate an inspection and flow evaluation of Collector Well 5. This work could be conducted in conjunction with future maintenance work on the other collector wells to minimize costs.

6.0 REFERENCES

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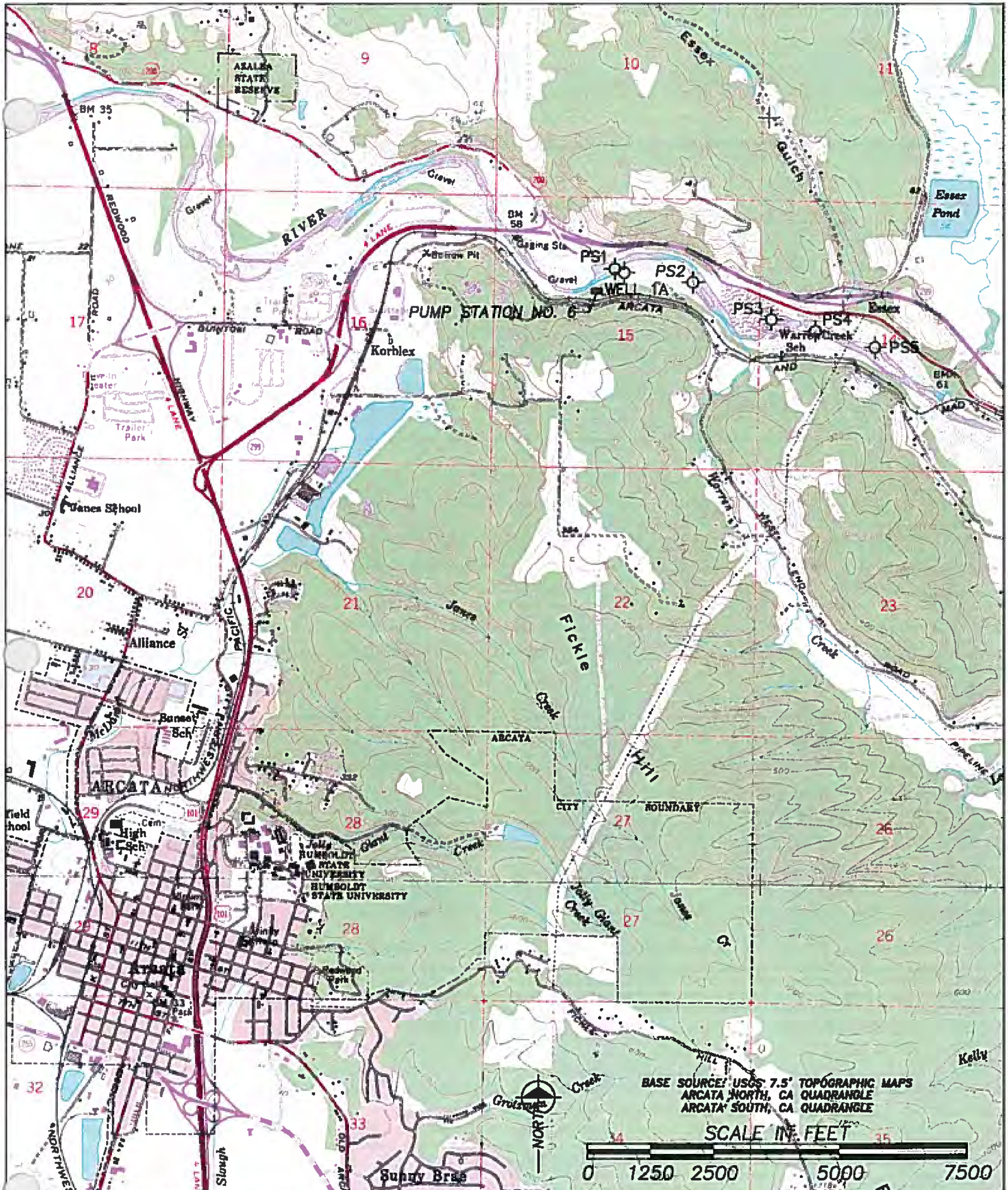
FIGURES



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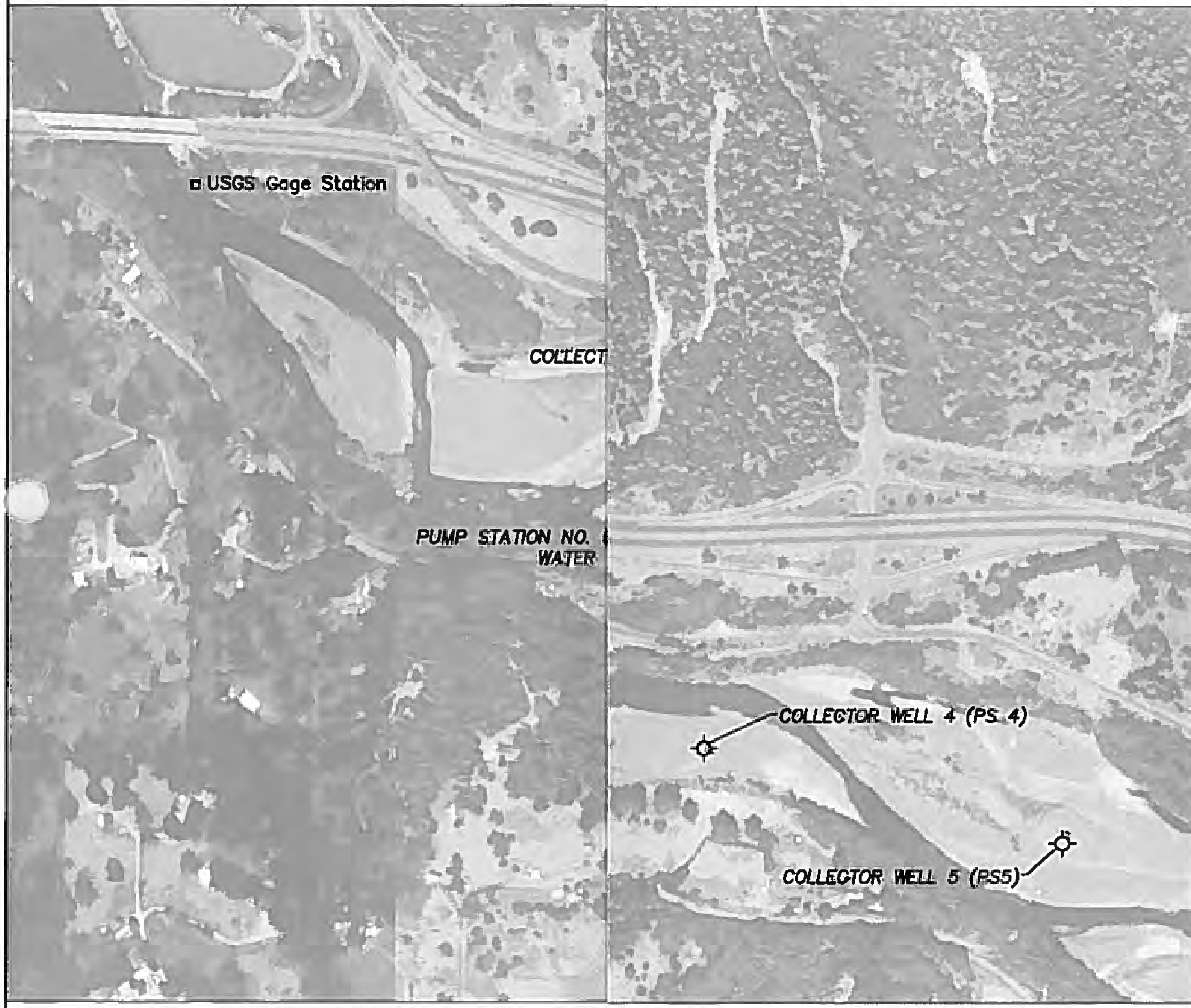
PROJECT LOCATION MAP
HUMBOLDT BAY MUNICIPAL WATER DISTRICT
ARCATA, CALIFORNIA

FIGURE 1

PROJECT NUMBER	DATE	FILE NAME	SCALE
7303	10/24/06	7303-01	1" = 2500'



LEGEND

COLLECTOR WELL
MONITORING WELL
OBSERVATION WELL

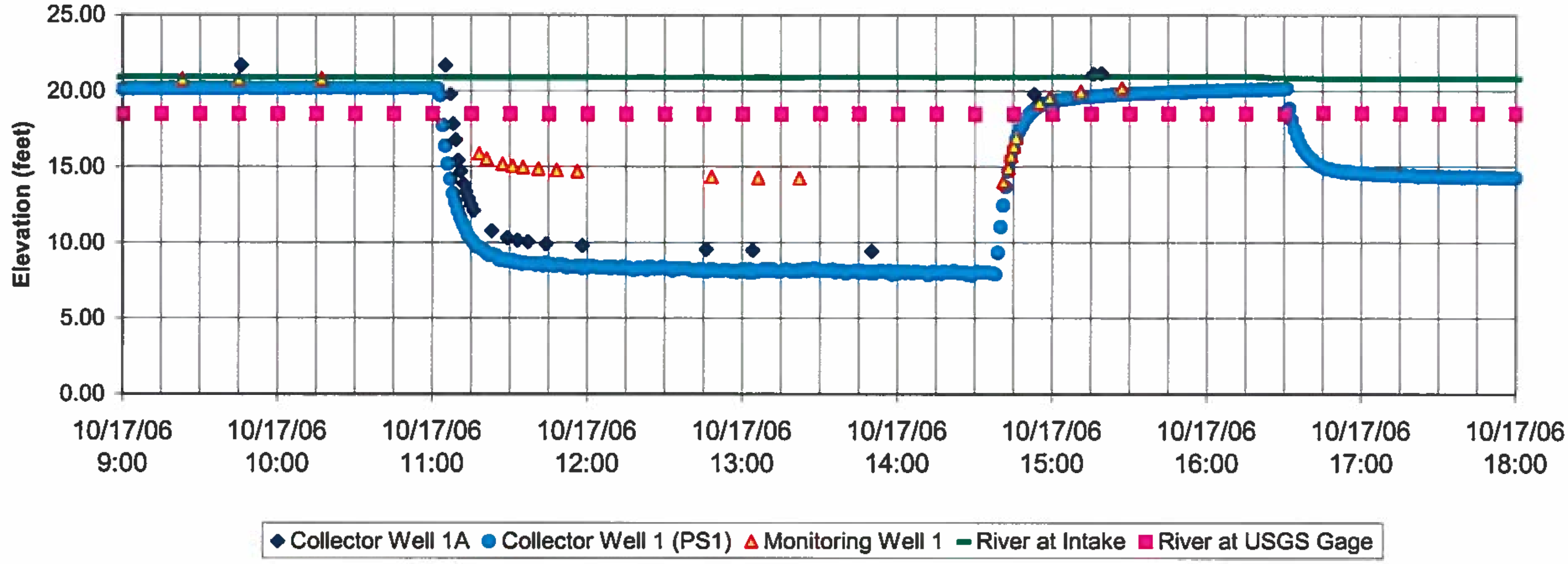
Base Source: Color Infared Air Photo Image Obtained from
Photo sources: NAPP 1282 198, NAPP 1282 200, NAPP 128
Flight Date: August 18, 1988

WELL LOCATION MAP

HUMBOLDT BAY MUNICIPAL WATER DISTRICT

FILE NAME: 7303-02	DATE: 10/24/06	FIGURE 2
PROJECT #: N.T.S.	SCALE: 1" = 500'	

FIGURE 3
Collector Well 1A Inspection Hydrographs
Humboldt Bay Municipal Water District



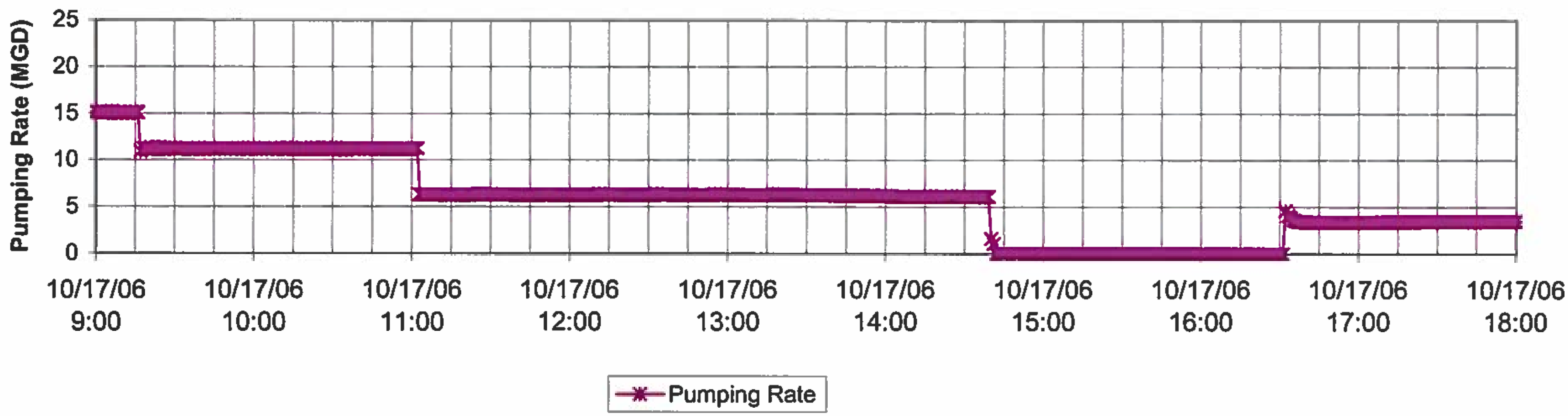


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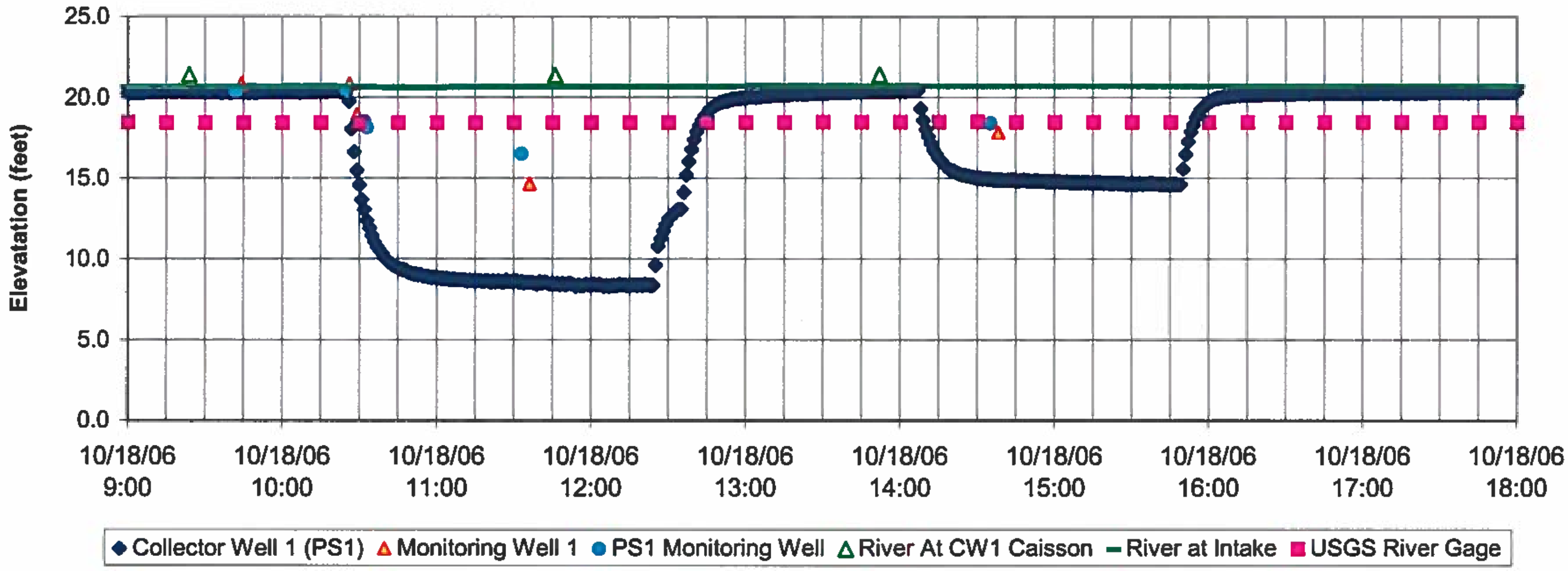
FIGURE 4
Collector Well 1 Inspection Hydrographs
Humboldt Bay Municipal Water District



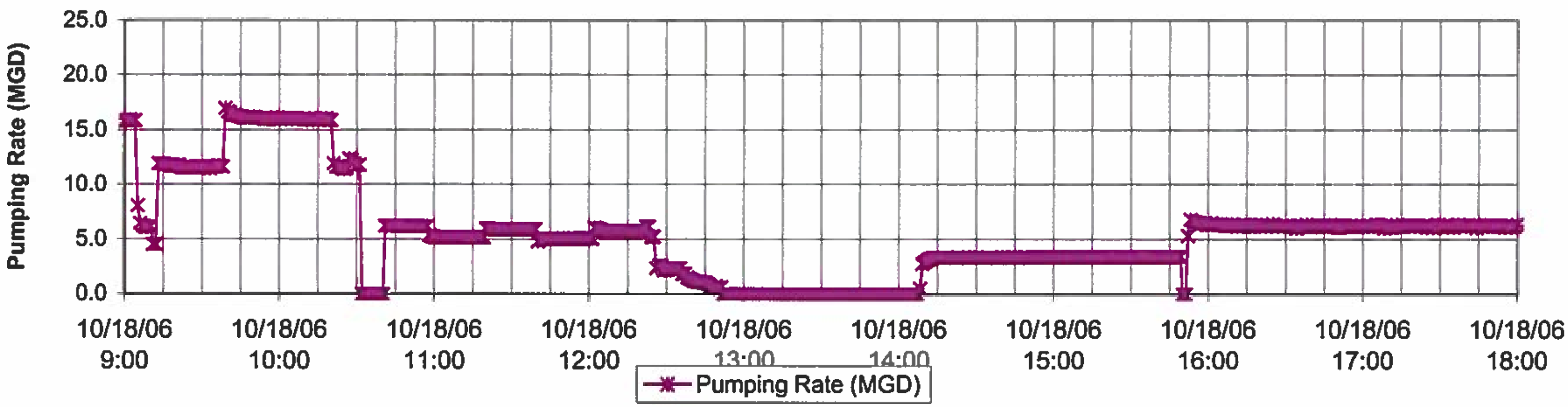


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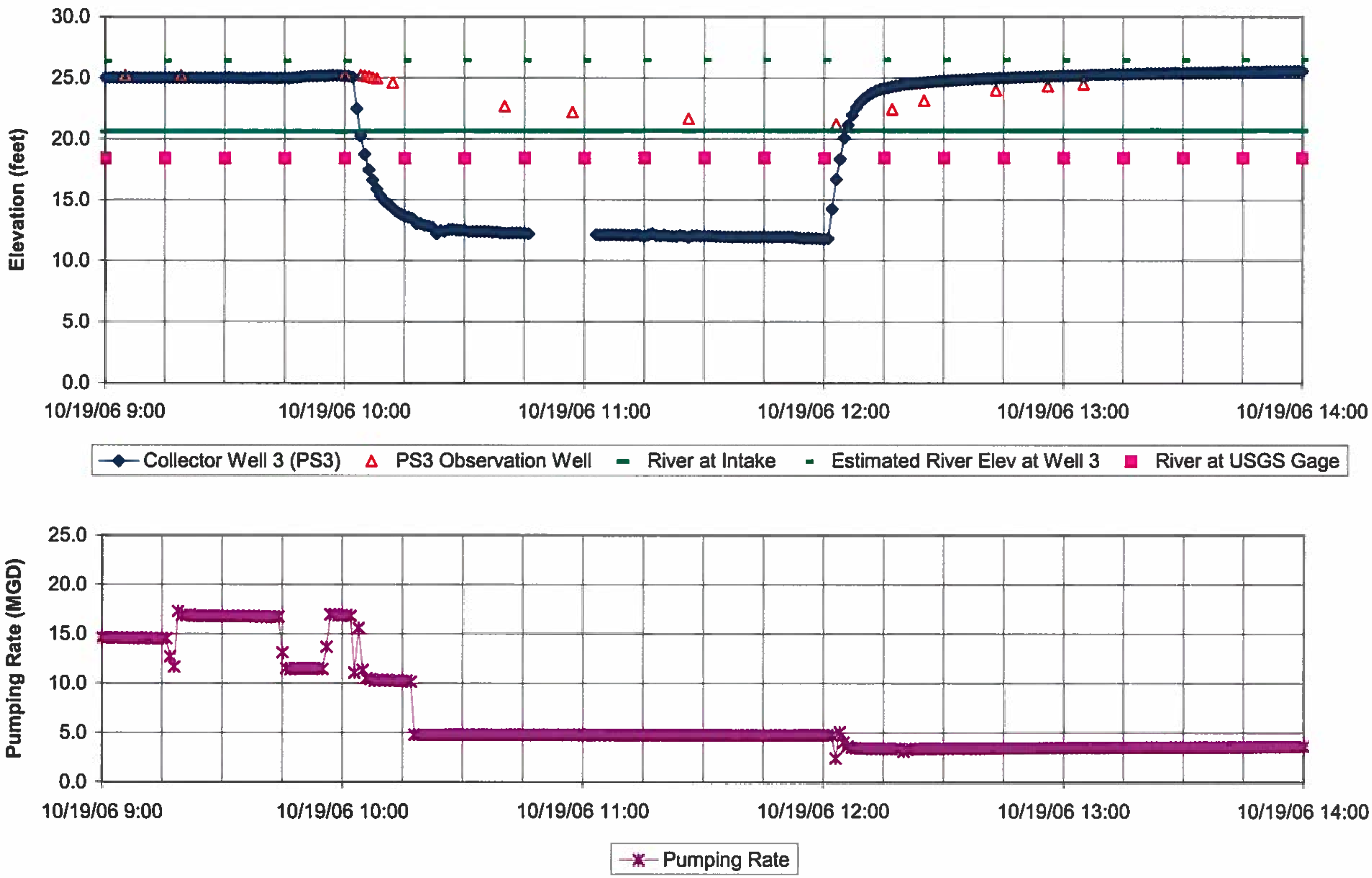
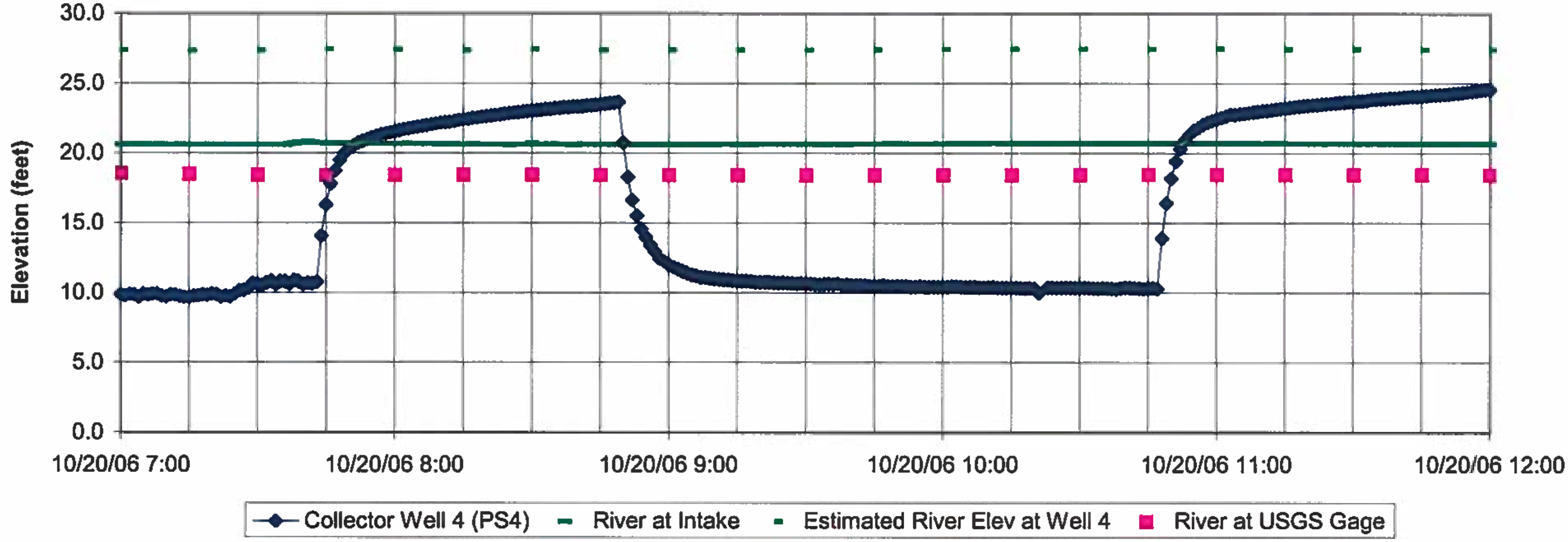
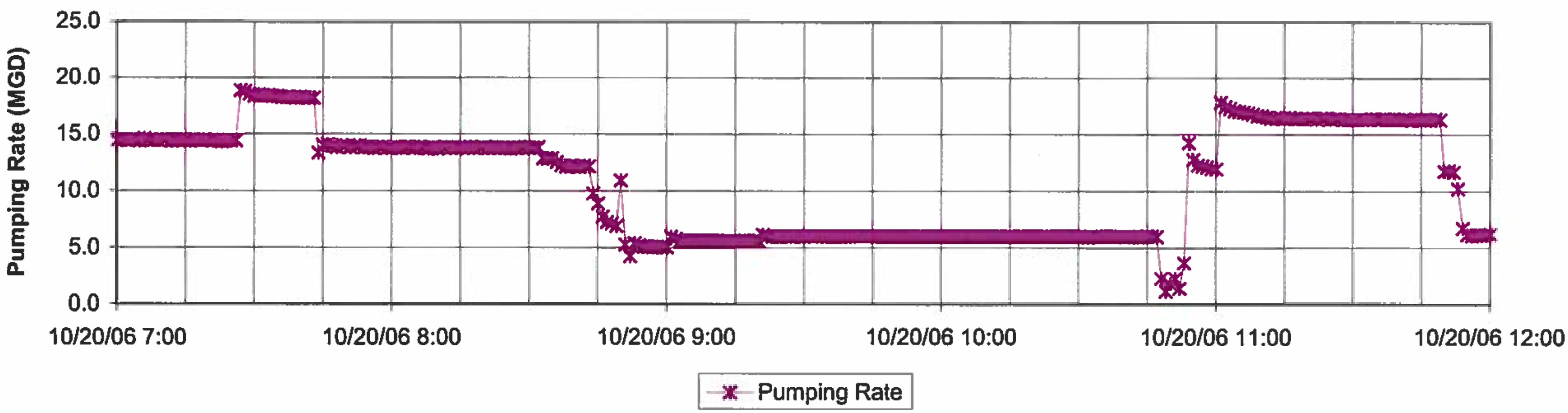
FIGURE 5
Collector Well 3 Inspection Hydrographs
Humboldt Bay Municipal Water District



File: Humboldt Collector Well Data.xls Print Date: 01/10/07

FIGURE 6
Collector Well 4 Inspection Hydrographs
Humboldt Bay Municipal Water District





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TABLES

TABLE 1

Collector Well Information Summary
Humboldt Bay Municipal Water District

Well	Top Slab Elevation (feet)		Bottom of Caisson Elevation (feet)		Top of Plug Elevation (feet)	Total Depth of Caisson [4] (feet)		Total Depth of Well [5] (feet)	Centerline Elevation of B-tier (upper) Laterals (feet)		Centerline Elevation of A-tier (lower) Laterals (feet)	Ground Surface Elevation (feet)		Number of Laterals	Reported Total Lateral Length (feet)		Approximate Open Lateral Length (feet)
	Source [1]	Source [2]	Source [1]	Source [2]	Source [1]	Source [1]	Source [2]	Source [1]	Source [1]	Source [2]	Source [1]	Source [1]	Source [2]		Source [1]	Source [2]	
1A		40.8		-33			73.8			-30			-25	12			725 Est. Current Inspection
1	48 [3]		-46.2	-41.7	-39.9	92.2	89.7	87.9	-29.0	-38.7	-36.9	27	23	10	672	586	604 All laterals closed
2	50 [3]		-71.7	-64.2	-65.2	119.7	114.2	115.2	-53.2	-62.2	-62.2	30	25	9	602	586	451 Based on 2005 Maintenance
3	53 [3]		-37.4		-30.9	88.4		83.9	-26.9	-30.9	-27.9	46	29	5	430		301 Est. Current Inspection
4	54 [3]		-47.7	-40	-41.2	99.7	94	95.2	n/a	-37	-38.2	34	30	6	478		299 Est. Current Inspection
5		56		-23			79			-20			31	6		378	

1) From Installation Report (Ranney, 1962)
2) From well illustration from inside water treatment building at wellfield.
3) Top slab elevations assume that top slab thickness is 2 feet, so 2 feet was added to the elevation shown for "top of caisson" in 1962 performance report.
4) Total depth from top of caisson to bottom of cutting shoe.
5) Total depth from top of top slab to top of plug.

TABLE 2
Collector Well Inspections Water Level and Pumping Rate Summary
Humboldt Bay Municipal Water District

Well	Date	Approx. Pumping Start Time	Approx. Pumping End Time	Duration of Pumping (hours)	Caisson Water Elevation Before Start of Pumping (feet)	Caisson Water Elevation at end of Pumping (feet)	Observed Drawdown at End of Pumping (feet)	Average Meter Pumping Rate (MGD)	Average Meter Pumping Rate (gpm)	Approximate Specific Capacity at End of Pumping (gpm/ft)
Collector Well 1A	10/17/06	11:02	14:38	3.6	21.69	9.35	12.34	6.268 (1)	4350 (1)	350
Collector Well 1 (PS1)	10/18/06	10:43	12:23	1.7	20.44	8.42	12.01	5.623 (1)	3900 (1)	n/a
	10/18/06	14:15	15:49	1.6	20.80	14.65	6.15	3.413 (1)	2370 (1)	n/a
Collector Well 3 (PS3)	10/19/06	10:01	12:01	2.0	25.25	11.83	13.42	4.799	3,330	250
Collector Well 4 (PS4)	10/20/06	8:49	10:47	2.0	23.69	10.32	13.37	6.023	4,180	310

1) Pumping from Collector Well 1, with the majority of the water obtained from Collector Well 1A through the siphon line.

TABLE 3

Collector Well 1A Lateral Condition Summary
Humboldt Bay Municipal Water District

Inspection Date: October 17, 2006   Number of Laterals: 12

Lateral ID [1]	Estimated Total Length (feet)	Videoed Length (feet)	Observations
A1	61	60	There are relatively uniform lumpy black and reddish deposits on the screen probably about 1 inches thick. The lumps appear to form in between the slot openings which are only partially visible. The deposits appear slightly thicker at the caisson end of the lateral. The camera was advanced to 60 feet and the end was visible at about 61 to 62 feet
A2	61	57	There are relatively uniform lumpy black and reddish deposits on the screen less than 1 inches thick. The slot openings are partially visible. The camera was advanced to 57 feet and the end was visible at about 60 to 62 feet
A3	61	60	There are relatively uniform lumpy black and reddish deposits on the screen probably about 1/2 inches thick. The deposits appear slightly thicker farther from the caisson end of the lateral. The slot openings are generally visible. The camera was able to reach the end of the lateral about 60 feet from the caisson and the end was visible at about 61 feet from the caisson.
A4	62 ?	55	There are relatively thin uniform black and reddish deposits on the screen less than 1/2 inch thick. The slot openings are visible. There is loose gravel on the bottom of the screen starting at about 40 feet from the caisson. The gravel increases in thickness so that by 55 feet the lateral is more than half full. Did not reach the end of the lateral during video inspection, because the camera could not be pushed past the gravel at 55 feet.
A5	61.5	61.5	There are relatively thin (less than 1/2 inch) uniform black and reddish deposits on the screen, similar to the deposits in B4. The slot openings are visible. There is some loose gravel on the bottom of the screen starting at about 50 feet from the caisson and extending to the end of the lateral. The camera reached the end of the lateral at about 61.5 feet from the caisson.
A6	61	61	There are relatively uniform lumpy black and reddish deposits on the screen probably about 1/2 inches thick. The deposits appear slightly thicker farther from the caisson end of the lateral. The slot openings are generally visible. There is some gravel on the bottom of the lateral from about 50 feet. The camera was able to reach the end of the lateral about 61 feet from the caisson.
B1	62	62	There are relatively uniform lumpy black and reddish deposits on the screen probably about 1/2 inches thick. The slot openings are partially visible. The visibility was poor where the camera stopped, but the end of the lateral appeared to be at about 62 feet.
B2	61	60	There are relatively uniform lumpy black and reddish deposits on the screen probably about 1/2 inches thick. The slot openings are partially visible. There is some gravel on the bottom of the lateral from about 55 to 60 feet. The camera was advanced to 60 feet, and the end of the lateral was visible at about 61 feet.

TABLE 3

Collector Well 1A Lateral Condition Summary
Humboldt Bay Municipal Water District

Inspection Date: October 17, 2006 Number of Laterals: 12

Lateral ID [1]	Estimated Total Length (feet)	Videoed Length (feet)	Observations
B3	62	61	There are relatively uniform lumpy black and reddish deposits on the screen probably about 1/2 inches thick. The slot openings are partially visible. There is some gravel on the bottom of the lateral from about 55 to 60 feet. The camera was advanced to 61 feet, and the end of the lateral was visible at about 62 feet.
B4	61.5	61	There are relatively uniform lumpy black and reddish deposits on the screen probably about 1/2 inches thick. The slot openings are partially visible. The camera was advanced to 61 feet, and the end of the lateral was visible at about 61.5 feet.
B5	62	60	There are relatively uniform lumpy black and reddish deposits on the screen probably about 1/2 inches thick. The slot openings are partially visible. There is some relatively clean gravel visible in the lower portion of the lateral about 55 to 60 feet. The camera was advanced to 60 feet, and the end of the lateral was visible at about 62 feet.
B6	62	61	There are relatively uniform lumpy black and reddish deposits on the screen probably about 1 inches thick. The slot openings are only partially visible. There is some gravel on the bottom of the lateral from about 50 to 60 feet from the end. The camera was advanced to 61 feet and the end was visible at about 62 feet
Total	**739**	**719.5**	
			There are no pumps in this well.
			The siphon line leading to PS1 is just to the left of the ladder. The siphon line has a 90° elbow where it comes through the caisson wall and about 20 feet of vertical pipe leading down to the belled opening.
			There is about 6-inches to 1 foot of loose sand and gravel and probably some small chunks of concrete on the caisson floor.
			The lower end of the ladder is loose from the caisson wall.
			All of the valves have actuator rods that lead up through the top slab.

1) The original lateral identifications were not available at the time of the inspection and report preparation.
The laterals have been labeled with the A-tier for the lower laterals, and the B-tier for the upper laterals.
The laterals have been numbered clockwise from the access ladder starting with number 1 being the first one to the right of the ladder.

TABLE 4

Lateral Information and Flow Analysis
Collector Well 1A - Inspection, October 17, 2006
Humboldt Bay Municipal Water District

Lateral No. [1]	Tier	Total Estimated Lateral Length, feet from inside wall	Lateral Velocity [2] kilometers/hour	Water Temperature [2] °F	Per Cent of Total Flow	Approx. Flow gpm	Approximate Flow, gpm per foot of Screen
B1	Upper	62	0.60	64.3	4.3%	190	3.1
B2	Upper	61	0.49	65.2	3.5%	150	2.5
B3	Upper	62	1.73	64.7	12.3%	530	8.5
B4	Upper	61.5	1.42	62.5	10.1%	440	7.2
B5	Upper	62	1.22	63.5	8.7%	380	6.1
B6	Upper	62	0.43	62.9	3.0%	130	2.1
A1	Lower	61	0.23	63.6	1.6%	70	1.1
A2	Lower	61	1.22	64.1	8.7%	380	6.2
A3	Lower	61	1.39	64.7	9.9%	430	7.0
A4	Lower	62	2.19	61.3	15.6%	680	11.0
A5	Lower	61.5	2.30	63.6	16.3%	710	11.5
A6	Lower	61	0.86	63.4	6.1%	260	4.3
AVERAGE		62		63.4 [3]			5.9

Pumping Rate During Flow Measurements = 4,350 gpm

Notes:
1) The original lateral identifications were not available at the time of the inspection and report preparation.
The laterals have been labeled with the A-tier for the upper laterals, and the B-tier for the lower laterals.
The laterals have been numbered clockwise from the access ladder starting with number 1 being the first one to the right of the ladder.
2) Lateral velocity and water temperature are the average of two readings.
3) Average temperature weighted for lateral flow

File: Humboldt Well Inspection Report Tables.xls Print Date: 01/08/07

TABLE 5
Collector Well 1 Lateral Condition Summary
Humboldt Bay Municipal Water District

Inspection Date: October 18, 2006 Number of Laterals: 11

Lateral ID (1)	Reported Length (feet)	Videoed Length (feet)	Observations
A1	?	0	There is no valve on this lateral. It is plugged with wood.
A2	?	0	There is no valve on this lateral. It is plugged with wood.
A3	48	0	There is no valve on this lateral. It is capped with a flange that has a pipe fitting in the middle. There are small diameter pipes sticking up on both sides of the flange.
A4	56	0	24-inch diameter corrugated pipe without a flange. It is plugged with wood. The wood is decaying.
A5	?	0	There are 2 valves fitted together on the end of this lateral. The outer valve is closed.
A6	12	0	The valve on this lateral is partially open about 1-inch. There is very strong flow from this lateral.
B1	88	0	This valve on this lateral is partially open about 1/4-inch. There is some flow from this lateral.
B2	88	0	The valve on this lateral is closed.
B3	50	0	The valve on this lateral is closed.
B4	80	0	The valve on this lateral is closed.
B5	72	0	The valve on this lateral is closed.
B6	93	0	The valve on this lateral is closed. There is a slight amount of flow through the valve seal.
B7	85	0	The valve on this lateral is cracked open and has a small amount of flow coming through it.
Total	**739**	**0**	
			Pump 1-3 had a basket screen, Pumps 1-2 and 1-4 did not have basket screens.
			The siphon line leading from Collector Well 1A is to the right of the ladder. The siphon line has an 90° elbow where it comes through the caisson wall and about 20 feet of vertical pipe leading down to the belled opening that is about 10 feet above the caisson floor.
			There are small diameter pipes sticking up behind the flanges on the laterals.
			There is a large amount of debris on the caisson floor including scrap metal, wood, chunks of concrete, etc.
			What appears to be a stilling pipe is corroded through and is just barely attached.

1) The number of laterals and their orientations does not match the drawing in the installation report.
The laterals have been labeled with the A-tier for the lower laterals, and the B-tier for the upper laterals.
The laterals have been numbered clockwise from the access ladder starting with number 1 being the first one to the right of the ladder.

TABLE 6

Collector Well 3 Lateral Condition Summary
Humboldt Bay Municipal Water District

Inspection Date: October 19, 2006 — Number of Laterals: 5

Lateral ID [1]	Reported Length (feet)	Videoed Length (feet)	Observations
A2	104	100	There are relatively uniform gray and reddish deposits on the screen less than 1/2 inches thick. The slot openings were visible near the caisson end of the laterals, but were generally covered by deposits from about 90 feet out from the caisson. The end of the lateral is visible at 100 feet from the caisson.
A3	110	0	There is a 90^{o} elbow on the end of this lateral pointing down. The valve open only about 1 to 1-1/2 inches so there is no video of the lateral. There is flow from the lateral. This is the only lateral in PS3 that does not have a cable attached to the valve actuator.
A4	84	79	There are relatively uniform gray and reddish deposits on the screen less than 1/2 inches thick. The slot openings were visible near the caisson end of the laterals, but were generally covered by deposits from about 40 feet out from the caisson. The end of the lateral is visible at about 79 feet from the caisson.
A5	68	62	There are relatively uniform gray and reddish deposits on the screen less than 1/2 inches thick. The slot openings were visible near the caisson end of the laterals, but were generally covered by deposits from about 40 feet out from the caisson. There is some debris, probably sand and gravel, on the lower portion of the lateral at about 58 feet and 62 from the caisson. Could not advance the camera past 62 feet from the caisson, and the end of the lateral was not visible at this point.
B2	64	61	There are relatively uniform gray and reddish deposits on the screen less than 1/2 inches thick. The slot openings were visible near the caisson end of the laterals, but were generally covered by deposits from about 40 feet out from the caisson. There is some debris in the lower part of the lateral about 52 feet from the caisson, probably sand and gravel. The end of the lateral is visible at 61 feet from the caisson.
Total	**430**	**302**	
			Neither pump has basket screens.
			There is a t-shaped I-beam assembly about 20 feet below the static water level (approx. elevation 15 feet) that is attached to the wall at two points and suspended by a cable on the free end.
			There is a valve port in this well that appears to be for a surface water intake. The port is at approx. elevation of 20 feet.
			The valves have long-stemmed actuator assemblies, and all but the valve on lateral A3 have a cable attached to the actuator that leads up to the intermediate floor.
			There are pipes leading to the bottom of the caisson that are attached to what appears to be some type of venturi lift system.
			The floor of the caisson has relatively little debris.

1) The number, lengths and orientations of the laterals generally matches the drawing in the installation report.

TABLE 7

Lateral Information and Flow Analysis
Collector Well 3 - Inspection, October 19, 2006
Humboldt Bay Municipal Water District

Lateral No.	- Tier	Total As-Built Lateral Length, feet from inside wall	Lateral Velocity [1] kilometers/hour	Water Temperature [1] °F	Per Cent of Total Flow [2]	Approx. Flow gpm [3]	Flow, gpm per foot of Screen [3]
A2	Upper	104	4.45	61.2	36.4%	1,210	11.6
A3	Upper	110	Lateral Valve Partially Opened	61.7	Lateral Valve Partially Opened		
A4	Upper	84	2.62	61.8	21.4%	710	8.5
A5	Upper	68	2.92	63.0	23.9%	800	11.8
B2	Lower	64	2.24	62.3	18.3%	610	9.5
AVERAGE		86		61.9 [4]			10.3

Pumping Rate During Flow Measurements = 3,330 gpm

<u>Notes:</u>
1) Lateral velocity and water temperature are the average of two readings.
2) Percentage of flow from laterals A2, A4, A5 and B2.
3) Assumes all flow is from laterals A2, A4, A5 and B2.
4) Average temperature weighted for lateral flow

TABLE 8
Collector Well 4 Lateral Condition Summary
Humboldt Bay Municipal Water District

Inspection Date: October 20, 2006 Number of Laterals: 6

Lateral ID [1]	Reported Length (feet)	Videoed Length (feet)	Observations
A1	40	0	Valve about 40% open, no video taken inside the lateral.
A2	70	68	There are relatively uniform gray deposits on the screen greater than 1/2 inches thick. Thickness of deposits generally increases away from the caisson. The slot openings are generally not visible. Some of the deposits are loose and silty especially past 30 feet. Camera appeared to reach the end of the lateral at 68 feet from caisson but visibility was poor.
A3	121	0	Valve open only about 1-inch, no video taken inside the lateral.
A4	120	108	There are relatively uniform gray deposits on the screen greater than 1/2 inches thick. Thickness of deposits generally increases away from the caisson. The slot openings are generally not visible. Some of the deposits are loose and silty especially past 40 feet. Camera reached 108 feet from caisson but lost visibility at 100 feet.
A5	89	88	There are relatively uniform gray deposits on the screen less than 1/2 inches thick. The slot openings are generally visible. Camera reached the end of the lateral at 88 from the caisson.
A6	38	35	There are relatively uniform gray deposits on the screen approx. 1/2 inches thick. The slot openings are generally not visible. Camera reached the end of the lateral at 35 feet from the caisson.
Total	**478**	**299**	
			Neither pump has basket screens.
			There is a t-shaped I-beam assembly with one end resting on the valve actuator of lateral A2, one end against the side of valve actuator on lateral A6 and the third end resting on the caisson floor.
			There is a valve port in this well that appears to be for a surface water intake. The port is at approx. 35 feet below the intermediate floor and is located between laterals A1 and A2.
			The valves have long-stemmed actuator assemblies, and all have a cable attached to the actuator that leads up to the intermediate floor.
			There are pipes leading to the bottom of the caisson that are attached to what appears to be some type of venturi lift system.
			The lower end of the ladder is loose from the caisson wall.
			There is 2 to 8 inches of loose sand and gravel on the caisson floor.

1) The number, lengths and orientations of the laterals generally matches the drawing in the installation report.

TABLE 9

Lateral Information and Flow Analysis
Collector Well 4 - Inspection, October 20, 2006
Humboldt Bay Municipal Water District

Lateral No.	Tier	Total As-Built Lateral Length, feet from inside wall	Lateral Velocity (1) kilometers/hour	Water Temperature (1) °F	Per Cent of Total Flow (2)	Approx. Flow gpm (3)	Flow, gpm per foot of Screen (3)
A1	Upper	40	Lateral Valve About 40% Open	59.9	Lateral Valve About 40% Open		
A2	Upper	70	4.99	60.4	42.6%	1,780	25.4
A3	Upper	120	Lateral Valve Open About 1-inch	60.8	Lateral Valve Open About 1-inch		
A4	Upper	120	2.12	60.9	18.1%	750	6.3
A5	Upper	89	4.53	60.7	38.6%	1,610	18.1
A6	Upper	38	0.09	59.6	0.7%	30	0.8
AVERAGE		80		60.4 (4)			12.6

Pumping Rate During Flow Measurements = 4,180 gpm

Notes:
1) Lateral velocity and water temperature are the average of two readings.
2) Percentage of flow from laterals A2, A4, A5 and A6.
3) Assumes all flow is from laterals A2, A4, A5 and A6.
4) Average temperature weighted for lateral flow

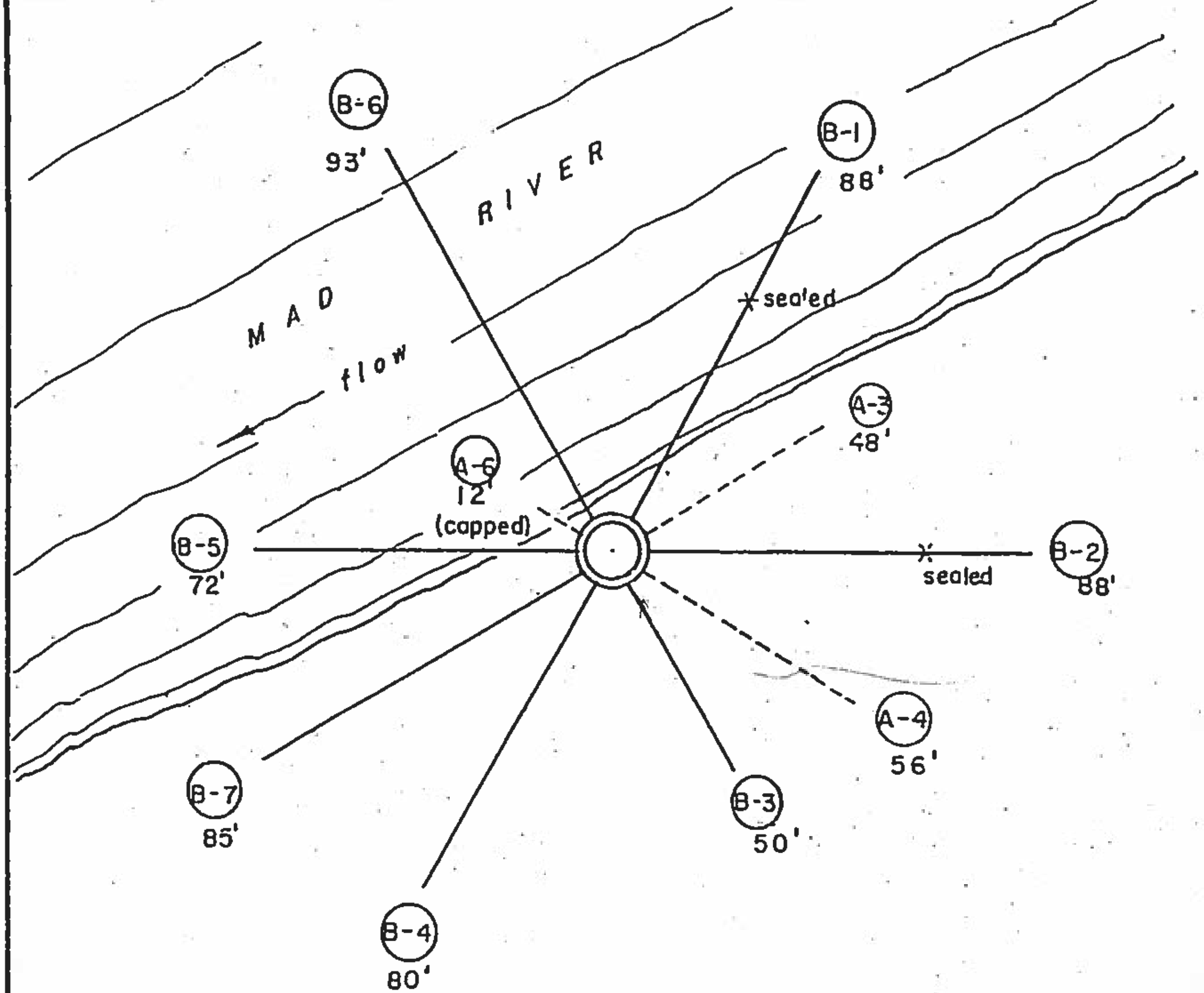
TABLE 10
Laboratory Water Quality Analysis Results
Humboldt Bay Municipal Water District

Constituent	Units	MCL	NTL/NCL Detection Limits	Collector Well 1A 10/17/06	Collector Well 3 10/19/06	NCL Analysis Collector Well 3 12/20/06	Collector Well 4 10/20/06	NCL Analysis Collector Well 4 12/20/06	Mad River 10/20/06
Aluminum	mg/l	0.2	0.1	ND	ND		ND		ND
Arsenic	mg/l	0.01	0.005	ND	ND		ND		ND
Barium	mg/l	2.00	0.30	ND	ND		ND		ND
Cadmium	mg/l	0.005	0.002	ND	ND		ND		ND
Calcium	mg/l		2.0	26	27		28		27
Chromium	mg/l	0.1	0.010	ND	ND		ND		ND
Copper	mg/l	1.3	0.004	ND	0.096		0.017		ND
Iron	mg/l	0.3	0.020	0.048	0.041		0.34 *		0.024
Lead	mg/l	0.015	0.002/ 0.001	ND	0.058 *	ND	0.010	ND	ND
Magnesium	mg/l		0.10	4.4	4.5		4.6		4.3
Manganese	mg/l	0.05	0.004/ 0.001	ND	ND		0.072 *	0.013	ND
Mercury	mg/l	0.002	0.001	ND	ND		ND		ND
Nickel	mg/l	0.1	0.02	ND	ND		ND		ND
Selenium	mg/l	0.05	0.020	ND	ND		ND		ND
Silver	mg/l	0.1	0.002	ND	ND		ND		ND
Sodium	mg/l		1	4	4		4		4
Zinc	mg/l	5	0.004	ND	0.040		0.015		0.007
Alkalinity, Total, as CaCO3	mg/l		20	78	92		86		82
Chloride	mg/l	250.0	5.0	ND	ND		ND		ND
Fluoride	mg/l	4	0.5	ND	ND		ND		ND
Total Hardness as CaCO3	mg/l		10	83	86		89		85
Nitrate as N	mg/l	10	0.5	ND	ND		ND		ND
Nitrite as N	mg/l	1	0.5	ND	ND		ND		ND
pH	S.U.	6.5-8.5		7.0	6.8		6.9		7.9
Sulfate	mg/l	250	5.0	10	10		10		10
Total Dissolved Solids (TDS)	mg/l	500	20	91	100		99		95
Trihalomethanes and VOCs									
See Laboratory Reports for Parameter List				ND	ND		ND		ND

* The MCL (Maximum Contaminant Level) or SMCL (Secondary Maximum Contaminant Level) has been exceeded for this parameter. SMCL values are based on aesthetic concerns and are not related to health affects.

ND - The contaminant was not detected at or above the stated detection limit.

APPENDIX A
Collector Well Information



LATERAL PROJECTION DIAGRAM

(Scale: 1" = 40')

Total length of laterals = 672 feet (Effective = 604feet)

——— Tier B

----Tier A

Revised 4/15/64

Revised 12/21/62

ELEVATIONS

Top of caisson	+46.00
Ground surface	+27.0
℄ of laterals - Tier B	−29.0
℄ of laterals - Tier A	−36.9
Top of plug	−39.9
Cutting shoe	−46.2

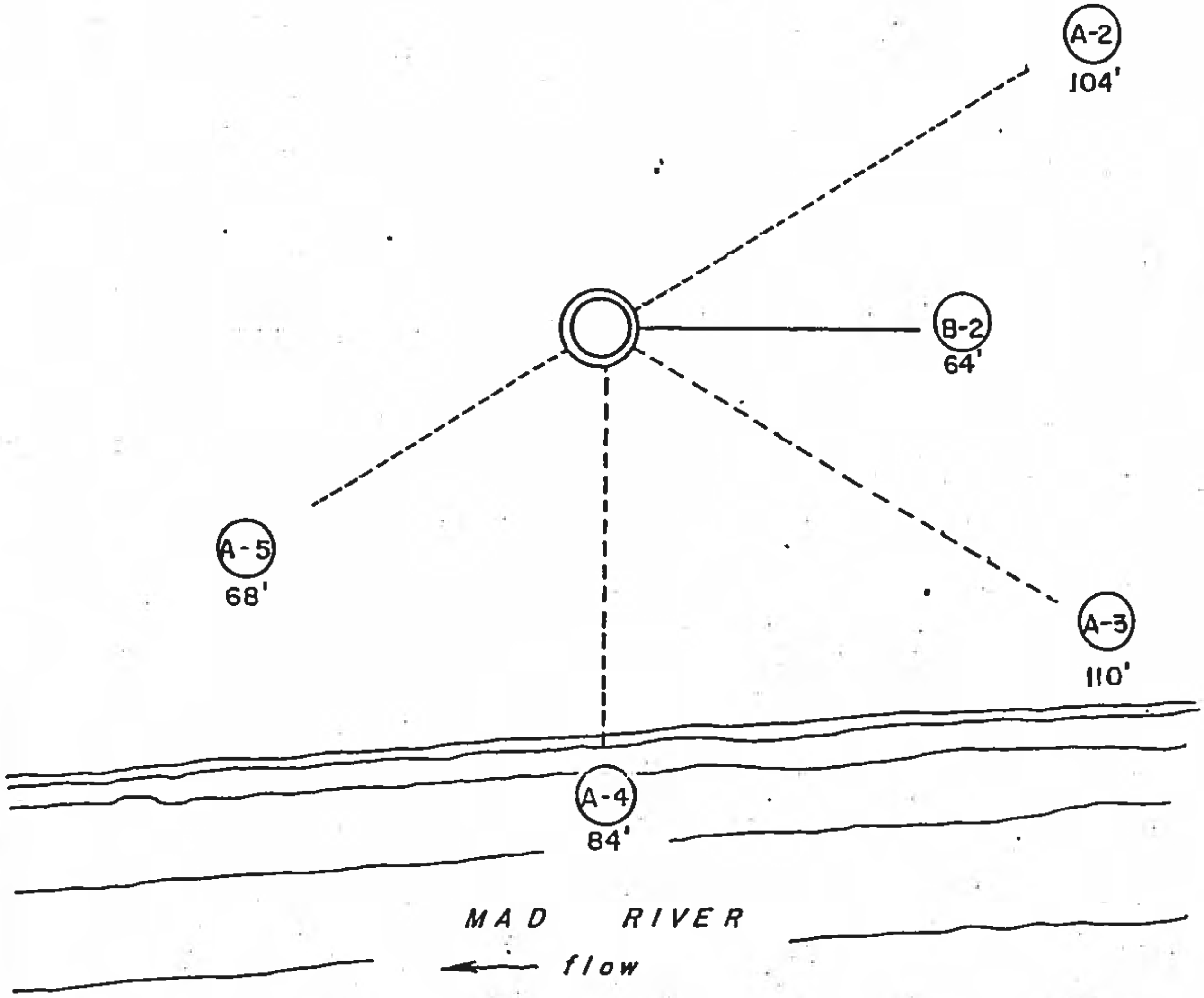
RANNEY METHOD
WESTERN OF CALIF., INC.
SACRAMENTO, CALIF.

BECHTEL CORPORATION
CONSULTING ENGINEERS

HUMBOLDT BAY
MUNICIPAL WATER DISTRICT

CONSTRUCTION DETAILS
COLLECTOR NO. 1

DRAWN J.S.	APPROVED J.E.M.
DATE 5/22/62	FIGURE JW-17-02



LATERAL PROJECTION DIAGRAM

(Scale: 1" = 40')

Total length of laterals = 430 feet (Effective = 430 feet).

—— Tier B

- - - - Tier A

ELEVATIONS

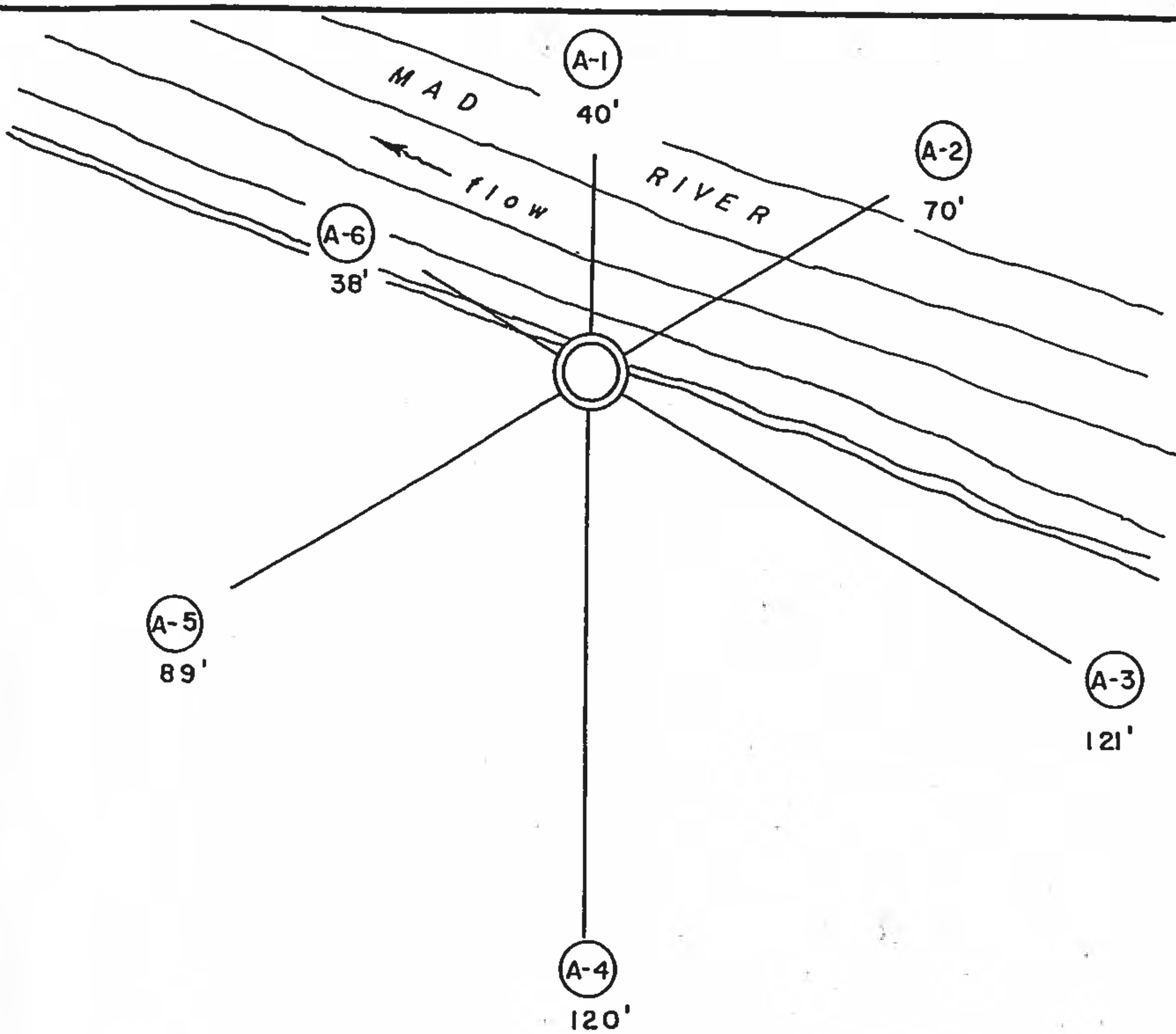
Top of caisson	+51.00
Ground surface	+46.0
℄ of laterals - Tier B	-26.9
℄ of laterals - Tier A	-27.9
Top of plug	-30.9
Cutting shoe	-37.4

RANNEY METHOD
WESTERN OF CALIF., INC.
SACRAMENTO, CALIF.

BECHTEL CORPORATION
CONSULTING ENGINEERS
HUMBOLDT BAY
MUNICIPAL WATER DISTRICT

CONSTRUCTION DETAILS
COLLECTOR NO. 3

DRAWN: J.S.	APPROVED: J.C.M.
DATE: 5 / 22 / 62	FIGURE: JW-17-04



LATERAL PROJECTION DIAGRAM

(Scale: 1" = 40')

Total length of laterals = 478 feet (Effective = 478 feet)

---- Tier B

—— Tier A

ELEVATIONS

Top of caisson	+ 52.00
Ground surface	+ 34.0
℄ of laterals - Tier B	——
℄ of laterals - Tier A	- 38.2
Top of plug	- 41.2
Cutting shoe	- 47.7

RANNEY METHOD WESTERN OF CALIF., INC.
SACRAMENTO, CALIF.

~~BECHTEL CORPORATION~~
CONSULTING ENGINEERS
HUMBOLDT BAY MUNICIPAL WATER DISTRICT

CONSTRUCTION DETAILS
COLLECTOR NO. 4

DRAWN: J.S.	APPROVED: 7.S.M.
DATE: 5 / 22 / 62	FIGURE: JW-17-05

APPENDIX B
Water Level Data

Humboldt Bay Water Municipal Water District
Water Level Measurements

Well: Collector Well 1A

Measuring Point: Top of caisson top slab
Assumed Measuring Point Elevation: 40.8 feet

Date/Time	Depth to Water (feet)	Water Elevation (feet)
10/17/06 9:46	19.11	21.69
10/17/06 11:05	19.11	21.69
10/17/06 11:07	21.00	19.80
10/17/06 11:08	22.95	17.85
10/17/06 11:09	24.00	16.80
10/17/06 11:10	25.37	15.43
10/17/06 11:11	26.10	14.70
10/17/06 11:12	26.93	13.87
10/17/06 11:13	27.46	13.34
10/17/06 11:14	27.88	12.92
10/17/06 11:15	28.31	12.49
10/17/06 11:16	28.68	12.12
10/17/06 11:23	30.01	10.79
10/17/06 11:29	30.47	10.33
10/17/06 11:33	30.63	10.17
10/17/06 11:37	30.73	10.07
10/17/06 11:44	30.87	9.93
10/17/06 11:58	30.98	9.82
10/17/06 12:46	31.22	9.58
10/17/06 13:04	31.28	9.52
10/17/06 13:50	31.35	9.45
10/17/06 14:39	31.45	9.35
10/17/06 14:48	23.23	17.57
10/17/06 14:53	21.00	19.80
10/17/06 15:16	19.67	21.13
10/17/06 15:19	19.62	21.18

Humboldt Bay Water Municipal Water District
Water Level Measurements

Well: Monitoring Well MW-1

Measuring Point: Top of steel casing
Assumed Measuring Point Elevation: 37.05

Date/Time	Depth to Water (feet)	Water Elevation (feet)
10/17/06 8:50	16.28	20.77
10/17/06 9:23	16.25	20.80
10/17/06 9:45	16.25	20.80
10/17/06 10:17	16.23	20.82
10/17/06 11:18	21.16	15.89
10/17/06 11:21	21.51	15.54
10/17/06 11:27	21.85	15.20
10/17/06 11:31	21.98	15.07
10/17/06 11:35	22.06	14.99
10/17/06 11:41	22.18	14.87
10/17/06 11:48	22.25	14.80
10/17/06 11:56	22.33	14.72
10/17/06 12:48	22.69	14.36
10/17/06 13:06	22.76	14.29
10/17/06 13:22	22.79	14.26
10/17/06 14:41	23.02	14.03
10/17/06 14:43	22.11	14.94
10/17/06 14:44	21.31	15.74
10/17/06 14:45	20.67	16.38
10/17/06 14:46	20.08	16.97
10/17/06 14:55	17.80	19.25
10/17/06 14:59	17.47	19.58
10/17/06 15:11	17.05	20.00
10/17/06 15:27	16.81	20.24
10/18/06 7:32	18.93	18.12
10/18/06 8:41	16.12	20.93
10/18/06 9:44	16.17	20.88
10/18/06 10:26	16.17	20.88
10/18/06 10:29	18.06	18.99
10/18/06 10:30	18.49	18.56
10/18/06 11:36	22.36	14.69
10/18/06 14:38	19.19	17.86

Humboldt Bay Water Municipal Water District
Water Level Measurements

Well: Collector Well 1 (PS1)
Measuring Point: Edge of hatch curb 7-1/2 inches above intermediate floor.
Assumed Measuring Point Elevation: 48 feet

Date/Time	Depth to Water (feet)	Water Elevation (feet)
10/18/06 9:19	27.70	20.30
10/18/06 9:22	27.70	20.30
10/18/06 10:06	27.74	20.26
10/18/06 10:20	27.75	20.25
10/18/06 10:40	38.20	9.80
10/18/06 11:02	39.67	8.33
10/18/06 11:18	39.85	8.15
10/18/06 11:48	40.05	7.95
10/18/06 11:51	40.05	7.95

River at Collector Well 1 (PS1)
Measuring Point: Top of caisson top slab
Assumed Measuring Point Elevation: 58.51 feet

Date/Time	Depth to Water (feet)	Water Elevation (feet)
10/18/06 9:24	37.07	21.44
10/18/06 11:46	37.08	21.43
10/18/06 13:52	37.05	21.46

Well: 12-inch Diameter Well 104 feet west of Collector Well 1
Measuring Point: Top of well cap fitting
Assumed Measuring Point Elevation: 25.98 feet

Date/Time	Depth to Water (feet)	Water Elevation (feet)
10/18/06 7:34	7.41	18.57
10/18/06 8:36	5.61	20.37
10/18/06 9:42	5.59	20.39
10/18/06 10:25	5.58	20.40
10/18/06 10:32	7.40	18.58
10/18/06 10:33	7.78	18.20
10/18/06 11:33	9.43	16.55
10/18/06 14:35	7.52	18.46

Humboldt Bay Water Municipal Water District
Water Level Measurements

Well: 8-inch well 39 feet west of Collector Well 3
Measuring Point: Top of steel casing
Assumed Measuring Point Elevation: 50.8 feet

Date/Time	Depth to Water (feet)	Water Elevation (feet)
10/18/06 15:20	25.62	25.18
10/19/06 7:52	25.45	25.35
10/19/06 8:34	25.52	25.28
10/19/06 9:05	25.56	25.24
10/19/06 9:19	25.57	25.23
10/19/06 10:00	25.55	25.25
10/19/06 10:04	25.55	25.25
10/19/06 10:05	25.61	25.19
10/19/06 10:06	25.67	25.13
10/19/06 10:07	25.74	25.06
10/19/06 10:08	25.81	24.99
10/19/06 10:12	26.18	24.62
10/19/06 10:40	28.09	22.71
10/19/06 10:57	28.58	22.22
10/19/06 11:26	29.10	21.70
10/19/06 12:03	29.55	21.25
10/19/06 12:17	28.34	22.46
10/19/06 12:25	27.62	23.18
10/19/06 12:43	26.79	24.01
10/19/06 12:56	26.45	24.35
10/19/06 13:05	26.30	24.50
10/19/06 13:12	26.18	24.62

Humboldt Bay Water Municipal Water District
Water Level Measurements

Well: Collector Well 4

Measuring Point: Top of curb for pump column 6-inches above the intermediate floor
Assumed Measuring Point Elevation: 54.38 feet

Date/Time	Pump House Level Indicator	Depth to Water (feet)	Water Elevation (feet)
10/19/06 14:41	46.5		
10/20/06 7:59	41.7	33.12	21.26
10/20/06 8:33	43.1		
10/20/06 8:36		31.26	23.12
10/20/06 8:49	43.6	30.90	23.48
10/20/06 8:51	41.80		
10/20/06 8:52	39.1	35.20	19.18
10/20/06 8:53	37.3	37.51	16.87
10/20/06 8:54	36	38.75	15.63
10/20/06 8:55	34.9	39.75	14.63
10/20/06 8:56	34.1	40.50	13.88
10/20/06 8:57	33.5	41.08	13.3
10/20/06 8:59	32.7		
10/20/06 9:16	30.9		
10/20/06 9:28	30.7		
10/20/06 9:37	30.6		
10/20/06 9:45	30.4	43.95	10.43
10/20/06 9:54	30.4	43.97	10.41
10/20/06 10:09	30.4	44.03	10.35
10/20/06 10:48		40.10	14.28
10/20/06 10:58	42	32.55	21.83
10/20/06 11:03	42.6	31.88	22.5
10/20/06 11:18	43.3	31.24	23.14
10/20/06 11:55	44.30	30.20	24.18

APPENDIX C
Diver Observations

MM DIVING SERVICES

UNDERWATER CONSTRUCTION
CA. Class A-General Engineering Licensee # 817400
325 Sleepy Hollow Road
Crescent City, CA 95531
Telephone: (707) 465-0909
Fax: (707) 464-5200

Customer: Collector Wells
Location: HBMWD
Date: 10/20/06
Job #: 137

Job Summary

Diving commenced 10/17/06 at HBMWD collector wells 1A, 1, 3 & 4. Normal Lockout/Tag out and confined space safety procedures were carried out daily prior to divers entering.
All data provide with this report from the field notes. The videos provided from each well site must be reviewed to ensure data accuracy.
In addition to the Well reports it should be brought to HBMWD attention that:
Well #1 has a section of 6"pipe which corroded through 100% secured with rope by divers.
Well #3 pump I-beam stabilizer is loose, hanging at an angle and partially supported with a ¼ inch wire 20 feet off bottom.
Well #4 pump I-beam stabilizer is on bottom at an angle and resting on lateral valve bodies.

Each of the above items represents unsafe working conditions. Removal of the items must be considered prior to re entry.
Underwater burning would cut each piece into a size for recovering through the entry point. An air winch would be used for the vertical lift if not accessible by a crane.

A full report on the wells conditions will be forth coming from Collector Wells.

Please do not hesitate to call with any questions or if I may be of further assistance.

MM Diving Services
Owner
Vic Markytan 24 hr (707) 954-0623
markytan@charter.net

MM DIVING SERVICES

Job report for: Collector Wells
Location: HBMWD
Job Number: 137 **Diver in charge:** Markytan

Date	Time	Description of Work
10/17/06	0730	Arrive HBMWD - inspect Well #1A.
		Video interior and all Laterals to end, approx 61 feet.
	1600	Depart.
10/18/06	0730	Inspect Well #1, Install pump safety cage, video interior and laterals.
		Lateral's are closed or plugged SEE VIDEO.
		Moderate debris on bottom- ladder unsecured below water line. 20 of 6 inch pipe corroded to separation. Secured in the vertical position with rope.
	1530	Depart.
		Lateral's are closed or plugged SEE VIDEO.
10/19/06	0730	Inspect Well #3. Install suction safety cage.
		Video internal conditions and 5 laterals.
		Unsecured I beam pump brace hanging loosely.
		Will require burning to remove.
		All valves have 3/16" wire supporting in open position.
		Relocate dive spread and set up to dive at Well#4.
	1530	Depart.
10/20/06	0730	Inspect Well #4. Install suction cage.
		Video laterals. 6 laterals total.
		No internal video on #4&#6. Valves not open enough for camera.
		Pump I beam stabilizer on bottom resting on valves. Requires burning.
		All valves have wire supporting open position
	1520	Arrive CC.

MM Diving Services

Class A-General Engineering #817400

325 Sleepy Hollow Road
Crescent City, Ca 95531
Telephone: 707 465-0909
Fax: 707 464-5200
E-mail: markytan@charter.net

10/19/06
HBMWD Well #1A-Row
Ladder is used as the 12:00 position

A ROW		Location	Open/Closed	Leaking	Tested	Video	Depth
1		1:00	0pen		X	X	60
2		2:00	0pen		X	X	60
3		5:00	0pen		X	X	60
4		6:00	0pen		X	X	55
5		7:00	0pen		X	X	61
6		10:00	0pen		X	X	61

B ROW	Location	Open/Closed	Leaking	Tested	Video	Depth
1	1:00	0pen		X	X	62
2	2:00	0pen		X	X	60
3	5:00	0pen		X	X	61
4	6:00	0pen		X	X	61
5	7:00	0pen		X	X	61
6	10:00	0pen		X	X	61

A full color video was provided of the Well #1A inspection. The specific information on each lateral will need to be reviewed to double check Data recorded as the diving took place. The video will answer any questions you may have on Well # 1A, 1, 3 & 4

Vic Markytan
Cell 707-954-0623

MM Diving Services

Class A-General Engineering #817400

325 Sleepy Hollow Road
Crescent City, Ca 95531
Telephone: 707 465-0909
Fax: 707 464-5200
E-mail: markytan@charter.net

10/19/06
HBMWD Well #1.
Ladder for reference represents the 12:00 position.

A ROW	Location	Open/Closed	Leaking	Tested	Video	Depth
1	1:00	No valve	N-?	N	X	NA
2	3:00	No Valve	N-?	N	X	NA
3	5:00	Blinded	N	N	X	NA
4	7:00	Stub-plug	N-?	N	X	NA
5	9:00	Closed	N	N	X	NA
6	11:00	1" Open	Y	N	X	NA

B ROW	Location	Open/Closed	Leaking	Tested	Video	Depth
1	12:30	Closed	1/4"open	N	External	NA
2	2:00	Closed	N-?	N	External	NA
3	3:00	Closed	N-?	N	External	NA
4	6:00	Closed	N-?	N	External	NA
5	8:00	Closed	N-?	N	External	NA
6	9:00	Closed	N-?	N	External	NA
7	11:00	Closed	1" open	N	External	NA

20ft 6" pipe found corroded through, secured with rope. Will require burning to extract. Camera traveled 170 feet from Well# 1 siphon towards Well # 1A. See Video to confirm field data.

MM Diving Services
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(707)465-0909

MM Diving Services

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Fax: 707 464-5200
E-mail: markytan@charter.net

10/19/06
HBMWD Well #3.
Ladder for reference represents the 12:00 position.

ROW	Location	Open/Closed	Leaking	Tested	Video	Depth
1-B	12:00	Open		Y	X	61
2-A	1:00	Closed	1"open	Y	X	NA
3-A	3:00	Open		Y	X	79
4-B	5:00	Open		Y	X	66
5-A	11:00	Open		Y	X	100

Broken I beam pump stabilizer. Hanging on angle with previously installed 3/16" cable to help remaining bolts support. Will require burning to extract from well. Elevation difference between A&B row is minimal. See video. All lateral valves have wire supporting open position.

MM Diving Services
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Crescent City, Ca 95531
Telephone: 707 465-0909
Fax: 707 464-5200
E-mail: markytan@charter.net

10/20/06
HBMWD Well #4.
Ladder for reference represents the 12:00 position.

A-ROW	Location	Open/Closed	Leaking	Tested	Video	Depth
1-A	1:00	Open		Y	X	108
2-A	3:00	Open		Y	X	88
3-A	6:00	Open		Y	X	35
4-A	9:00	Open	40% open	Y	external	?
5-A	10:00	Open		Y	X	68
6-A	11:00	Closed	5% open	Y	external	?

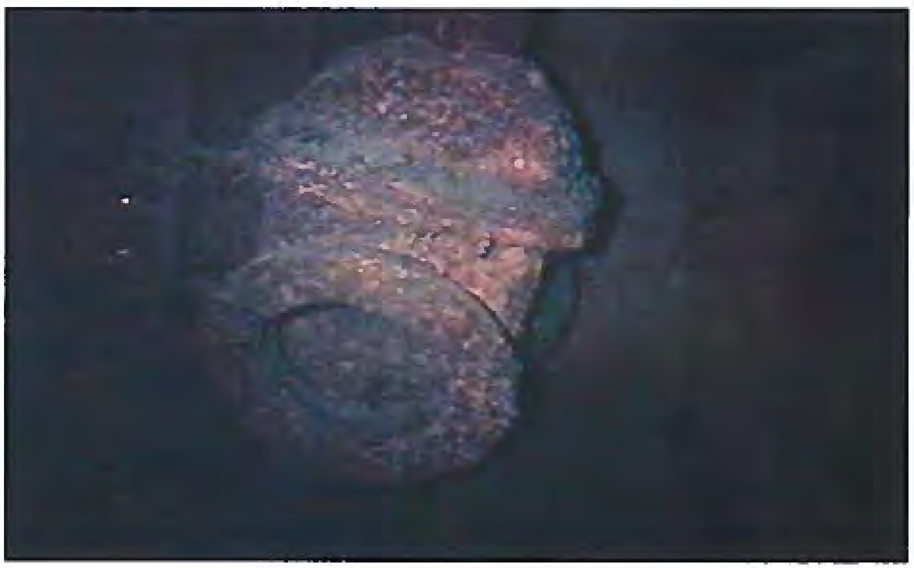
I-beam pump stabilizer framework lying on bottom at an angle and resting on lateral valve bodies. Recommend removal for safe working conditions.

Vic Markytan
Cell 707-954-0623

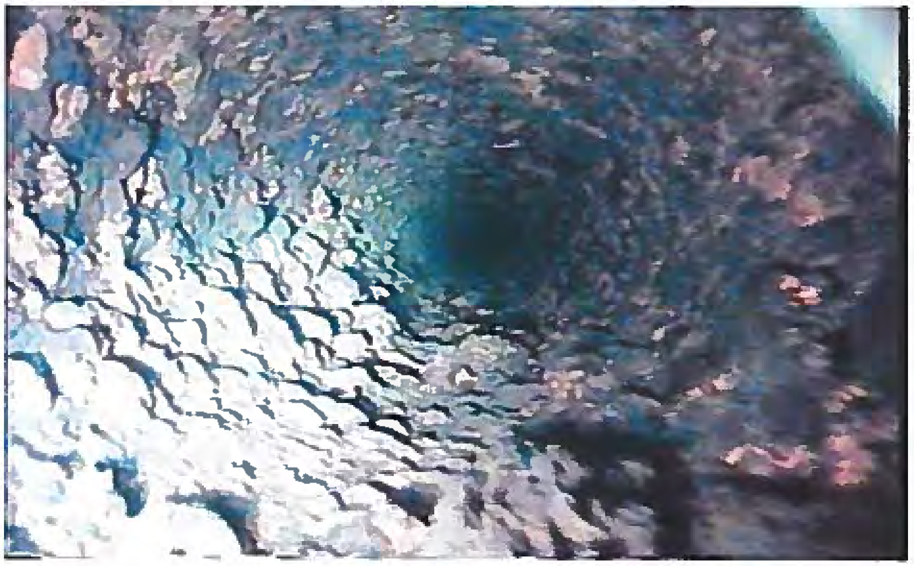
APPENDIX D
Inspection Photographs and Still Images from Video
Collector Well 1A


Collector Well 1A, top of caisson


Collector Well 1A, access hatch on top of caisson

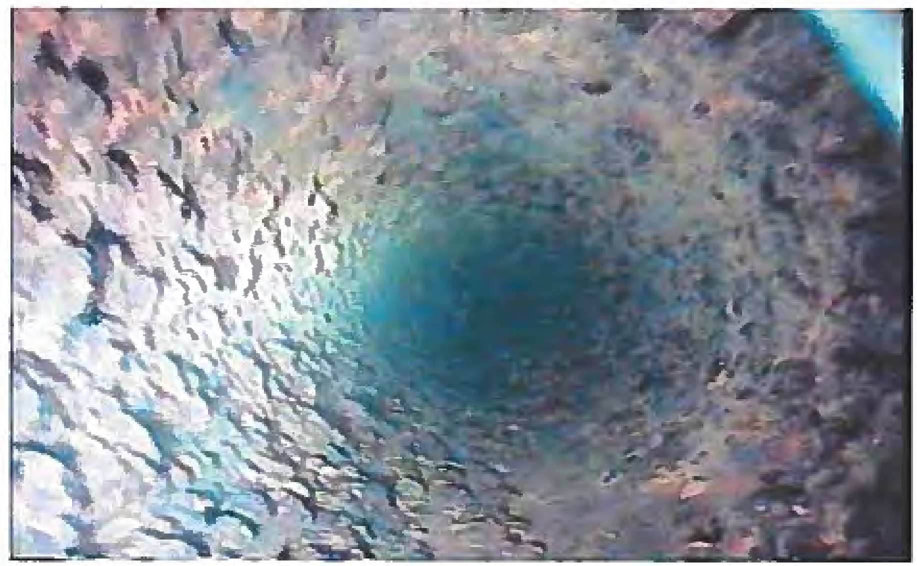

Collector Well 1A, Valve on lateral A1

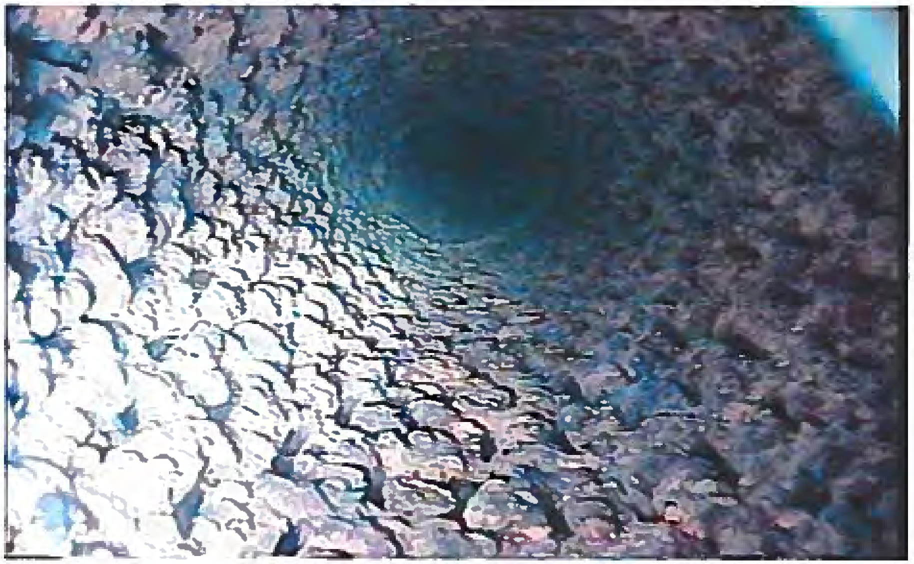

Collector Well 1A, Interior of lateral A1 near caisson


Collector Well 1A, Lateral A1 about 40 feet from caisson


Collector Well 1A, End of Lateral A1

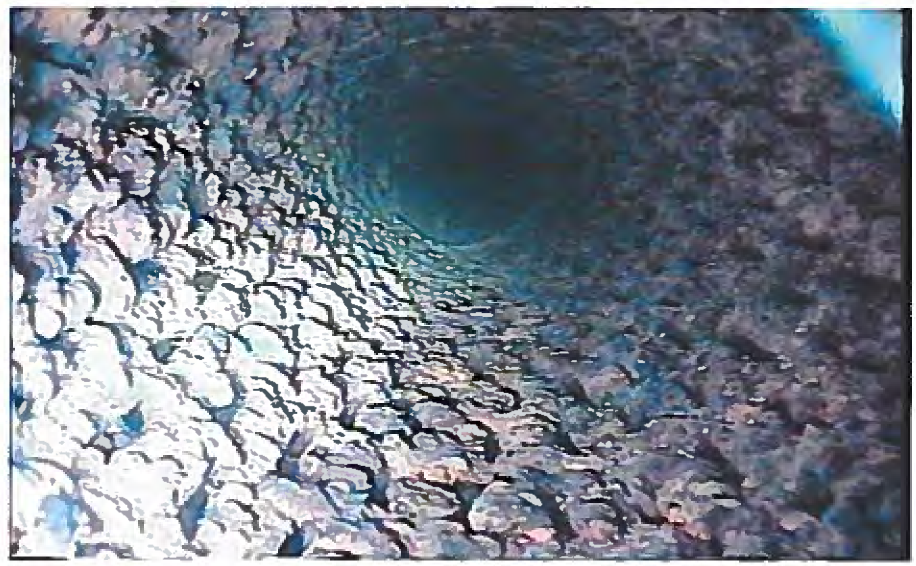

Collector Well 1A, Valve on lateral A2

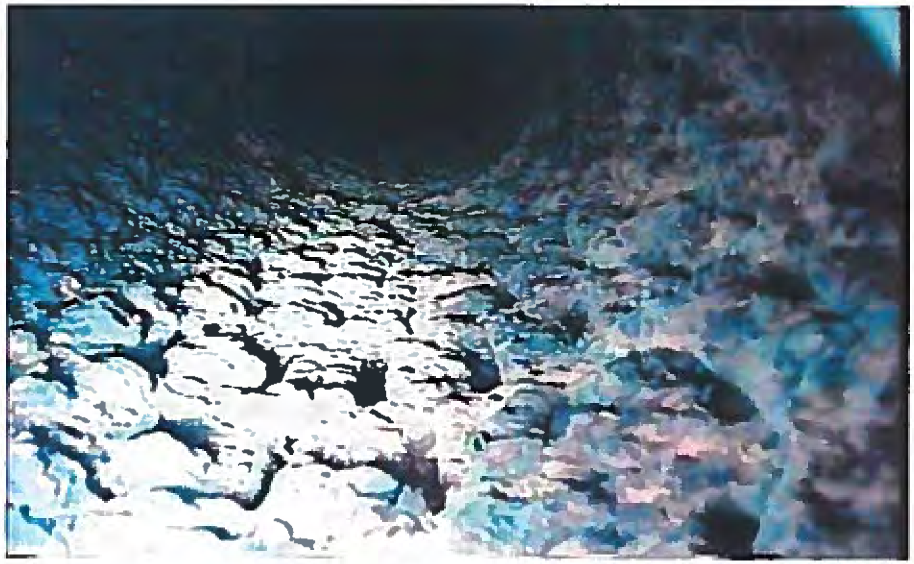

Collector Well 1A, Interior of lateral A2 near caisson


Collector Well 1A, Lateral A2 about 40 feet from caisson


Collector Well 1A, End of Lateral A2


Collector Well 1A, Valve on lateral A3

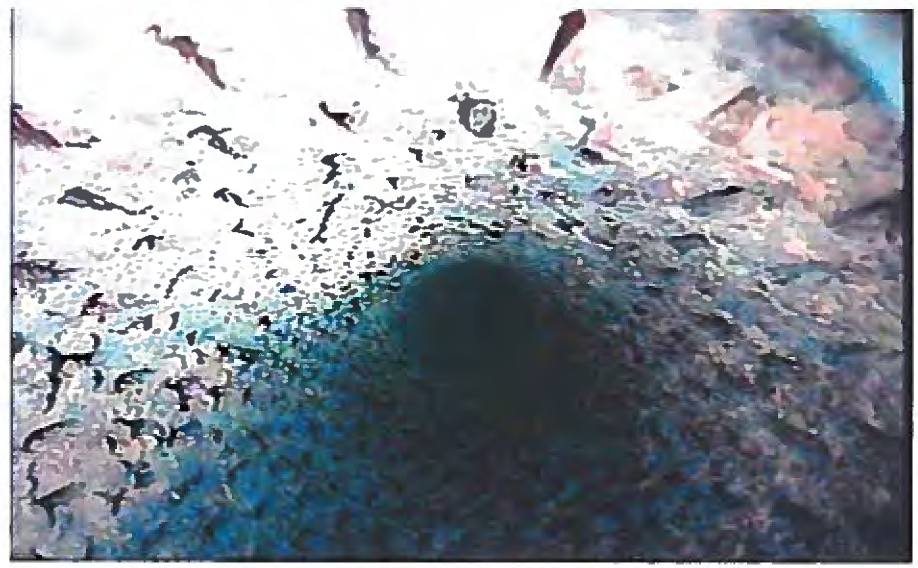

Collector Well 1A, Interior of lateral A3 near caisson



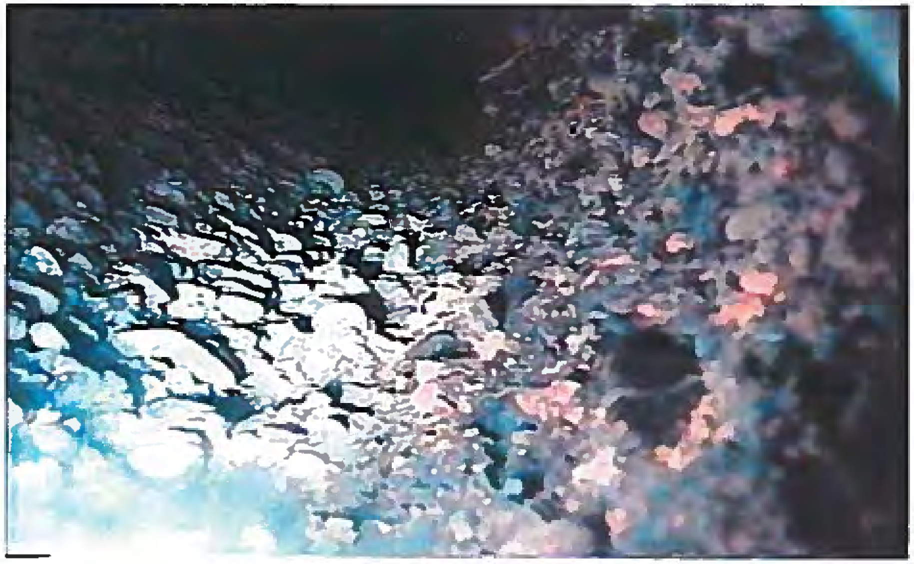
Collector Well 1A, Lateral A3 about 40 feet from caisson

Collector Well 1A, End of Lateral A3

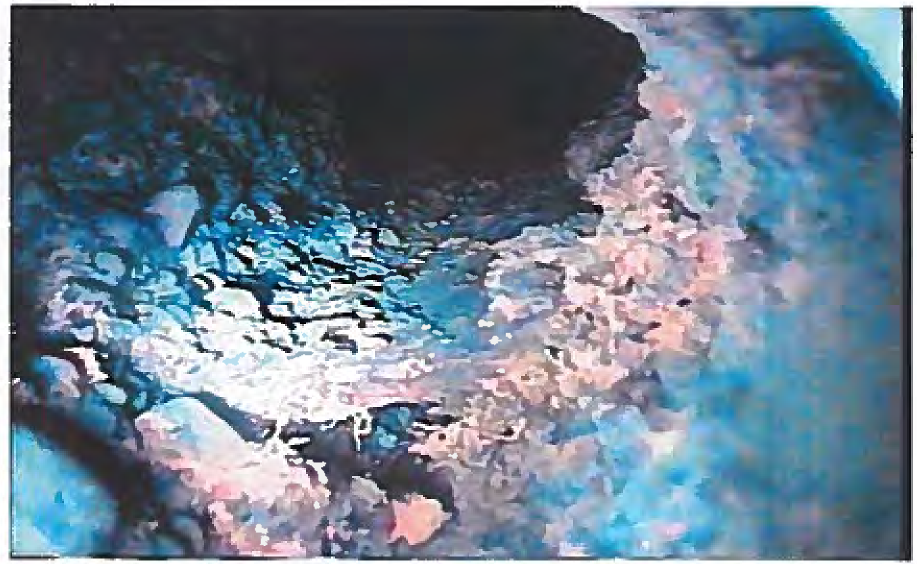
Collector Well 1A, Valve on lateral A4



Collector Well 1A, Interior of lateral A4 near caisson



Collector Well 1A, Lateral A4 about 40 feet from caisson

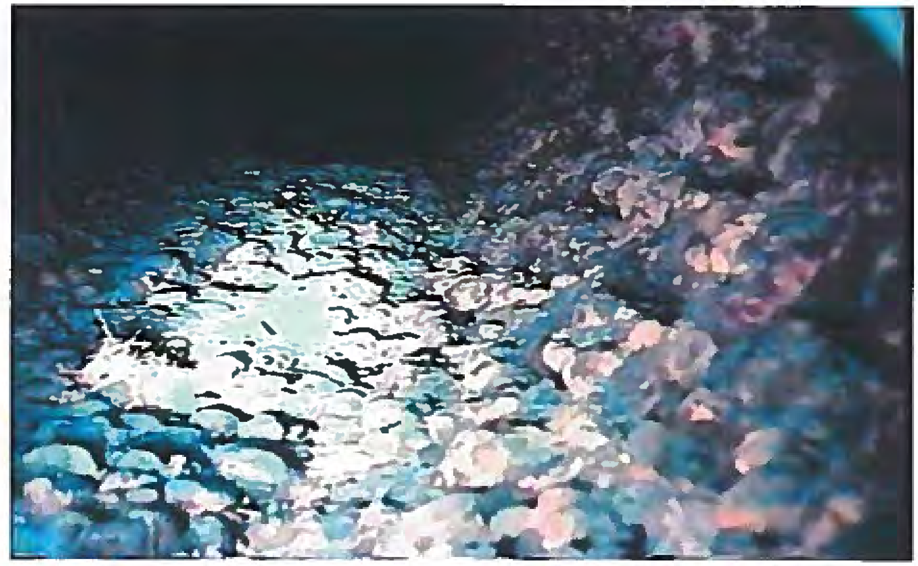


Collector Well 1A, Debris blocking Lateral A4

Collector Well 1A, Valve on lateral A5

Collector Well 1A, Interior of lateral A5 near caisson

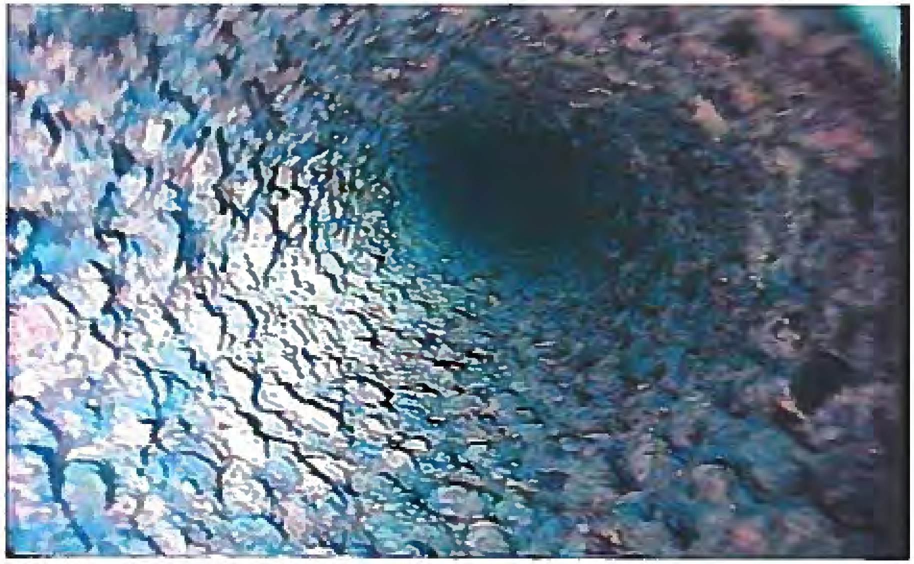
Collector Well 1A, Lateral A5 about 40 feet from caisson



Collector Well 1A, Sand and gravel in Lateral A5

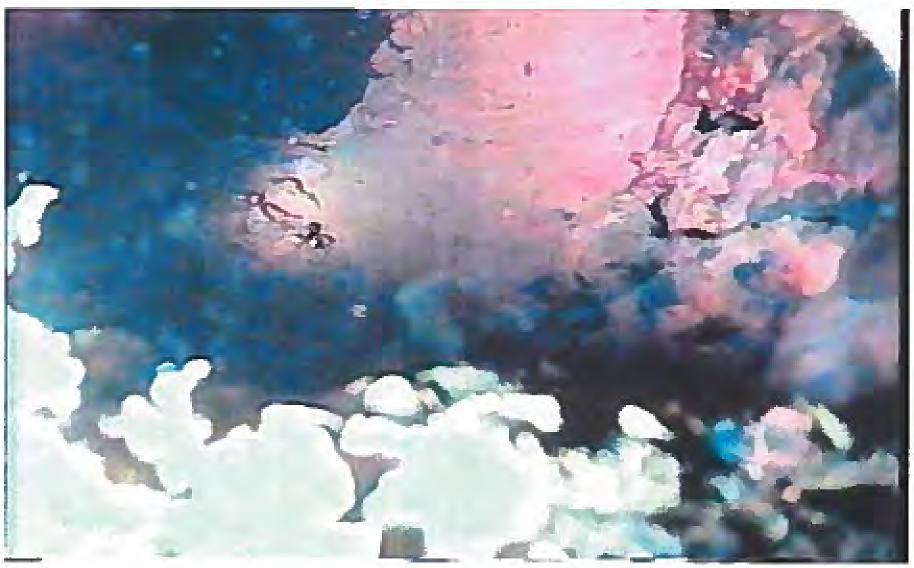
Collector Well 1A, End of Lateral A5

Collector Well 1A, Valve on lateral A6

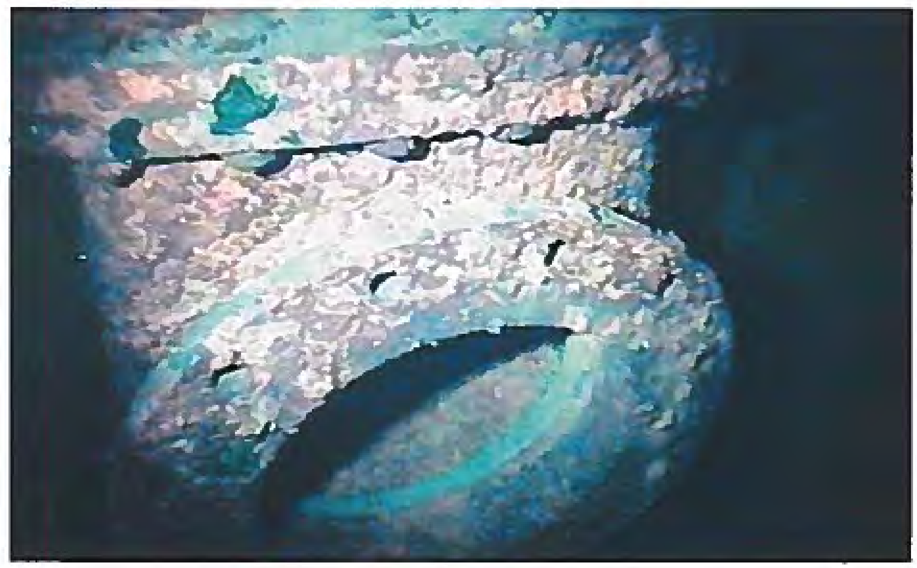


Collector Well 1A, Lateral A6 about 40 feet from caisson

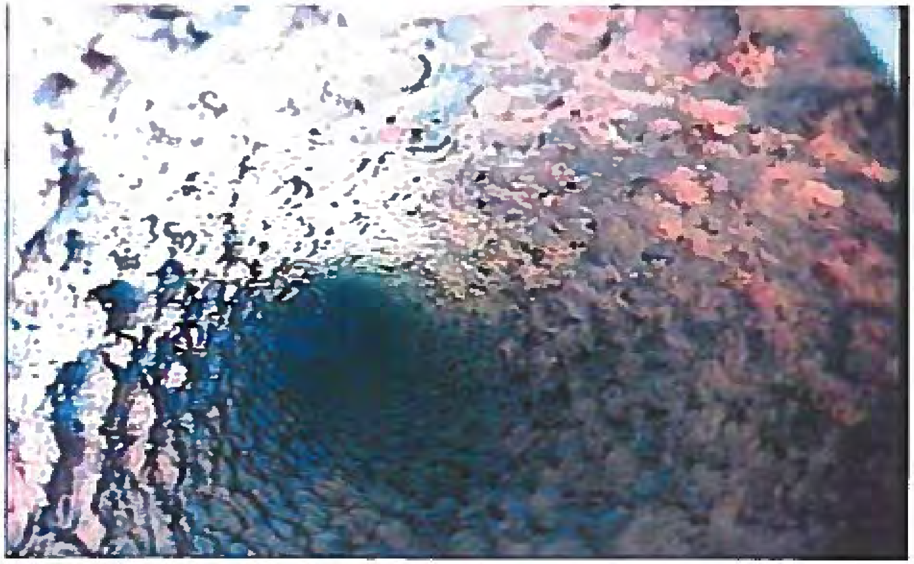
Collector Well 1A, Sand and gravel in Lateral A6



Collector Well 1A, End of Lateral A6



Collector Well 1A, Valve on lateral B1

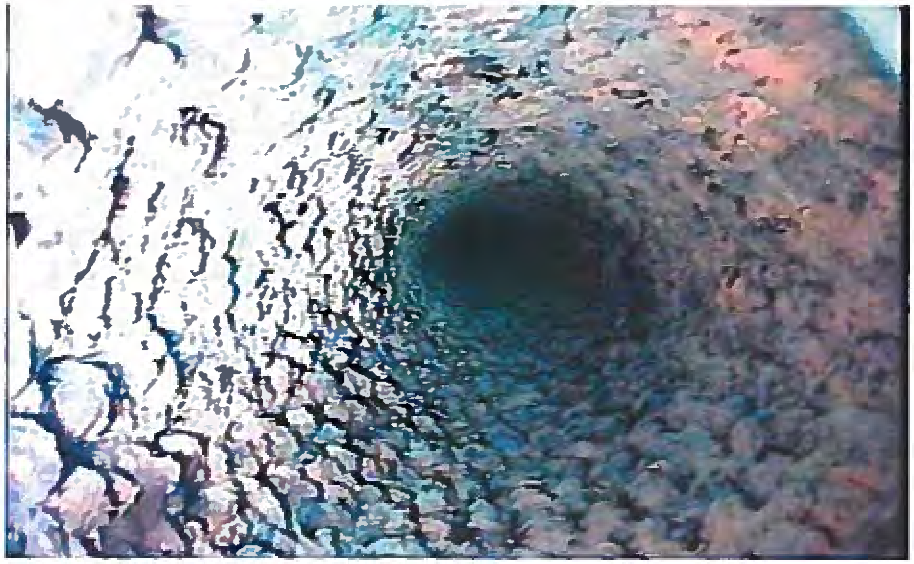


Collector Well 1A, Interior of Lateral B1 near caisson

Collector Well 1A, Lateral B1 about 40 feet from caisson

Collector Well 1A, End of Lateral B1

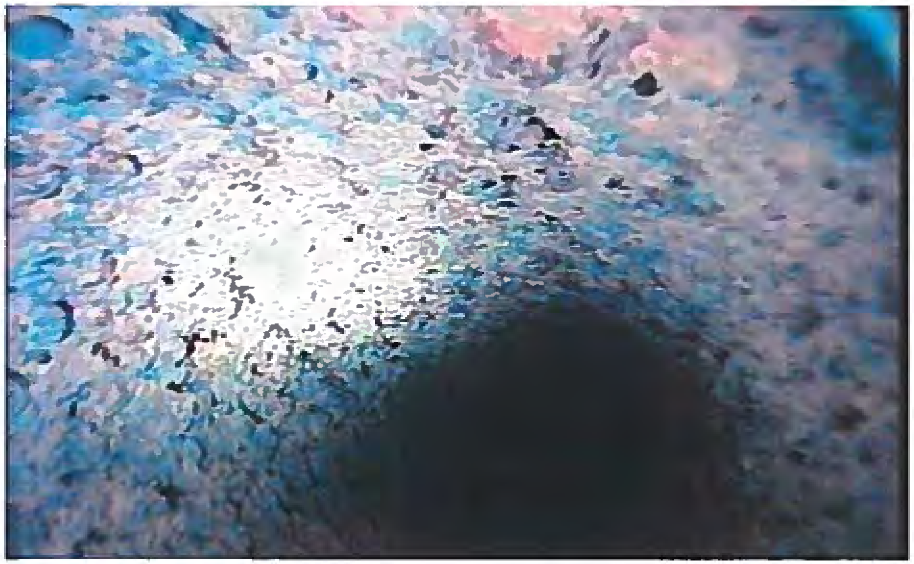
Collector Well 1A, Valve on lateral B2


Collector Well 1A, Interior of Lateral B2 near caisson

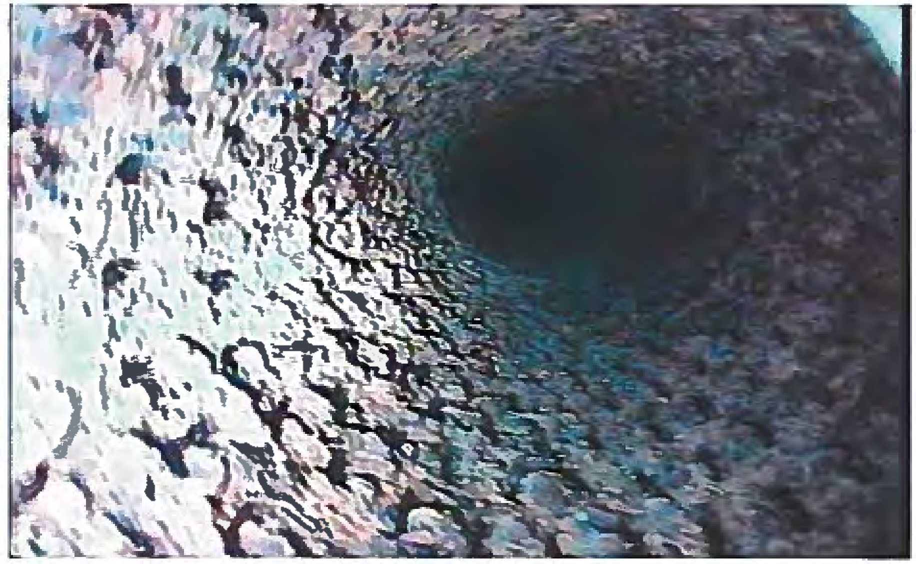

Collector Well 1A, Lateral B2 about 40 feet from caisson


Collector Well 1A, End of Lateral B2


Collector Well 1A, Valve on lateral B3



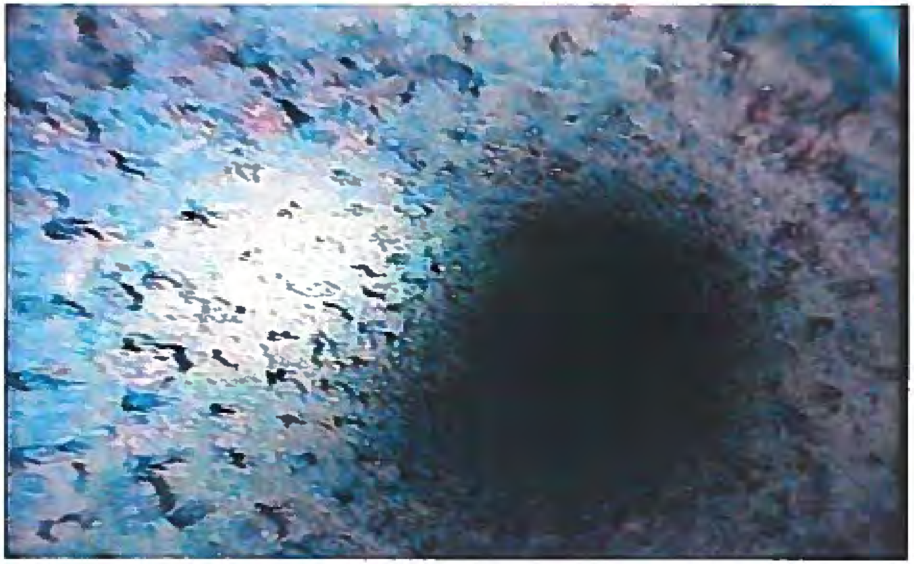
Collector Well 1A, Interior of Lateral B3 near caisson



Collector Well 1A, Lateral B3 about 40 feet from caisson

Collector Well 1A, End of Lateral B3

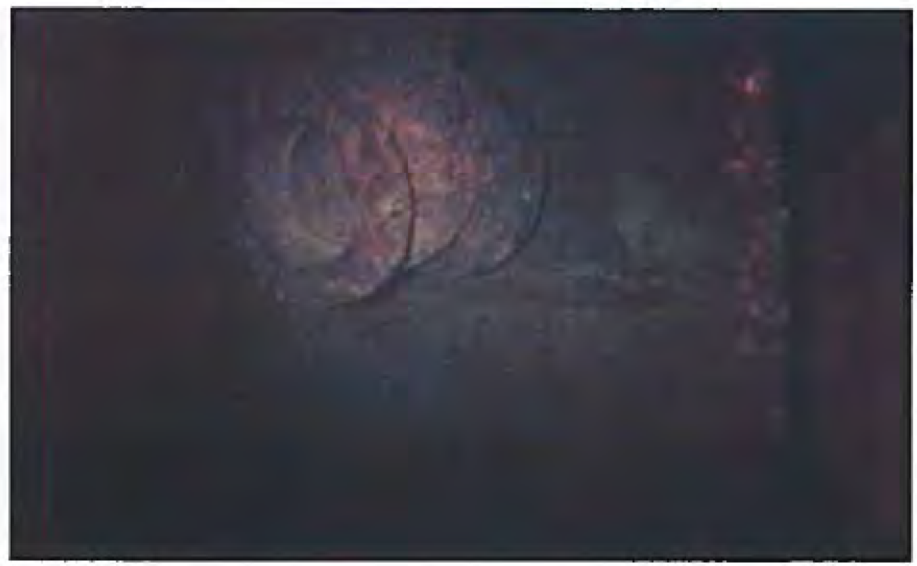
Collector Well 1A, Valve on lateral B4



Collector Well 1A, Interior of Lateral B4 near caisson

Collector Well 1A, Lateral B4 about 40 feet from caisson

Collector Well 1A, End of Lateral B4

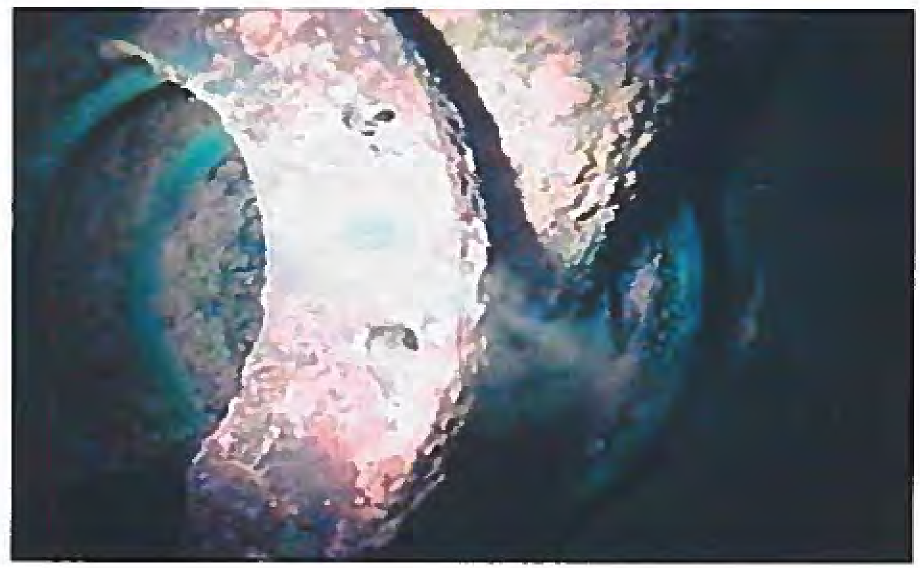


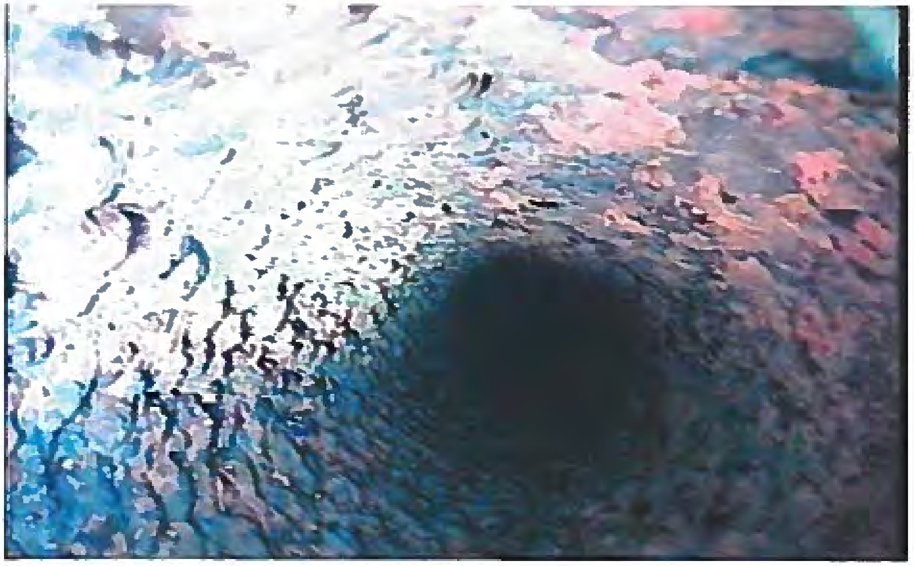
Collector Well 1A, Valve on lateral B5


Collector Well 1A, Interior of Lateral B5 near caisson


Collector Well 1A, Lateral B5 about 40 feet from caisson


Collector Well 1A, End of Lateral B5


Collector Well 1A, Valve on lateral B6



Collector Well 1A, Interior of Lateral B6 near caisson

Collector Well 1A, Lateral B6 about 40 feet from caisson

Collector Well 1A, End of Lateral B6

APPENDIX E
Inspection Photographs and Still Images from Video
Collector Well 1 (PS1)


Collector Well 1 (PS1)


Collector Well 1 pump


Collector Well 1 (PS1) Looking down access hatch

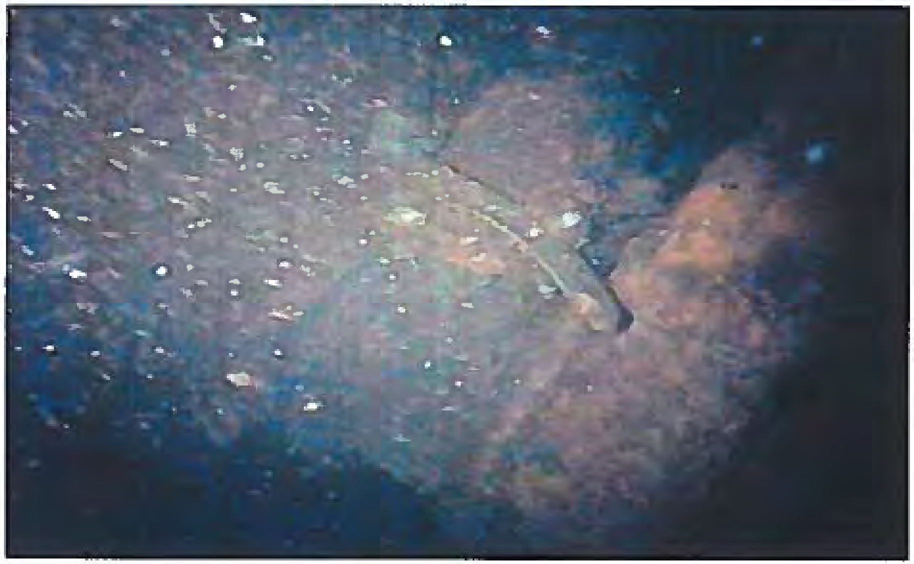

Collector Well 1, Lateral A1


Collector Well 1, Lateral A2


Collector Well 1, Lateral A3

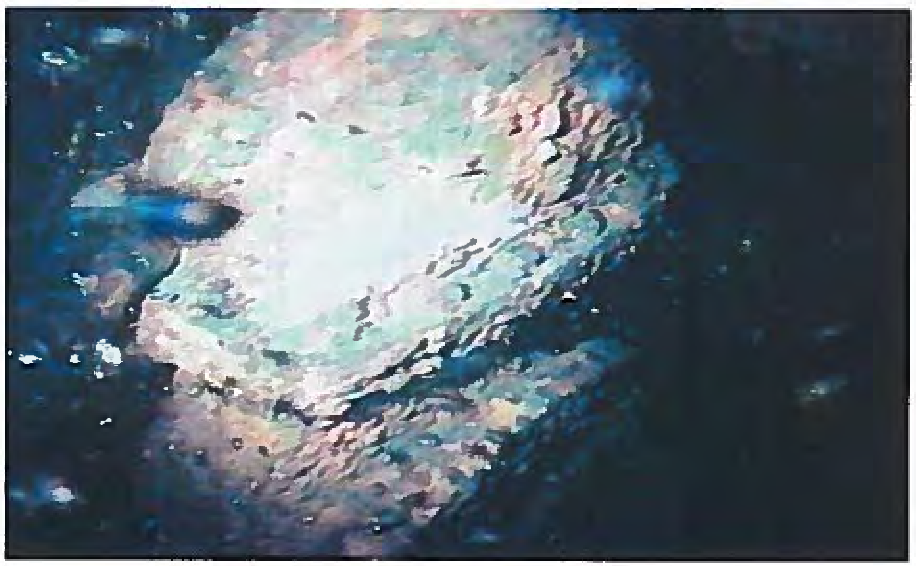

Collector Well 1, "Lateral A4" 24-inch corrugated pipe


Collector Well 1, "Lateral A4" 24-inch corrugated pipe

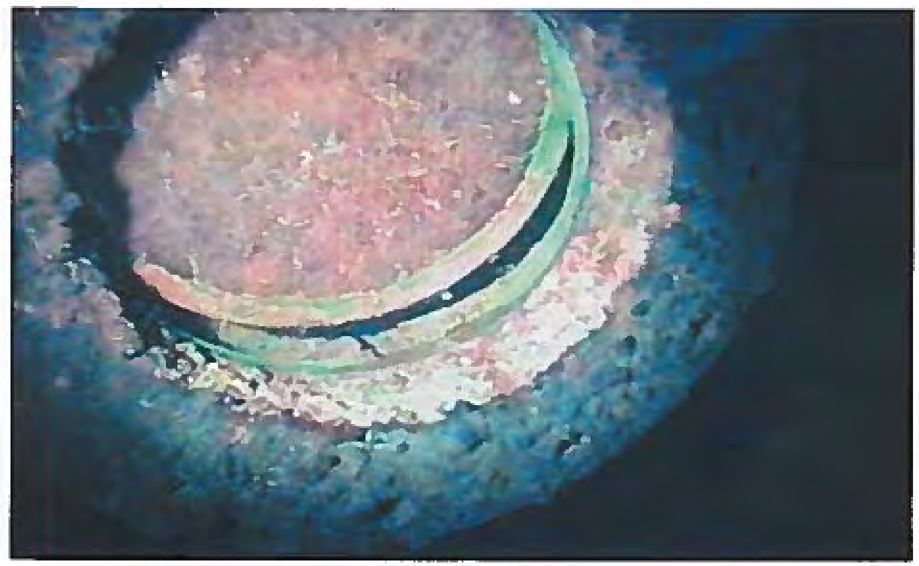


Collector Well 1, Lateral A5 Valves

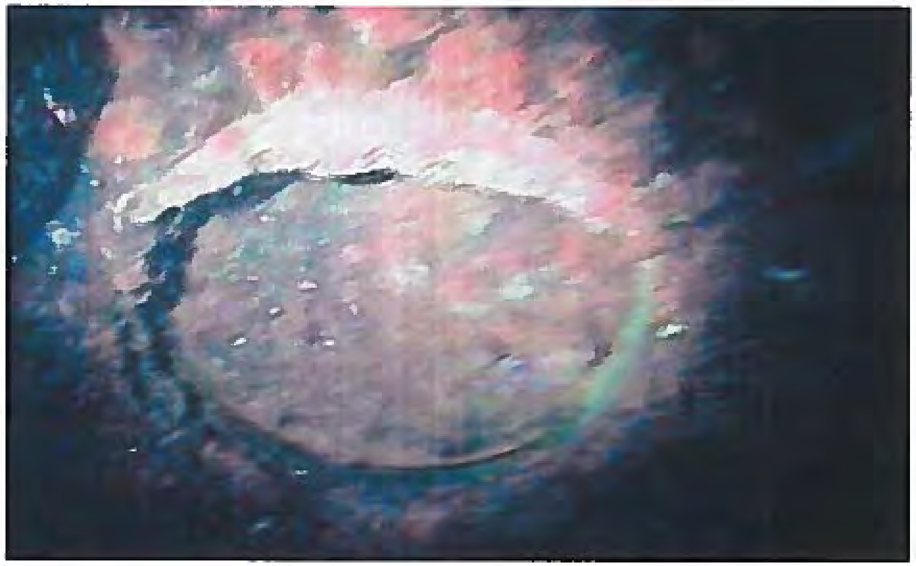
Collector Well 1, Lateral A5 Valve opening

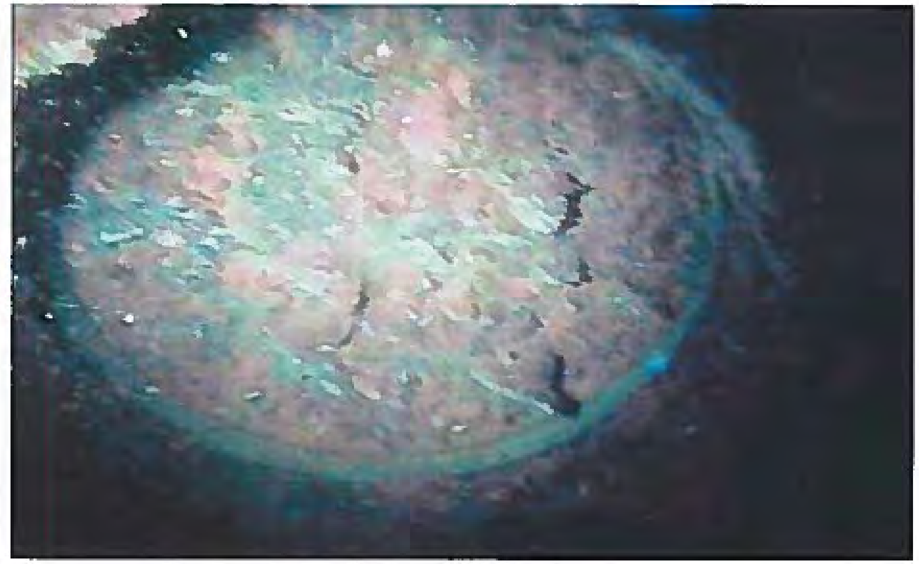


Collector Well 1, Lateral A6 Valve



Collector Well 1, Lateral A6 Valve opening


Collector Well 1, Lateral B1 Valve opening


Collector Well 1, Lateral B2 Valve opening

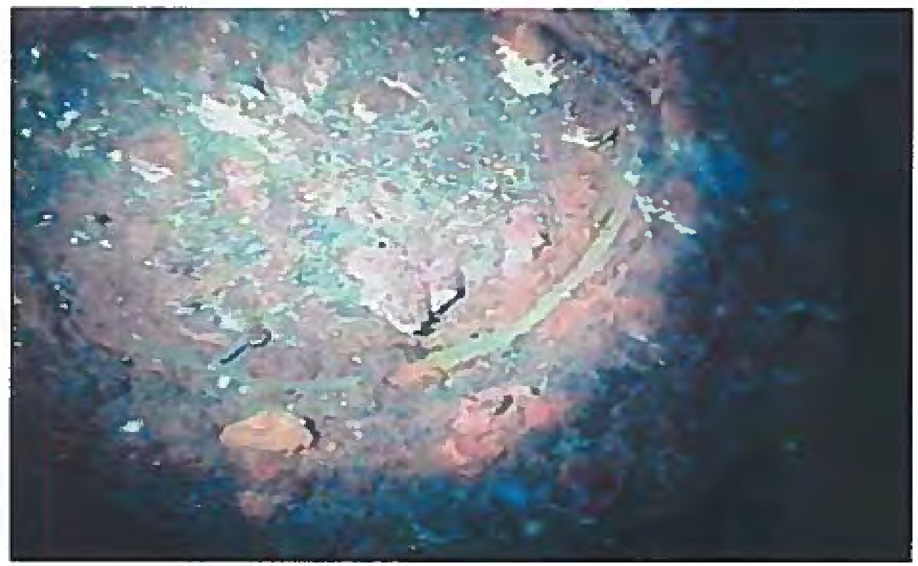

Collector Well 1, Lateral B2 Behind Valve


Collector Well 1, Lateral B3 Valve opening

Collector Well 1, Lateral B3 Behind Valve

Collector Well 1, Lateral B4 Valve opening

Collector Well 1, Lateral B4 Behind Valve

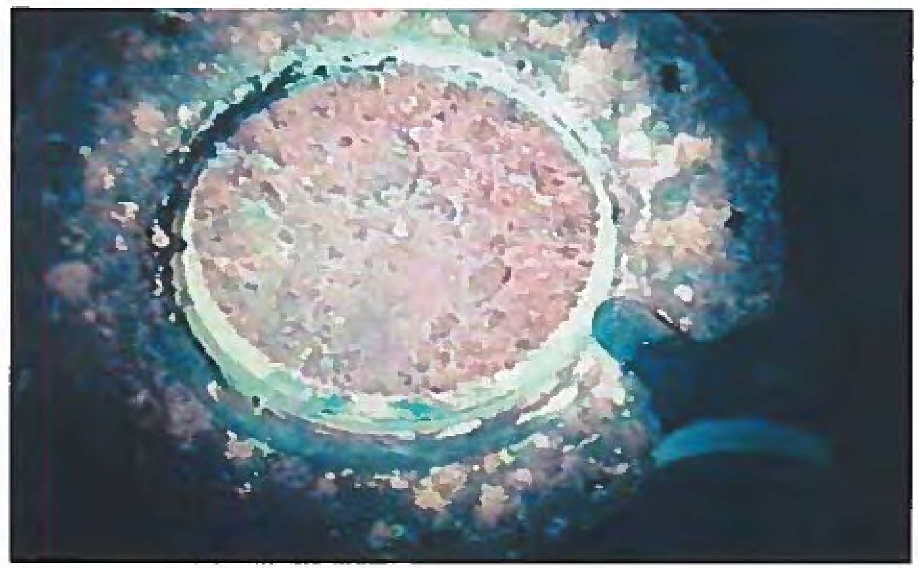


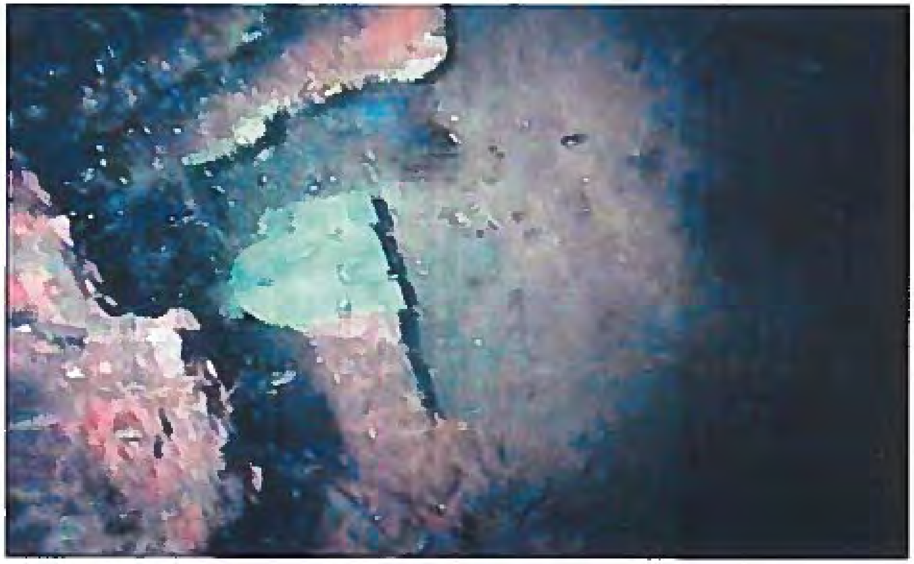
Collector Well 1, Lateral B5 Valve opening


Collector Well 1, Lateral B5 Behind Valve


Collector Well 1, Lateral B6 Valve opening


Collector Well 1, Lateral B6 Behind Valve


Collector Well 1, Lateral B7 Valve opening



Collector Well 1, Lateral B7 Behind Valve

Collector Well 1, Corroded pipe by access ladder

APPENDIX F
Inspection Photographs and Still Images from Video
Collector Well 3 (PS3)

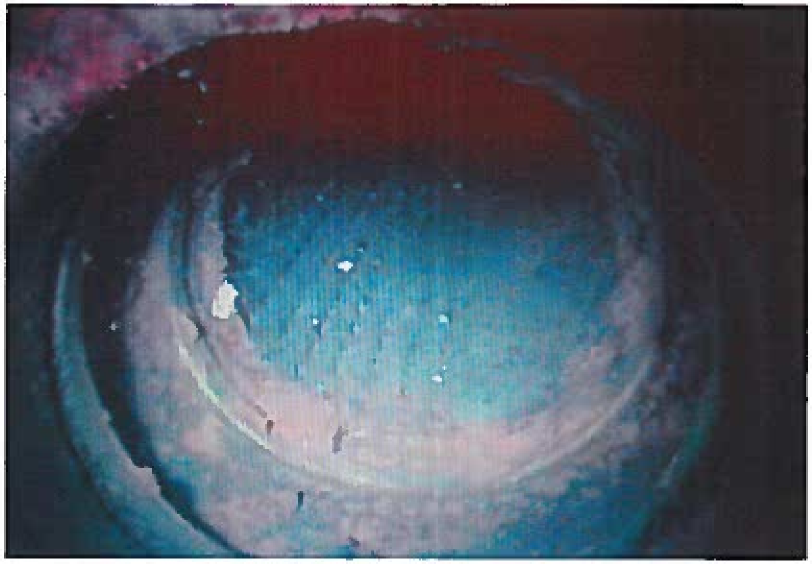
Collector Well 3 (PS3)

Collector Well 3, looking down access hatch

Collector Well 3, valve port, possibly for surface intake

Collector Well 3, access hatch

[redacted]


Collector Well 3, Lateral A2 Valve opening


Collector Well 3, Lateral A2 Behind valve


Collector Well 3, A2 Interior near caisson

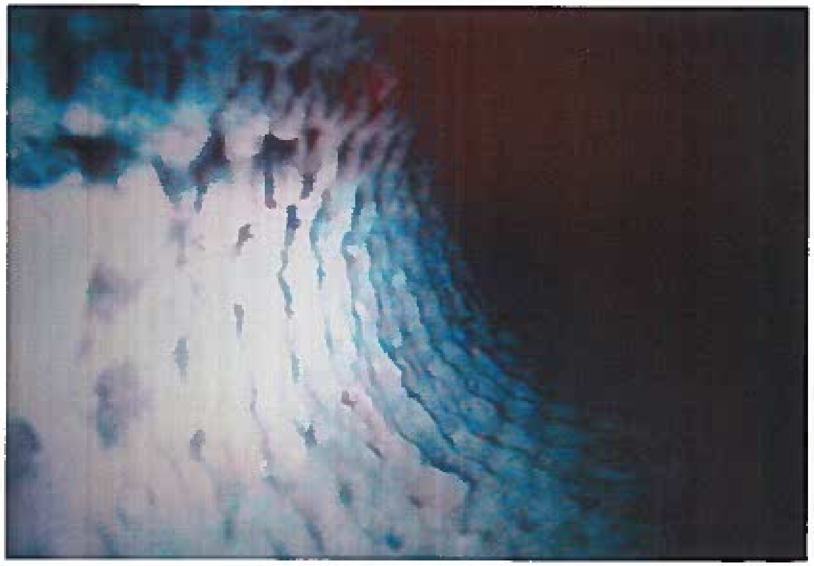

Collector Well 3, A2 Interior 10 feet from caisson


Collector Well 3, A2 Interior 40 feet from caisson


Collector Well 3, A2 Interior at end of lateral


Collector Well 3, Lateral B2 Valve opening


Collector Well 3, Lateral B2 Behind Valve



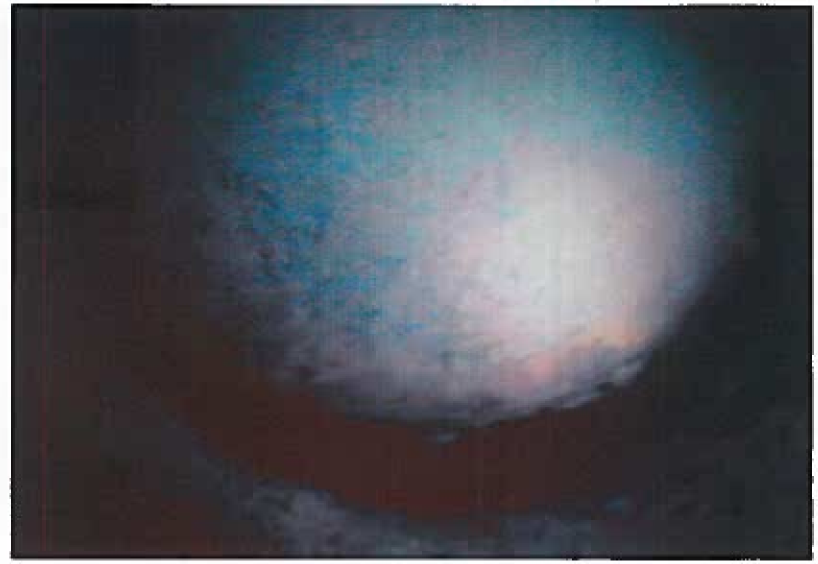
Collector Well 3, Lateral B2 Interior near caisson

Collector Well 3, Lateral B2 about 10 feet from caisson

Collector Well 3, Lateral B2 about 40 feet from caisson

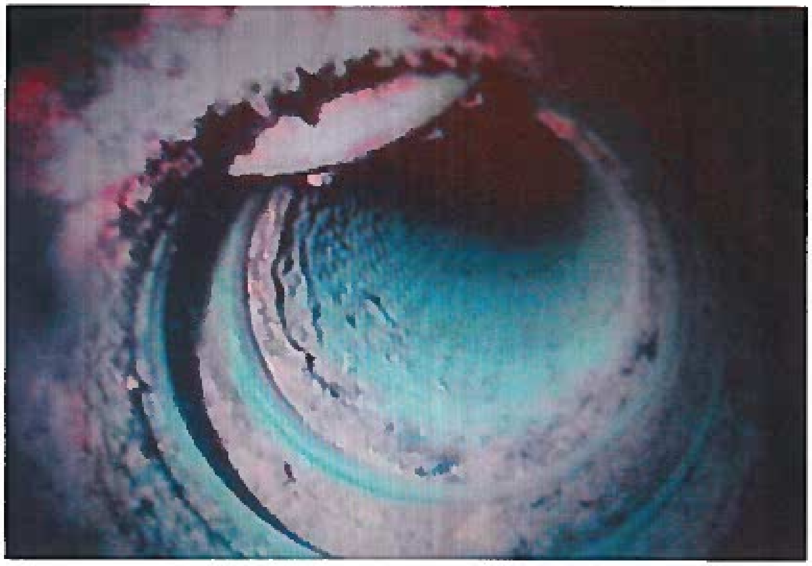
Collector Well 3, End of Lateral B2


Collector Well 3, Lateral A3 valve and elbow


Collector Well 3, Lateral A3 valve opening


Collector Well 3, Lateral A4 Valve


Collector Well 3, Lateral A4 Behind Valve

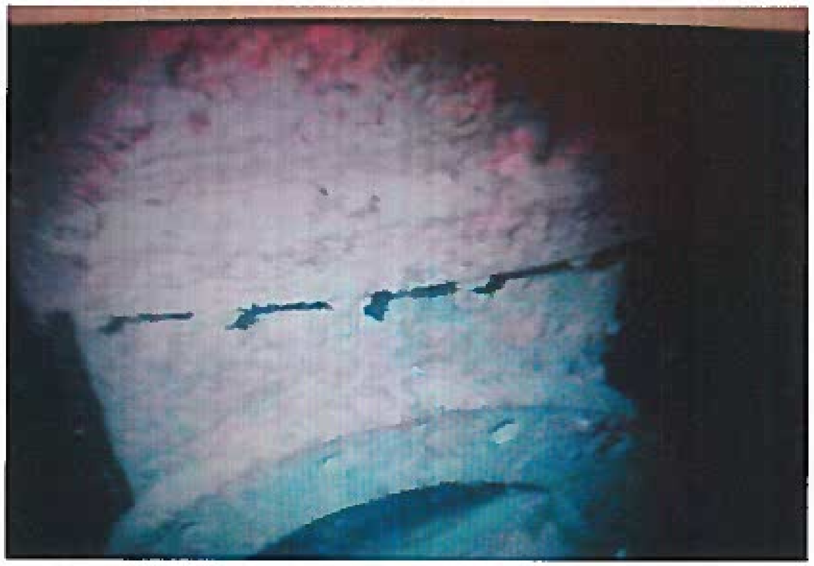


Collector Well 3, Lateral A4 Valve opening

Collector Well 3, Lateral A4 interior near caisson

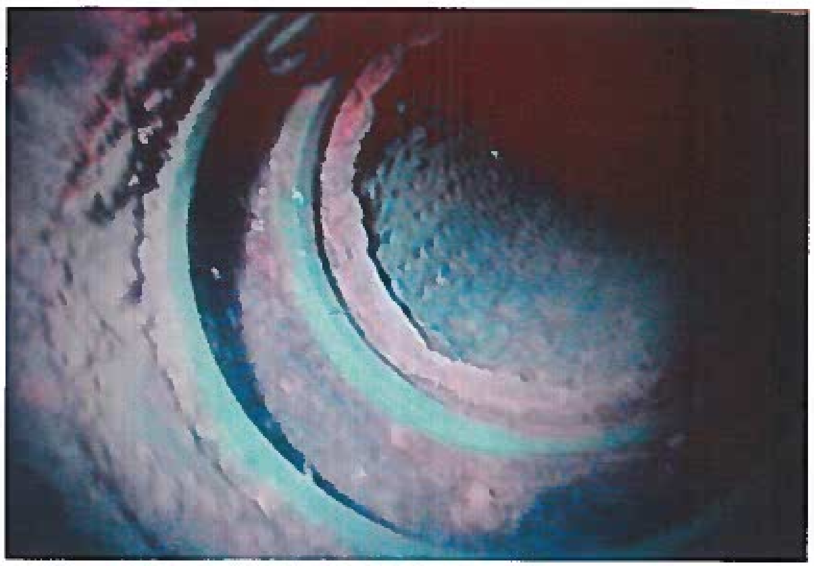
Collector Well 3, Lateral A4 about 40 feet from caisson

Collector Well 3, End of Lateral A4

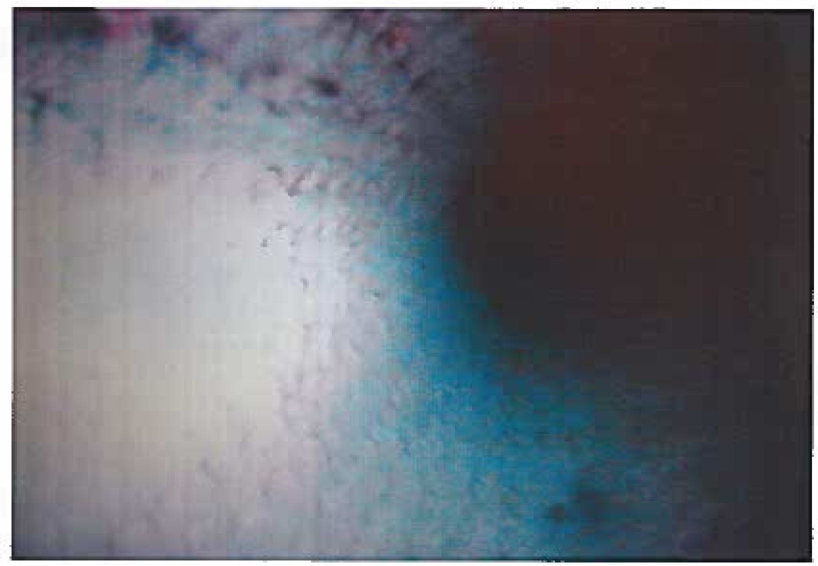


Collector Well 3, Lateral A5 Valve

Collector Well 3, Lateral A5 Behind Valve



Collector Well 3, Lateral A5 Valve opening



Collector Well 3, Lateral A5 Interior near caisson

Collector Well 3, Lateral A5 Interior 40 feet from caisson

Collector Well 3, Lateral A5 Interior at end

Collector Well 3, I-beam assembly
where it is suspended by a cable

Collector Well 3, End of I-beam assembly
where it is attached to caisson

Collector Well 3, venturi assembly

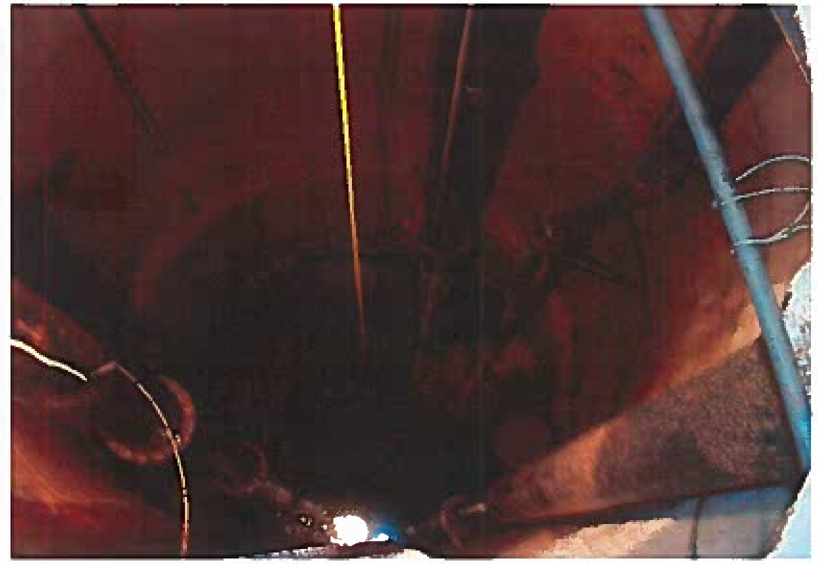
Collector Well 3, venturi assembly

Collector Well 3, lateral valve actuator

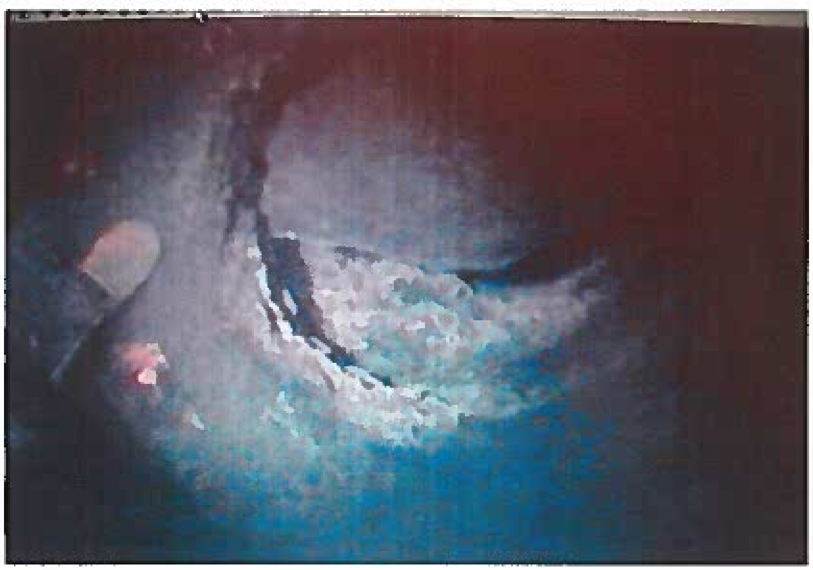
Collector Well 3, lateral valve actuator

APPENDIX G
Inspection Photographs and Still Images from Video
Collector Well 4 (PS4)

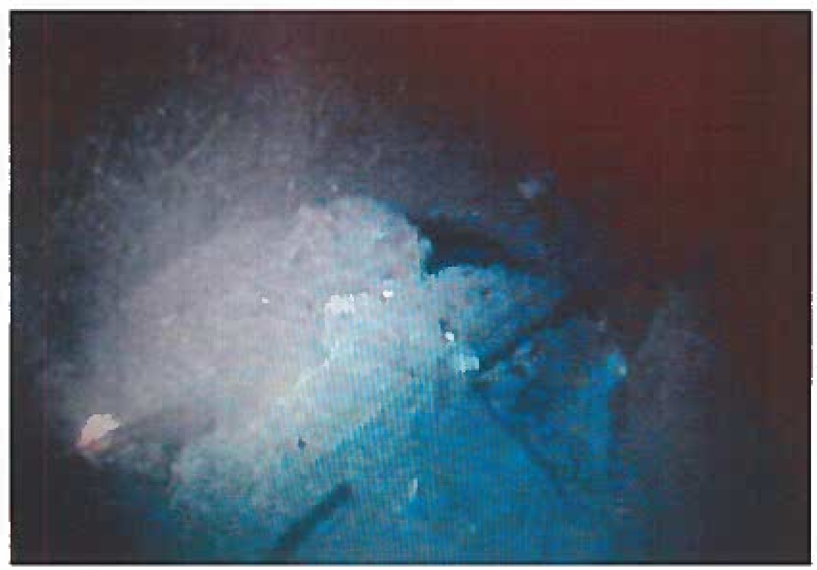
Collector Well 4 (PS4)



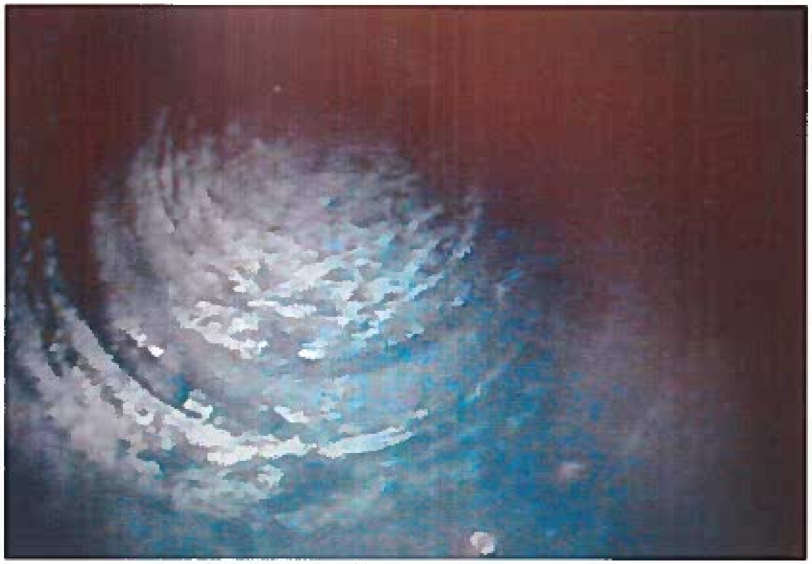
Collector Well 4, Looking down access hatch



Collector Well 4, Lateral A1 Valve opening



Collector Well 4, Lateral A1 Behind Valve

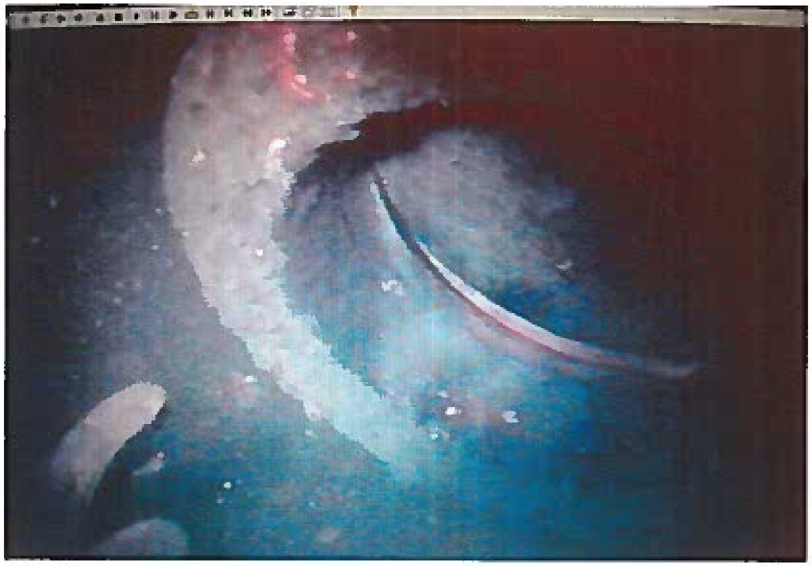


Collector Well 4, Lateral A2 Valve opening

Collector Well 4, Lateral A2 Behind Valve

Collector Well 4, Lateral A2 Interior 10 feet from caisson

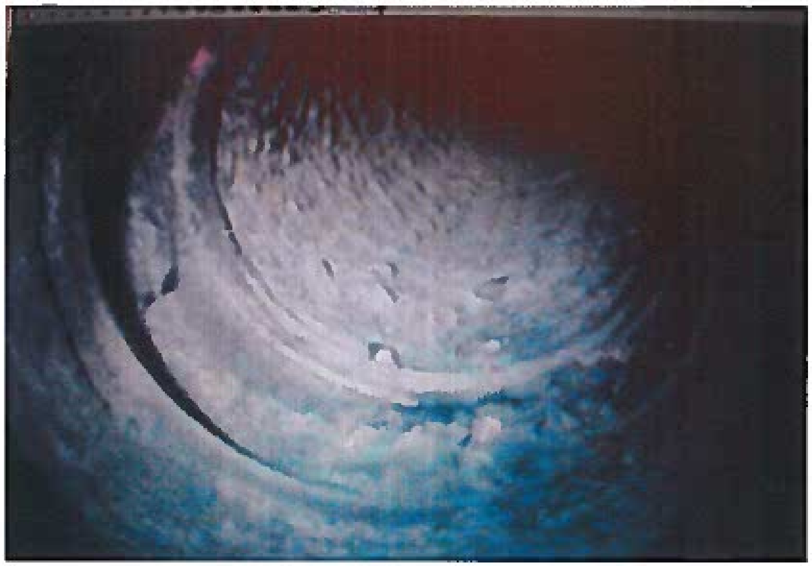
Collector Well 4, Lateral A2 Interior 40 feet from caisson


Collector Well 4, Lateral A4 Valve opening


Collector Well 4, Lateral A4 Behind Valve

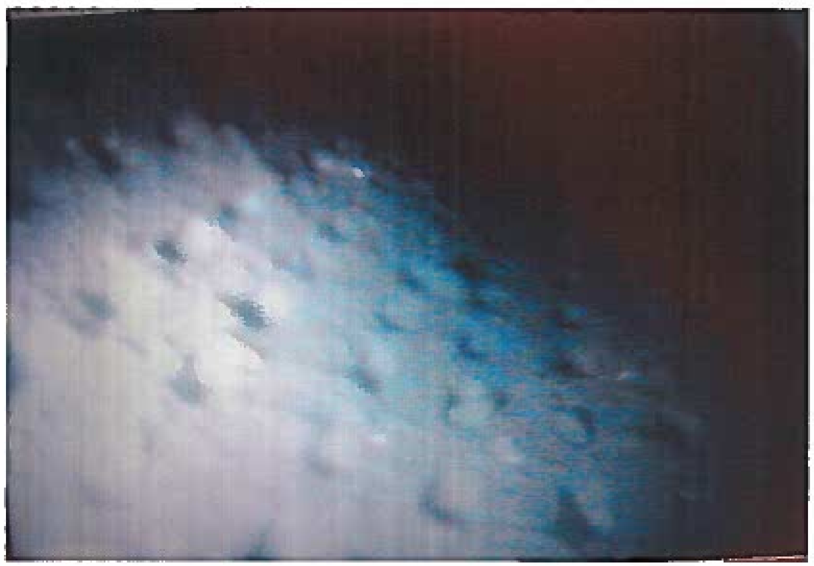

Collector Well 4, Lateral A4 Interior 10 feet from caisson


Collector Well 4, Lateral A2 Interior 40 feet from caisson

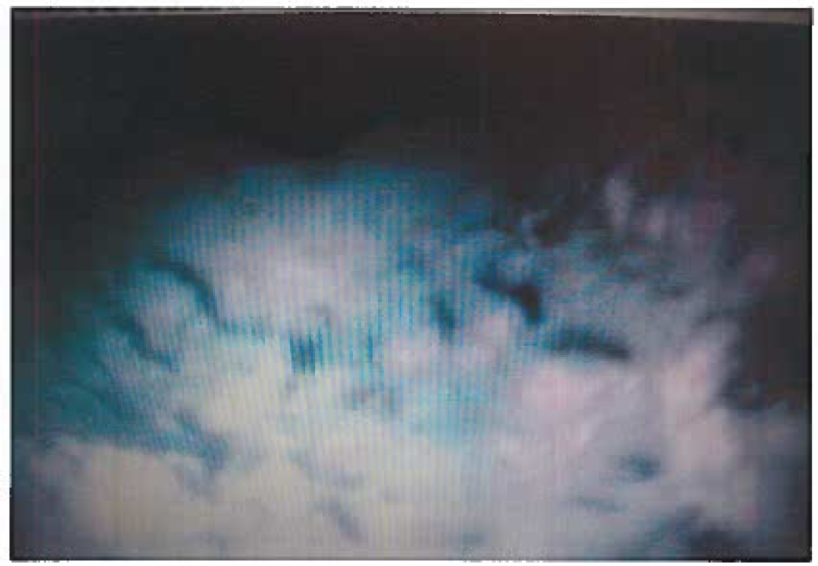


Collector Well 4, Lateral A5 Valve opening

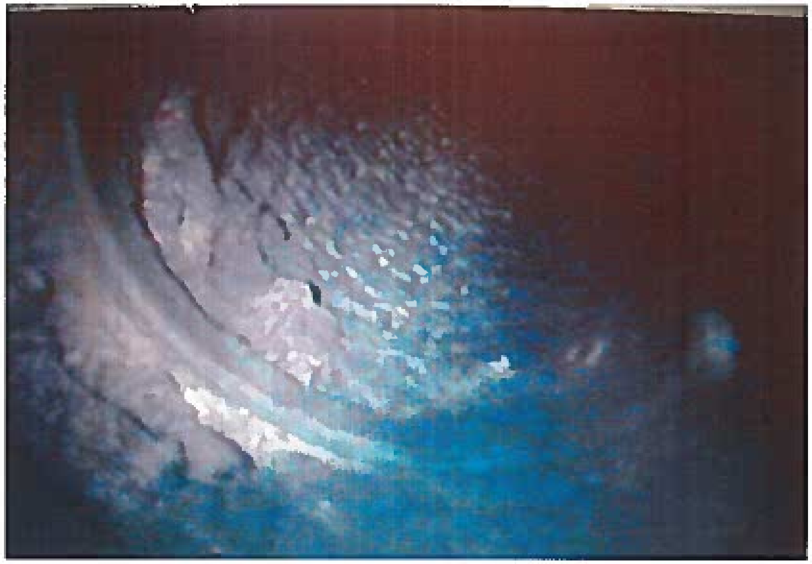
Collector Well 4, Lateral A5 Behind Valve

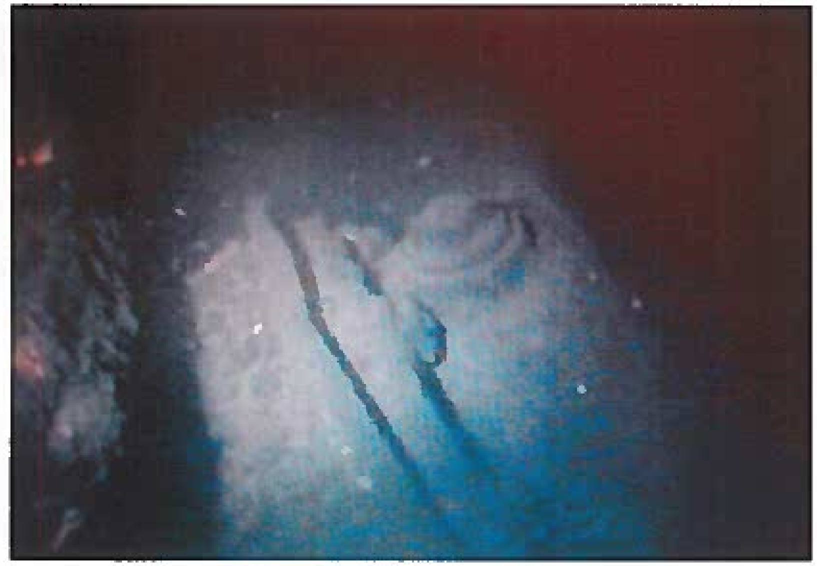


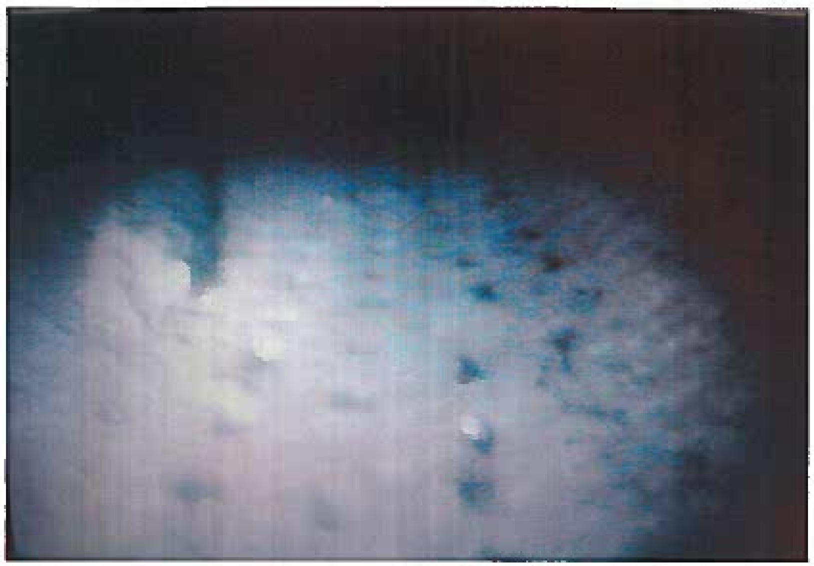
Collector Well 4, Lateral A5 Interior 10 feet from caisson



Collector Well 4, Lateral A5 Interior at end


Collector Well 4, Lateral A6 Valve opening


Collector Well 4, Lateral A6 Behind Valve


Collector Well 4, Lateral A6 Interior 10 feet from caisson


Collector Well 4, Lateral A6 Interior at end

Collector Well 4, I-beam resting on
Lateral A2 valve actuator

Collector Well 4, I-beam against side
of Lateral A6 valve actuator

APPENDIX H
Water Quality Laboratory Reports

DATE COLLECTED	DATE RECEIVED	DATE COMPLETED	SAMPLE CODE
10/19/06	10/23/06	10/27/06	660960

CUSTOMER ADDRESS

HUMBOLDY BAY WATER DIST.

DEALER ADDRESS

COLLECTOR WELLS INTL
6360 HUNTLEY RD
COLUMBUS, OH 43229-

NATIONAL TESTING LABORATORIES LTD.
6571 Wilson Mills Road
Cleveland, OH 44143
(440) 449-2525

DRINKING WATER ANALYSIS RESULTS

ID: WELL WATER
COLLECTOR WELL 3

NOTE: "*" The MCL (Maximum Contaminant Level) or an established guideline has been exceeded for this contaminant.
"**" Bacteria results may be invalid due to lack of collection information or because the sample has exceeded the 30-hour holding time.
"ND" This contaminant was not detected at or above our stated detection level.
"NBS" No bacteria submitted. "NBR" No Bacteria Required.
"P" = PRESENCE "A" = ABSENCE
"EP" = E. COLI PRESENCE "EA" = E. COLI ABSENCE
"NA" Not Analyzed

Analysis Performed	MCL (mg/l)	Det. Level	Level Detected
Total coliform	P	P	NBR
Inorganic chemicals - metals:			
Aluminum	0.2	0.1	ND
Arsenic	0.010	0.005	ND
Barium	2	0.30	ND
Cadmium	0.005	0.002	ND
Calcium	---	2.0	27
Chromium	0.1	0.010	ND
Copper	1.3	0.004	0.096
Iron	0.3	0.020	0.041
Lead	0.015	0.002	0.058*
Magnesium	---	0.10	4.5
Manganese	0.05	0.004	ND
Mercury	0.002	0.001	ND
Nickel	---	0.02	ND
Selenium	0.05	0.020	ND
Silver	0.1	0.002	ND
Sodium	---	1	4
Zinc	5	0.004	0.040
Inorganic chemicals - other, and physical factors:			
Alkalinity (Total as CaCO3)	---	20	92
Chloride	250	5.0	ND
Fluoride	4	0.5	ND
Hardness (suggested limit = 100)		10	86
Nitrate as N	10	0.5	ND
Nitrite as N	1	0.5	ND
pH (Standard Units)	6.5-8.5	---	6.8
Sulfate	250	5.0	10
Total Dissolved Solids	500	20	100
Turbidity (Turbidity Units)	1.0	0.1	0.6
Organic chemicals - trihalomethanes:			
Bromodichloromethane	---	0.002	ND
Bromoform	---	0.004	ND
Chloroform	---	0.002	ND
Dibromochloromethane	---	0.004	ND
Total THMs	0.080	0.002	ND

Analysis performed	MCL (mg/l)	Detection Level	Level Detected
1,1,1,2-Tetrachloroethane	---	0.002	ND
1,1,1-Trichloroethane	0.2	0.001	ND
1,1,2,2-Tetrachloroethane	---	0.002	ND
1,1,2-Trichloroethane	0.005	0.002	ND
1,1-Dichloroethane	---	0.002	ND
1,1-Dichloroethene	0.007	0.001	ND
1,1-Dichloropropene	---	0.002	ND
1,2,3-Trichlorobenzene	---	0.002	ND
1,2,3-Trichloropropane	---	0.002	ND
1,2,4-Trichlorobenzene	0.07	0.002	ND
1,2-Dichlorobenzene	0.6	0.001	ND
1,2-Dichloroethane	0.005	0.001	ND
1,2-Dichloropropane	0.005	0.002	ND
1,3-Dichlorobenzene	---	0.001	ND
1,3-Dichloropropane	---	0.002	ND
1,4-Dichlorobenzene	0.075	0.001	ND
2,2-Dichloropropane	---	0.002	ND
2-Chlorotoluene	---	0.001	ND
4-Chlorotoluene	---	0.001	ND
Benzene	0.005	0.001	ND
Bromobenzene	---	0.002	ND
Bromomethane	---	0.002	ND
Carbon Tetrachloride	0.005	0.001	ND
Chlorobenzene	0.1	0.001	ND
Chloroethane	---	0.002	ND
Chloromethane	---	0.002	ND
cis-1,2-Dichloroethene	0.07	0.002	ND
cis-1,3-Dichloropropene	---	0.002	ND
Dibromochloropropane (DBCP)	---	0.001	ND
Dibromomethane	---	0.002	ND
Dichlorodifluoromethane	---	0.002	ND
Dichloromethane	0.005	0.002	ND
Ethylbenzene	0.7	0.001	ND
Ethylenedibromide (EDB)	---	0.001	ND
Methyl-Tert-Butyl-Ether	---	0.004	ND
Styrene	0.1	0.001	ND
Tetrachloroethene (PCE)	0.005	0.002	ND
Toluene	1	0.001	ND
Trans-1,2-Dichloroethene	0.1	0.002	ND
trans-1,3-Dichloropropene	---	0.002	ND
Trichloroethene (TCE)	0.005	0.001	ND
Trichlorofluoromethane	---	0.002	ND
Vinyl Chloride	0.002	0.001	ND
Xylene	10	0.001	ND

We certify that the analyses performed for this report are accurate, and that the laboratory tests were conducted by methods approved by the U.S. Environmental Protection Agency or variations of these EPA methods.

These test results are intended to be used for informational purposes only and may not be used for regulatory compliance.

National Testing Laboratories Ltd.

NATIONAL TESTING LABORATORIES LTD.

DATE COLLECTED	DATE RECEIVED	DATE COMPLETED	SAMPLE CODE
10/17/06	10/19/06	10/26/06	660823

NATIONAL TESTING LABORATORIES LTD.
6571 Wilson Mills Road
Cleveland, OH 44143
(440) 449-2525

CUSTOMER ADDRESS

HUMBOLDT BAY WATER DIST.

DEALER ADDRESS

COLLECTOR WELLS INTL
6360 HUNTLEY RD
COLUMBUS, OH 43229-

DRINKING WATER ANALYSIS RESULTS

ID: COLLECTOR WELL 1 A

NOTE: "*" The MCL (Maximum Contaminant Level) or an established guideline has been exceeded for this contaminant.
"**" Bacteria results may be invalid due to lack of collection information or because the sample has exceeded the 30-hour holding time.
"ND" This contaminant was not detected at or above our stated detection level.
"NBS" No bacteria submitted. "NBR" No Bacteria Required.
"P" = PRESENCE "A" = ABSENCE
"EP" = E. COLI PRESENCE "EA" = E. COLI ABSENCE
"NA" Not Analyzed

Analysis Performed	MCL (mg/l)	Det. Level	Level Detected
Total coliform	P	P	NBR
Inorganic chemicals - metals:			
Aluminum	0.2	0.1	ND
Arsenic	0.010	0.005	ND
Barium	2	0.30	ND
Cadmium	0.005	0.002	ND
Calcium	---	2.0	26
Chromium	0.1	0.010	ND
Copper	1.3	0.004	ND
Iron	0.3	0.020	0.048
Lead	0.015	0.002	ND
Magnesium	---	0.10	4.4
Manganese	0.05	0.004	ND
Mercury	0.002	0.001	ND
Nickel	---	0.02	ND
Selenium	0.05	0.020	ND
Silver	0.1	0.002	ND
Sodium	---	1	4
Zinc	5	0.004	ND
Inorganic chemicals - other, and physical factors:			
Alkalinity (Total as CaCO3)	---	20	78
Chloride	250	5.0	ND
Fluoride	4	0.5	ND
Hardness (suggested limit = 100)		10	83
Nitrate as N	10	0.5	ND
Nitrite as N	1	0.5	ND
pH (Standard Units)	6.5-8.5	---	7.0
Sulfate	250	5.0	10
Total Dissolved Solids	500	20	91
Turbidity (Turbidity Units)	1.0	0.1	0.4
Organic chemicals - trihalomethanes:			
Bromodichloromethane	---	0.002	ND
Bromoform	---	0.004	ND
Chloroform	---	0.002	ND
Dibromochloromethane	---	0.004	ND
Total THMs	0.080	0.002	ND

page 2. Sample code: 660823

Analysis performed	MCL (mg/l)	Detection Level	Level Detected
1,1,1,2-Tetrachloroethane	---	0.002	ND
1,1,1-Trichloroethane	0.2	0.001	ND
1,1,2,2-Tetrachloroethane	---	0.002	ND
1,1,2-Trichloroethane	0.005	0.002	ND
1,1-Dichloroethane	---	0.002	ND
1,1-Dichloroethene	0.007	0.001	ND
1,1-Dichloropropene	---	0.002	ND
1,2,3-Trichlorobenzene	---	0.002	ND
1,2,3-Trichloropropane	---	0.002	ND
1,2,4-Trichlorobenzene	0.07	0.002	ND
1,2-Dichlorobenzene	0.6	0.001	ND
1,2-Dichloroethane	0.005	0.001	ND
1,2-Dichloropropane	0.005	0.002	ND
1,3-Dichlorobenzene	---	0.001	ND
1,3-Dichloropropane	---	0.002	ND
1,4-Dichlorobenzene	0.075	0.001	ND
2,2-Dichloropropane	---	0.002	ND
2-Chlorotoluene	---	0.001	ND
4-Chlorotoluene	---	0.001	ND
Benzene	0.005	0.001	ND
Bromobenzene	---	0.002	ND
Bromomethane	---	0.002	ND
Carbon Tetrachloride	0.005	0.001	ND
Chlorobenzene	0.1	0.001	ND
Chloroethane	---	0.002	ND
Chloromethane	---	0.002	ND
cis-1,2-Dichloroethene	0.07	0.002	ND
cis-1,3-Dichloropropene	---	0.002	ND
Dibromochloropropane (DBCP)	---	0.001	ND
Dibromomethane	---	0.002	ND
Dichlorodifluoromethane	---	0.002	ND
Dichloromethane	0.005	0.002	ND
Ethylbenzene	0.7	0.001	ND
Ethylenedibromide (EDB)	---	0.001	ND
Methyl-Tert-Butyl-Ether	---	0.004	ND
Styrene	0.1	0.001	ND
Tetrachloroethene (PCE)	0.005	0.002	ND
Toluene	1	0.001	ND
Trans-1,2-Dichloroethene	0.1	0.002	ND
trans-1,3-Dichloropropene	---	0.002	ND
Trichloroethene (TCE)	0.005	0.001	ND
Trichlorofluoromethane	---	0.002	ND
Vinyl Chloride	0.002	0.001	ND
Xylene	10	0.001	ND

We certify that the analyses performed for this report are accurate, and that the laboratory tests were conducted by methods approved by the U.S. Environmental Protection Agency or variations of these EPA methods.

These test results are intended to be used for informational purposes only and may not be used for regulatory compliance.

National Testing Laboratories Ltd.

DATE COLLECTED	DATE RECEIVED	DATE COMPLETED	SAMPLE CODE
10/20/06	10/23/06	10/27/06	660961

NATIONAL TESTING LABORATORIES LTD.
6571 Wilson Mills Road
Cleveland, OH 44143
(440) 449-2525

CUSTOMER ADDRESS

HUMBOLDT BAY WATER DIST.

DEALER ADDRESS

COLLECTOR WELLS INTL
6360 HUNTLEY RD
COLUMBUS, OH 43229-

DRINKING WATER ANALYSIS RESULTS

ID: WELL WATER
COLLECTOR WELL NO 4

NOTE: "*" The MCL (Maximum Contaminant Level) or an established guideline has been exceeded for this contaminant.
"**" Bacteria results may be invalid due to lack of collection information or because the sample has exceeded the 30-hour holding time.
"ND" This contaminant was not detected at or above our stated detection level.
"NBS" No bacteria submitted. "NBR" No Bacteria Required.
"P" = PRESENCE "A" = ABSENCE
"EP" = E. COLI PRESENCE "EA" = E. COLI ABSENCE
"NA" Not Analyzed

Analysis Performed	MCL (mg/l)	Det. Level	Level Detected
Total coliform	P	P	NBR
Inorganic chemicals - metals:			
Aluminum	0.2	0.1	ND
Arsenic	0.010	0.005	ND
Barium	2	0.30	ND
Cadmium	0.005	0.002	ND
Calcium	---	2.0	28
Chromium	0.1	0.010	ND
Copper	1.3	0.004	0.017
Iron	0.3	0.020	0.34*
Lead	0.015	0.002	0.010
Magnesium	---	0.10	4.6
Manganese	0.05	0.004	0.072*
Mercury	0.002	0.001	ND
Nickel	---	0.02	ND
Selenium	0.05	0.020	ND
Silver	0.1	0.002	ND
Sodium	---	1	4
Zinc	5	0.004	0.015
Inorganic chemicals - other, and physical factors:			
Alkalinity (Total as CaCO3)	---	20	86
Chloride	250	5.0	ND
Fluoride	4	0.5	ND
Hardness (suggested limit = 100)		10	89
Nitrate as N	10	0.5	ND
Nitrite as N	1	0.5	ND
pH (Standard Units)	6.5-8.5	---	6.9
Sulfate	250	5.0	10
Total Dissolved Solids	500	20	99
Turbidity (Turbidity Units)	1.0	0.1	2.4*
Organic chemicals - trihalomethanes:			
Bromodichloromethane	---	0.002	ND
Bromoform	---	0.004	ND
Chloroform	---	0.002	ND
Dibromochloromethane	---	0.004	ND
Total THMs	0.080	0.002	ND

page 2. Sample code: 660961

Analysis performed	MCL (mg/l)	Detection Level	Level Detected
1,1,1,2-Tetrachloroethane	---	0.002	ND
1,1,1-Trichloroethane	0.2	0.001	ND
1,1,2,2-Tetrachloroethane	---	0.002	ND
1,1,2-Trichloroethane	0.005	0.002	ND
1,1-Dichloroethane	---	0.002	ND
1,1-Dichloroethene	0.007	0.001	ND
1,1-Dichloropropene	---	0.002	ND
1,2,3-Trichlorobenzene	---	0.002	ND
1,2,3-Trichloropropane	---	0.002	ND
1,2,4-Trichlorobenzene	0.07	0.002	ND
1,2-Dichlorobenzene	0.6	0.001	ND
1,2-Dichloroethane	0.005	0.001	ND
1,2-Dichloropropane	0.005	0.002	ND
1,3-Dichlorobenzene	---	0.001	ND
1,3-Dichloropropane	---	0.002	ND
1,4-Dichlorobenzene	0.075	0.001	ND
2,2-Dichloropropane	---	0.002	ND
2-Chlorotoluene	---	0.001	ND
4-Chlorotoluene	---	0.001	ND
Benzene	0.005	0.001	ND
Bromobenzene	---	0.002	ND
Bromomethane	---	0.002	ND
Carbon Tetrachloride	0.005	0.001	ND
Chlorobenzene	0.1	0.001	ND
Chloroethane	---	0.002	ND
Chloromethane	---	0.002	ND
cis-1,2-Dichloroethene	0.07	0.002	ND
cis-1,3-Dichloropropene	---	0.002	ND
Dibromochloropropane (DBCP)	---	0.001	ND
Dibromomethane	---	0.002	ND
Dichlorodifluoromethane	---	0.002	ND
Dichloromethane	0.005	0.002	ND
Ethylbenzene	0.7	0.001	ND
Ethylenedibromide (EDB)	---	0.001	ND
Methyl-Tert-Butyl-Ether	---	0.004	ND
Styrene	0.1	0.001	ND
Tetrachloroethene (PCE)	0.005	0.002	ND
Toluene	1	0.001	ND
Trans-1,2-Dichloroethene	0.1	0.002	ND
trans-1,3-Dichloropropene	---	0.002	ND
Trichloroethene (TCE)	0.005	0.001	ND
Trichlorofluoromethane	---	0.002	ND
Vinyl Chloride	0.002	0.001	ND
Xylene	10	0.001	ND

We certify that the analyses performed for this report are accurate, and that the laboratory tests were conducted by methods approved by the U.S. Environmental Protection Agency or variations of these EPA methods.

These test results are intended to be used for informational purposes only and may not be used for regulatory compliance.

National Testing Laboratories Ltd.

DATE COLLECTED	DATE RECEIVED	DATE COMPLETED	SAMPLE CODE
10/20/06	10/23/06	10/27/06	660962

NATIONAL TESTING LABORATORIES LTD.
6571 Wilson Mills Road
Cleveland, OH 44143
(440) 449-2525

DRINKING WATER ANALYSIS RESULTS

CUSTOMER ADDRESS

HUMBOLDT BAY WATER DIST.

DEALER ADDRESS

COLLECTOR WELLS INTL
6360 HUNTLEY RD
COLUMBUS, OH 43229-

ID: RIVER WATER
MAD RIVER

NOTE: "*" The MCL (Maximum Contaminant Level) or an established guideline has been exceeded for this contaminant.
"**" Bacteria results may be invalid due to lack of collection information or because the sample has exceeded the 30-hour holding time.
"ND" This contaminant was not detected at or above our stated detection level.
"NBS" No bacteria submitted. "NBR" No Bacteria Required.
"P" = PRESENCE "A" = ABSENCE
"EP" = E. COLI PRESENCE "EA" = E. COLI ABSENCE
"NA" Not Analyzed

Analysis Performed	MCL (mg/l)	Det. Level	Level Detected
Total coliform	P	P	NBR
Inorganic chemicals - metals:			
Aluminum	0.2	0.1	ND
Arsenic	0.010	0.005	ND
Barium	2	0.30	ND
Cadmium	0.005	0.002	ND
Calcium	---	2.0	27
Chromium	0.1	0.010	ND
Copper	1.3	0.004	ND
Iron	0.3	0.020	0.024
Lead	0.015	0.002	ND
Magnesium	---	0.10	4.3
Manganese	0.05	0.004	ND
Mercury	0.002	0.001	ND
Nickel	---	0.02	ND
Selenium	0.05	0.020	ND
Silver	0.1	0.002	ND
Sodium	---	1	4
Zinc	5	0.004	0.007
Inorganic chemicals - other, and physical factors:			
Alkalinity (Total as CaCO3)	---	20	82
Chloride	250	5.0	ND
Fluoride	4	0.5	ND
Hardness (suggested limit = 100)		10	85
Nitrate as N	10	0.5	ND
Nitrite as N	1	0.5	ND
pH (Standard Units)	6.5-8.5	---	7.9
Sulfate	250	5.0	10
Total Dissolved Solids	500	20	95
Turbidity (Turbidity Units)	1.0	0.1	0.2
Organic chemicals - trihalomethanes:			
Bromodichloromethane	---	0.002	ND
Bromoform	---	0.004	ND
Chloroform	---	0.002	ND
Dibromochloromethane	---	0.004	ND
Total THMs	0.080	0.002	ND

Analysis performed	MCL (mg/l)	Detection Level	Level Detected
1,1,1,2-Tetrachloroethane	---	0.002	ND
1,1,1-Trichloroethane	0.2	0.001	ND
1,1,2,2-Tetrachloroethane	---	0.002	ND
1,1,2-Trichloroethane	0.005	0.002	ND
1,1-Dichloroethane	---	0.002	ND
1,1-Dichloroethene	0.007	0.001	ND
1,1-Dichloropropene	---	0.002	ND
1,2,3-Trichlorobenzene	---	0.002	ND
1,2,3-Trichloropropane	---	0.002	ND
1,2,4-Trichlorobenzene	0.07	0.002	ND
1,2-Dichlorobenzene	0.6	0.001	ND
1,2-Dichloroethane	0.005	0.001	ND
1,2-Dichloropropane	0.005	0.002	ND
1,3-Dichlorobenzene	---	0.001	ND
1,3-Dichloropropane	---	0.002	ND
1,4-Dichlorobenzene	0.075	0.001	ND
2,2-Dichloropropane	---	0.002	ND
2-Chlorotoluene	---	0.001	ND
4-Chlorotoluene	---	0.001	ND
Benzene	0.005	0.001	ND
Bromobenzene	---	0.002	ND
Bromomethane	---	0.002	ND
Carbon Tetrachloride	0.005	0.001	ND
Chlorobenzene	0.1	0.001	ND
Chloroethane	---	0.002	ND
Chloromethane	---	0.002	ND
cis-1,2-Dichloroethene	0.07	0.002	ND
cis-1,3-Dichloropropene	---	0.002	ND
Dibromochloropropane (DBCP)	---	0.001	ND
Dibromomethane	---	0.002	ND
Dichlorodifluoromethane	---	0.002	ND
Dichloromethane	0.005	0.002	ND
Ethylbenzene	0.7	0.001	ND
Ethylenedibromide (EDB)	---	0.001	ND
Methyl-Tert-Butyl-Ether	---	0.004	ND
Styrene	0.1	0.001	ND
Tetrachloroethene (PCE)	0.005	0.002	ND
Toluene	1	0.001	ND
Trans-1,2-Dichloroethene	0.1	0.002	ND
trans-1,3-Dichloropropene	---	0.002	ND
Trichloroethene (TCE)	0.005	0.001	ND
Trichlorofluoromethane	---	0.002	ND
Vinyl Chloride	0.002	0.001	ND
Xylene	10	0.001	ND

We certify that the analyses performed for this report are accurate, and that the laboratory tests were conducted by methods approved by the U.S. Environmental Protection Agency or variations of these EPA methods.

These test results are intended to be used for informational purposes only and may not be used for regulatory compliance.

NORTH COAST LABORATORIES LTD.

January 03, 2007

HBMWD/Humboldt Routine
7270 West End Rd.
Arcata, CA 95521-9279

Attn:

RE:

Order No.: 0612551
Invoice No.: 63467
PO No.:
ELAP No. 1247-Expires July 2008

SAMPLE IDENTIFICATION

Fraction	Client Sample Description
01A	PS3
02A	PS4

ND = Not Detected at the Reporting Limit
Limit = Reporting Limit
All solid results are expressed on a wet-weight basis unless otherwise noted.

REPORT CERTIFIED BY

Laboratory Supervisor(s)

QA Unit

Jesse G. Chaney, Jr.
Laboratory Director

Date: 03-Jan-2007
WorkOrder: 0612551

ANALYTICAL REPORT

Client Sample ID: PS3 **Received:** 12/20/06 **Collected:** 12/20/06 9:30
Lab ID: 0612551-01A

Test Name: ICP-MS Metals **Reference:** EPA 200.8

Parameter	Result	Limit	Units	DF	Extracted	Analyzed
Lead	ND	1.0	µg/L	1.0	12/28/06	01/02/07

Client Sample ID: PS4 **Received:** 12/20/06 **Collected:** 12/20/06 10:00
Lab ID: 0612551-02A

Test Name: ICP-MS Metals **Reference:** EPA 200.8

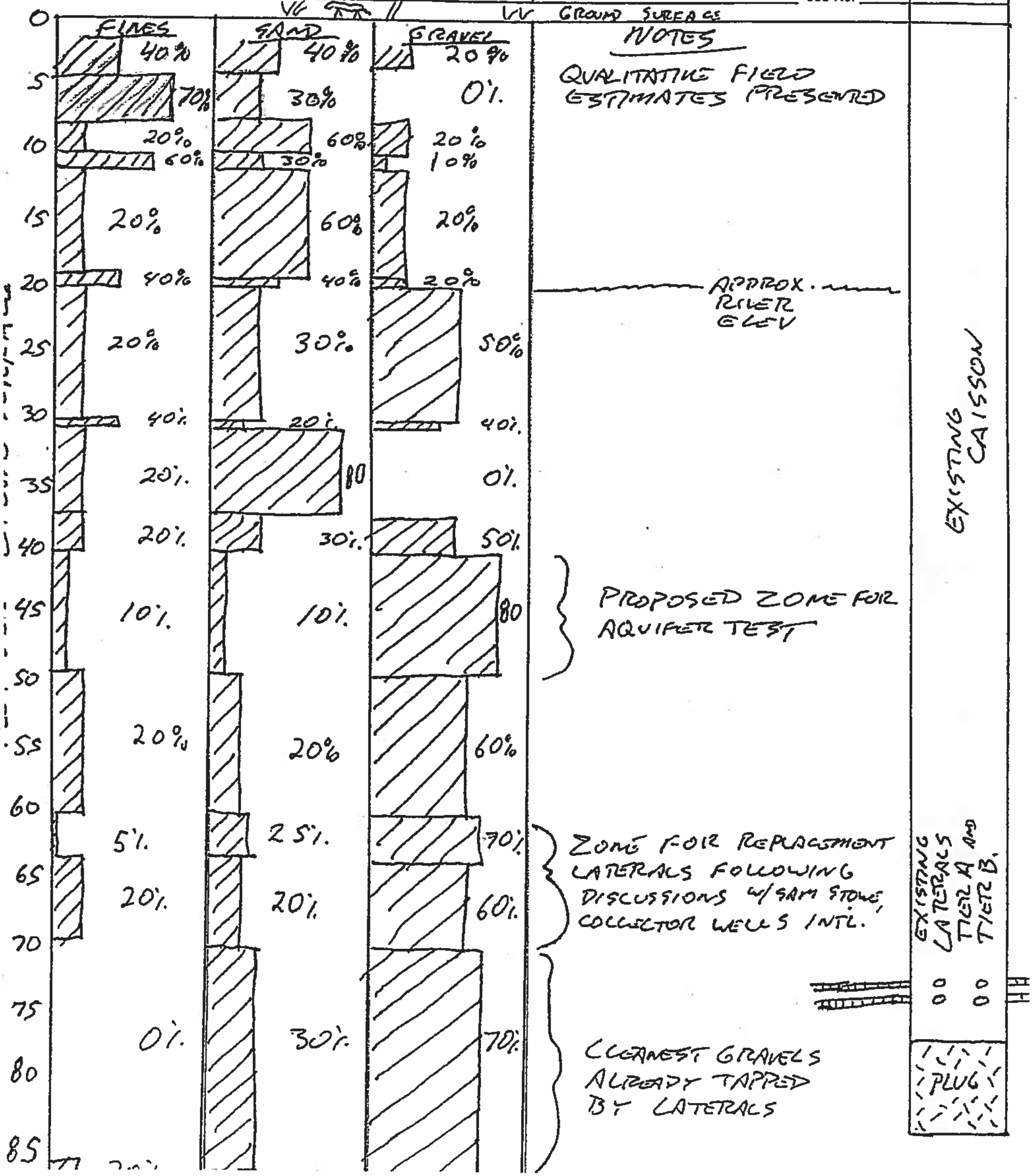
Parameter	Result	Limit	Units	DF	Extracted	Analyzed
Lead	ND	1.0	µg/L	1.0	12/28/06	01/02/07
Manganese	13	1.0	µg/L	1.0	12/28/06	01/02/07

APPENDIX I
Collector Well 3 Test Boring Data

WINZLER & KELLY
CONSULTING ENGINEERS
633 Third Street, Eureka, CA 95501-0417
(707) 443-8326 / FAX (707) 444-8330

By THIESSEN Date 4/13/06 Client HUMBOLDT BAY MUN. WATER DIST. Sheet No. ____ of ____

Subject SONIC BORING LOG @ RANNEY COLLECTOR #3 Job No. ____



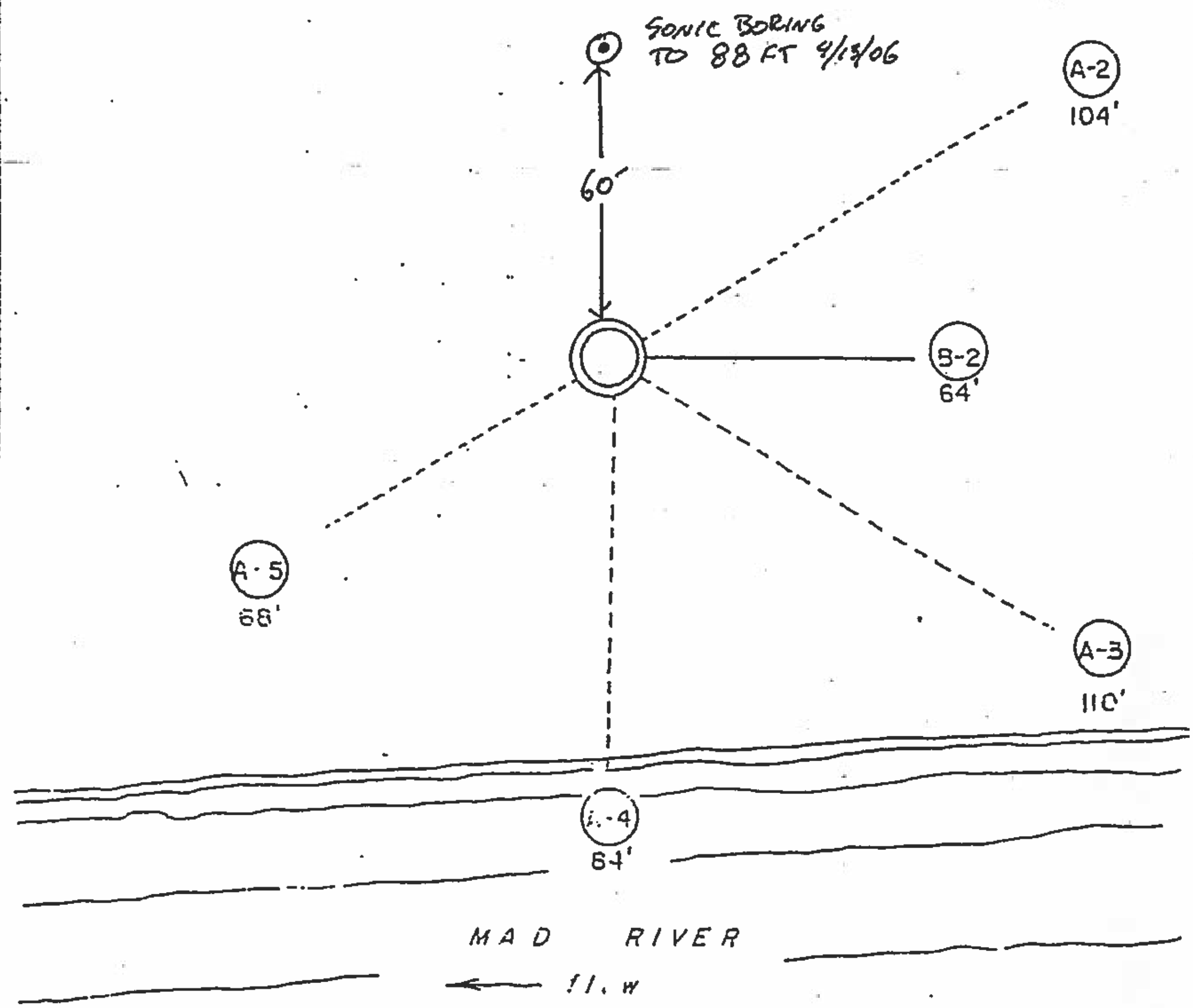
WINZLER & KELLY
CONSULTING ENGINEERS
633 Third Street, Eureka, CA 95501-0417
(707) 443-8326 / FAX (707) 444-8330

By THIES Date 4/13/6 Client NBMWD Sheet No. ______ of ______
Subject B-1 MK II BORING LOG Job No. ______

DEPTH FEET	% FINES	% SAND	% GRAVEL	TEXTURE	MOISTURE	NOTES
0-3½	40	40	20	LOOSE	DRY	BASE ROCK
3½-7½	70	30	0	PARTLY CONSOLIDATED	MOIST	OVERBANK SI
7½-9	20	60	20	LOOSE	MOIST	
9-11	60	30	10	PARTLY CONSOLIDATED	MOIST	
11-18	20	60	20	LOOSE	LOW MOISTURE	COBBLES TO 4"
18-20	40	40	20	LOOSE	MOIST	
20-30	20	30	50	LOOSE	MOIST	CLAST-SUPPORT CLASTS TO 4"
30-31	40	20	40	PARTLY CONSOLIDATED	WET	TRANSITION ZONE
31-36½	20	80	0	LOOSE TO PARTIALLY COHESIVE	WET	MINOR ORGANICS
36½-40	20	30	50	LOOSE	MOIST	
41-49	10	10	80	LOOSE	WET	
49-60	20	20	60	PARTIALLY COHESIVE	WET	MAINLY PEA GRAVEL
60-63	5	25	70	LOOSE	WET	
63-69	20	20	60	~~LOO~~ PARTLY COHESIVE	WET	
69-86	0	30	70	LOOSE	WET	PEA-2" CLEAN GRAVEL
86-88	20	20	60	LOOSE	WET	

END OF HOLE 88'

NOTE - EXISTING CAISSONS ~74 FT BGS IN CLEAN GRAVELS



LATERAL PROJECTION DIAGRAM

(Scale: 1" = 40')

Total length of laterals = 430 feet (Effective=430 feet)

—— Tier B

- - - - Tier A

ELEVATIONS

Top of caisson	- [illegible]1.00
Ground surface	+ 46.0
℄ of laterals - Tier B	- 26.9
℄ of laterals - Tier A	- 27.9
Top of plug	- 30.9
Cutting shoe	- 37.4

RANNEY METHOD
WESTERN OF CALIF., INC.
SACRAMENTO, CALIF.

BECHTEL CORPORATION
CONSULTING ENGINEERS

HUMBOLDT BAY
MUNICIPAL WATER DISTRICT

CONSTRUCTION DETAILS
COLLECTOR NO. 3

DRAWN J. S.	APPROVED [illegible]
DATE [illegible]/22/62	FIGURE: JW-17 04

Step-drawdown aquifer test from boring 60 feet north of Ranney #3, HBMWD, Essex CA. 4/14/06

Aquifer test data from 60 to 70 foot interval.
19 gallons per minute (~25% pump capacity)

Minute	DTW (ft)	Q out (gpm)	Notes
1	20.550	19	
2	20.560	19	
3	20.550	19	
4	20.560	19	
5	20.560	19	
6	20.560	19	
8	20.560	19	
10	20.570	19	
12	20.570	19	
15	20.570	19	
20	20.570	19	
25	20.570	19	
30	20.570	19	

Notes:
Depth to water data taken from top of well casing 20 inches (1.67 feet) above ground surface.

Initial static depth to water following well development = 20.35 ft 3:23 PM 4/14/06.

Aquifer test started at 3:24 PM 4/14/06.

Pump used = 3 hp borrowed from local driller (Prosonic 5 hp pump inoperable)

Water entered pump from 4" continuous slot wire well screen and gap between well screen and bottom of 8" casing. (no packer used)

Kenneth Thiessen, Geologist
Winzler & Kelly Consulting Engineers

Aquifer test data from 60 to 70 foot interval.
33 gallons per minute (~50% pump capacity)

Minute	DTW (ft)	Q out (gpm)	Notes
1	20.660	33	
2	20.780	33	
3	20.780	33	
4	20.790	33	
5	20.790	33	
6	20.790	33	
8	20.795	33	
10	20.800	33	
12	20.800	33	
15	20.790	33	
20	20.800	33	
25	20.850	33	wind starts
30	30.910	33	

Note: Depth to water data taken from top of well casing 20 inches (1.67 feet) above ground surface.

Aquifer test data from 60 to 70 foot interval.
50 gallons per minute (~75% pump capacity)

Minute	DTW (ft)	Q out (gpm)	Notes
1	21.260	50	
2	21.270	50	
3	21.280	50	
4	21.300	50	
5	21.300	50	
6	21.310	50	
8	21.330	50	
10	21.350	50	
12	21.360	50	
15	21.360	50	
20	21.380	50	
25	21.390	50	
30	21.400	50	

Note: Depth to water data taken from top of well casing 20 inches (1.67 feet) above ground surface.

Aquifer test data from 60 to 70 foot interval.
71 gallons per minute (100% pump capacity)

Minute	DTW (ft)	Q out (gpm)	Notes
1	22.080	71	
2	22.120	71	
3	22.130	71	
4	22.130	71	
5	22.140	71	
6	22.130	71	
8	22.140	71	
10	22.110	71	gusty strong winds
12	22.130	71	
15	22.140	71	
20	22.150	71	
25	22.160	71	
30	22.160	71	

Note: Depth to water data taken from top of well casing 20 inches (1.67 feet) above ground surface.

Aquifer test data from 60 to 70 foot interval.
Recovery test, pump stopped (standpipe not allowed to drain)

Minute	DTW (ft)	Q out (gpm)	Notes
1	20.710	0	
2	20.690	0	
3	20.680	0	
4	20.660	0	
5	20.640	0	
6	20.640	0	
8	20.620	0	
10	20.620	0	gusty strong winds
12	20.621	0	
15	20.615	0	
20	20.620	0	
25	20.615	0	
30	20.615	0	

Note: Depth to water data taken from top of well casing 20 inches (1.67 feet) above ground surface.

04-1055-03.010

HUMBOLDT BAY
MUNICIPAL WATER DISTRICT
GROUNDWATER MANAGEMENT ASSISTANCE ACT OF 2000
AGREEMENT NO. 4600003652
FINAL REPORT

May 2006

Prepared for:
Humboldt Bay Municipal Water District
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APPENDICES

HUMBOLDT BAY
MUNICIPAL WATER DISTRICTGROUNDWATER STUDY
FINAL REPORT

1.0 EXECUTIVE SUMMARY

The Humboldt Bay Municipal Water District (District) is located in Humboldt County and serves the Humboldt Bay region, which is the most heavily populated and developed part of Humboldt County. The District was established in 1956 to provide domestic and industrial water to various municipal agencies and industrial water users. Appendix A contains a Location and Vicinity Map of the District.

The District is contracted to provide wholesale drinking water to the cities of Eureka, Arcata and Blue Lake, McKinleyville Community Services District (CSD), Fieldbrook CSD, Humboldt CSD, and Manila CSD. In addition, the District serves a limited amount of retail customers through its filtered water system. The total current population the District serves is approximately 80,000 people.

The District currently delivers an average of approximately 12 million gallons per day (MGD) with a peak use of approximately 16.5 MGD through four Ranney collectors adjacent to the Mad River. The Ranney collectors draw water from an aquifer 100 feet below the Mad River and have a known peak sustained capacity of 17.1 MGD.

This Final Report describes, in detail, the purpose and methodology that was followed to complete the Groundwater Study that the District received the Grant for. Also included is a summary of actual costs and the schedule for completion of the study. There were no major problems that occurred in meeting the project goals and objectives. Some tasks were completed under budget allowing for the District to expand the scope in several tasks and complete additional work. All additional work was authorized by DWR staff.

The purpose of the Groundwater Study was to complete and adopt a Groundwater Monitoring Plan, install monitoring wells, build a conceptual groundwater model, research and collect data and calibrate the groundwater model so that the District can determine the long term capability of the aquifer and Ranney collectors to meet the projected long term water demands of the District. A copy of the Groundwater Study is included in Appendix A.

The following tasks were completed as a part of the work and in order to conceptually build, calibrate and run various demand, water quality and pumping scenarios with respect to the groundwater model:

1.1 Geologic/Geophysical Investigation

Background information and existing data was reviewed by a registered geologist in order to gain information regarding the existing aquifer. A seismic refraction survey was completed to measure the thickness, depth and configuration of seismic (geologic) layers of the limits of the defined aquifer under study. The information was used in aiding the development of the conceptual groundwater model. NORCAL Geophysical Consultants completed the seismic refraction study and their report is included with the Groundwater Study in Appendix A.

1.2 Monitoring Wells Installation

Four 100-foot deep groundwater modeling wells were installed adjacent to and between the District's Ranney collectors as a part of the original workplan for the Groundwater Study. The depth of the monitoring wells was based on the depth of the existing lateral well screens in the aquifer. The four wells were installed between the District's Collectors designated Pump Station No.1 and Pump Station No. 2. The Ranney collectors were also be used to gather depth to groundwater and drawdown levels during various pumping scenarios that aided in model calibration. The wells were drilled with an air rotary drill and were developed by surging and pumping. A registered geologist was onsite to log the borings during well construction.

Based on lower than budgeted costs for installing the four monitoring wells the District was able to have a fifth well installed and an additional boring completed to gain further aquifer data near the District's Pump Station No.3. The additional work was approved by Department of Water Resources staff.

1.3 Groundwater Modeling

A MODFLOW-based hydrologic modeling system, MODFLOW-SURFACT, was used for development of the groundwater model. A complete description of the model and efforts associated with the groundwater modeling including results are contained in Appendix A.

1.4 CEQA Compliance/Permitting

Activities requiring CEQA compliance and/or permits were the drilling and installation of the monitoring wells. A Categorical Exemption was completed and Notice of exemption filed on behalf of the District for these efforts. Consultation with the Army Corps of Engineers, Fish & Game, and National Marine Fisheries Service was completed for permitting of drilling of monitoring wells located in the riverbed.

1.5 Public Meetings

Throughout the development of the groundwater model and associated tasks, public meetings were held every several months at regularly scheduled District Board meetings in order to update the District, public, and interested parties on the status of the project. Public input was considered and included in the study. In addition, preliminary findings of activities as they developed were discussed at quarterly meetings with the District's municipal customers. Upon completion of the study a final public meeting was held at a regularly scheduled District Board meeting to present the results of the study.

1.6 Groundwater Management Plan

A GWMP was completed and adopted as a part of the study. The Humboldt Bay Municipal Water District (District) had not completed or adopted a Groundwater Management Plan (GWMP) prior to obtaining the grant from DWR. Completion of the GWMP was a requirement of obtaining the Grant. As required by the California Water Code Section 10753 the District followed the specified steps to notice and adopt the GWMP. A properly noticed public hearing was held to discuss the proposed GWMP. During the hearing a resolution of intention to adopt a GWMP was passed. Subsequent to the hearing draft goals and the purpose of the GWMP were developed. Section 10753.3 requires a publishing of the Resolution of Intention to adopt a Groundwater Management Plan. The resolution of intention to adopt the GWMP was not published as required. Subsequent to the hearing there were at least four public meetings where the GWMP was discussed and presented to the public and District Board of Directors. There was not one public comment against the GWMP. In addition, the purpose and goals of the GWMP were presented to the seven municipalities and the stakeholders at regularly scheduled meetings held quarterly with representatives from each of the municipalities to discuss the purpose and goals of the GWMP. Following completion of the draft plan the GWMP was publicly noticed and presented to the Board at the December 2005 District Board Meeting after which it was formally adopted with the passing of a Resolution to Adopt the GWMP in accordance with procedures set forth in California Water Code Section 10753. Based on a lack of interest for and no objections to the GWMP, DWR has concluded that the lack of posting of the resolution of intention to adopt the GWMP should not be a reason to repost and readopt the GWMP.

Current and historical information regarding the groundwater basin was reviewed during development of the GWMP through the tasks outlined in the proposal. The GWMP includes the following suggested and required elements:

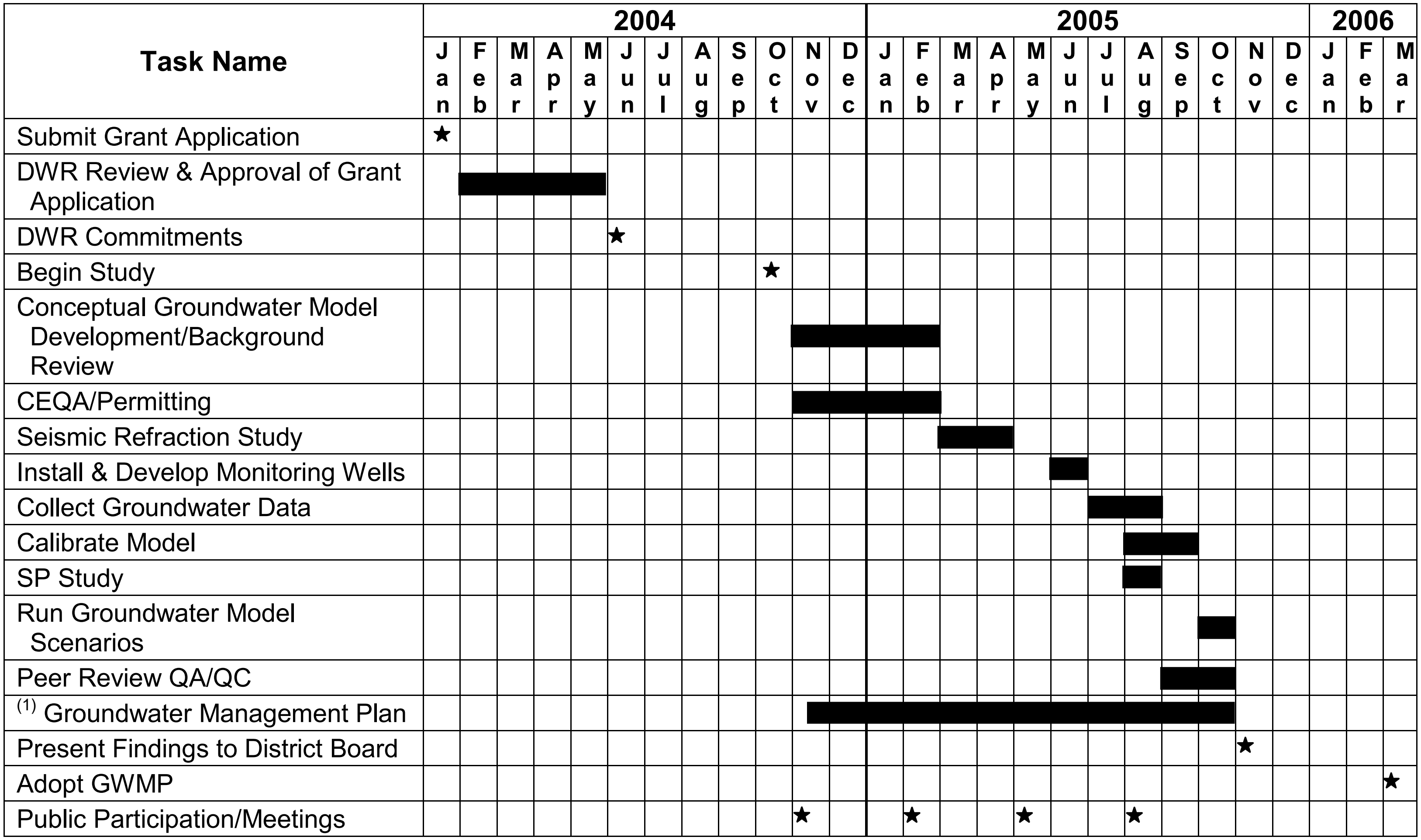
1. A written statement documenting that the public was informed as to the nature in which interested parties may participate in the development of the GWMP.
2. Basin management objectives.
3. Methods for monitoring and the management of groundwater levels, water quality, changes in surface water flow and quality that directly affects the groundwater levels or quality.
4. A plan to involve other agencies whose service boundary overlies the groundwater basin.
5. Adoption of monitoring protocols.
6. A map showing the area of the groundwater basin.

A complete copy of the Groundwater Management Plan developed for the Humboldt Bay Municipal Water District is included in Appendix B.

1.7 Schedule

The proposed schedule for project completion as submitted with the Grant Application and the actual project schedule are included with this summary.

HUMBOLDT BAY MUNICIPAL WATER DISTRICT
LOCAL GROUNDWATER ASSISTANCE GRANT
GROUNDWATER STUDY SCHEDULE



(1) Refer to Section B-1.2 for a detailed schedule for completion of the GWMP.

HUMBOLDT BAY MUNICIPAL WATER DISTRICT
LOCAL GROUNDWATER ASSISTANCE GRANT
ACTUAL GROUNDWATER STUDY SCHEDULE

Task Name	2004												2005												2006				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Submit Grant Application	★																												
DWR Review & Approval of Grant Application		■	■	■	■																								
DWR Commitments						★																							
Begin Study										★																			
Conceptual Groundwater Model Development/Background Review													■	■	■	■													
CEQA/Permitting										■	■	■	■																
Seismic Refraction Study												■	■																
Install & Develop Monitoring Wells														■	■													■	
Collect Groundwater Data																			■	■									
Calibrate Model																					■	■	■	■					
Run Groundwater Model Scenarios																								■	■	■			
Peer Review QA/QC																					■	■	■	■	■	■			
Groundwater Management Plan											■	■	■	■	■	■	■	■	■	■	■	■							
Present Findings to District Board											★			★			★			★			★						
Adopt GWMP																								★					
Public Participation/Meetings											★			★			★			★			★						
Finalize Study																											■	■	

1.8 Budget Information

The following table summarizes the project expenses as budgeted and included in the Grant Agreement between the Department of Water Resources and the Humboldt Bay Municipal Water District and as actually expended throughout the project. Budget changes were made as actual costs for subcontractors and expenses were finalized based on approvals by DWR. Additional monitoring wells were installed near the District's Pump Station 3 due to funds made available as tasks were completed under budget. The project was completed on budget.

		Original Cost Estimate	Actual Cost
Task 1	Geologic/Geophysical Investigation	$49,640	$25,194
Task 2	Monitoring Well Installation	$62,420	$70,691.27
Task 3	Groundwater Modeling	$70,440	$82,917.65
Task 4	CEQA Compliance/Permitting	$12,230	$12,230
Task 5	Public Meetings/Presentation	$24,500	$21,197.08
Task 6	Groundwater Management Plan	$28,540	$35,540
TOTAL		$247,770	$247,770

Appendix A Final Report
Groundwater Study

Appendix B Final Report
Groundwater Management Plan

01055-05015-11015

PUMP STATION 2 EVALUATION
FINAL REPORT

June 2006

Prepared for:
Humboldt Bay Municipal
Water District
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Prepared by:

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PUMP STATION 2 EVALUATION FINAL REPORT

1.0 INTRODUCTION

1.1 Purpose

The evaluation of Pump Station 2 began in 2002 and initially began as a Feasibility Study to:

1. Identify and contact agencies which have had rehabilitation of existing laterals, or have installed new laterals on Ranney Collectors to determine what their experience was and how the collector performed before and after restoration work was completed.
2. Based on the findings in Reynolds, Inc. report "Inspection and Pump Test of Ranney Well No. 2 (PS2), February 2003" and the information obtained for activity 1 (above), evaluate and provide a summary of long-term supply alternatives (e.g., rehabilitate or replace Ranney laterals vs. other supply alternatives).
3. Provide a brief summary of the permit and other regulatory requirements for the various options.

Following completion of the Feasibility Study and with the information developed as a part of the study, it was determined and approved by the Humboldt Bay Municipal Water District Board of Directors to undertake a project to clean the laterals in Pump Station 2 (PS2). The purpose of cleaning the laterals was to gain a true understanding of the condition of the laterals, to determine if cleaning the laterals is a worthwhile investment to maintain the laterals in their present condition and potentially increase production and efficiency of the collectors. The project was bid and completed by Collector Wells International in the summer of 2005. The purpose of this final report is to finalize the evaluation of PS2 by completing the following tasks:

1. Evaluate and quantify the potential for energy savings due to the increase in efficiency from decreased drawdown in PS2 as a result of the lateral cleaning and redevelopment.
2. Evaluate the increase in production due to the increase in efficiency from the lateral cleaning and redevelopment.
3. Evaluate the economic feasibility and quantify the potential for increased production and energy savings by installing new pumps in PS 2 using the data provided by the FLOWSERVE Engineering Study.
4. Summarize the activities completed to date associated with the various stages of the rehabilitation of PS2.
5. Establish recommendations on the next steps the District should take based on the results of the evaluation and work completed to date.

1.2 PS2 Background

1.2.1 Well Description

The PS2 Ranney Collector Well was constructed by the Ranney Method Western Corporation in 1962 and is located on the south bank of the Mad River in Arcata, California. The collector is constructed of a 13-foot inside by16-foot outside diameter reinforced concrete caisson that is sunk to a depth of 102 feet in the Mad River Bed. The caisson extends 18 feet above ground and is completed with a pump house. The collector has two 350 hp Worthington vertical turbine pumps that are installed in the central caisson.

The collector has a series of eight lateral well screens that are projected horizontally from the caisson in two tiers. The B-tier laterals and A-tier laterals are positioned at elevations of 83 feet and 93 feet below ground surface, respectively. The eight laterals vary in length from 16 to 137 feet and have a total length of 602 feet.

The laterals are constructed of 12-inch outside diameter punch-slotted steel well screen. The slots are rectangular in shape and the slot size is 3/8-inch by 1-1/16-inch. The well screens had a calculated open area of 18.6% (Ranney Method Western Corporation, 1962) at the time of installation.

1.2.2 Well Performance

Pumping test data collected in 1962 at the time of construction indicated that PS2's specific capacity was 225 gallons per minute per foot of drawdown (Ranney Method Western Corporation, 1962). Recent pumping tests performed in 2002 during an inspection by Reynolds, Inc., an Ohio based water resource construction company, indicated that the specific capacity of PS2 was 227 gpm/ft. The accuracy of the Reynolds, Inc. pumping test data is questionable because the water pumped during the test was discharged on the river gravels near the well. This situation likely resulted in an inaccurately high specific capacity measurement because the pumped water likely recharged the aquifer during the test.

1.3 Summary of Project Activities

Project activities completed to date include a Feasibility Study to evaluate options for rehabilitating the District's Ranney Collectors. A copy of the Feasibility Study is included in Appendix A. Following the completion of the Feasibility Study, the Board of Directors approved a project to clean the laterals of Pump Station 2. The maintenance project was completed during the summer of 2005 by Collector Wells International, a Columbus Ohio based firm that specializes in the design, construction, and rehabilitation of water supply systems. Following the completion of the cleaning and redevelopment of PS2, the HBMWD Board of Directors authorized the completion of this Final Report to summarize the activities to date and make a recommendation for further rehabilitation based on the work completed to date.

2.0 FEASIBILITY STUDY

2.1 Summary

A Feasibility Study for rehabilitating the Ranney Collectors was prepared for HBMWD by Winzler & Kelly. The Feasibility Study identified several agencies that had rehabilitation work completed on their Ranney Collectors in order to gather information regarding the experiences of these agencies and the effectiveness of various rehabilitation activities. In addition, the Feasibility Study evaluated and provided a summary of long-term supply alternatives for the continued use of the Ranney Wells based on the findings in the Reynolds, Inc. report and the information gathered from the agencies that had rehabilitation work performed. A brief summary of the permit and other regulatory requirements for the various rehabilitation options was included in the study.

The Feasibility Study included findings of inquiries made with eleven water suppliers who had recent rehabilitation work performed on their Ranney Collector wells. The rehabilitation work performed on the wells included cleaning and rehabilitation of well caissons and laterals, installation of new laterals, and construction of new collector wells. In addition, three companies that provide collector well cleaning and rehabilitation services were identified and reviewed. The companies were Reynolds, Inc., Collector Wells International, and LiquiVision Technology.

Several alternatives were identified to rehabilitate, repair, or upgrade the existing Ranney Collectors and laterals. The alternatives may result in increased efficiency and collector life and should allow the continued use of the existing wells and related infrastructure. A complete copy of the Feasibility Study is included in Appendix A.

2.2 Recommendations

A step-by-step approach to rehabilitating the collectors was recommended to allow for their continued operation over the next 40 to 50 years. The following steps were recommended:

1. Develop a project to clean and rehabilitate PS2, and put the project out to bid with the requirement that the company performing the work has the capability to install new laterals.
2. Following the completion of item 1, video inspect all of the laterals in the collector network to catalogue the condition of the laterals.
3. Clean and rehabilitate the remaining collectors based on the results of the video inspections, existing condition of the collectors and results from the rehabilitation of PS2.
4. Install new laterals in the near future following a condition survey and cleaning as outlined above.

The above approach was designed to give the District a clear understanding of the condition of PS2 and a good indicator of the conditions of the remaining collectors due to similar installation conditions. A need for the District to begin a program to install new laterals to extend the life of the collectors should be established because the existing laterals cannot be expected to last another 40 years.

Reported base costs based on contacts with various water suppliers and estimates of cost from Collector Wells International established the costs for the cleaning rehabilitation as approximately $120,000 to $180,000 per collector.

3.0 PS2 REHABILITATION

3.1 Introduction

Following completion of the Feasibility Study, it was determined and approved by the District's Board of Directors to undertake a project to clean and redevelop the PS2 laterals. The PS2 cleaning and redevelopment was completed in part to provide an understanding of the condition of the Ranney Collectors which could be used to develop a plan to rehabilitate the District's Ranney Collectors which serve as the foundation of the District's domestic water supply.

3.2 Project Activities

Collector Wells International conducted a 21-hour constant-rate pumping test of PS2 using the existing well pumps to determine the well's specific capacity prior to rehabilitation. The well's pre-maintenance specific capacity was measured to both document changes in the well's performance since its construction and to quantify any improvements in the wells performance resulting from the redevelopment.

Redevelopment of the lateral well screens was carried out following the pre-maintenance pumping test. A diver was sent into the caisson to conduct pre-maintenance testing activities. Collector Wells International determined during this time that the eight existing lateral gate valves were inoperable. The gate valves were replaced along with the removal of a deteriorated ladder that had been installed inside the caisson.

Blind flanges were installed on the gate valves and the caisson was dewatered and prepared for cleaning. Each of the accessible portions of the well's lateral lines was individually redeveloped using a rotating water jet system. The jetting was carried out at a slow uniform rate using a nozzle pressure of 2,500 to 2,900 psi. Lateral redevelopment was continued until a specified level of turbidity was reached. The cleaned length of each lateral was measured.

When the cleaning and redevelopment activities were complete, the accessible lengths of selected laterals were video inspected using a remote-controlled camera. The condition of the laterals was observed and catalogued. Following the video inspection, a 24-hour post-maintenance constant-rate pumping test was performed. A copy of the videos is included with this report in Appendix B.

The actual cost to clean PS2 was approximately $303,000. Site specific construction issues related to discharge of the water used during the cleaning operations caused the project to cost approximately $50,000 more than a similar project may cost at another site. Specifically all the waste water from the operation was routed to a constructed percolation pond and a new pipeline that was 2100 feet long was constructed to route the discharge from the pump testing to Pump Station 6. In addition, all of the gate valves on the laterals inside the caisson were replaced at a cost of $51,000.

3.3 Rehabilitation Results

3.3.1 Lateral Well Screen Structural Condition

Video inspection showed that the redevelopment activities were successful in removing bacterial and mineral deposits from the well screens. In general, PS2's lateral well screens generally appear structurally sound. However, several of the laterals have structural problems which were identified during the video inspection. Structural problems include blocked laterals, collapsed laterals, enlarged slot openings, separated joints between screen sections, circumferential cracks, screen breaks, and screen and separations. A summary of findings and a description of the structural condition of each lateral can be found in *Maintenance Report Collector Well Pumping Station No.2*, Collector Wells International, Inc., October 2005.

Several of PS2's laterals are severely deflected because they were not projected horizontally during the well's construction. Portions of these laterals were inaccessible for cleaning due to deflections in the screen and the presence of broken sandlines. Sandlines were used during construction to remove gravels from in front of the laterals as they were jacked into the aquifer formation. The sandlines were placed inside the well screen during construction and normally removed once the lateral was installed. It was decided not to attempt to remove the broken sandlines from laterals A-2 through A-5 because the level of deflection in the laterals was too great to successfully remove them.

The presence of sandlines in also prevented redevelopment of these laterals beyond the location of the broken end of the sandline. A total of 296 feet of the wells laterals were cleaned. A summary of the percentage cleaned for each of the eight individual laterals can be found in *Maintenance Report Collector Well Pumping Station No.2*, Collector Wells International, Inc., October 2005.

3.3.2 Lateral Well Screen Flow Analysis

The total effective lateral length for PS2 was determined to be no more than 469 feet. Using a percentage open area of the screen of 18.6%, the average slot velocity would be 2.0 feet per minute (fpm) at a pumping rate of 4,200 gpm. At the well's estimated maximum yield of 6,340 gpm, the average slot velocity would be 3.1 fpm.

The total length of the A-tier and B-tier laterals is 229 feet and 357 feet, respectively. Prior to the maintenance, approximately 75% of the collector's production was evenly distributed between the three upper B-tier laterals, with each lateral producing about 1000 gpm during the pumping test. The lower A-tier laterals A2 – A4 were producing 131, 609, and 283 gpm. Laterals A5 – A6 were determined to be not producing during the pre-maintenance pumping test.

Post-maintenance lateral flow analysis indicated significant improvement and more even distribution in the flow characteristics, particularly for the lower A-tier laterals. Production measurements from the post-maintenance pumping test indicated that laterals A2 – A4 were producing 279, 389, and 1,108 gpm. Production in lateral A5, which had been previously not producing, increased to 384 gpm.

The post-maintenance flow characteristics indicated a better balance of flow amongst the collector's eight laterals with 48.5% of the total production coming from the B-tier and 51.5% coming from the A-tier. The post maintenance distribution of lateral production has the benefit of decreasing the slot velocities of the B-tier laterals resulting in both increased lateral well screen life and overall collector efficiency. A summary of lateral flow characteristics during the pre-and post-maintenance pumping tests can be found in *Maintenance Report Collector Well Pumping Station No.2*, Collector Wells International, Inc., October 2005.

3.3.3 Collector Performance

The collector's observed specific capacity increased as a result of the maintenance from a pre-maintenance measurement of 168 gpm/ft to a post-maintenance measurement of 189 gpm/ft, a 13% increase. The post-maintenance drawdown differential based on water levels in the PS2

Observation Well was about 3.6 ft/1000 gpm. This corresponds with a decrease in drawdown differential of about 12% as a result of the maintenance.

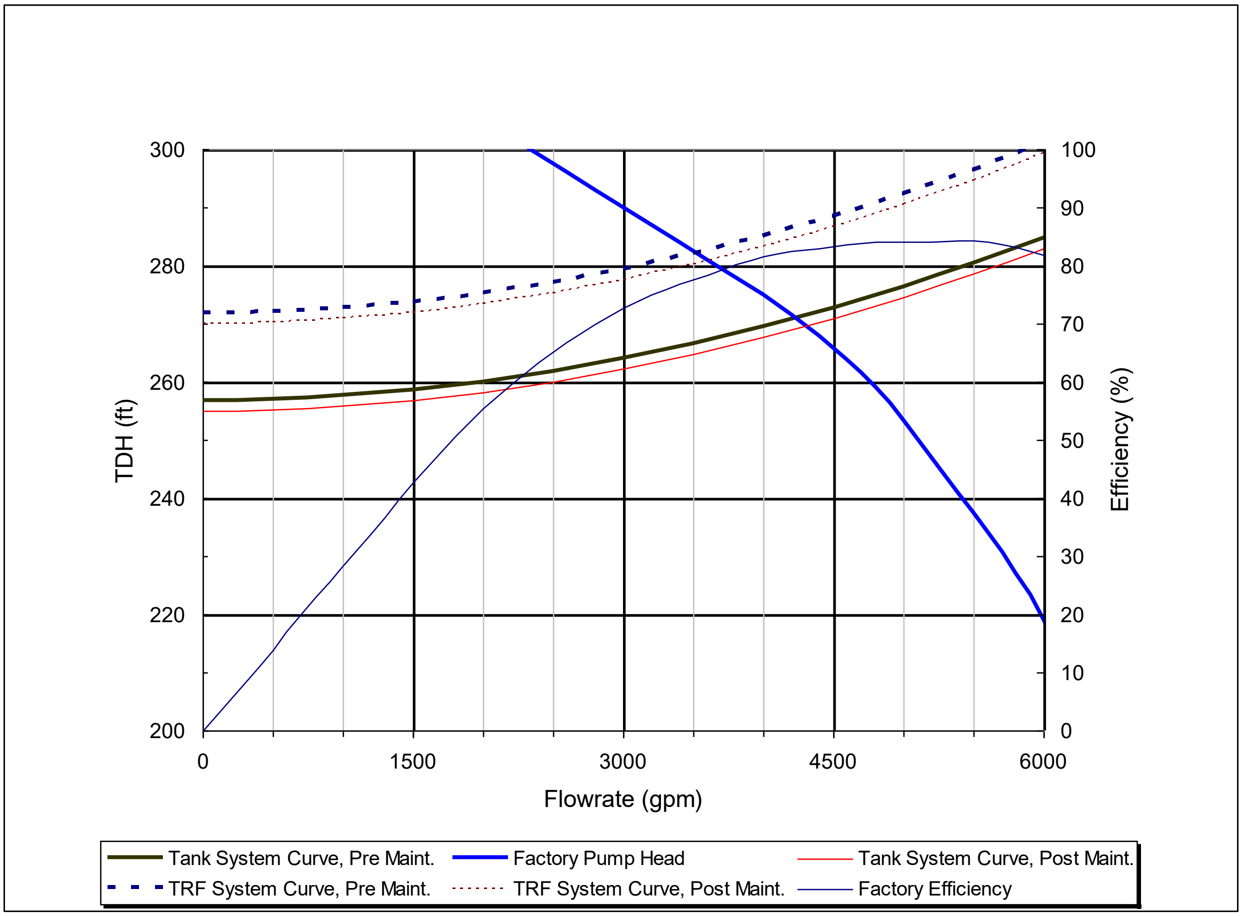
4.0 PS2 EFFICIENCY AND PRODUCTION ANALYSIS

4.1 Introduction

A pumping system hydraulic analysis was performed for PS2 in order to quantify potential energy savings resulting from the increase in well efficiency. Separate system head curves were developed for PS2 based on the pre-and post-maintenance pumping level measurements. The 1.8 foot decrease in static lift measured during the post-maintenance pumping results in a minor decrease in energy costs for pumping to the Korblex reservoir. The hydraulic analysis was completed based on PS2 operating independently of any other pump station.

In order to determine Pump 2.1 and 2.2's operating points in the piping system, the pump head-capacity curve was superimposed on the system head curve. The point of intersection of the two curves is the pump operating point. The pump operating point should ideally be at or near the maximum efficiency of the pump. Figure 1 illustrates the operating points for the system with two levels of static lift for pre-and post-maintenance.

Figure 1. Pump Station 2 System and Pump Head Curves



Pumps 2.1 and 2.2 have experienced some loss in performance due to the effect of pump wear on capacity as is expected for centrifugal pumps. The loss of performance has resulted in the pump head-capacity curve falling and the path of the operating point being extended further left along the pump curve, no longer fitting the efficiency curve well.

4.2 Energy Usage Analysis

4.2.1 Summertime Pre-and Post-Maintenance Comparative Operational Costs

Energy costs for pre-and post-maintenance operation of PS2 pumps 2.1 and 2.2 are given in Tables 4.1 and 4.2 based on an assumed power cost of $0.09/kW-hr for comparison purposes. The power cost used for our analysis is based on average costs from the PG&E rate schedule E-20 used as a basis for electrical power charges to the District. The calculated pre-and post-maintenance pumping cost savings is given in Table 4.3. The rehabilitation resulted in a minimal pumping cost decrease.

Table 4.1. Computation of Power Cost for Pre-Maintenance Operation

Pump	Total head ft	Discharge gal/min	Total pump kW	Specific energy kW-hr/MG	Power Rate cost/kW-hr	Power cost/hr	Power cost/MG
2.1	261.3	3609	261.9	1209.5	$0.09	$23.57	$108.85
2.2	264.7	3583	280.1	1303.0	$0.09	$25.21	$117.27

Table 4.2. Computation of Power Cost for Post-Maintenance Operation

Pump	Total head ft	Discharge gal/min	Total pump kW	Specific energy kW-hr/MG	Power Rate cost/kW-hr	Power cost/hr	Power cost/MG
2.1	259.5	3609	260.1	1201.2	$0.09	$23.41	$108.10
2.2	262.9	3583	278.2	1294.2	$0.09	$25.04	$116.47

Table 4.3. Post Maintenance Power Cost Savings

Pump	Savings/hr	Savings/MG	Savings/Yr
2.1	$0.16	$0.75	$869.08
2.2	$0.17	$0.80	$924.26

4.3 Efficiency Analysis

The efficiency of PS2 was slightly improved as a result of the maintenance. The cleaning of the well screens and redevelopment of the aquifer in the immediate vicinity of the screens produced a reduction in headloss for water entering the collector. The improved efficiency resulted in a decrease in observed drawdown of 1.8 feet. A payback analysis using the power cost savings to offset the capital cost of the well maintenance indicates that the rehabilitation through cleaning of the laterals is not cost effective from an economic standpoint. Energy cost savings due to cleaning are estimated at less than $1,000/year. The number of years for the power cost savings to offset the capital cost of the maintenance exceeds the useful life of the well.

4.4 Analysis of Pump Replacement

4.1.1 Description

Our analysis contained herein is based on our engineering analysis and information contained in the Flowserve Performance and Vibration Evaluation Report dated April 2005. The specific pump recommendations are based on hydraulics of the system with only PS2 operating and average power costs. We recommend discussing the required flows from PS2 and operational procedures further and refining the recommendation prior to finalization of pump selection. In addition, as stated in the Collector Wells International Maintenance Report on PS2, higher yields can be expected from PS2. To obtain higher yields new larger pumps would need to be installed in PS2.

Pumps are ideally operated near their best efficiency point. Pump wear and the associated loss in performance has resulted in a decrease in pump efficiency for both of PS2's vertical turbine pumps. Pumps 2.1 and 2.2 operate at 9.2% and 7.9% below their initial factory curves (Flowserve Performance and Vibration Evaluation, 2005). Pumps 2.1 and 2.2 both operate to the left of their best efficiency point. Field measurements taken for pumps 2.1 and 2.2 indicate that the pumps are operating at efficiencies of 73.7% and 69.3%. These efficiencies are well below the 81.0% design operating point efficiency and 84.5% pump peak efficiency.

This section evaluates two potential alternatives that the HBMWD has for replacing PS2's pumps with new pumps and premium efficiency motors in order to raise the overall efficiency of the pumping station and reduce power costs.

4.1.2 Install New Similar Capacity Pumps

PS2 pumps 2.1 and 2.2 could be replaced by new vertical turbine pumps of the same 4000 gpm (5.8 MGD) capacity as the existing Worthington 24M pumps. Energy costs could be reduced and the overall efficiency of PS2 could be increased by replacing pumps 2.1 and 2.2 with new pumps that operate near their peak efficiencies. In addition, we recommend that the pumps be specified with premium high efficiency motors that have efficiencies in the range of 94 to 96%. Figure 1 illustrates the Flowserve 17EPH pump head-capacity curve superimposed on the system head curve for PS2. The bowl efficiency at pump operating point is 84.5%, near the maximum efficiency of the pump.

An estimate of energy cost savings based on initial pump selections made for new Flowserve 17EPH 4000 gpm capacity pumps operating near their peak efficiency are given in Table 4.4. The capital cost for installing these pumps is approximately $226,600. Costs are based on the District purchasing the pumps with installation by a Contractor or pump supplier. The following is a breakdown of the pump cost:

460V 350 Hp Premium Efficient Motor	$24,800
Pump Bowl Assembly and Discharge Head	$24,000
Discharge Column (93 ft @ $300/ft)	$27,900
Freight	$1000
Installation	$30,000
Tax	$5,600
	$113,300 per pump

Figure 2. Flowserve 17EPH Pump and System Head Curves

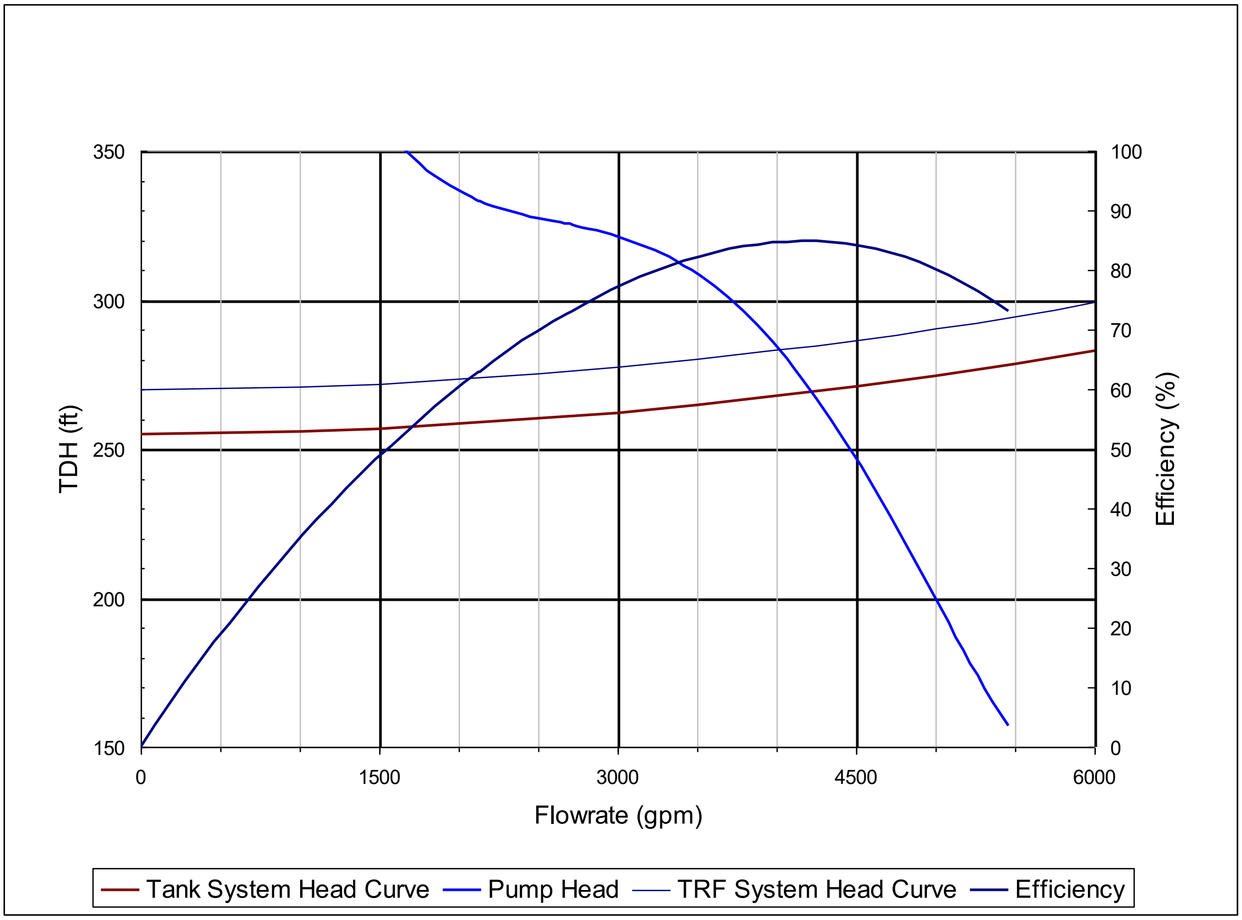


Table 4.4 Comparison of Power Cost for New Pumps versus Pump 2.1

Pump	Total head ft	Discharge gal/min	Total pump kW	Specific energy kW-hr/MG	Power Rate cost/kW-hr	Power cost/hr	Power cost/MG
17EPH	269.0	4200	269.1	1067.9	$0.09	$24.22	$96.11
20ENH	284.5	6150	402.4	1090.6	$0.09	$36.22	$98.15
2.1	261.3	3609	261.9	1209.5	$0.09	$23.57	$108.85

The required volume pumped to offset the capital cost of the new pumps would be 17,787 MG. Using an average PS2 pumped volume of 1,159 MG/year, the power cost savings would offset the capital cost of the new pumps in approximately 15.4 years based on the costs shown above.

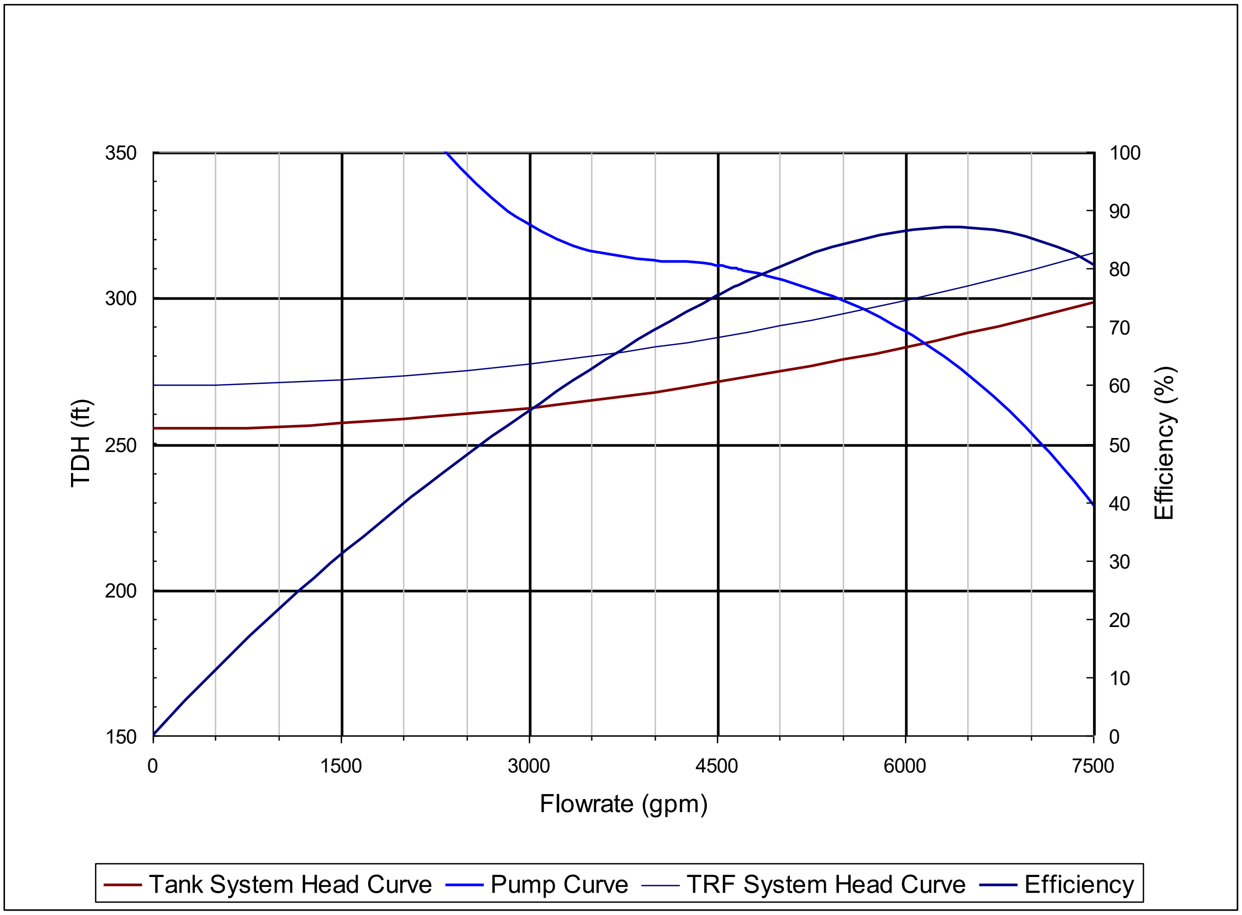
4.1.3 Install New Higher Capacity Pumps

The Maintenance Report prepared for PS2 by Collector Wells International indicated potential summertime yields of 5,900 gpm (8.5 MGD) based on their analysis of the aquifer and the pumping test data. Power costs could be decreased and production increased by installing new 5,900 gpm pumps that would operate near their peak efficiencies and use premium high efficiency motors. Figure 2 illustrates the Flowserve 20ENH pump head-capacity curve superimposed on the system head curve for PS2. The bowl efficiency at pump operating point is 85.8%, near the maximum efficiency of the pump. The capital cost for installing these pumps is approximately \$273,400. Additional costs may be required for electrical upgrade at the pump station. These costs are not included or evaluated for this report. The following is a breakdown of the pump cost:

460V 600 Hp Premium Efficient Motor	\$41,400
Pump Bowl Assembly and Discharge Head	\$24,000
Discharge Column (95 ft @ \$300/ft)	\$28,500
Freight	\$1000
Installation	\$40,000
Tax	\$6,800
	\$131,700 per pump

Energy cost savings per million gallons based on initial pump selections made for new 5,900 gpm pumps are given in Table 4.4.

Figure 3. Flowserve 20ENH Pump and System Head Curves



The required volume pumped to offset the capital cost is 24,611 MG. Using an average PS2 pumped volume of 1,159 MG/year, the power cost savings would offset the capital cost of the new pumps in approximately 21.2 years based on the costs shown above.

5.0 CONCLUSIONS AND RECOMMENDATIONS

As discussed in the Ranney Collectors Rehabilitation Study the long term use, condition and maintenance of the Ranney Collectors is of significant importance to the operations of the District. It has been acknowledged that due to the potential cost to install a new collector, rehabilitation of the existing collectors makes the most sense economically for providing water supply to the District's customers.

The rehabilitation completed in the summer of 2005 by Collector Wells International provided valuable information on the condition of PS2. The information developed from the work completed by Collector Wells International is invaluable in helping the District make a decision on the next steps to take in planning for the future of the Districts Ranney Collectors. Although there are some structural deficiencies in the laterals, it is our opinion that the laterals are not at risk of catastrophic failure, giving the District some time to plan for the next step in the rehabilitation of the Ranney Collectors. The following is a summary and conclusion of issues established to date based on the work regarding PS2:

1. Cleaning of the laterals provided valuable information regarding the condition of the laterals in PS2. As discussed in the Maintenance Report of PS2 by Collector Wells International, Inc. the cleaning increased the specific capacity of the well by 13% with a decrease in drawdown of approximately 1.8 feet. The economic result of the decrease in drawdown as calculated in this report, translates to a savings to the District of less than $1000/yr. based on current average power rates. Based on economics we do not recommend cleaning of the Ranney Collectors laterals to rehabilitate the remaining pump stations.

2. Production increases due to cleaning appear to be minimal in PS2. As discussed in the Maintenance Report of PS2 by Collector Wells International, Inc. if the District needs to increase production from PS2 or other Ranney Collectors new laterals should be installed. New laterals will increase the total screen open area and reduce entrance velocity that translates to less potential for turbidity in the well.

3. The pumps currently in place in PS2 are operating below there original efficiency as is expected. As pumps age they gradually lose efficiency due to wear on the rotating parts which translates to higher power costs to pump an equivalent volume of water. The analysis provided by Flowserve in April, 2005 shows that the pumps in PS2 have worn and should be overhauled and/or replaced with a higher efficiency pump. Our analysis herein shows that a pump could be specified that will operate more efficiently and save dollars due to more efficient pumping. However, we do recommend taking a closer look at the hydraulics as they relate to operations. Our analysis focused on PS2 operating independently of the other Ranney Collectors. Costs were calculated as average pumping costs to the Korblex reservoir. We estimate that replacement costs would be paid back in approximately 15 years based on current average power costs.

4. Economics are not the only driving factor in the decision to purchase or overhaul the pumps. Operational considerations are necessary in determining when to replace or overhaul the pumps. The District has to deliver water to customers and it is necessary to have redundancy in each Ranney Well and throughout all of the Pump Stations in the event one is not operational for a period of time.

As a result of this report, work completed to date, the Flowserve Performance report and Collector Well International, Incs. Report of Maintenance of PS2 we recommend the following:

1. Inspect and videotape the remaining Ranney Wells and laterals in the District's system to catalogue the current condition of the Collectors.

2. Plan for and begin pump replacement and/or overhauling of the pumps in the Ranney Wells.

3. Installation of new laterals will provide for added operational life to the system and may also allow for an increase in production if system demands increase in the future. Begin to plan for installation of new laterals in the Ranney Wells. We recommend choosing one of the Ranney Wells and begin exploratory borings to get accurate aquifer data in order to determine the best place to install new laterals. Specify and bid the installation of new laterals. As discussed in the Maintenance Report of PS2 by Collector Wells International. Inc., production could be increased with the addition of laterals to the Collector. We recommend increasing production, if deemed necessary, by replacing existing pumps with new more energy efficient pumps as discussed in this report in conjunction with the installation of new laterals. Pump replacement should begin after additional laterals are installed and the Ranney Well(s) can be evaluated for efficiency and expected hydraulic capacity.

Appendix A
Ranney Collector Rehabilitation Feasibility Report

Appendix B
Pump Station 2 Laterals
Post Maintenance Videos

01055-07003-11025

HUMBOLDT BAY MUNICIPAL WATER DISTRICT
RANNEY COLLECTOR FINAL EVALUATION REPORT

June 2008

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HUMBOLDT BAY MUNICIPAL WATER DISTRICT
RANNEY COLLECTOR FINAL EVALUATION REPORT

1.0 INTRODUCTION

The Humboldt Bay Municipal Water District (District) began recent investigations and studies of the Ranney Collector Wells that provide the source groundwater to the District from the Mad River in an effort to understand the physical condition of the Ranney Collectors and to aid in future planning efforts as they relate to the District's Capital Improvement Plan (CIP). This report serves as a focused engineering study to provide information for the maintenance and replacement of the District's infrastructure and facilities as described in the HBMWD Infrastructure and Capital Improvement Program. The work recently completed has included focused physical assessments of collectors, the development of a groundwater model and several reports to provide an understanding of the condition of the system and is summarized in the following completed documents:

1. 2002 – Video Inspection and Pump Test of Pump Station 2, Reynolds, Inc.
2. 2003 – Ranney Collector Rehabilitation Feasibility Report, Winzler & Kelly
3. 2005 – Pump Station 2 Cleaning and Rehabilitation, Maintenance Report, Collector Well Pumping Station No.2, Collector Wells International, Inc.
4. 2006 – Humboldt Bay Municipal Water District Groundwater Study, Winzler & Kelly
5. 2006 - Pump Station 2 Evaluation Final Report, Winzler & Kelly
6. 2006 – Inspection Report Collector Wells 1, 1A, 3, 4, Collector Wells International, Inc.

As discussed in the previously completed reports listed above, the long term use, condition and maintenance of the existing Ranney Collectors is of significant importance to the District. The collectors represent the foundation of the District's domestic water supply and must be maintained and rehabilitated so that they remain in use another 40 or 50 years. To date, the District has experienced a reasonable and useful life from the collectors and with good planning and maintenance should be able to operate the collectors for an extended time in the future. Installation of new laterals will be required to provide added operational life to the system and may also allow for an increase in production if system demands increase in the future. Replacement of laterals is necessary to the District primarily for the continued use of the Ranney Collectors and for meeting current and future demands. Additional capacity from the installation of replacement and new laterals would be an additional benefit if realized.

The Humboldt Bay Municipal Water District Groundwater Study completed by Winzler & Kelly in 2006 developed a groundwater model of the District's Ranney Collectors that focused on Collectors 1, 1A, and 2. A location map of the location of District's collectors is shown in Figure 1 for reference. The Groundwater Study completed in 2006 was developed under a Department of Water Resources Local Groundwater Assistance Grant and is included for reference in Appendix A. The purpose of this report is to: 1) update and refine the previously developed groundwater model with additional data near Collectors 3 and 4 not included in the original groundwater modeling efforts; 2) to complete a final evaluation to determine the potential yields from Collectors 3 and 4, and 3) to provide a recommendation to the District regarding at which

Collector the District should start the lateral replacement program under the broader Ranney Rehabilitation program being developed in the CIP.

As a part of this final evaluation, Winzler & Kelly oversaw the coordination of the drilling of several new monitoring wells, collected extensive drawdown data at the new monitoring wells and refined the existing groundwater model to incorporate the new boring log and drawdown data from the monitoring wells around Collectors 3 and 4.

This report summarizes the results of the data collection, analysis, modeling efforts and makes recommendations for future capacity and installation of laterals at Collectors 3 and 4. The report is organized systematically in Sections 2 through 6 to describe the development of the data collected through installation of monitoring wells, technical development and analysis of collected drawdown data, additional model development including calibration and model results. Additional technical data regarding the model can be found in Appendix A. Section 7 provides conclusions and recommendations based on the results of the work completed to date.

2.0 MONITORING WELL DRILLING AND DEVELOPMENT

One of the major limitations identified in the previous groundwater modeling effort was the lack of boring logs and monitoring wells in the vicinity of Collectors 3 and 4 to characterize the hydraulic properties of the aquifer in this region. As a result, the previous model extrapolated all soil properties from Collectors 1/1A and 2 and applied them in these regions with limited data. One of the major advances realized through this current effort was the drilling and development of several new monitoring wells around Collectors 3 and 4 to better characterize the aquifer properties in this region and improve the models' predictive capabilities.

In October 2007, one new monitoring well (MW-7) was drilled approximately 235 feet northwest of Collector 3, and two new monitoring wells (MW-5 & MW-6) were drilled at Collector 4. MW-5 is located approximately 170 feet east-southeast of Collector 4, while MW-6 is located approximately 195 feet southwest of Collector 4. All new monitoring wells were drilled by Cascade Drilling with a Winzler & Kelly geologist on site responsible for logging of the wells. The boring logs for the three new monitoring wells are located in Appendix B.

In addition to the three new monitoring wells drilled as part of this project, two other monitoring wells surrounding Collector 3 were installed since completion of the 2006 groundwater modeling report as part of another project. These wells are known as MW-1 and MW-4, and provided further soils information for refinement of the groundwater model. Boring logs for these wells are also included in Appendix B.

A site plan showing the location of the new monitoring wells is shown in Figure 2.

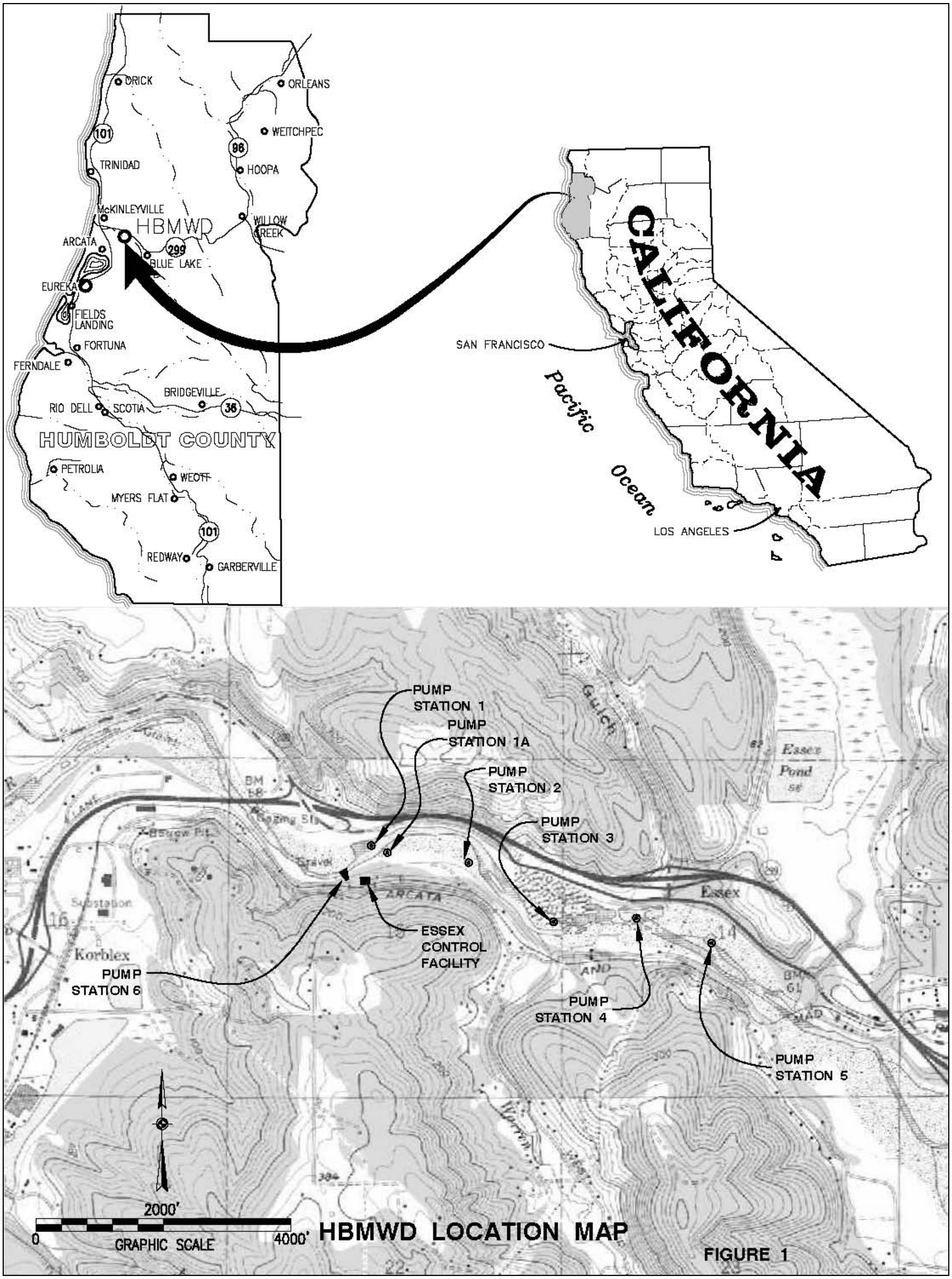

Figure 1. HBMWD Ranney Collector Location Map

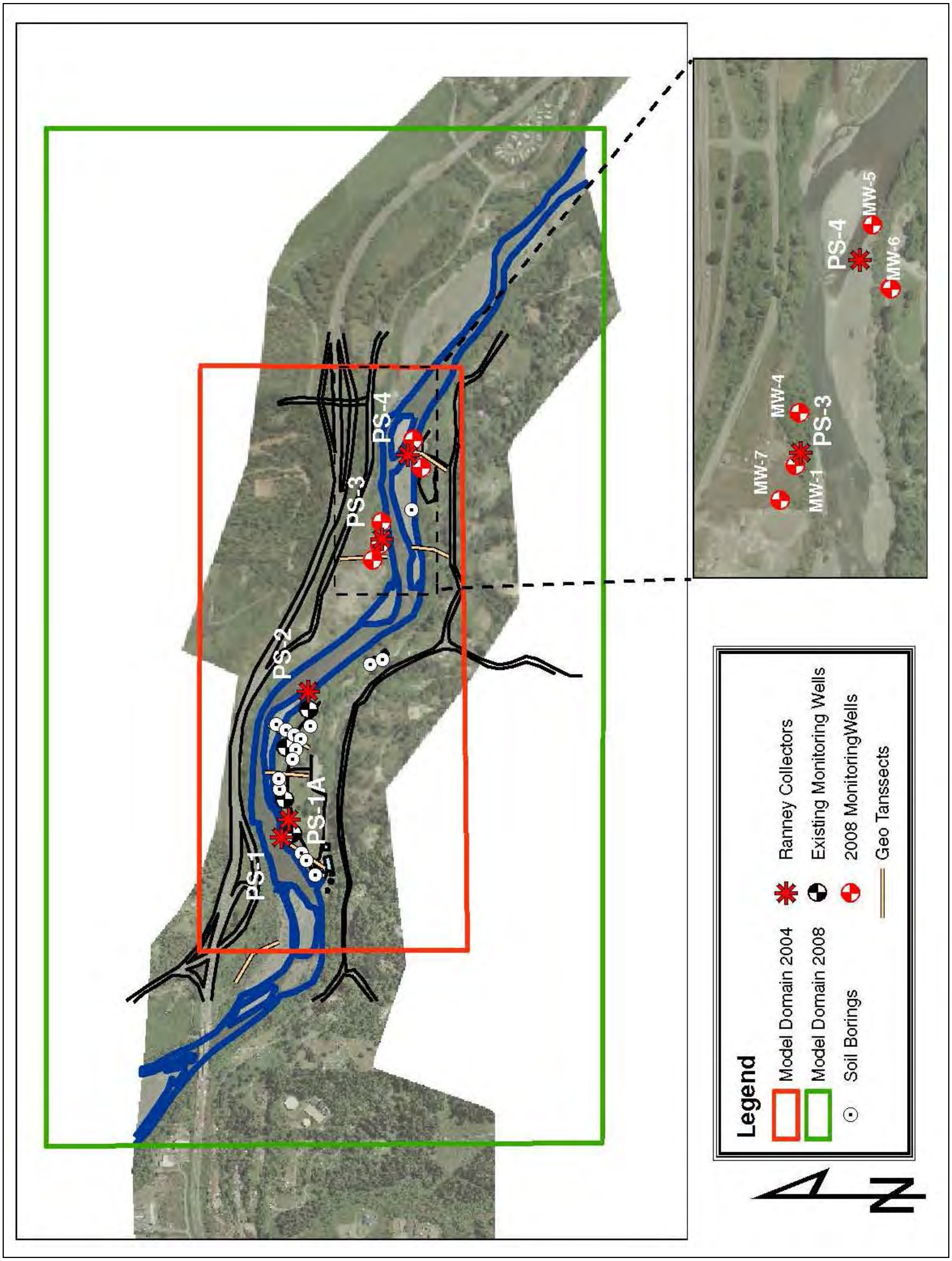

Figure 2. HBMWD Site Map and Monitoring Well Locations.

3.0 ESTIMATION OF HYDROGEOLOGIC MODELING PARAMETERS AND MONITORING WELL DRAWDOWN DATA

The computer modeling of the groundwater system performed in this study employs the use of several hydrogeologic parameters. These parameters represent physical properties of the groundwater system. Of these the parameters, model output is most sensitive to the hydraulic conductivity. This sensitivity was identified in previous studies and is also confirmed in a review of pertinent literature. This section of the report gives in in-depth summary of the estimation of the hydraulic conductivity values used in this model. The discussion and summary of the estimation of hydraulic parameters is important because it establishes the technical basis of review for other agencies such as the Department of Water Resources(DWR) and others.

Hydraulic conductivity is the soil property that describes the ease with which groundwater can move through pore spaces in the soil. In the case of the Humboldt Bay Municipal Water District Ranney Collectors, it describes the groundwater flow from the Holocene River Deposits to the Ranney Collector laterals. The hydraulic conductivity in this study was determined by several different methods: direct estimation, experimental estimation, and matching observed operational drawdown. Direct estimation relies on relating soil classifications from boring logs to conductivity values for similar types of soils. Experimental estimation employs methodologies developed by the United States Geological Survey (USGS). These methods involve pumping groundwater at a known rate and measuring the impacts on groundwater elevations. These methods are described in greater detail later in this section. Matching observed operational drawdown involves adjusting the hydraulic conductivities used in the model so that the modeled results accurately represent the observed drawdown. The adjustment of the hydraulic conductivity was restricted to a range of values that were determined in the previous two estimation methods.

Some of the USGS experimental methods used in this study estimate a parameter, *transmissivity*, which is closely related to the hydraulic conductivity. The transmissivity is a measure of how much water can be transmitted horizontally through an aquifer. The transmissivity is the hydraulic conductivity times the saturated thickness of the aquifer.

$$T = k_s b$$

where:

$$T = \text{transmissivity}$$

$$k_s = \text{saturated hydraulic conductivity}$$

$$b = \text{thickness of the saturated aquifer}$$

3.1 Analysis of Observed Pumping Data

Following the drilling and development of the new monitoring wells at Collectors 3 and 4, level transducers with data loggers were installed in each of the wells to collect continuous drawdown data during regular pumping and operation of the collectors. Continuous data was collected for seventeen days between November 20, 2007 and December 6, 2007 at each of the five new monitoring wells. Several periods of pumping and associated drawdown data were analyzed to estimate hydraulic conductivity using several established USGS hydrogeologic methods.

A figure showing drawdown at each of the collectors during the period of record for which transducer data was being collected at the monitoring wells is shown below in Figure 3.

Figure 3. Pumping schedules at HBMWD collectors over period of monitoring well data collection.

As shown in the above figure, the District pumped from multiple collectors nearly over the entire period of record. In determining which pumping schedules and associated monitoring well drawdown data would be used for input in estimating hydraulic conductivities, efforts were made to identify periods in which either Collector 3 or Collector 4 were operating independently, so as to isolate the drawdown effects in the monitoring wells to a single collector and minimize interference between the wells. There were a total of three occurrences when Collector 3 was operating independently, and two occurrences when Collector 4 was operating independently. These were the data sets used in estimating the conductivity of the Mad River's underlying gravels in the vicinity of Collector 3 and 4. Table 1 summarizes these data sets, and Figures 4 and 5 show the monitoring well drawdown data from these data sets.

Table 1. Pumping periods used for estimating hydraulic conductivity.

Collector	Data Sets	Date	Pump Start Time	Pump Stop Time	Pumping Rate (MGD)
3	Set 1	12/5/2007	10:17AM	4:05PM	5.68
	Set 2	11/25/2007	4:57AM	8:27AM	9.23
	Set 3	12/4/2007	8:21PM	11:58PM	4.08
4	Set 1	11/30/2007	1:47PM	7:55PM	6.26
	Set 2	11/29/2007	3:26PM	5:55PM	4.04

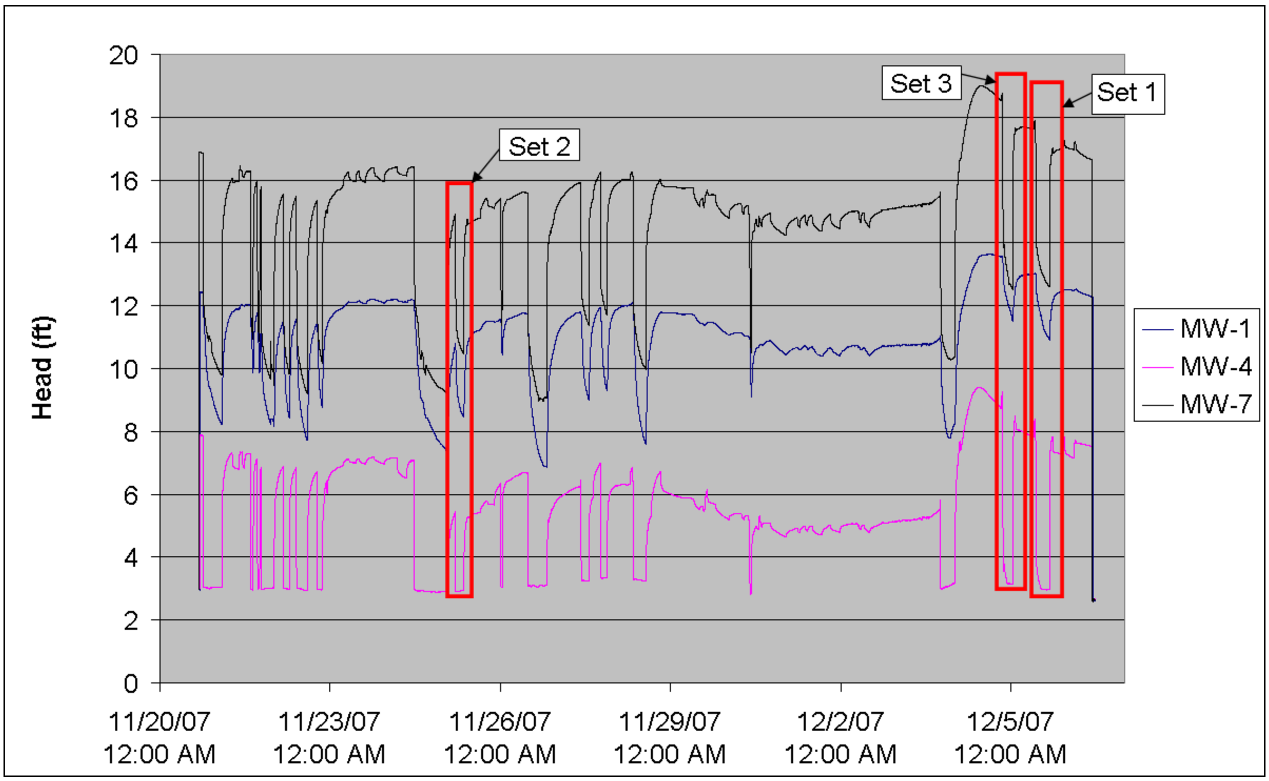

Figure 4. Drawdown data sets from Collector 3 monitoring wells used in estimating hydraulic conductivity.

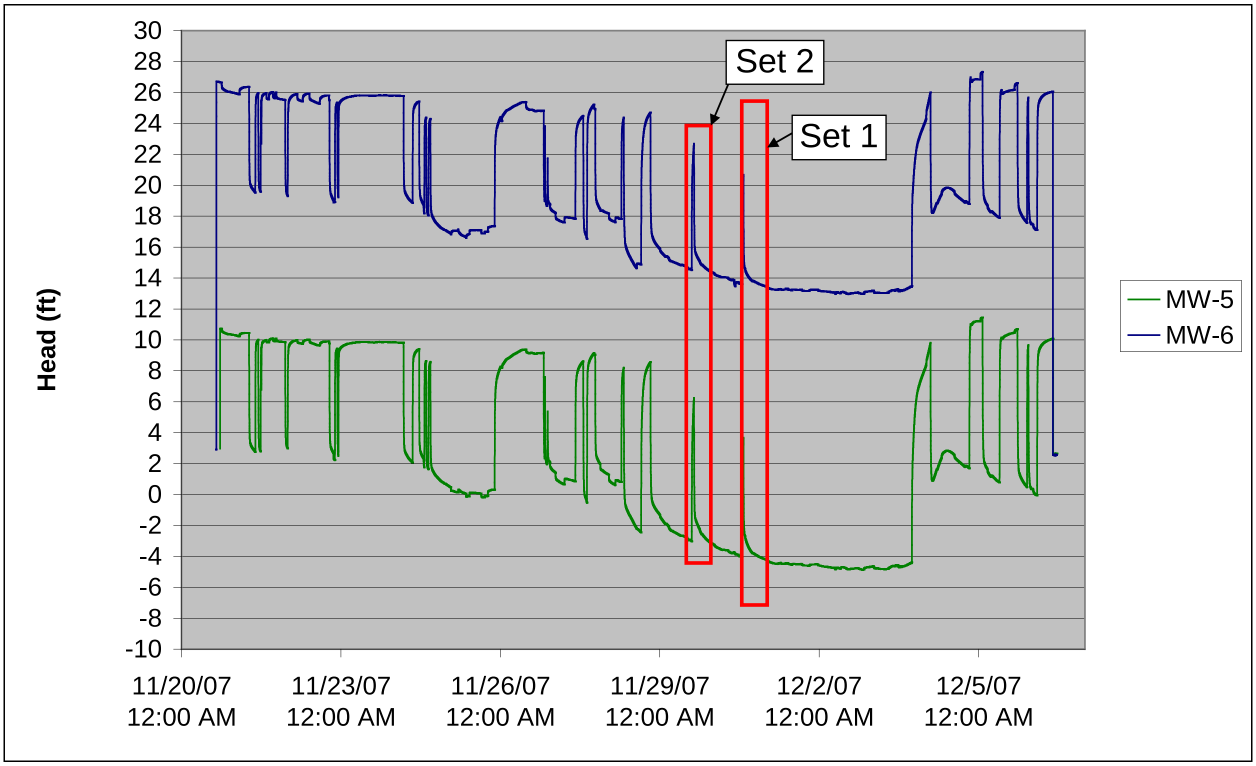

Figure 5. Drawdown data sets from Collector 4 monitoring wells used in estimating hydraulic conductivity.

3.2 Experimental Estimation of Hydraulic Conductivity/Transmissivity

The USGS has developed several spreadsheets for the analysis of aquifer pumping and drawdown data. One common method is the Cooper-Jacob straight-line method for analyzing data from a single pumping well. In this method, drawdown from a nearby observation well is plotted with an arithmetic scale on the y-axis versus time plotted on a logarithmic scale on the x-axis. The transmissivity of the aquifer can then be derived from the slope of a straight-line drawn through this plot using Equation 1:

$$T = \frac{2.3Q}{4\pi}\frac{1}{\Delta s}$$

where Δs is the change in drawdown per log-cycle of time.

The hydraulic conductivity can then be determined from the transmissivity by multiplying times the saturated depth of the aquifer. The hydraulic conductivity estimates resulting from the Cooper-Jacob analysis on the data sets described above are shown below in Table 2.

Table 2. Hydraulic conductivity estimates from Cooper-Jacobs straight-line method analysis.

Data Set	Monitoring Well ID	Estimated K	Figure Location
Collector 3 Set 1	MW1	1500	Appendix C Page 1
	MW4	2300	Appendix C Page 2
	MW7	1700	Appendix C Page 3
Collector 3 Set 2	MW1	3300	Appendix C Page 4
	MW4	1500	Appendix C Page 5
	MW7	4300	Appendix C Page 6
Collector 3 Set 3	MW1	1600	Appendix C Page 7
	MW4	1400	Appendix C Page 8
	MW7	980	Appendix C Page 9
Collector 4 Set 1	MW5	1900	Appendix C Page 10
	MW6	2600	Appendix C Page 11
Collector 4 Set 2	MW5	1400	Appendix C Page 12
	MW6	1700	Appendix C Page 13

The results of the Cooper-Jacob analysis indicates that the hydraulic conductivity estimates are extremely sensitive to the pumping rate and resulting drawdown curve data, which should not be the case for this method. In actuality, different pumping rates should result in a different drawdown curve, such that the straight line slope and pumping rate input into Equation 1 on the preceding page result in the same transmissivity value.

The reason the Cooper-Jacob analysis failed to provide consistent results is because the Ranney Collectors do not satisfy the underlying assumptions behind the analytical solution for point source wells. Since water is pulled from such a large area through the laterals, high pumping flow rates in the Collector result in less drawdown than would result in the case of a point source well. This is illustrated graphically below in Figure 6.

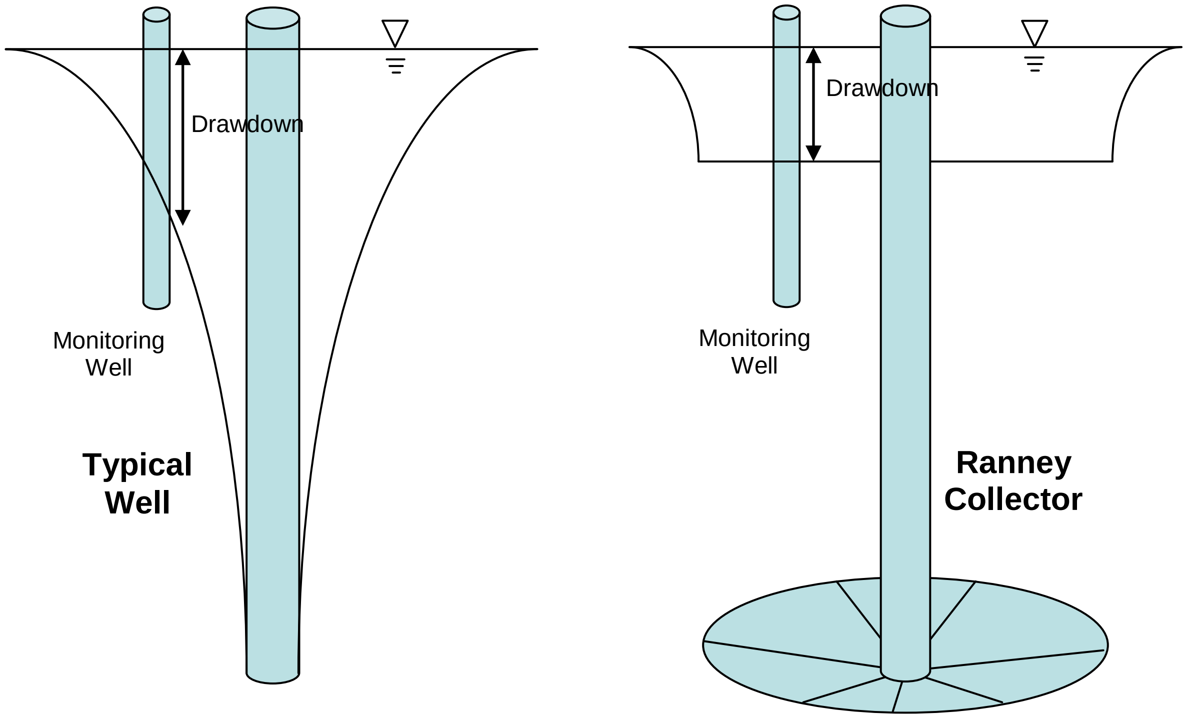

Figure 6. Illustration of difference in drawdown between point source wells and Ranney Collectors.

Several other USGS methods were tested resulting in the same conclusion – equations developed for point source wells cannot be used to estimate hydraulic conductivity from drawdown data resulting from pumping of a Ranney Collector. However, the drawdown data collected from the new monitoring wells did serve an important role in setting a range of values that were used to bracket hydraulic conductivity values that were determined during the calibrations process. The refining and calibrating the groundwater model is described in Section 5.

4.0 MODEL DEVELOPMENT

The existing HBMWD groundwater model developed by Winzler & Kelly in 2004 has been updated and refined based on newly acquired monitoring well boring logs and drawdown data in the vicinity of Collectors 3 and 4. MODFLOW-SURFACT was once again selected as the model of choice for the District due to its robustness in simulating interactions between groundwater and surface water and its variably saturated flow capabilities. Groundwater Vistas, a graphical user interface, was used for all pre- and post-processing.

The following sections describe the numeric model domain, model layer discretization, aquifer parameters, and boundary conditions used in the model.

4.1 Numeric Model Domain and Discretization

The 2004 groundwater model originally developed for the District lacked predictive capabilities around Collectors 3 and 4 as the model was calibrated using drawdown data from monitoring wells focused around Collectors 1, 1A, and 2. With the addition of monitoring wells around Collector 3 and 4 and additional data with which to refine the model, the model domain for this study was expanded due to the proximity of the boundary conditions to Collector 4. The expanded model domain increased the distance between the upstream boundary condition and Collector 4 resulting in a more stable model with less interference. Figure 2 shows the extents of both the previous and the refined model domains.

The new model domain is comprised of a grid of rectangular computational cells as in the previous model, but the discretization of the model has also been refined. The previous model domain covered an area of 5,800 feet by 2,600 feet with 100 foot grid spacing that decreased to a finer resolution of between 25 and 50 feet approaching the Collectors. The updated model domain covers an area nearly four times as large measuring 10,500 feet by 5,750 feet with a grid spacing of 50 feet that decreases to within 5 feet and 25 feet approaching the Collectors. Overall, the updated model domain is comprised of 184 rows by 284 columns.

Figure 7 below shows the entire updated model domain and its horizontal discretization.

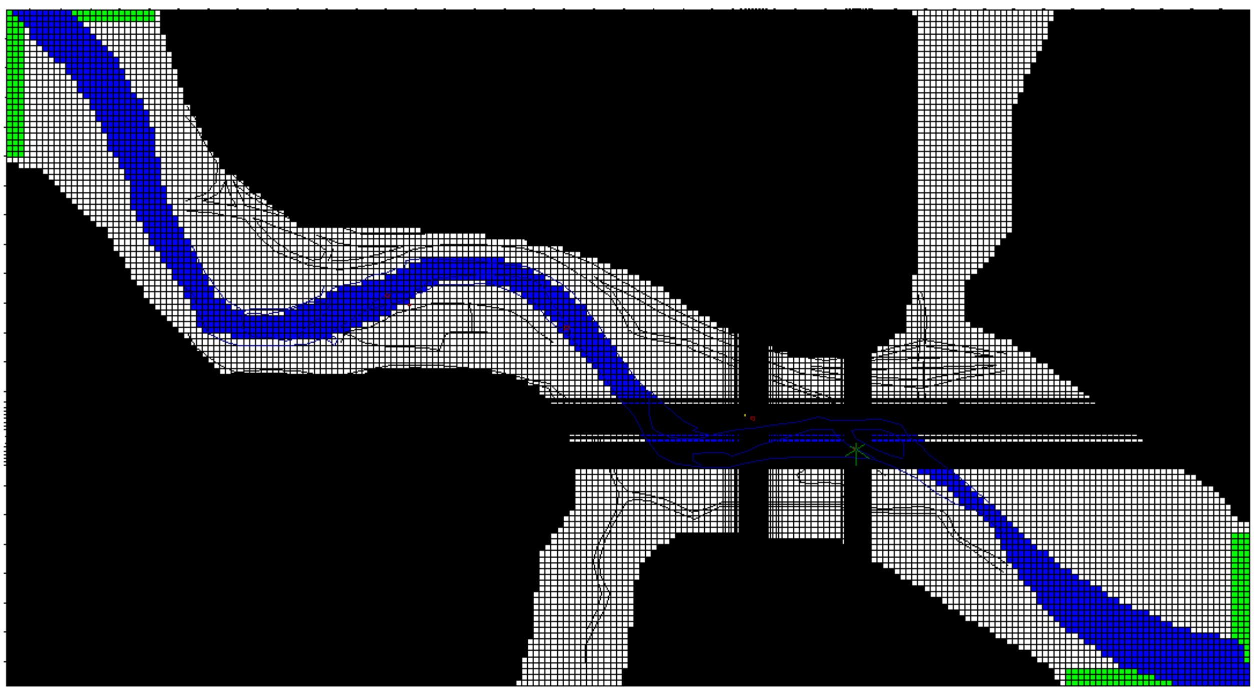

Figure 7. Model domain and horizontal discretization as depicted by the graphical user interface Groundwater Vistas.

The vertical discretization, or layering, of the model has not changed since the previous model. Horizontal cells are bounded by the top and bottom of individual layers to create volumetric cells, each having the capability of being assigned specific hydraulic parameters. The vertical extent of the model is comprised of the Holocene River Channel deposits, ranging from the confining bedrock below to the surface. This hydrologic unit is divided into eight separate layers in the model to simulate the various zones of the river and the two tiers of laterals present within Collectors 3 and 4. Figure 8 below is a graphical representation of the model's vertical layers.

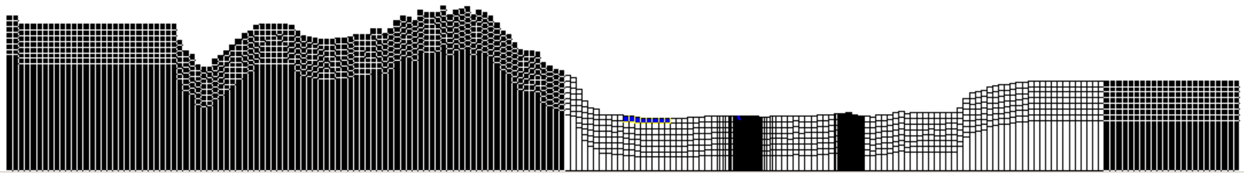

Figure 8. Vertical layers of the groundwater model.

4.2 Aquifer Parameters

Aquifer parameters, including specific storage, specific yield, porosity, and transmissivity, are required input for the model. The previous model utilized three zones each with unique values for each of these parameters – one zone for the Holocene River Channel deposits, a second zone for the laterals and siphon, and a third zone for the Franciscan bedrock.

During calibration of the previous model, it was found that the model results were not sensitive to variations in specific yield, specific storage, and porosity. Given this, the refined and updated model utilized a single zone for specific storage, specific yield, and porosity with values of 0.01 (1/ft), 0.01 (ft^3/ft^3), and .28 (ft^3/ft^3), respectively. Due to the model's sensitivity to values of transmissivities, three zones were maintained in which the transmissivities were varied. The following table summarizes the aquifer parameters used in the model.

Table 3. Summary table of aquifer parameters.

<table>
<tr><th rowspan="2">Hydrologic Zone</th><th colspan="3">Model Transmissivity (ft^2/day)</th><th rowspan="2">Specific Storage (1/ft)</th><th rowspan="2">Specific Yield (ft^3/ft^3)</th><th rowspan="2">Porosity (ft^3/ft^3)</th></tr>
<tr><th>T_x</th><th>T_y</th><th>T_z</th></tr>
<tr><td>Holocene River Channel Deposits @ Collector 3</td><td>850</td><td>850</td><td>0.6</td><td rowspan="4">0.1</td><td rowspan="4">0.1</td><td rowspan="4">.28</td></tr>
<tr><td>Holocene River Channel Deposits @ Collector 4</td><td>1600</td><td>1600</td><td>1.4</td></tr>
<tr><td>Collector Laterals</td><td>500,000</td><td>500,000</td><td>500,000</td></tr>
<tr><td>Franciscan Bedrock</td><td>5E-6</td><td>5E-6</td><td>5E-6</td></tr>
</table>

4.3 Boundary Conditions

Boundary conditions between the previous and current models did not change significantly. The primary boundary conditions used in both models were river boundaries, constant head boundaries, extraction wells, and no flow boundaries. For further discussion on boundary conditions, refer to the 2004 report included in Appendix A.

5.0 MODEL CALIBRATION

Numerical and parameter calibrations were performed in a similar manner with the refined model as they were with the original model. The numerical calibration refers to the ability of the model to accurately converge on a solution system and is assessed by checking the conservation of mass within the model. The numeric calibration standard used in the model with regard to mass balance was 0.001 ft^3. Therefore, the model continues running until this standard is achieved.

Parameter calibration refers to adjusting aquifer parameters in the model to achieve accurate results. Localized adjustments were made to the transmissivity zones within the model until model results matched the observed drawdown data within the monitoring wells and collectors. Parameter calibration results are shown below in Figure 9.

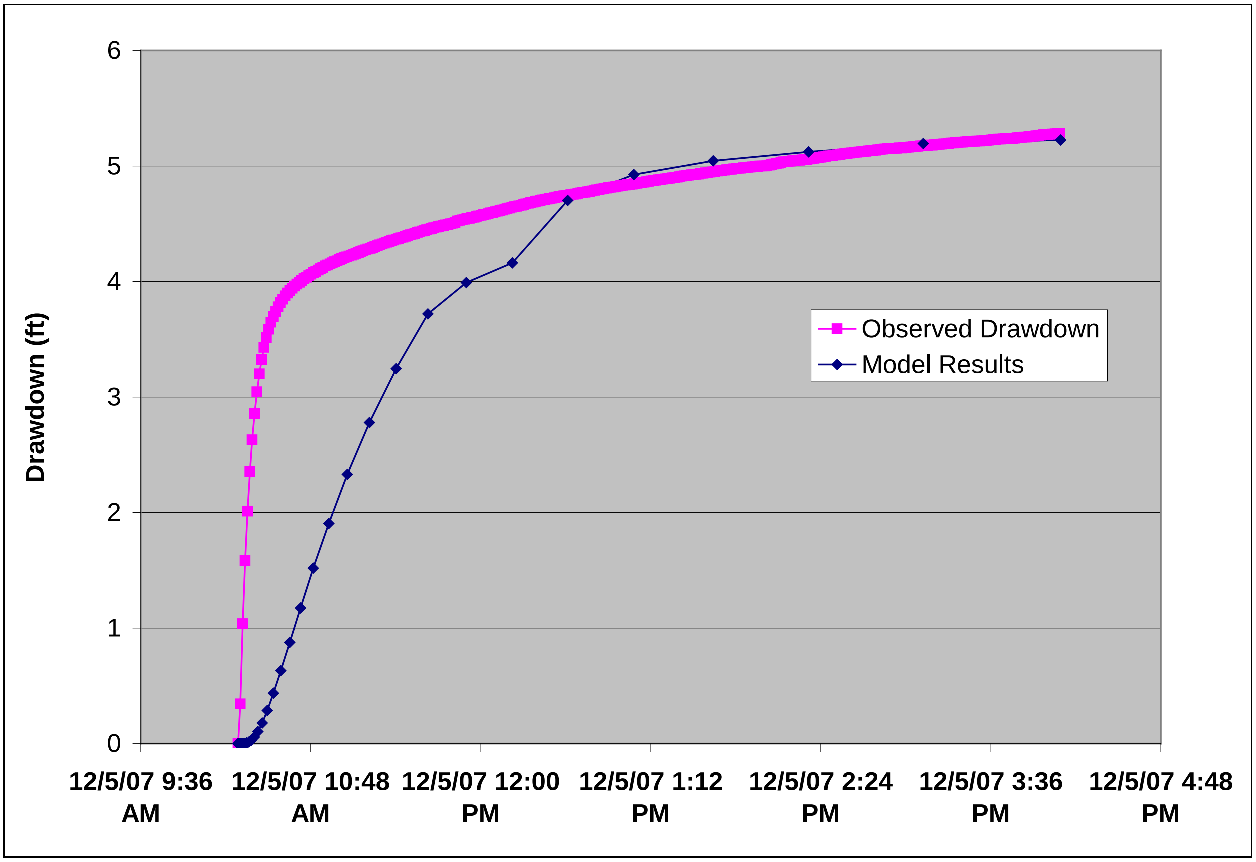

Figure 9. Model results and observed drawdown at MW-7 for Collector 3 Set 1 data.

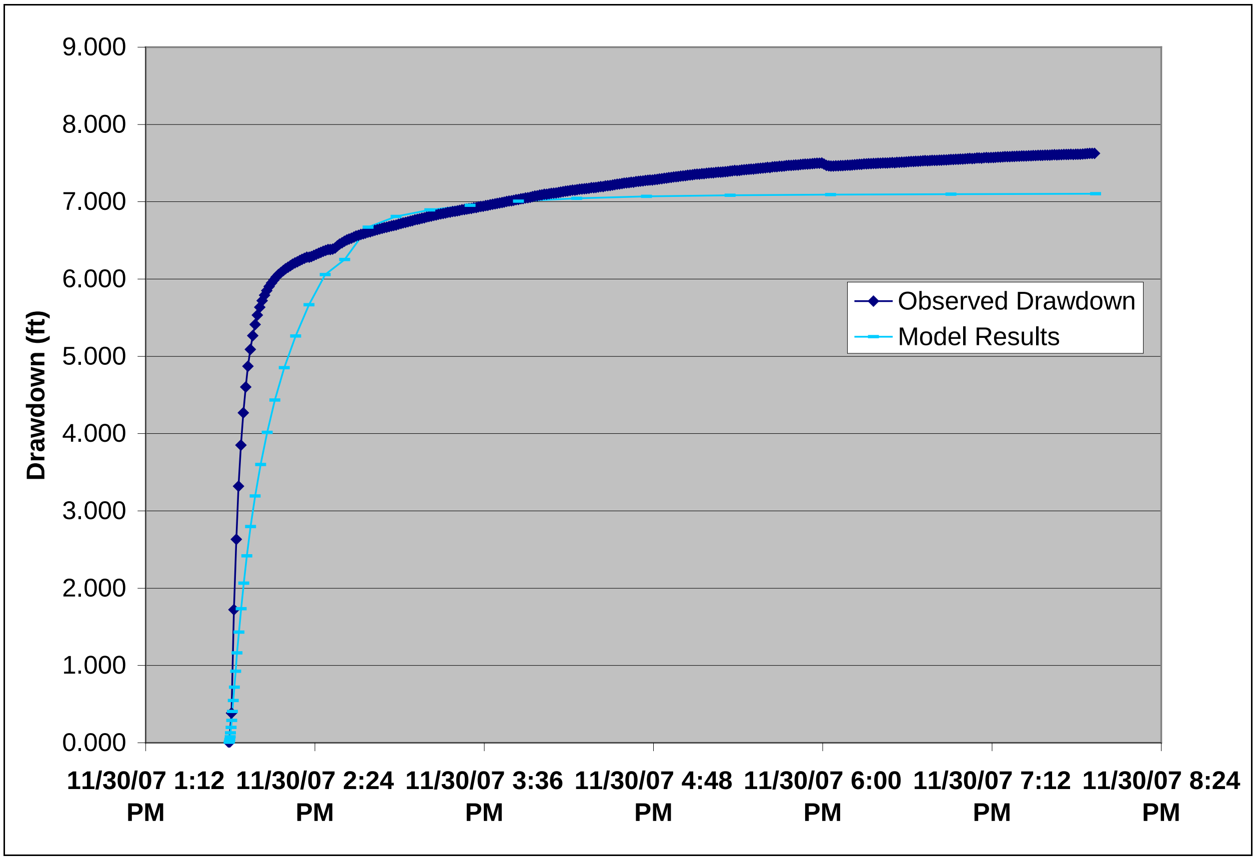

Figure 10. Model results and observed drawdown at MW-5 for Collector 4 Set 1 data.

The results of the calibration, as shown in the above figures, indicate that the model closely predicts the observed drawdown during each of the pumping scenario data sets presented earlier in Table 1.

6.0 MODEL RESULTS

The HBMWD groundwater model has been updated and refined in the vicinity of Collectors 3 and 4 to enhance its predictive capabilities in this region. The main purpose behind this update was to develop a model with the resolution needed to be used as a predictive tool to:

- estimate the increase in individual and collective capacity possible from the Collectors;
- simulate interactions between Collectors 3 and 4; and
- make recommendations with respect to when and where to project new laterals.

An example model simulation result for the first pumping scenario listed in Table 1 is shown in Figure 10. The color flood map represents the pressure head within each node of the model.

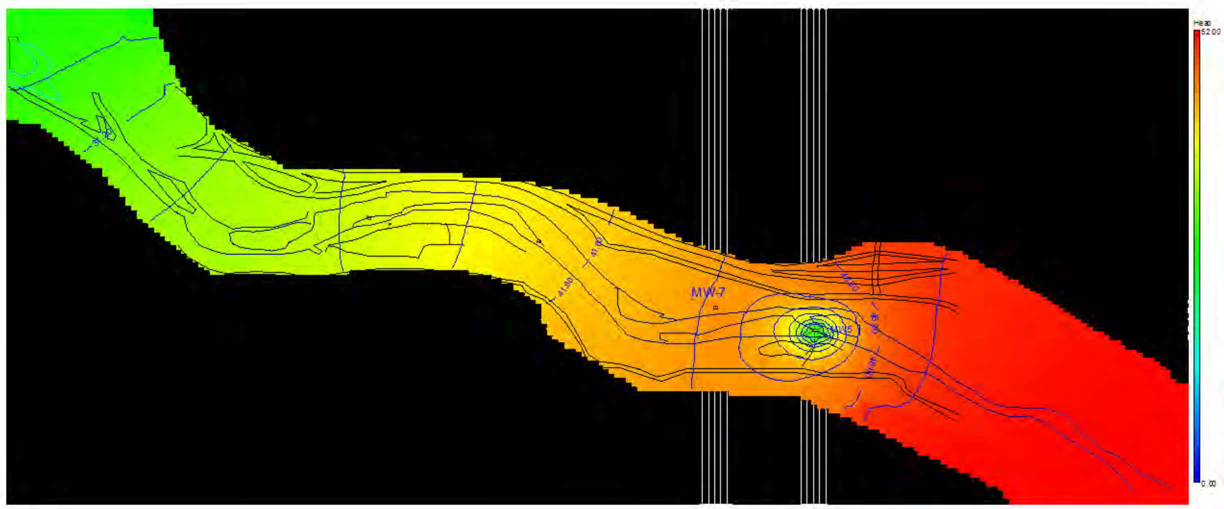

Figure 11. Model Results of Existing Groundwater Heads for Pumping at PS-4

Several simulations using the model were preformed to predict the total yield for the groundwater aquifer and to evaluate the groundwater interactions between the pumping stations.

To evaluate the impacts on drawdown due to various pumping rates the model was used to simulate the drawdown in the aquifer. The model simulated the drawdown for a given pumping rate and the drawdown at the pump station was recorded. The simulated pumping rate was then increased and a new drawdown level was determined. These results are used to create pumping rate drawdown curve for a given configuration. Pumping drawdown curves were created or PS-3 and PS-4 and are shown in Figures 12 and 13, respectively. This data is also shown in tabular form in Table 4. The table lists PS-3 initial conditions (PS-3 IC), PS-3 with additional laterals (PS-3 OPT1), PS-4 initial conditions (PS-4 IC), PS-4 with additional laterals (PS-4 OPT1), combined pumping effects at PS-3 (PS-3 Combined), and combined pumping effects at PS-4 (PS-4 Combined). Three configurations were simulated: existing lateral configuration with the pump stations pumping separately, 200 feet of additional laterals for PS-3 and PS-4 with the pump stations pumping separately, and 200 feet of additional laterals for PS-3 and PS-4 with the pump stations pumping concurrently.

Table 4. Tabular Model Results, Pumping Rate Drawdown

Pumping Rate MGD	Drawdown (ft)					
	PS-3 IC	PS-3 OPT 1	PS-3 Combined	PS-4 IC	PS-4 OPT 1	PS-4 Combined
2	5.29	4.76	5.02	3.73	3.38	3.52
4	11.86	10.43	11.27	7.73	6.72	7.23
6	16.30	13.92	14.99	11.38	9.34	10.07
8	24.36	20.28	22.27	16.21	12.62	14.18
10	30.00	24.86	26.91	18.06	14.14	16.31

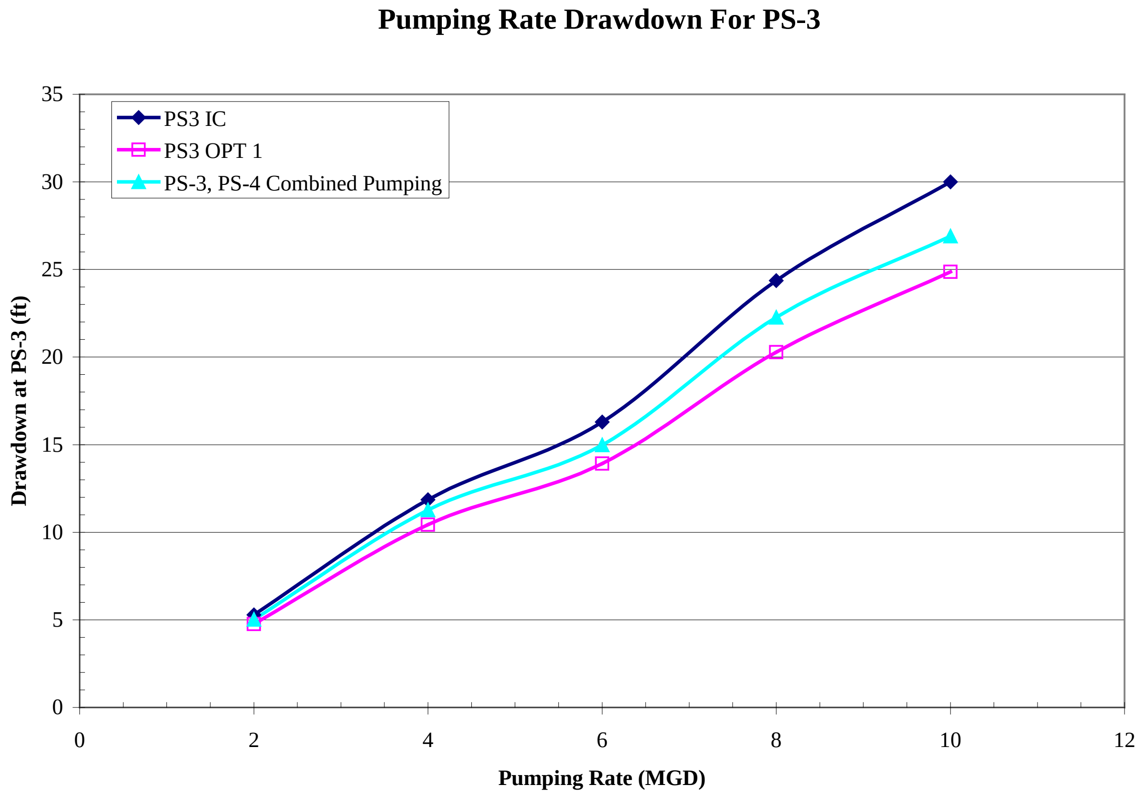

Figure 12. Model Results, Pumping Rate Drawdown Curve for PS-3

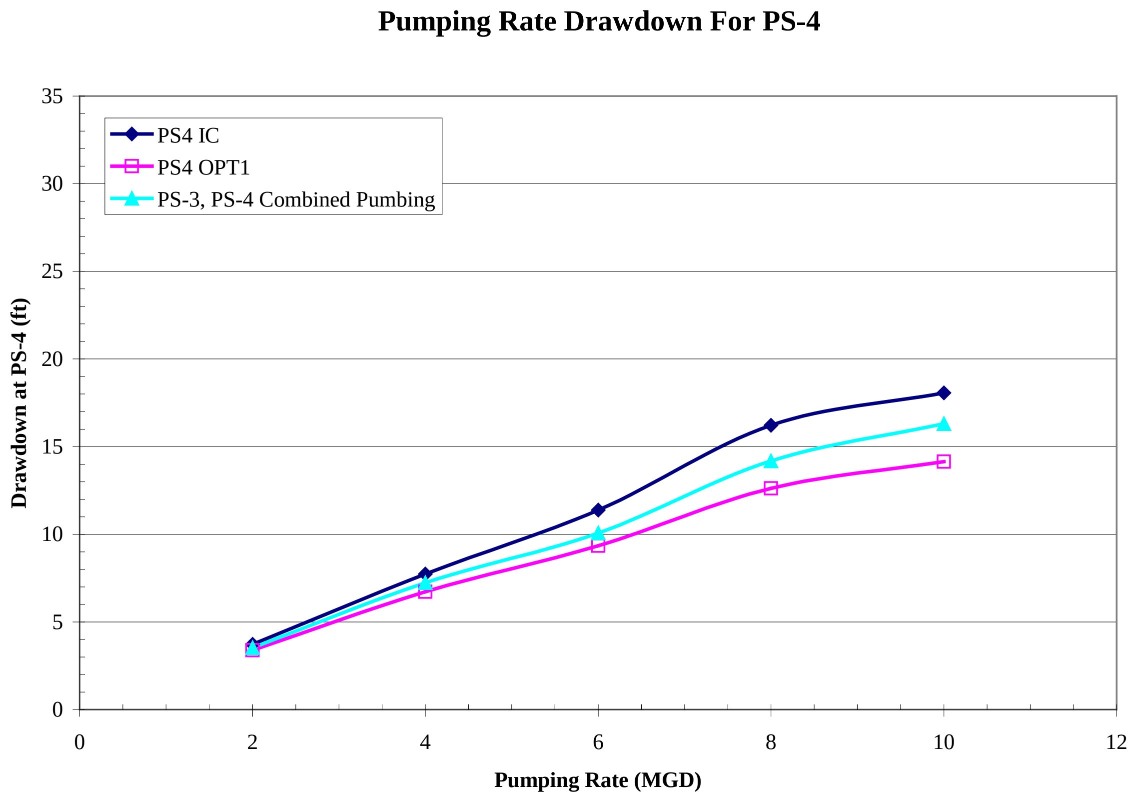

Figure 13. Model Results, Pumping Rate Drawdown Curve for PS-4

6.1 Evaluation of Individual Collector Capacities

One of the main goals of this final groundwater evaluation was to estimate the maximum individual capacities of Collectors 3 and 4. Pumping rates at each collector were systematically increased to estimate the maximum individual capacity for each. Extraction capacity at each collector is limited by two main constraints – the physical constraint of the minimum submergence requirement of the pump's bowl assemblies and a water quality constraint of increased turbidity at increased drawdown levels. Turbidity is introduced to the groundwater system by creating localized regions of higher vertical infiltration rates. For continued production of high quality groundwater it is advantageous to maintain horizontal flow into the laterals/collectors. As pumping rates increase, drawdown near the collectors causes increased vertical flow potential. Therefore, vertical flow velocities become the main limiting factor for the groundwater production.

The modeling results indicate that in order to maintain high quality groundwater under the current Pump Station's lateral configuration the maximum aquifer production rates for PS-3 are approximately 10 MGD and 8 MGD for PS-4. The modeling results indicate that there is approximately a 1 MGD increase in production per 100 feet of additional lateral.

Modeling results also indicate that portions of the laterals closer to the Pump Station caisson wall have a cumulative effect of increasing drawdown near the Pump Station. This situation could be mitigated by installing fewer but longer laterals, if possible, to achieve the total lateral replacement length. Additionally, laterals could be installed with the screened interval starting 15 feet away from the caisson wall and regular pipe for the first 15 feet in order to reduce velocities near the caisson.

6.2 Evaluation of Collective Capacity

In addition to the individual collector capacity evaluations, a separate analysis was conducted with the aim of estimating the collective capacity of the collectors. In this investigation, it was critical to consider interference between the Collectors, which is caused when the zones of capture or cones of depression of the wells overlap. The velocity vectors shown in the previous figure are also useful in visualizing the zone of capture for the Collectors and for assessing any potential interference between pumping of the Collectors. Figure 14 below demonstrates the concept of interference between wells.

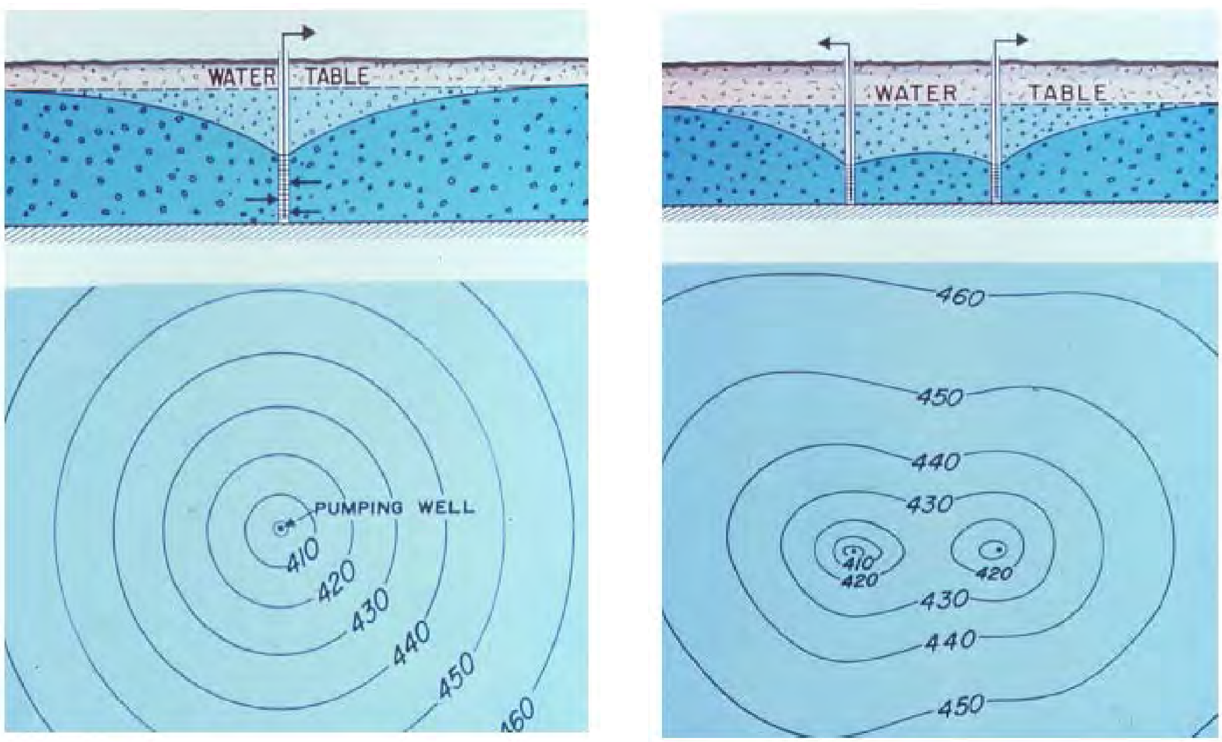

Figure 14. Graphical illustration of well interference caused by overlapping cones of depression.

Well interference is very important from an operational perspective since overlapping zones of capture lead to diminishing returns with respect to extraction rates. Once zones begin to overlap, less water is available collectively per unit of energy invested due to interference between the wells. Total extraction from wells experiencing interference is less than the sum of the wells' extraction potential when operating independently.

From an energy perspective, it is preferable to operate wells individually or at extraction rates that do not lead to well interference. However, during periods of high demand, it might be necessary to run the wells at high extraction rates with some level of interference. Therefore, the model was run to estimate maximum pumping rates capable from Collectors 3 and 4 without exceeding the minimum submergence criterion. The amount of impact to the drawdown varies by flow rate and is represented by the cyan line in Figures 12 and 13. The radius of influence and drawdown from the combined pumping from PS-3 and PS-4 can be seen in Figure 15.

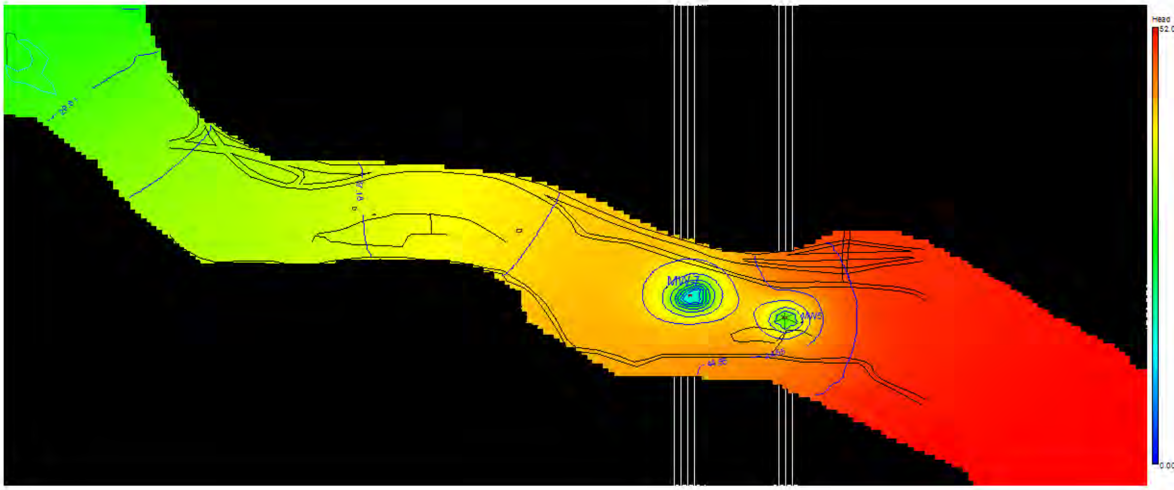

Figure 15. Model Results of Existing Groundwater Heads for Combined Pumping at PS-3 and PS-4

7.0 CONCLUSIONS AND RECOMMENDATIONS

The long term use, condition and maintenance of the existing Ranney Collectors are of significant importance to the District. Previous work completed has led the District to the conclusion that due to the potential cost to install a new collector, rehabilitation of the existing collectors makes the most sense economically for providing a continued water supply to the District's customers. The collectors are the heart of the District's potable water system and must be maintained and rehabilitated as they age so that they remain operational for another 40 or 50 years. The District has experienced a reasonable and useful life from the collectors and with good planning and maintenance should be able to operate the collectors for an extended time in the future. Installation of new laterals will be required to provide added operational life to the system and may provide additional capacity that would be beneficial. The recommendations contained within this report are intended to provide the District with guidance on when and where to project new laterals within the system specifically with regards to Collectors 3 and 4.

Previous recommendations included in the Pump Station 2 Evaluation Final Report, June 2006 completed by Winzler & Kelly include the recommendation of the identification of one of the collectors for further investigation to get additional aquifer data in order to develop the recommendation on where to project new laterals. An additional boring installed near Pump Station 3 with funds from the Local Groundwater Assistance Grant indicated a favorable zone to place new laterals near the collector. Discussions have been held with District staff and the District Board regarding which collector should be identified as to where to begin the installation of new and replacement laterals. The District has both land based collectors and collectors that are constructed on the river bar. Pump Station 1A and 3 are land based and Pump Stations 1, 2, and 4 are located on the river bar. The collectors on the river bar are generally only accessible during the summer as allowed by river stage and potentially environmental permits depending on the nature of the work. The focus of this report was Pump Stations 3 and 4 with the intent to identify and make a recommendation where the District should begin collector rehabilitation. Pump Station 3 was identified as a suitable collector to investigate for lateral replacement due to the fact that:

1. The boring installed adjacent to Pump Station 3 indicated a favorable zone to install laterals approximately 10 feet above the existing laterals.
2. Technical data developed indicate the potential for additional flow from Pump Station 3 to meet additional demand.
3. The construction and installation of new laterals will require taking a collector out of service until completion of the construction. Pump Station 3 is land based and accessible all year long so construction can occur during winter months that do not coincide with summer peak demands. The District relies operationally on all four collectors to provide peak flows during the summer peak demand period.

Based on the technical results of this report Pump Station 4 is also suitable for initial lateral installation, however because Pump Station 4 is located on the river bar work would be limited to summer time operations that could potentially coincide with peak summer time demands when all four collectors are required to meet the peak demands. We have recently been in contact with the Sonoma County Water Agency and discussed their construction of a new Ranney Collector complete with new laterals. The project experienced difficulties during the lateral installation that lasted more than a year. If there were construction problems during the installation of new laterals at Pump Station 4 the District could potentially not be able to provide summer time peak flows to its Municipal customers.

As discussed in previously completed reports the laterals have served a useful life but will not last forever. Rehabilitation of the collectors will include replacement of existing laterals to continue to provide for existing demands. It is assumed that to fully rehabilitate the collectors the District will install laterals with similar length as the existing laterals to continue to provide the same capacity for the next 50 years. In order to meet additional demands additional laterals or longer laterals may have to be installed as has been investigated in this study. Installation of the first phase of laterals will provide further information to the District that will help in future planning efforts such as actual yields realized based on the length of laterals installed. In addition advancements in screen type may prove to provide for more flow per lateral length.

Based on the information and conclusions developed as a part of this report we have the following recommendations:

1. Begin planning efforts for lateral installation. From the results of the modeling efforts we have determined that Pump Station 3 has a potential yield of 10 MGD at a drawdown of 30 feet based on installation of 200 feet of additional lateral length as described in Section 6.1. Based on the results of the modeling efforts, boring data collected and physical location we recommend that planning for the installation of new laterals be completed during the 08/09 fiscal year for Pump Station 3. Planning efforts will include

development of costs for installation of laterals, completion of CEQA and permitting requirements and development of specifications for installation. In addition, as a part of the cost analysis it would be prudent to analyze costs associated with full lateral replacement versus installation of only additional laterals with replacement laterals installed at a later date. Regardless of the ultimate capacity realized, the District will be installing laterals that have to be installed as replacement infrastructure so there will not be any wasted dollars spent. Subsequent to installation of new laterals in Pump Station 3 new data will be able to be collected and developed that will provide further information on the capability of the system and sustained yield that will help direct the next phase of lateral replacement.

2. Continue to develop additional information for lateral replacement. The installation of new laterals is a complex issue that will include additional analysis of the Districts infrastructure such as pump capacity, electrical capacity at individual collectors, pipeline condition and capacity and overall collector condition. Based on the results from the modeling efforts we have determined that Pump Station 4 has a potential yield of 8 MGD at a drawdown of 16.25 feet. As reported the results indicate that there is potential for additional yield at Pump Station 4. However due to an increase in velocities we have concern that there is potential for increased turbidity at higher flow rates at all collectors. The Maintenance Report Collector Well Pump Station No. 2 Report, Collector Wells International, Inc., October 2005 summarizes as it relates to Pump Station 2 that it is recommended to install additional and replacement laterals in order to pump at higher rates and to maximize well efficiency. Minimizing the screen entrance and approach velocities would help ensure that water velocity in the aquifer is sufficiently low to prevent movement of particulate matter and reduce the potential for increased turbidity. This concept is applicable to all work related to the collectors and should be considered when installing new laterals. We recommend investigating the possibility of variable speed pumping after installation of new laterals to increase the potential for increased sustained yield while minimizing the chance of increased turbidity due to an increase in yield. By installing variable speed drives the pump station output can be managed to maintain the highest level of sustained pumping while minimizing drawdown and turbidity. These issues should be studied.
3. Continue to investigate the system capacity at a broad level. We recommend to investigate the potential for increased yield in the system due to installation of new laterals with the developed groundwater model and to analyze the feasibility of generating additional capacity by a pump test of Pump Stations 1 and 1A. Pump Station 1A is also a land based collector and could be retrofitted to include additional laterals during winter months. In addition, Pump Station 1 has several closed laterals that could potentially provide additional summer time capacity. However, this option should be studied closely to determine effects of opening the laterals on the system groundwater classification before proceeding. As the District proceeds with lateral replacement new information will be developed that will help planning efforts and data will be developed indicating the true capacity of the collectors. Meeting future demands is a complex issue that could include investigation of alternate methods to meet increased demands such as storage and surface water treatment in addition to lateral replacement and installation of additional laterals.

Appendix A
2006 Winzler & Kelly Groundwater Model

04-1055-03.010

HUMBOLDT BAY MUNICIPAL WATER DISTRICT GROUNDWATER STUDY

May 2006

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HUMBOLDT BAY
MUNICIPAL WATER DISTRICTGROUNDWATER STUDY

1.0 INTRODUCTION

The Humboldt Bay Municipal Water District (HBMWD) produces water from four Ranney Wells located near the District's Essex Control Center on the Mad River in Arcata. The location of HBMWD Essex Control Center facility and the Ranney Wells are shown in Figure 1. The active Ranney Wells are labeled Pump Stations 1 through 4. Up to 21 million gallons per day (MGD) is pumped from the Holocene River Deposits that underlie the Mad River channel by the four Ranney Wells. This modeling effort focuses on the hydrologic system that supplies water to the four Ranney Wells. The extent of the study area is focused on the region that is influenced by Ranney Well production and is shown in Figure 1.

1.1 Modeling Report Organization

This report summarizes the modeling study of the groundwater system supplying the HBMWD Ranney Collectors at the Essex Control Center. The report is presented in six sections and appendices. A brief introduction of the model and HBMWD is given in Section 1. Section 2 describes the site conceptual model and identifies the sources of data used in developing the groundwater model. The site geology and lithology is also described in this section. The model construction is outlined in Section 3. The model construction includes a summary of the spatial discretization, boundary conditions, and input parameters. A discussion of the models numeric and parameter calibration is summarized in Section 4. The application of the groundwater model to various scenarios is discussed in Section 5. A brief summary is found in Section 6. Plots of model results for seven different pumping scenarios and each layer of the model are found in Appendix A. Relevant studies, such as the Geophysical Seismic Refraction Study Report and new monitoring well boring Logs are found in Appendix B.

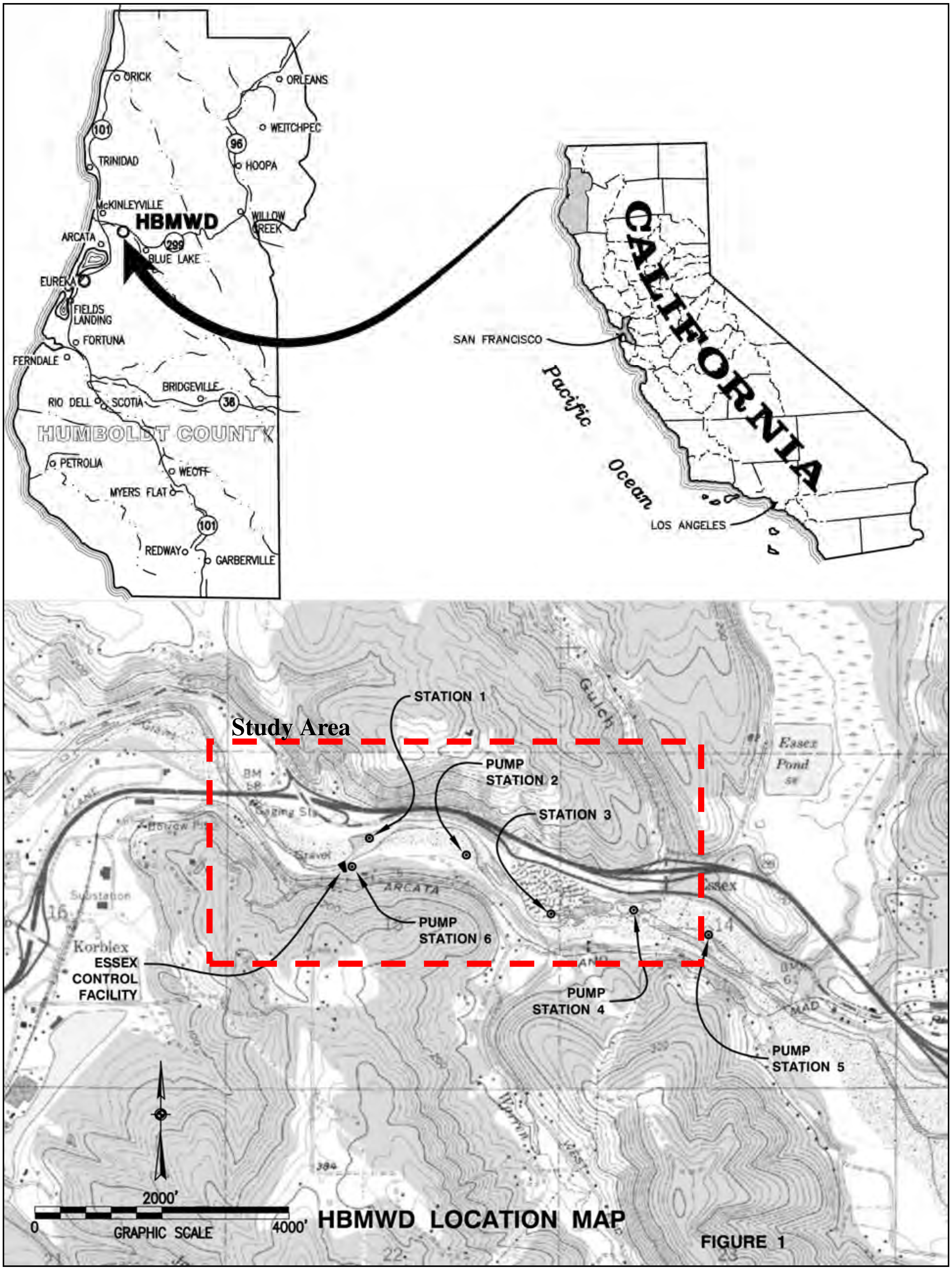


Figure 1. Humboldt Bay Municipal Water District Location Map, HBMWD Groundwater Study

2.0 CONCEPTUAL MODEL

The initial step in development of the groundwater model was to collect and assemble the three-dimensional spatially (geographic) dependant site and hydro geologic information in the region that was simulated in the groundwater model. The collection of the information is called the site hydro geologic conceptual model. The development of the conceptual model included: evaluation of previous studies and data collection, geology and structure, groundwater flow, and groundwater quality. The information used in developing the site conceptual model came from several sources, listed in Table 1.

Table 1. Source of Information for the Conceptual Model, HBMWD Groundwater Study

Previous studies
– **Engineering Report on Mad River Development, Feasibility of Supplying Filter Water to Municipal and Industrial Consumers**, Bechtel Corp, October 1960
- Boring Logs, soil lithography, depth to bedrock, permeability tests, transmissivity tests, pumping tests
– **California's Groundwater Bulletin 118 (2003)**, California Department of Water Resources
– **Geology and Ground-Water Features of the Eureka Area Humboldt County, California**, Geology Survey Water-Supply Paper 1470, California Department of Water Resources
– **Report on Hydrogeological Survey for Bechtel Corporation Consulting Engineers Humboldt Bay Municipal Water District**, September 1960
- Boring Logs, soil lithography, depth to bedrock, permeability tests, transmissivity tests, pumping tests
– **Construction of Pumping Stations, Buildings and Related Facilities for Mad River Project**, Bechtel Corp, December 1961
- Well schematics
– **Previous groundwater studies in the region**
- An Explicit Finite Difference Model for Unconfined Aquifers, Wen-sen Chu and Robert Willis, Groundwater Vol. 22, No 6, 1984
Geophysical Investigations
– Four new monitoring well
– Boring logs, sieve analysis, and pumping tests
– Seismic refraction study
– Depth to bedrock, lithologic stratification, and depth to water
Operational data
– Pumping rate by Ranney Well
– Drawdown and recovery time
– Turbidity at various pumping rates

2.1 Soil Boring, Well, and Geophysical Investigation Information

Lithologic data from wells and soil borings was used to develop the conceptual hydrologic model and are used to show surface elevation, depth to bedrock, soil type, and geologic structure. There are thirteen soil borings, four monitoring wells, and five Ranney Wells with boring logs, which provide the most comprehensive descriptions of the litho logic structure in the study area, which are used to define the inputs to the groundwater model. The location of each source of information is shown on the site map in Figure 2.

Table 2. Soil Boring and Well Log Locations, HBMWD Groundwater Study

Location	Type	Surface Elevation (ft)	Bedrock Elevation (ft)
CP-1	Soil Boring	25	-5
CP-2	Soil Boring	25	-42
CP-W	Soil Boring	25	-42
AP-1	Soil Boring	31	-68
AP-2	Soil Boring	32	-65
AP-W	Soil Boring	30	-70
AP-3	Soil Boring	33	-68
AR-1	Soil Boring	30	-65
AR-2	Soil Boring	27	-40
AR-3	Soil Boring	25	
BP-1	Soil Boring	29	
BP-2	Soil Boring		
BP-W	Soil Boring	29	-61
DP-1	Soil Boring	37	-32
MW-1	Monitoring Well	36	-62
MW-2	Monitoring Well	37	-56
MW-3	Monitoring Well	38	-62
MW-4	Monitoring Well	38	-42
SRP-1	Seismic Refraction Transect		
SRP-2	Seismic Refraction Transect		
SRP-3	Seismic Refraction Transect		
SRP-4	Seismic Refraction Transect		
SRP-5	Seismic Refraction Transect		
SRP-6	Seismic Refraction Transect		
SRP-7	Seismic Refraction Transect		
Ranney 1	Production Well	23	-42
Ranney 1A	Production Well	40.5	-33
Ranney 2	Production Well	25	-64
Ranney 3	Production Well	30	-33
Ranney 4	Production Well	35	-40

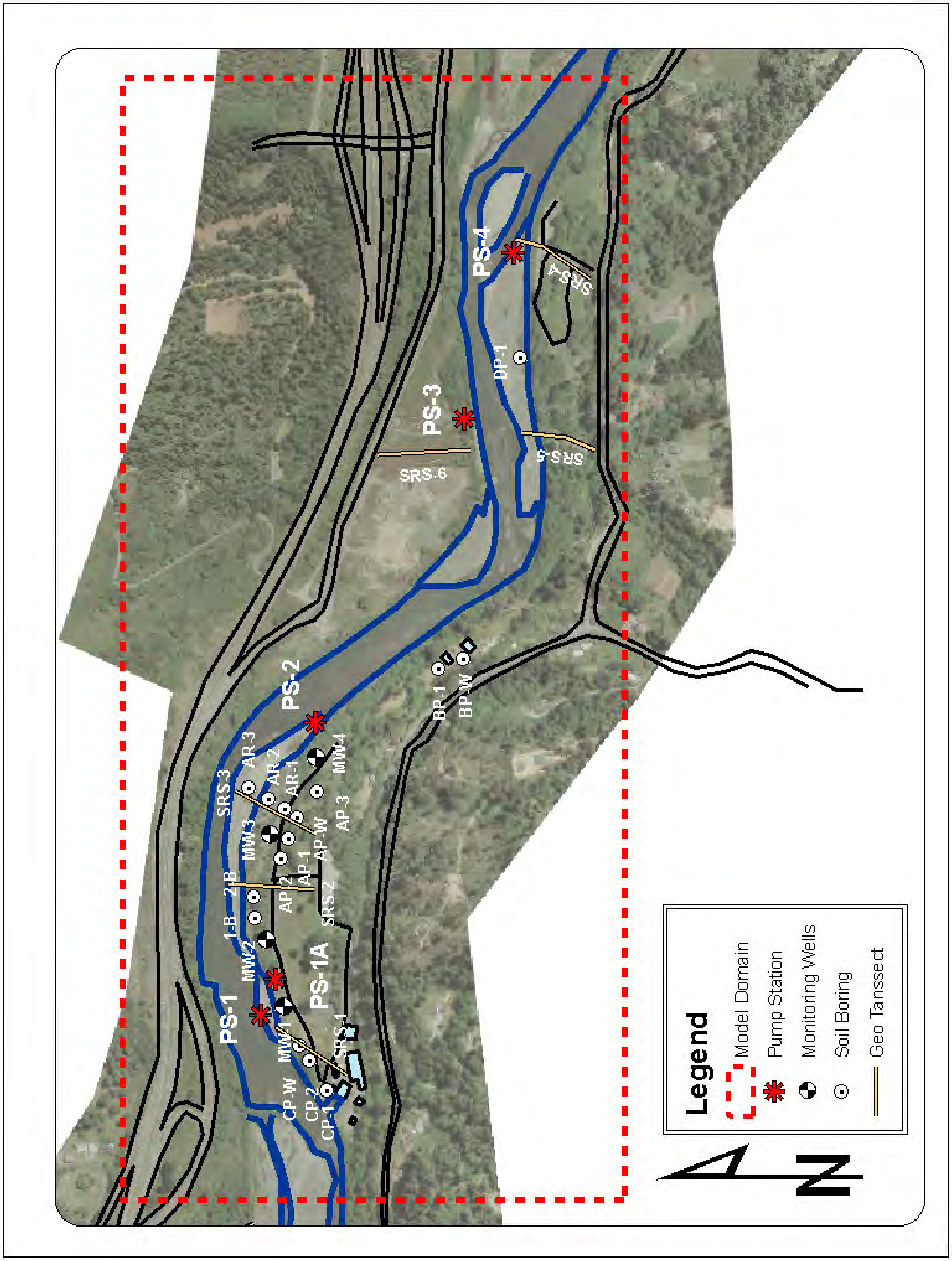


Figure 2. Site Map and Data Locations, HBMWD Groundwater Study

2.2 Conceptual Model Domain

The area of model focused on the regions that influence the production of potable water by the HBMWD at the Essex facility. The study area primarily includes the Holocene River Deposit along the Mad River valley parallel to Highway 299 between the 299 bridge near North Bank Road and Essex Lane. The area is approximately one-half square mile and encompasses the area around the four Ranney Wells. The model domain is 5500 feet long in the east-west direction and 2500 feet wide in the north-south direction. The depth ranges from 300 feet msl to -70 feet msl, however, the primary depths of the groundwater simulations are from the river level of ~35 ft msl to the bedrock at -70 ft msl. The top layer of the system is the ground surface and the bottom is bounded by the impermeable bedrock

2.3 Geologic Setting

The study area along the Mad River is characterized by river cut terraces, channels, and sand/gravel bars. The subsurface consists of fluvial deposits of Holocene River Channel Deposits, which overlay Franciscan bedrock. The Holocene River Channel Deposits consist of clay, silt, sand, gravel and boulders deposited in stream beds terraces, flood plains, and ponds. These sediments consist primarily of gravel with some inter-bedded clay. The clay layers are lenticular in nature and do not represent a retarding layer. At the time of construction of the Ranney Wells, pumping tests were performed at five locations along the study area. These tests showed that the Holocene River Channel Deposits in the study area had transmissibility of 98,000 gallons per day per foot and permeability of 1090 gallons per day per square foot.

The bedrock in the study area is the confining layer. The elevation of bedrock ranges from above the surface at approximately 25 ft mean sea level (msl) along the north bank of the river to 70 ft. below msl. The Franciscan bedrock consists of consolidated sediments of shale, sand stone, greywacke, green stone, and basalt. The river valley above (up river) and below (down river) broadens extensively and due to lower velocities at the time of deposition, the presence of finer material deposits can be expected. However, in the region of the study area the valley is constricted with bedrock rising on both the north and south sides of the river. This constriction would have caused higher velocities at the time of deposition and subsequently more gravels with fewer fines.

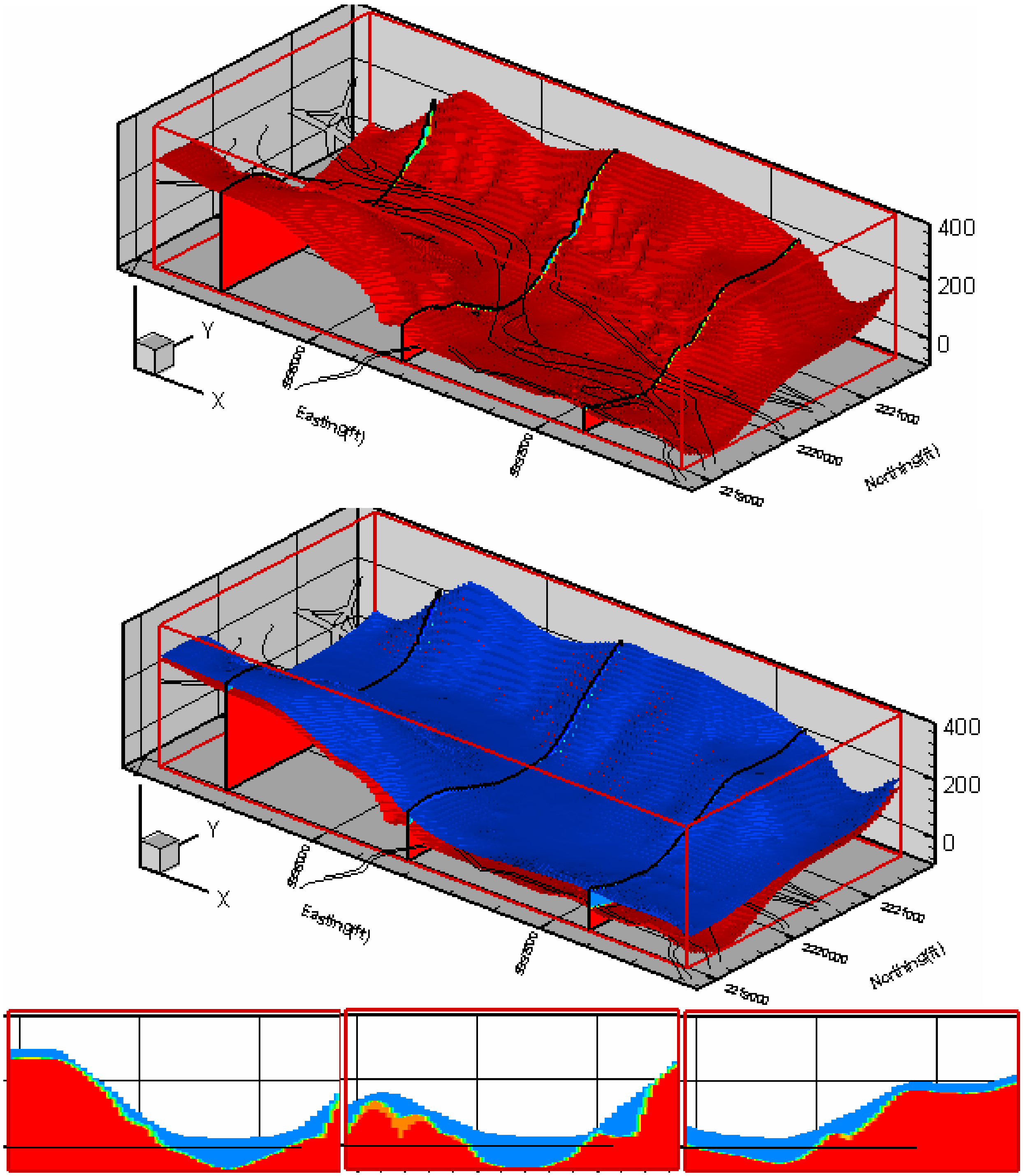


Figure 3. Site Conceptual Model Confining Layer, Overburden, and Cross Sections, HBMWD Groundwater Study

2.3.1 Groundwater Recharge Due to Precipitation

Despite the fact that the region has an average rainfall of over 40 inches per year, precipitation is not a large factor in the groundwater model because the recharge to the system is predominantly from the river and laterally from the Holocene River Deposits. The groundwater flows and recharge from the adjacent soils is of a lower magnitude largely because the recharge rates of the

Holocene River Deposits is so much greater than the adjacent soils which are high in silts and clay. In addition, sensitivity analysis showed that when precipitation was applied to the upper (higher elevations) of the model problems were caused with the numerical solution that could not be resolved without a great deal more head data.

3.0 MODEL CONSTRUCTION

A numerical groundwater model approximates groundwater flow conditions for a groundwater system based on conceptual model aquifer parameters, groundwater flow conditions, and stresses (extraction pumping) on the groundwater system. To ensure meaningful results and predictive capability, a MODFLOW-based hydrologic modeling system, MODFLOW-SURFACT, was used. MODFLOW-SURFACT combines fully integrated hydrologic water quality subsurface flow and transport capabilities with GIS capabilities under a graphical user interface, Groundwater Vistas. MODFLOW-SURFACT was specifically designed to accurately simulate the interactions between surface and groundwater systems and achieve mass conservative results where simpler computer codes fail to produce mass conservative results.

MODFLOW uses the block-centered finite-difference approach to simulate groundwater flow. Fully 3-D simulations of confined and unconfined layers may be performed; however, this analysis assumes an unconfined system. MODFLOW-SURFACT provides a rigorous well withdrawal package, unconfined recharge boundary conditions, and seepage face boundary conditions. MODFLOW-SURFACT contains additional capabilities which include rigorous saturated-unsaturated moisture movement simulation capability, air flow simulation capability, and a Newton-Raphson linearization package for improved robustness. These capabilities improve the model accuracy for simulating the groundwater system near the Ranney Wells because of the rapid hydraulic response in gravels and pumping rates from the Ranney Wells.

This section describes the numeric model domain, model layer discretization, aquifer parameters, boundary conditions, and hydrologic stresses.

3.1 Numerical Model Domain and Discretization

The numerical model domain is the same as the conceptual model domain and encompasses the regions around the Ranney Wells that influence or are influenced by the pumping of the Ranney Well.

3.1.1 Horizontal Model Discretization

The horizontal model domain is comprised of a grid of rectangular computational cells. The rectangular cells that are aligned along the principal groundwater flow direction, which is parallel to the Mad River channel. The long direction of the domain is 5800 feet with grid spacing of 100 feet. The grid spacing decreases to 50 and then 25 feet as it get near the Ranney Wells. The finer grid is necessary for the desired resolution around the Ranney Wells. The perpendicular direction of the domain is 2600 feet with 100 foot grid intervals and finer resolution near the Ranney Wells. Cells that are within the model domain but outside or above the river channel are assigned inactive status (no flow) during the model creation. Overall, the model grid is comprised of 52 rows and 87 columns.

3.1.2 Vertical Discretization

The vertical discretization of the numerical model is expressed in layers. The horizontal cells are bounded by the top and bottom of individual layers to create volumetric cells. Each individual volumetric cell may be assigned specific hydraulic parameters. The water bearing unit is comprised of the Holocene River Channel deposits and ranges from the confining bedrock to the surface, as discussed in the of the site conceptual model section. This one hydrologic unit it divided into eight separate layers in the model to accommodate the various elevations of the Ranney Wells and is discussed below. The top elevation of the first layer is defined by the ground surface elevation. The bottom of the last layer is defined bedrock elevation.

3.1.2.1 Vertical Discretization for Simulating the Ranney Wells

The method that extraction wells are simulated in MODFLOW and the configuration of the Ranney Wells requires additional layers in the numerical model to adequately simulate groundwater withdrawals. MODFLOW simulates an extraction well by removing water from an individual volumetric cell. The configuration of Ranney Wells draws groundwater into a caisson from several horizontal lateral well screens that project radially out into the aquifer. The laterals are one foot in diameter and vary in length from less than 50 to 100 feet. To simulate the laterals in the model a one foot thick layer is added at the elevation of each of the Ranney Well laterals. The cells within the radius of the laterals and at the lateral depth are assigned a very high hydraulic conductivity (4.0E5 ft/day). This approach allows flow to be simulated from a larger number of cells and more closely approximates the true system. The Ranney Well lateral elevations are shown in Table 2.

Table 3. Ranney Well Lateral Elevations

Ranney Well	Laterals	Surface Elevation (ft msl)	Lateral Elevation (ft msl)
1	6	23.0	-38.7
1A	6	40.5	-30
2	6	25.0	-62
3	6	30.0	-30.9
4	6	35	-37

The configuration of Ranney Wells 1 and 1A pose a unique computational problem which is solved in a similar manner as the lateral well projections. When Ranney Well 1 was initially installed it did not produce to design specifications. This is largely due to poor projection of the laterals and their proximity to the upward sloping bedrock. To resolve the low production rate an additional caisson and laterals, Ranney Well 1A, was installed near Ranney Well 1 (see Figure 2). The caisson of Ranney Well 1A was plumbed to Ranney Well 1 using a siphon, there is no pumping from wells 1A to 1 with the flow moving by gravity through the siphon. Groundwater from Ranney Wells 1 and 1A are pumped from the caisson of Well 1. Unfortunately, the flow measurements from Wells 1 and 1A are combined and the amount of flow from the individual wells is not known. To simulate the siphon connection between the wells a set of interconnecting cells joining the two wells is assigned a very high conductivity. Both sets of well laterals are simulated with thin zones of higher conductivity, as described above.

The Ranney Collectors are constructed with two tiers of laterals located at different elevations. Some of the laterals are equipped with valves that are close or of unknown operational status.

While it is possible to incorporate multiple tiers of laterals in the same manner as described above, the system was simplified and two discrete tiers were not incorporated in this modeling effort.

3.2 Boundary Conditions

Boundary conditions are used to describe the groundwater flow into or out of the model domain and are necessary to define how the model interacts with the entire flow system. Boundary conditions are source or sink terms that are assigned to computational cells. In addition, at boundary conditions cells there are geologic structures, primarily the underlain basin bedrock, which prevent or greatly limit groundwater flow. These boundaries are addressed by assigning the zone very low hydraulic conductivities and specific storage values; see Table 5 for aquifer parameters.

The primary boundary conditions for the groundwater model exist along the river, the layers within the Holocene River Channel Deposits at the edges of the model domain, and at the extraction wells.

The river boundary condition allows for transient flows to enter or leave the groundwater model based upon the conditions calculated in the model, location of the river boundary cells, and the assigned hydraulic parameters. The boundaries at the edges of the model domain in the Holocene River Channel Deposit are also transient boundaries and are a function of the hydrologic stresses calculated by the model.

Groundwater is pumped from the Holocene River Channel Deposits from the four Ranney Wells. A well boundary condition was assigned to a computational cell at the appropriate depth (see Table 2) for each Ranney Well. During model simulation a pumping (or sink) rate was assigned to each well. A summary of the boundary condition pumping rates for seven different pumping scenarios is shown in Table 3.

Table 4. Extraction Well Boundary Conditions and Pumping Rates

Pumping Scenario	PS-1 and 1A	PS-2	PS-3	PS-4
1	6 MGD			
2		6 MGD		
3			4 MGD	
4				6 MGD
5	4.8 MGD	4.8 MGD		4.8 MGD
6	5.2 MGD		5.2 MGD	5.2 MGD
7	5 MGD	5 MGD	5 MGD	5 MGD

3.3 Aquifer Parameters

Location specific aquifer parameters must be assigned to each of the computational cells for the model to estimate the groundwater flow. The parameters used by MODFLOW are hydraulic conductivity, model specific storage, model specific yield, and effective porosity. The aquifer parameters used are based upon data compiled during the development of the site conceptual model.

Hydraulic conductivity (K) is a soil property that describes the ease with which the soil pores permit water movement. Its value depends on the type of soil, porosity, and the configuration of the soil pores. Hydraulic conductivity has 3 components Kx, Ky, and Kz. Kx is the hydraulic conductivity in the X-direction or the long axis parallel to the river. Ky is the hydraulic conductivity in the Y-direction or the axis perpendicular to the river, and Kz is the vertical hydraulic conductivity. In some studies (particularly in the earlier studies), transmissivity is reported. Transmissivity is the hydraulic conductivity multiplied by layer thickness for confined layers.

The specific storage (S_s) of a saturated aquifer is defined as the volume of water that a unit volume of aquifer releases from storage under a unit decline in hydraulic head (or pressure). For unconfined aquifers other factors dominate in determining how much water is released and is addressed in the specific yield term. The volume of water released is due to two factors; the compaction of the aquifer caused by removing groundwater and thus increasing the effective stress of the soils (compressibility and subsidence), and the expansion of water caused by decreasing hydraulic pressure. The specific storage of the Holocene River Channel Deposits is very low because of the structure of the deposits, relatively shallow (lower hydraulic pressure) aquifer, and rapid recharge.

The storage term for unconfined aquifers is called specific yield (S_y) and is defined as the volume of water that an unconfined aquifer releases from storage per unit surface area of aquifer per unit decline in the water table. It is the water that is released from the pore space between soil particles from the dewatering of the soil. Values of specific yield are a unit less ratio that ranges from 0.01 to 0.30. The Holocene River Channel Deposits have a relatively higher porosity and low fines content that generally yield a higher specific yield.

The parameter values used in the numerical model can be grouped into three categories by soil type or flow type and they include; Holocene River Channel Deposits (Layers 1-7), Franciscan Bedrock (Layer 8), and well laterals and siphon interconnection. The values used in the model are summarized below in Table 5.

Table 5. Aquifer Property Model Input Parameters, HBMWD Groundwater Study

Hydrologic Unit	Model Hydraulic Conductivity			Specific Storage (1/ft)	Specific Yield	Effective Porosity
	K_X (ft/day)	K_Y (ft/day)	K_Z (ft/day)			
Holocene River Channel Deposits	1400 to 300	1400 to 300	1000 to 50	10E-5	.28	.32
Laterals and Siphon	4.4E5	4.4E5	1000 (laterals) 10E-4 (siphon)	10E-6	.99	.99
Franciscan Bedrock	0.001	0.001	10E-4	10E-6	.01	.01

4.0 MODEL CALIBRATION

To calibrate the model both numeric calibration and parameter calibration were performed. Numeric calibration refers to the ability of the model to accurately solve the system of groundwater equations and is assessed by a cumulative tracking of the volume of groundwater within the system. The tracking of the volume of groundwater in the model is referred to as the mass balance. In an uncelebrated model the change in volume of groundwater in the model domain does not equal the net change in the groundwater flux through the model boundaries (domain boundaries, river, and extraction wells). The numeric calibration standard with regards to mass balance used in this model is 0.001 ft^3 and simulation iterations continue until this standard is achieved.

4.1 Numeric Calibration

Numeric calibration also evaluates the changes in calculated heads between consecutive computation iterations. The cumulative sum of the squared error between consecutive head solutions is calculated and is called the residual. The simulation continues and results are not reported until the residual is less than 0.001 ft.

For groundwater flow simulations performed during model calibration the MODFLOW-Surfact solver (PCG4) was used to calculate the simulation results. The solver employs a Newton Raphson linearization to calculate the series of equations developed during solution of the groundwater model flow simulations. The solver is an iterative, bi-conjugate gradient routine that solves the large system of equations using both inner and outer iterations. The solver also employs a variable saturated soil function to accurately represent the rapid recharge of the river channel deposits present in this system. The rapid recharge rates of the Holocene deposits and the large groundwater pumping rates yielded a system of equations that was not solvable using the standard MODFLOW solver packages. The flow through variable saturated regions caused particular problems in the treatment of cells that were deactivated due to being drained during pumping and then re-wetted due to recharge. Overall, this solver is found to be stable and accurate in its solution of the sets of equations and all results met the required calibration standards.

4.2 Model Input Parameter Calibration

The calibration of the model with respect to input parameters focused on the hydraulic conductivity because it was identified as the most significant input parameter during sensitivity analysis, which was also supported in the literature. The values used to develop the hydraulic conductivity field are based on the review of test results and studies listed in Table 2 and on recent pumping test performed at Pump Station 2. Pump Station 2 was recently rehabilitated and pumping tests were performed post and prior to renovation. During the pumping test Pump Station 2 was pumped at approximately 6 MGD and the drawdown (piezometric pressure) was measured in the four newly installed monitoring wells (MW-1 through MW-4). Pump Station 1 was also operating at the time of the test. To calibrate the hydraulic conductivity field the modeled estimate of the hydraulic head at the monitoring wells was compared to the observed hydraulic heads. Localized adjustments to the hydraulic conductivity field were made until the model results matched the drawdown in the monitoring wells. The modification to the hydraulic conductivity field was also made to reflect localized variations shown in the well boring logs and seismic refraction surveys. There were discrepancies between the various sources of data and more credence was given to the more recently collected data. The calibration results are shown in Figure 4. The monitoring wells are aligned between PS 1/1A and PS-2 with MW- 4 closest to PS-2 and MW-1 closest to PS-1/1A, as shown in Figure 2. The results of the calibration show that the model closely predicts the observed drawdown during the pumping test. The model results diverge from the observed data in that the model consistently predicts that the drawdown occurs slightly earlier than observed and it slightly over predicts the observed drawdown. The simulation was also run until the model reached a steady state drawdown where the pumping test was terminated after two days. Also of interest, this calibration shows the interaction between PS-1/1A and PS-2. As expected, drawdown is first observed in MW-4 and is the greatest, which is closest to PS-2. It is then simultaneously observed in the rest of the monitoring wells. The magnitude of the drawdown in MW-3 and MW-2 is less than MW-4 and is consistent with their respective distance from PS-2. However, the magnitude of the drawdown in MW-1 is almost as great as in MW-4. MW-1 is furthest from PS-2 but is between PS-1 and PS-1A. The variation in arrival times of the start of the drawdown and the magnitude of the drawdown in MW-1 is due to the additional groundwater extraction from PS-1, thus depicting the groundwater interactions between the pump stations.

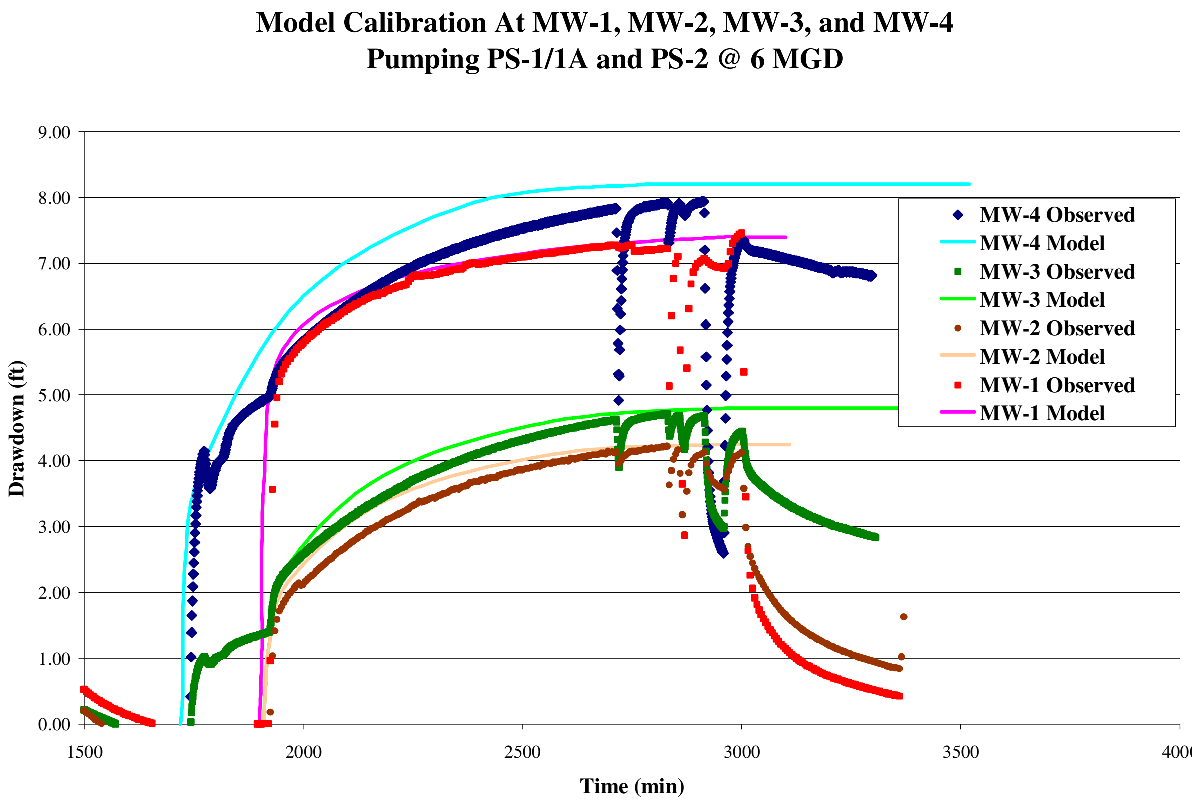


Figure 4. Model Calibration Drawdown Between PS-1/1A and PS-2, HBMWD Groundwater Study

The very close match between the model results and observed data is due to the very accurate and localized representation of the hydraulic conductivity. The high resolution of the conductivity field is only possible because of the preponderance of data in that area between PS-1/1A and PS-2 and the PS-2 pumping test. The quantity of data in the remainder of the model domain is much less and does not support the higher degree of resolution in the conductivity field. However, it is reasonable to extrapolate the average hydraulic conductivity to the remainder of the model domain and make localized adjustments as data is collected and becomes available in the future. This means that the high degree of accuracy shown in Figure 4 should be expected in the region of PS-1/1A and PS-2 and a lesser degree of accuracy in the remainder of the model domain.

5.0 USING THE GROUNDWATER MODEL AS A MANAGEMENT TOOL

The purpose of developing the groundwater model was to provide the operators of the HBMWD groundwater pumping facilities with a management tool that would aid the assessment of interactions and impacts of various pumping scenarios within the groundwater system around the Ranney Collectors. Of key interest to the District were to assess the:

- Impacts on the water table near the Ranney wells due to pumping drawdown,
- Maximum pumping rates from system while maintaining water quality objective,
- Down stream impacts on the Mad River due to pumping, and
- Impacts of the interactions between groundwater production well with respect to turbidity.

It should be noted, as stated in Section 4.2 Model Parameter Calibration, that the predictive capabilities of the model are greatest in the region between PS-1/1A and PS-2 due to the development of data in the area. The model uncertainty increases for regions where there is neither soil borings nor monitoring wells to calibrate the model and predictions in these regions are based on extrapolating model parameters from data rich regions to the remainder of the model domain. One outcome of the modeling process is the identification of regions where additional site data would increase the predictive capabilities of the model. As data is collected in the future these regions will be further refined and the model will be made more robust in areas of uncertainty.

5.1 Impacts on Water Table Drawdown

Impacts on water table drawdown due to pumping may be assessed by evaluating the groundwater heads predicted by the model. The model can report the hydraulic head at each of the computational nodes in the model. While the head at any specified location may be evaluated, it is easiest to view these results in a color flooded plan view map. A sample of such a map is shown below in Figure 5. The figure shows the river in dark blue, and roads as black lines. The groundwater heads are shown in color flood and with contour lines of light blue. The warmer orange color flood indicates higher heads and the cooler greens indicate lower heads. This plot is of the first model layer in Scenario 7, listed in Table 4, and has extraction from all four Ranney wells. Results like this can be viewed for each of the seven layers of the model. Results for all seven scenarios listed in Table 4 may be found in the Appendix A. The interactions between the Ranney Wells may also be viewed by plotting the flood plots with vectors indicating the speed and direction of groundwater flow. Figure 6 is the same results as shown in Figure 5 but with the groundwater velocity vectors shown. The velocity vectors clearly depict the regions that are impacted by the pumping at the various pump stations.

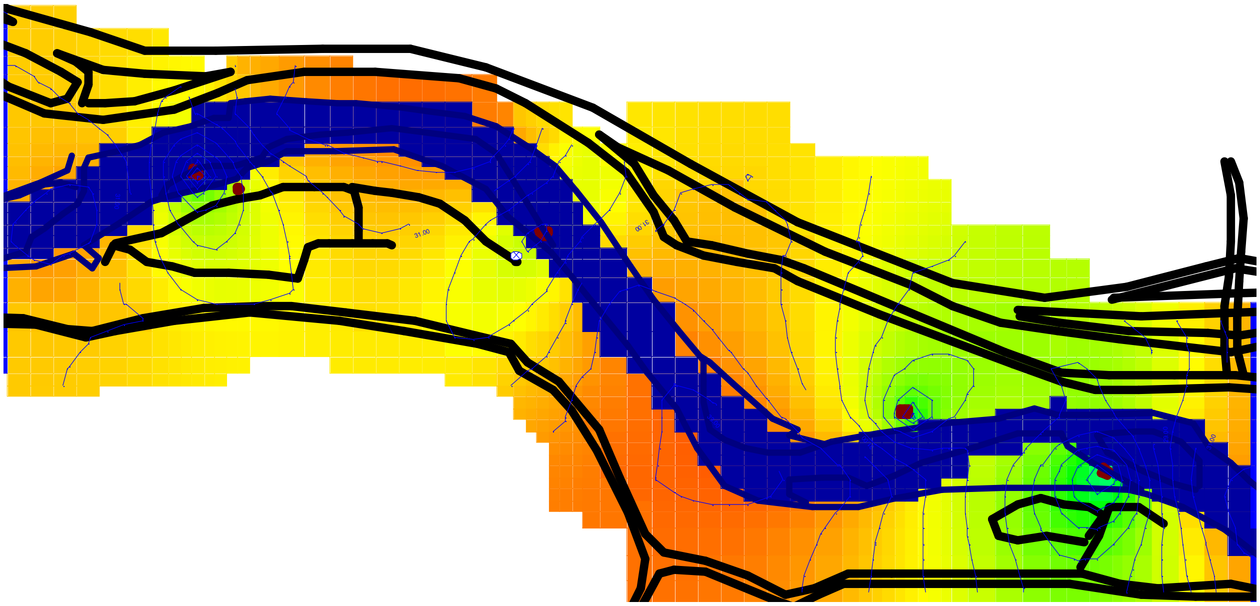


Figure 5. Sample Model Results of Groundwater Heads, HBMWD Groundwater Study

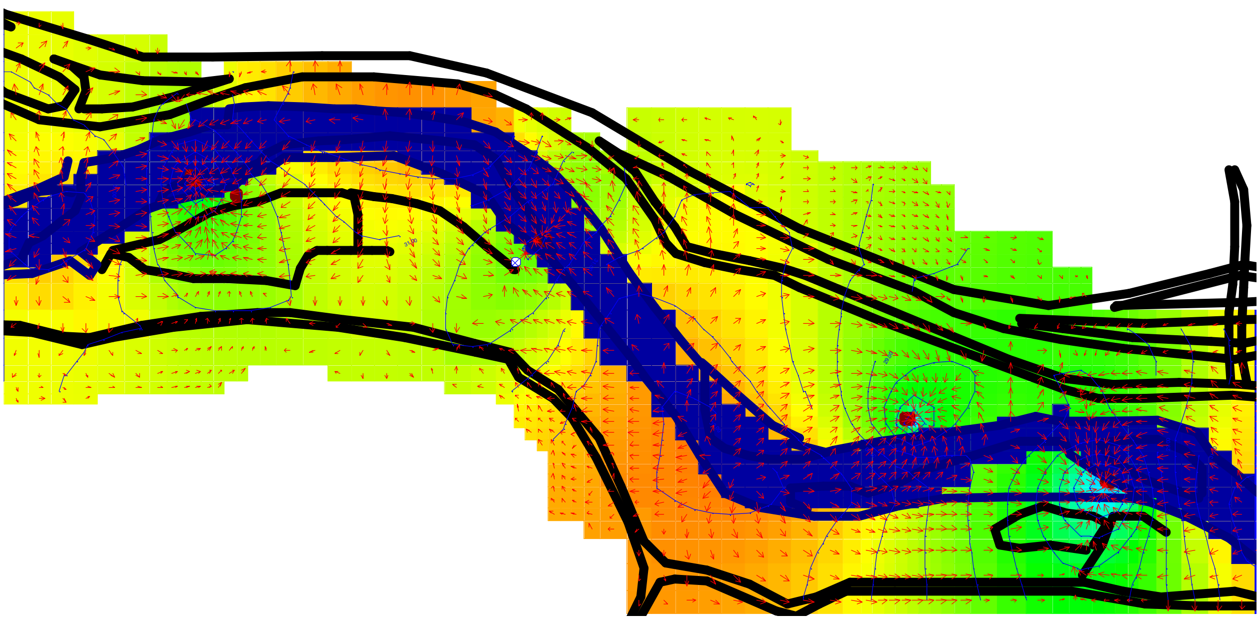


Figure 6. Sample Model Results of Groundwater Heads with Groundwater Velocity Vectors, HBMWD Groundwater Study

5.1.1 Vertical Velocity Profile

Interactions at specific collectors may also be depicted by plotting the cross section though the collector of the results with the velocity vectors. Figure 7 depicts the cross section of PS-3 with a pumping rate of 4 MGD. The velocity vectors depict the regions and extents where groundwater is moving laterally and vertically. As is expected, the results show that for this collector the predominance of groundwater entering the pump station is moving laterally through the aquifer with vertical migration limited to the regions directly above the collector.

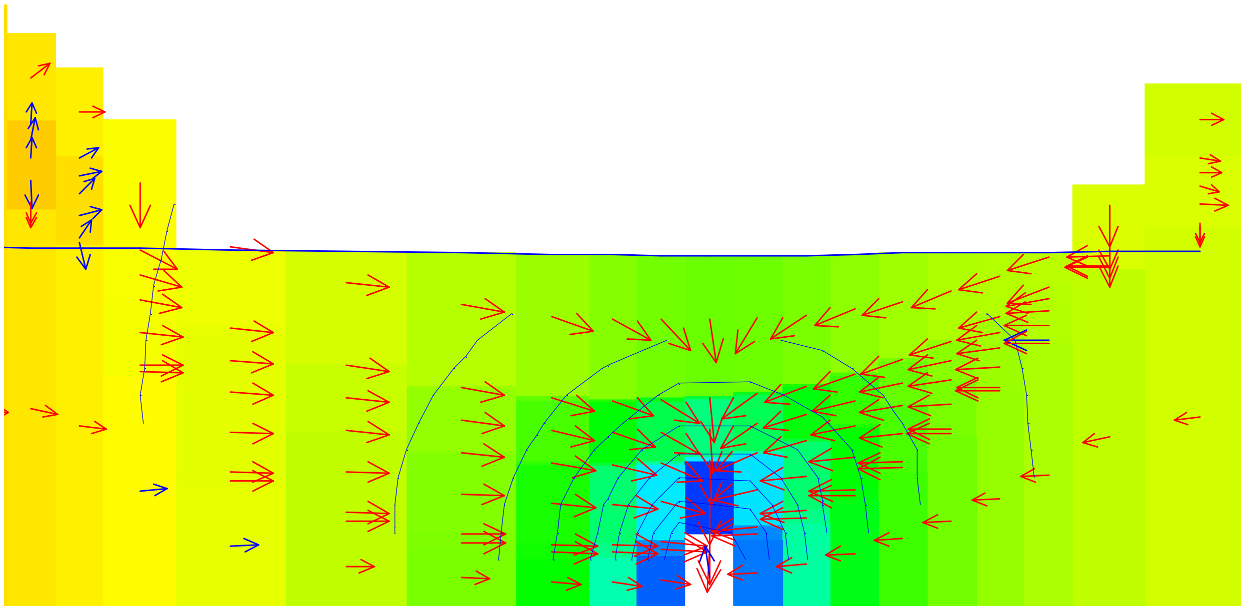


Figure 7. Cross Section of Groundwater Heads with Velocity Vectors of PS-3 Pumping at 4 MGD, HBMWD Groundwater Study

5.2 Maximum Pumping Rates

The question of determining the maximum pumping rates may be determined by estimating travel times of the groundwater recharge. This is done by plotting the capture paths of the recharge groundwater to the extraction wells. The velocity along the path of the recharge water is then used to calculate the travel time. This process was performed with theoretical pumping regimes and water quality standards but is not summarized in the report because model uncertainty needs to be addressed prior to practical application. Future use of the model will include theoretical prediction of maximum pumping rates to determine the ultimate yield to meet future demands.

5.3 Downstream Impact on the Mad River

Assessing the downstream impacts on the Mad River due to various pumping scenarios is evaluated using a mass balance approach. During model simulation all water entering and exiting the system boundaries are accounted for. In this system the boundaries are the eastern constant head boundary, western constant head boundary, river boundary, and the four extraction wells. Water is computationally allowed to enter or leave through the constant head and river boundaries and is a function of hydraulic heads created by stresses on the system when groundwater is extracted from the wells. In the absence of pumping stresses, groundwater tends to enter the system from the east and exit to the west due to topographic relief within the domain. The river tends to be a losing stream with steady recharging of the groundwater system. The model simulates flow from the river into the groundwater system but it is limited in that it does not simulate the hydraulics within the river channel and does not model the induced changes in the river flow. The model holds the level of the river constant with recharge across the river boundaries determined from the hydraulic head gradients and soil properties. The model does report the amount of water that enters the system through recharge from the river and is the change in the flow of the river.

5.4 Groundwater Velocity and Turbidity

The assessment of impacts of the well interactions with respect to turbidity was based on an assumed statistical correlation between groundwater velocity profiles and turbidity in the groundwater produced. However, after analyzing pumping data, production water quality data, river water quality data, and model results no correlation was found relating turbidity in the groundwater to groundwater velocities.

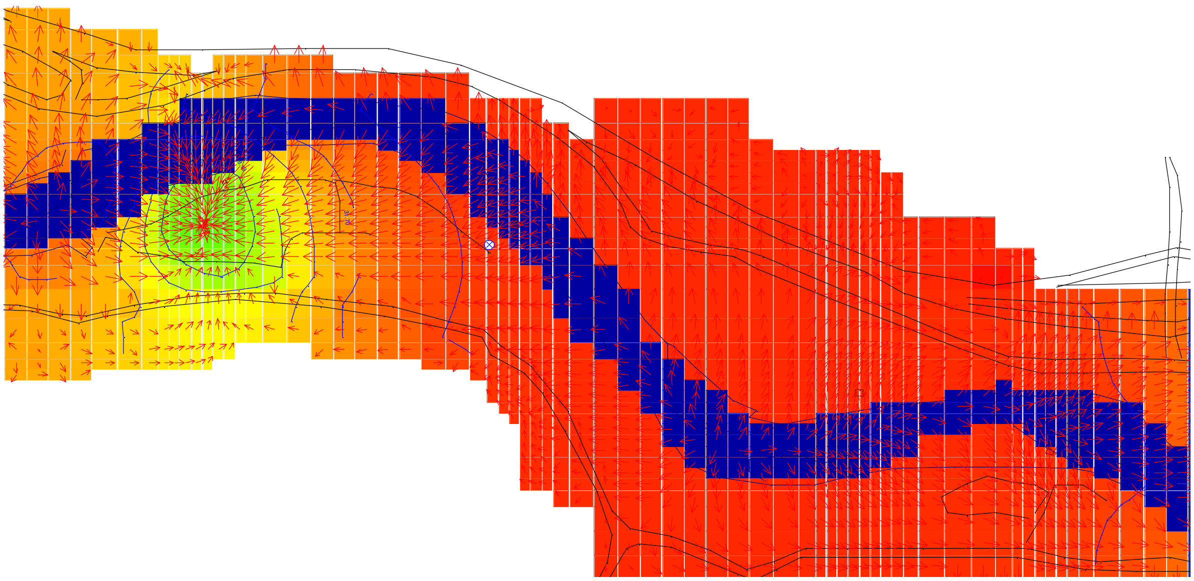
6.0 SUMMARY

The HBMWD groundwater study focused on the groundwater system in the region of the four active Ranney Collectors (PS-1 through PS-4) which supply water to the District. The activities of the study consisted of: collecting existing data (from construction plans, well logs, operational data, and previous studies), collecting new data (from the installation of four new monitoring wells and seismic refraction study), compiling the collected data into a site conceptual model, construction of the three dimensional computational model, numeric and parameter model calibration, and model application. The site conceptual model resulted in a three dimensional representation, shown in Figure 3, of the model domain depicting the confining layer and soil properties of the overlying hydro geologic units. The site conceptual model was used to construct the computational model. The computational model estimates the groundwater flow and head by solving the groundwater flow equations using MODFLOW-SURFACT, a MODFLOW based finite difference model. The modeling performed was particularly challenging due to the rapid recharge of groundwater from the Mad River and MODFLOW-SURFACT was used because it accurately simulates the interactions between surface and groundwater systems where simpler computer codes fail to produce mass conservative results.

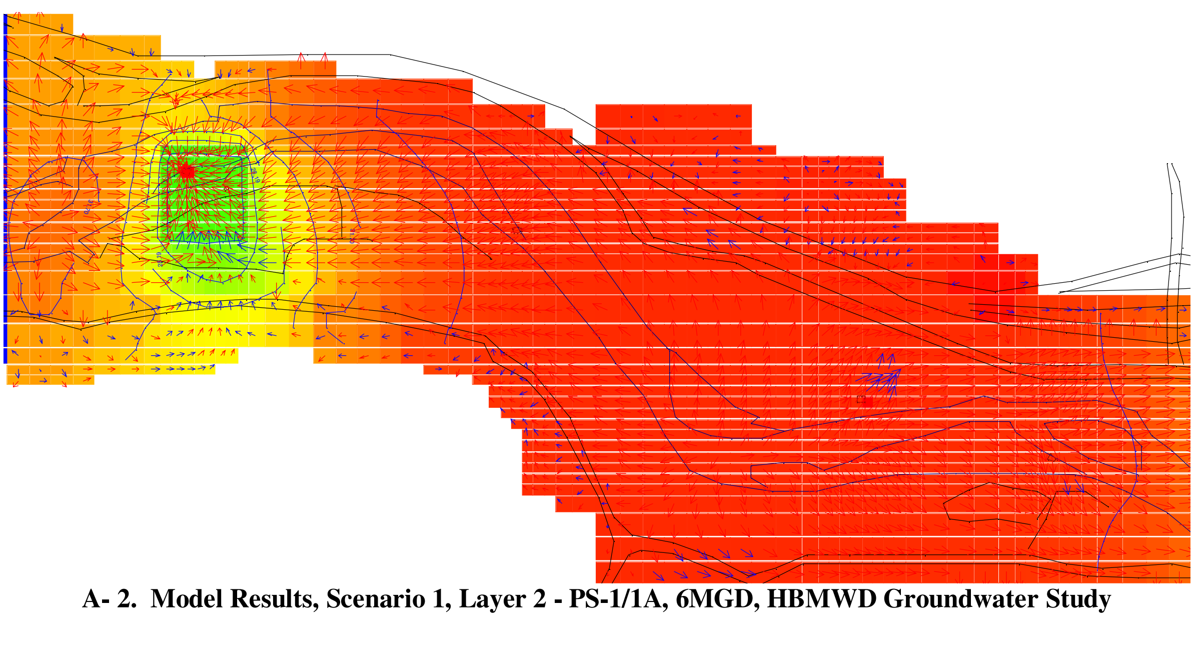
The model was applied to seven operational pumping regimes, as listed in Table 4, with the results shown in Appendix A. The model results closely match observed drawdown from pumping tests at the four new monitoring wells between collectors PS-1/1A and PS-2, shown in Figure 2. Observed drawdown at the Ranney collectors is generally less than what was predicted by the model. The quantity of soil data in this region was also greater than other regions of the model domain, which allowed for a higher degree of resolution in the input parameter estimation. The average soil properties from this region were extrapolated to all other regions of the model domain. Model verification in other regions of the model domain was limited due to the lack of monitoring points other than the extraction wells. Additional monitoring wells around the other Ranney Collectors would greatly reduce model uncertainty and increase model accuracy and will be installed in the future as funding becomes available.

The model will be used in the future to help the District with planning for meeting future water supply requirements and in helping assess affects of pumping one Ranney Well with respect to another.

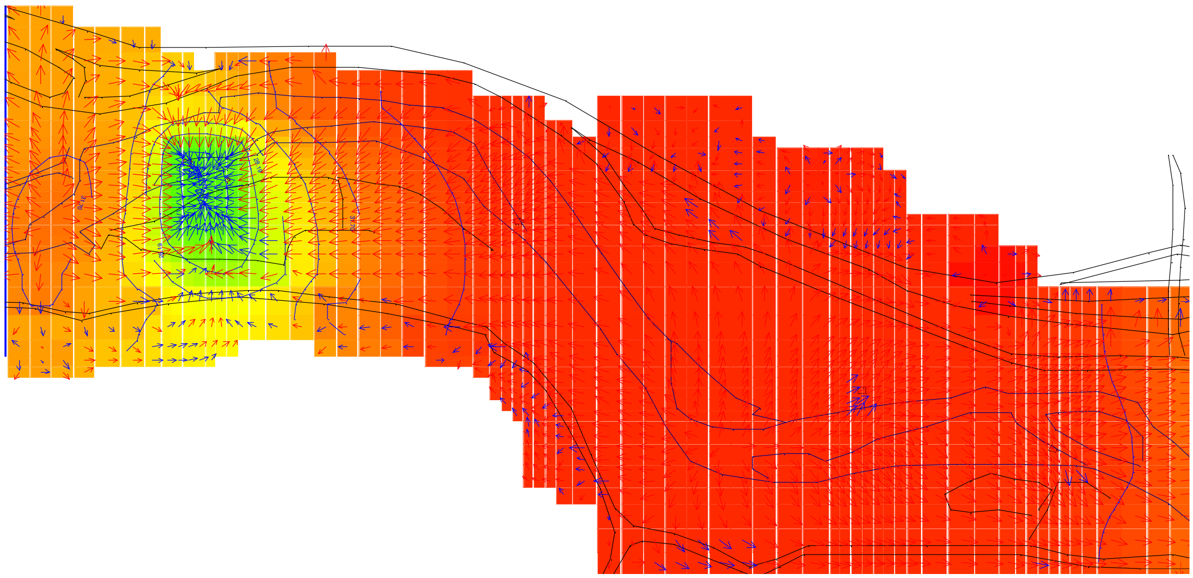
Appendix A
Figures of Model Results



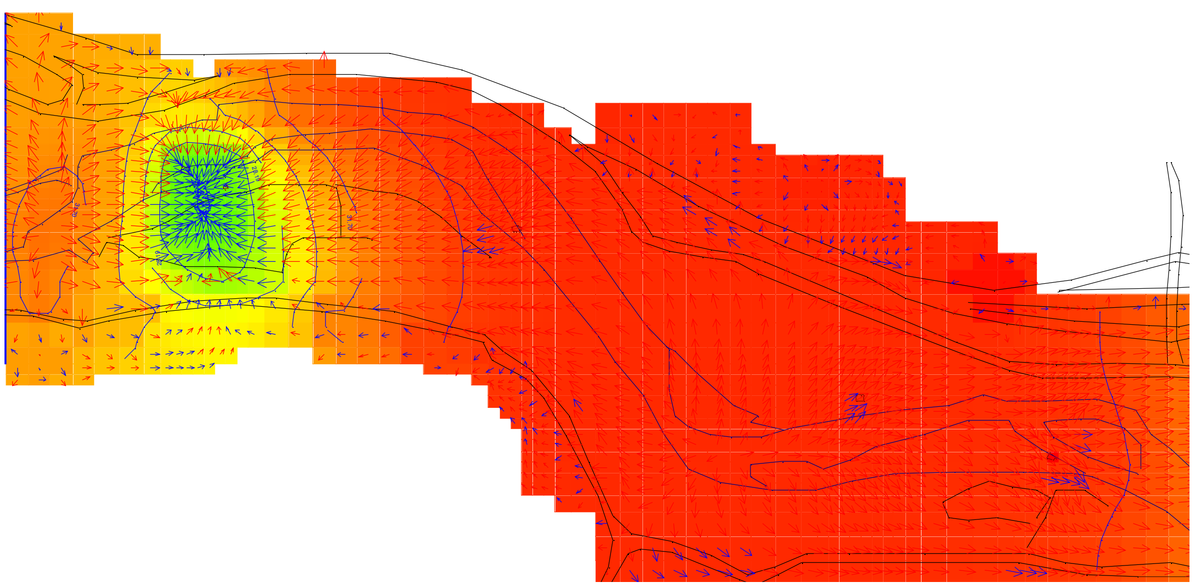
A- 1. Model Results, Scenario 1, Layer 1 - PS-1/1A, 6MGD, HBMWD Groundwater Study



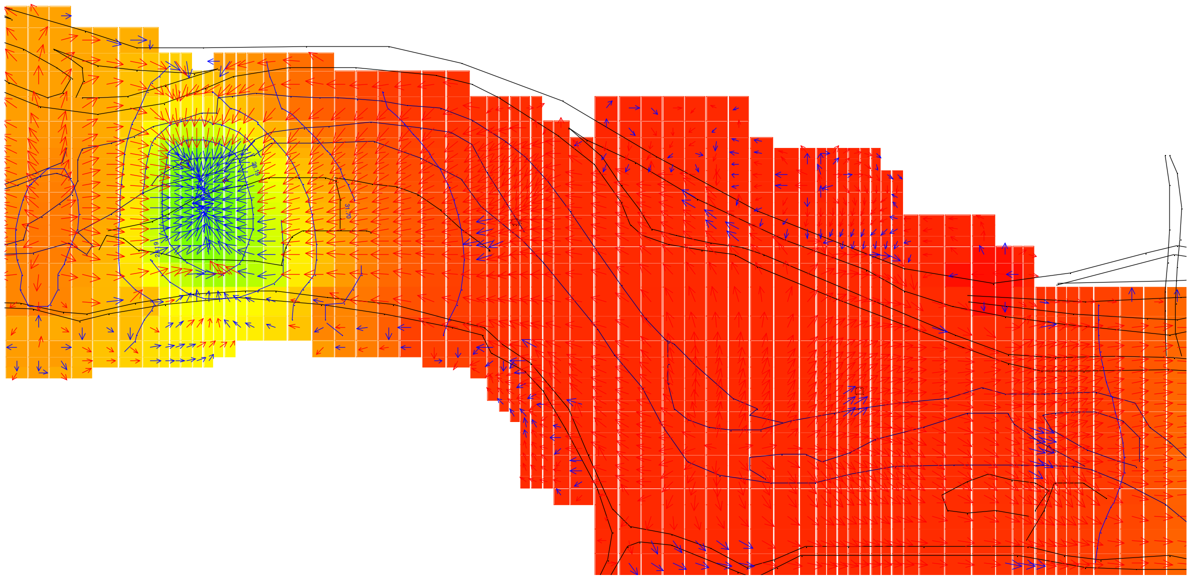
A- 2. Model Results, Scenario 1, Layer 2 - PS-1/1A, 6MGD, HBMWD Groundwater Study



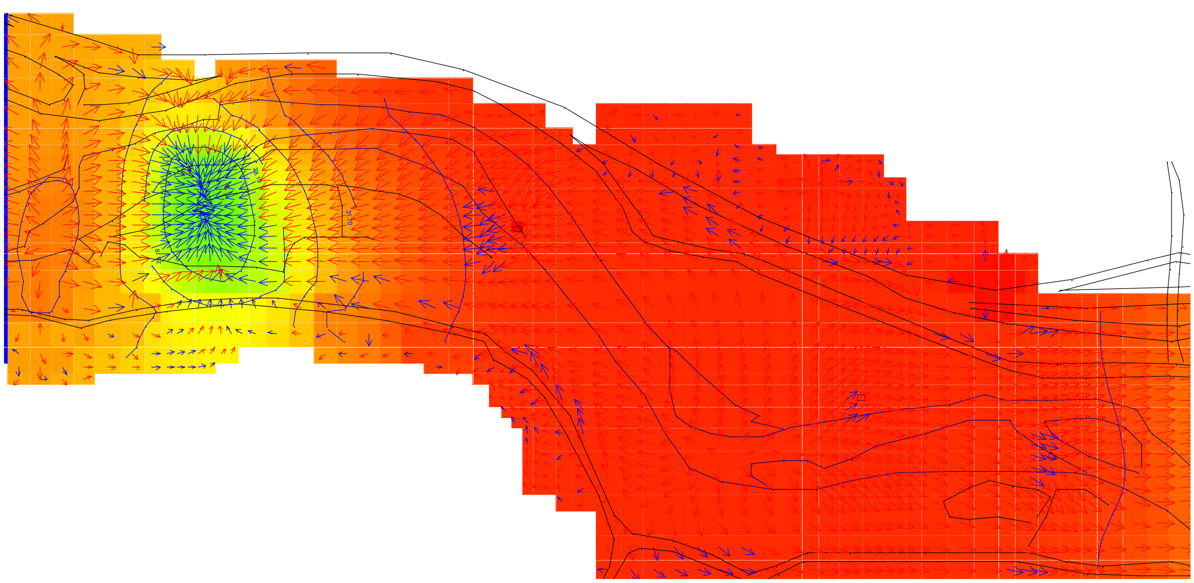
A- 3. Model Results, Scenario 1, Layer 3 - PS-1/1A, 6MGD, HBMWD Groundwater Study



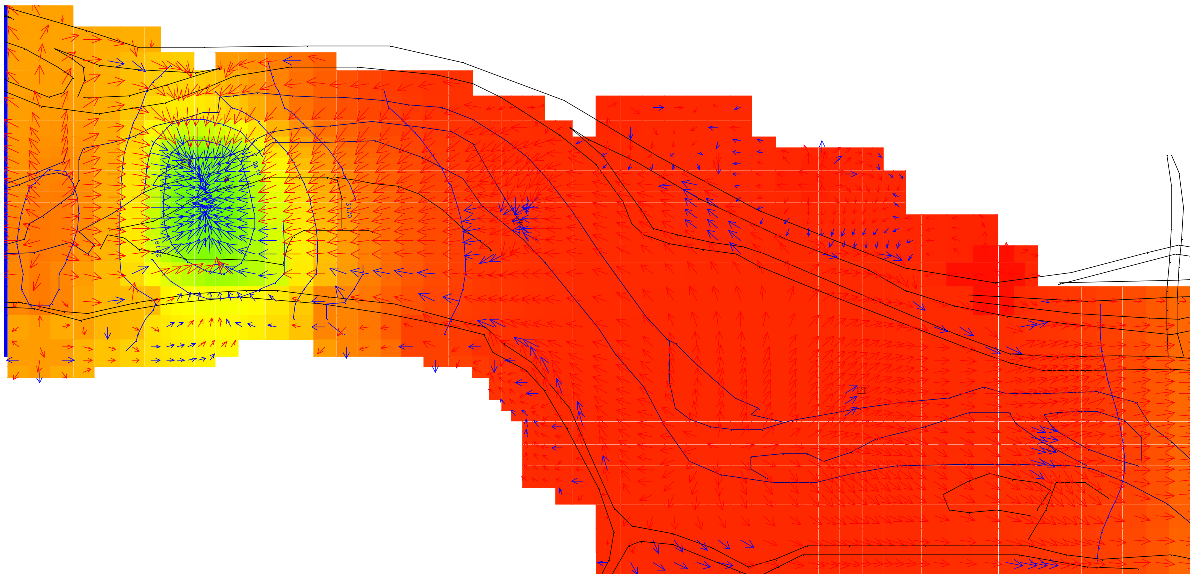
A- 4. Model Results, Scenario 1, Layer 4 - PS-1/1A, 6MGD, HBMWD Groundwater Study



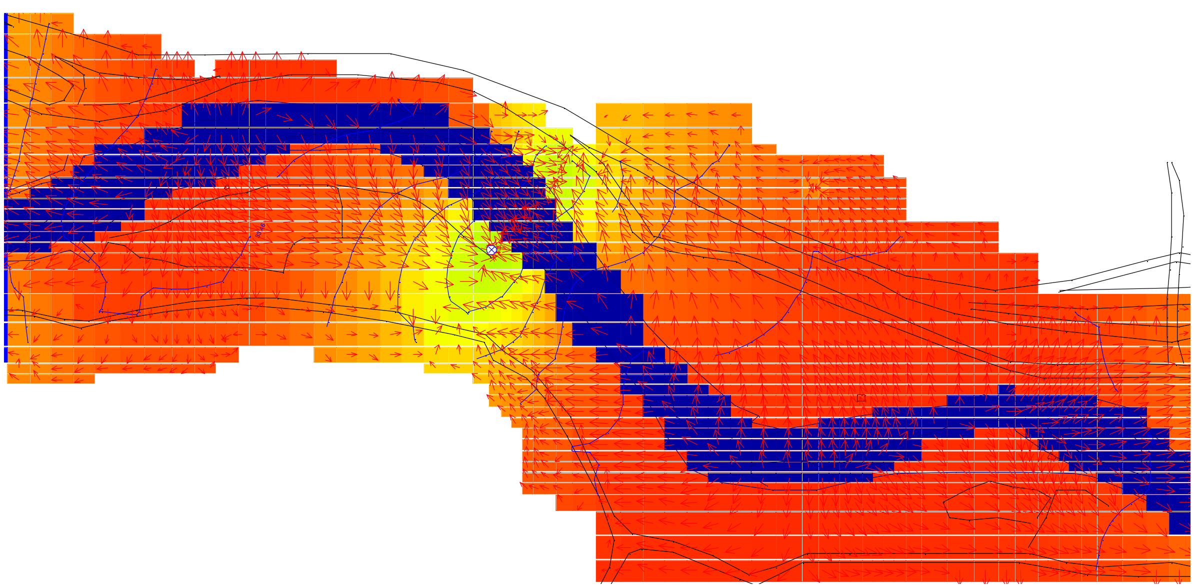
A- 5. Model Results, Scenario 1, Layer 5 - PS-1/1A, 6MGD, HBMWD Groundwater Study



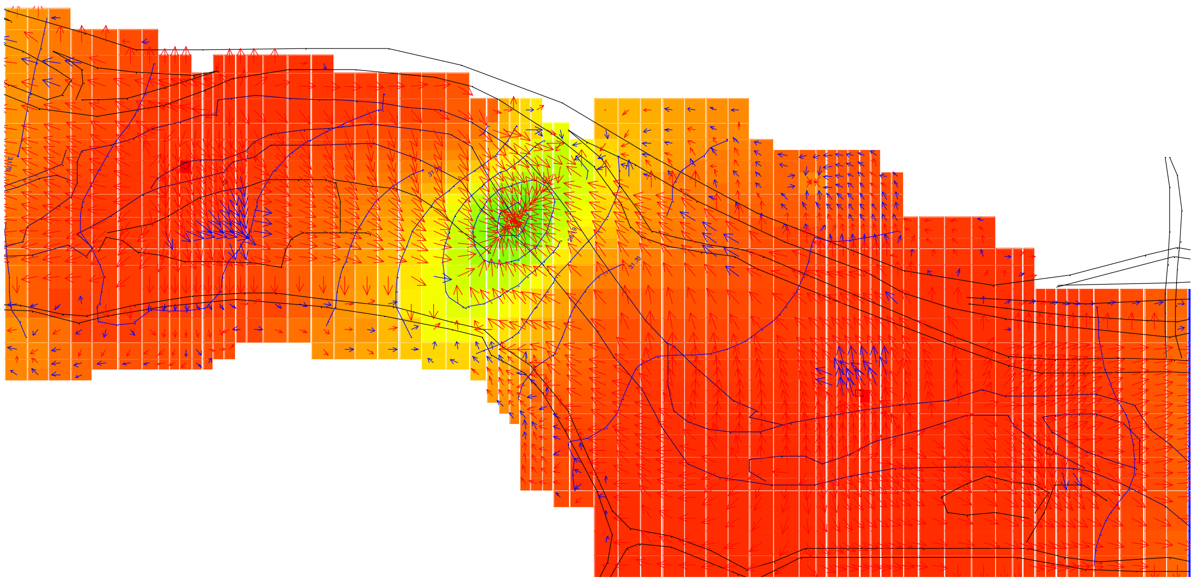
A- 6. Model Results, Scenario 1, Layer 6 - PS-1/1A, 6MGD, HBMWD Groundwater Study



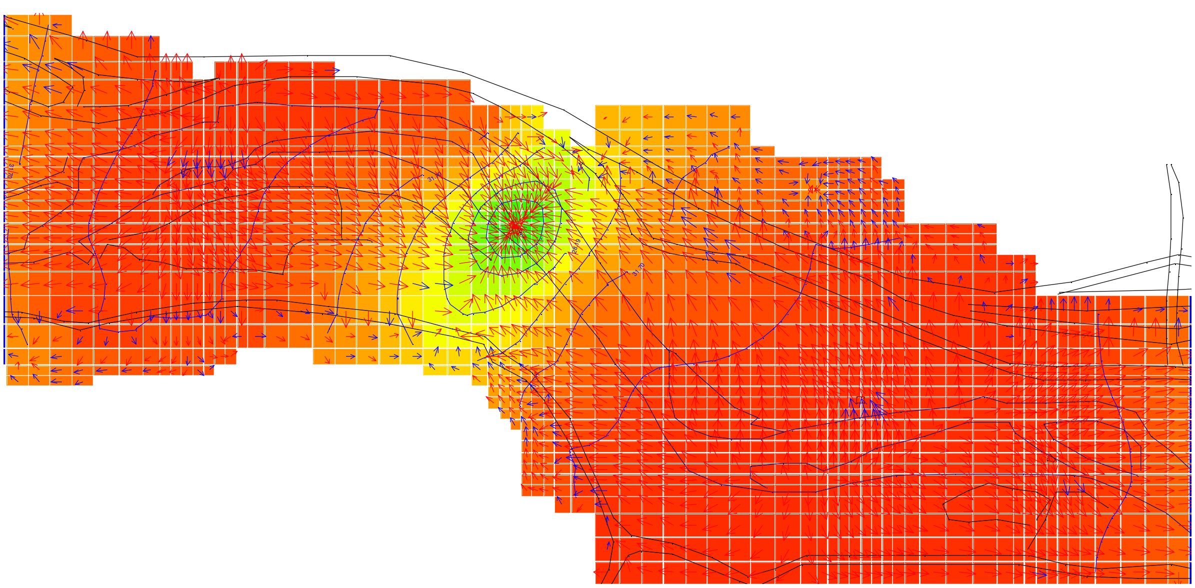
A- 7. Model Results, Scenario 1, Layer 7 - PS-1/!A, 6MGD, HBMWD Groundwater Study



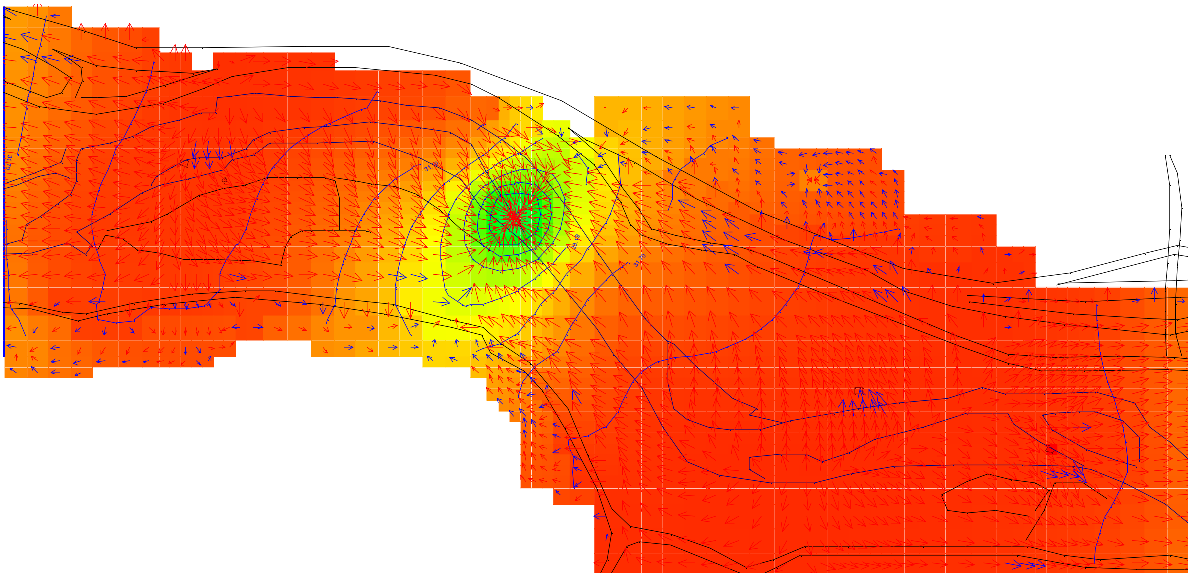
A- 8. Model Results, Scenario 2, Layer 1 - PS-2, 6MGD, HBMWD Groundwater Study



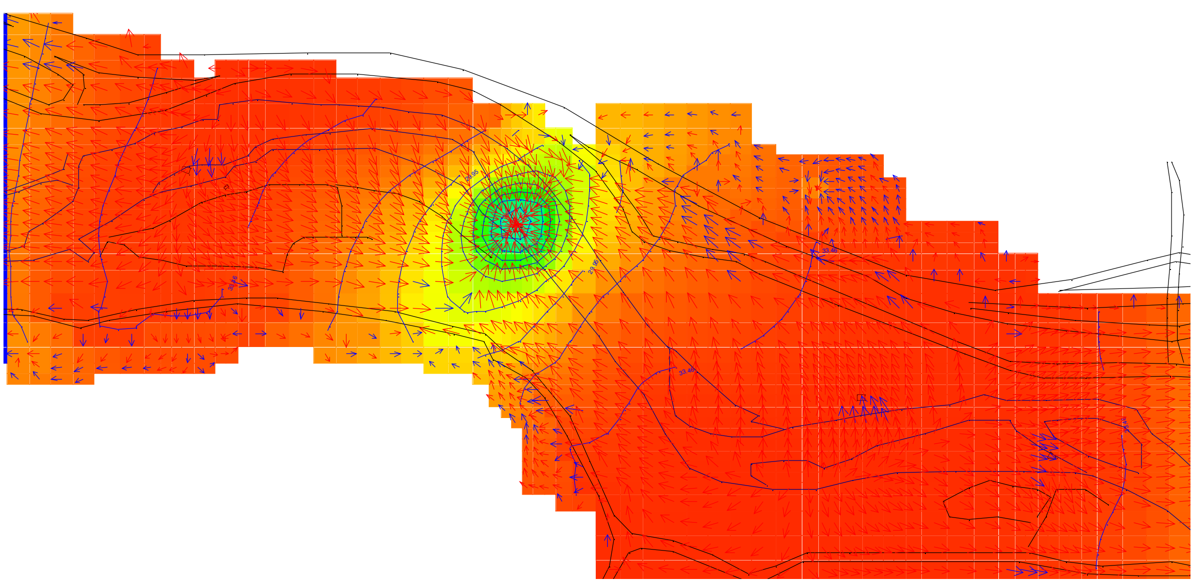
A- 9. Model Results, Scenario 2, Layer 2 - PS-2, 6MGD, HBMWD Groundwater Study



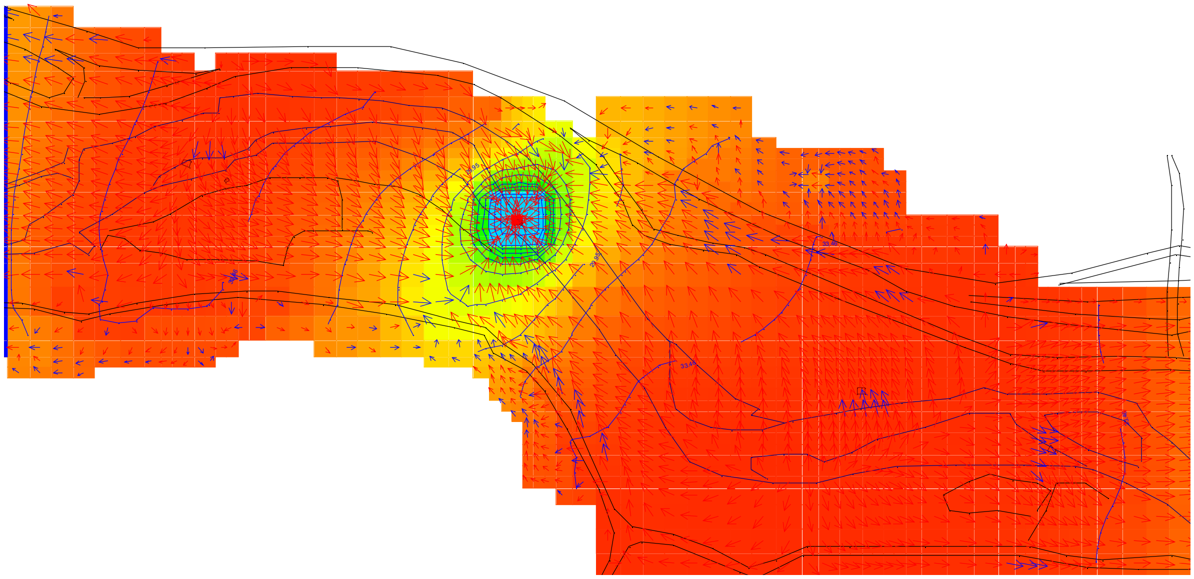
A- 10. Model Results, Scenario 2, Layer 3 - PS-2, 6MGD, HBMWD Groundwater Study



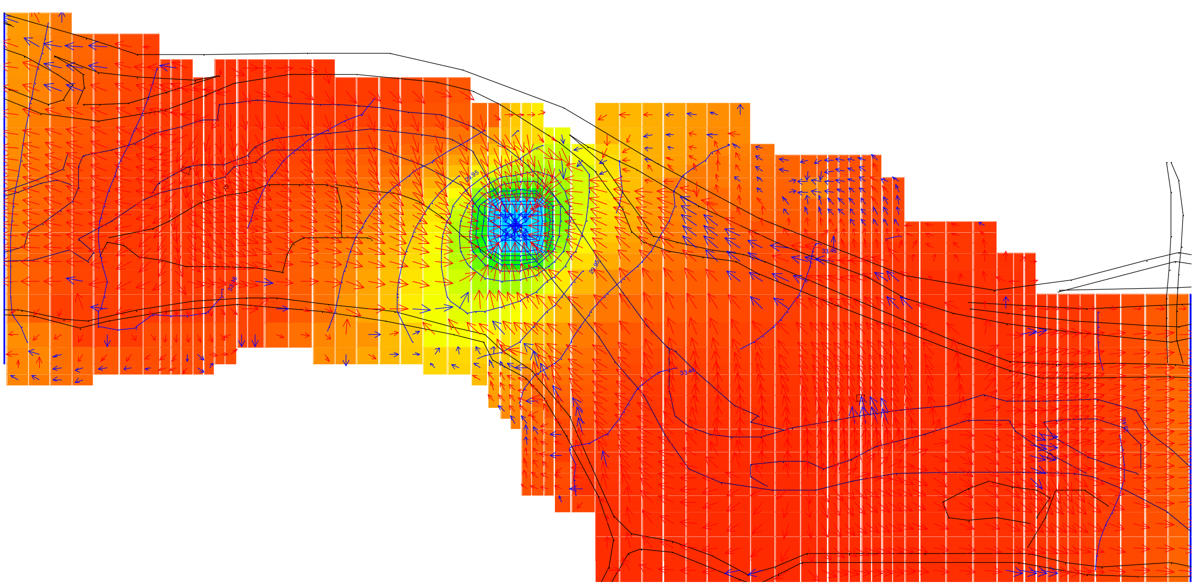
A- 11. Model Results, Scenario 2, Layer 4 - PS-2, 6MGD, HBMWD Groundwater Study



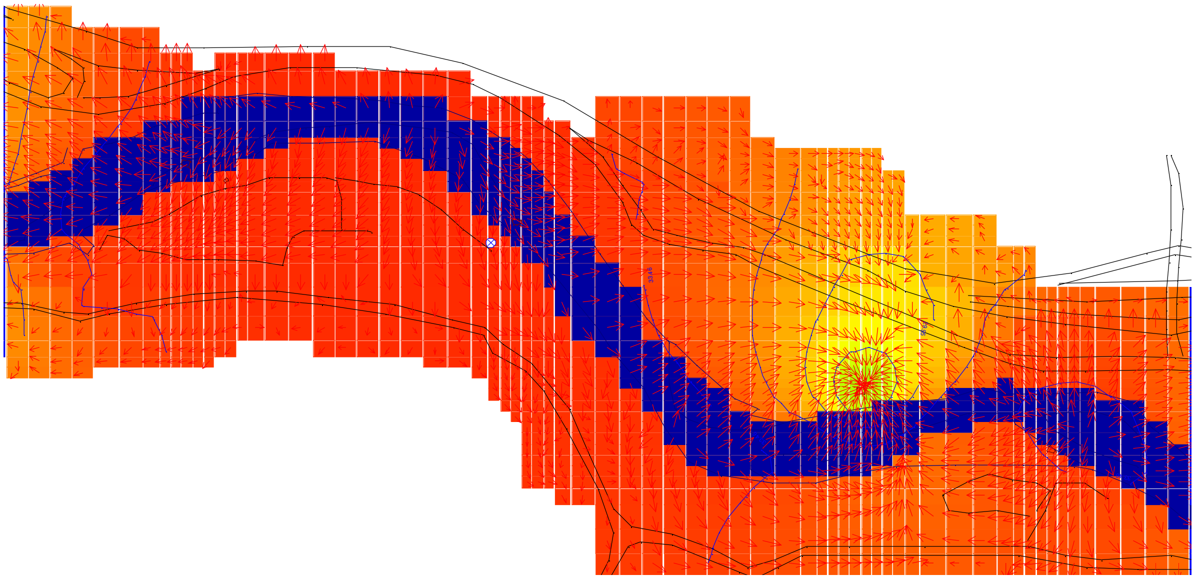
A- 12. Model Results, Scenario 2, Layer 5 - PS-2, 6MGD, HBMWD Groundwater Study



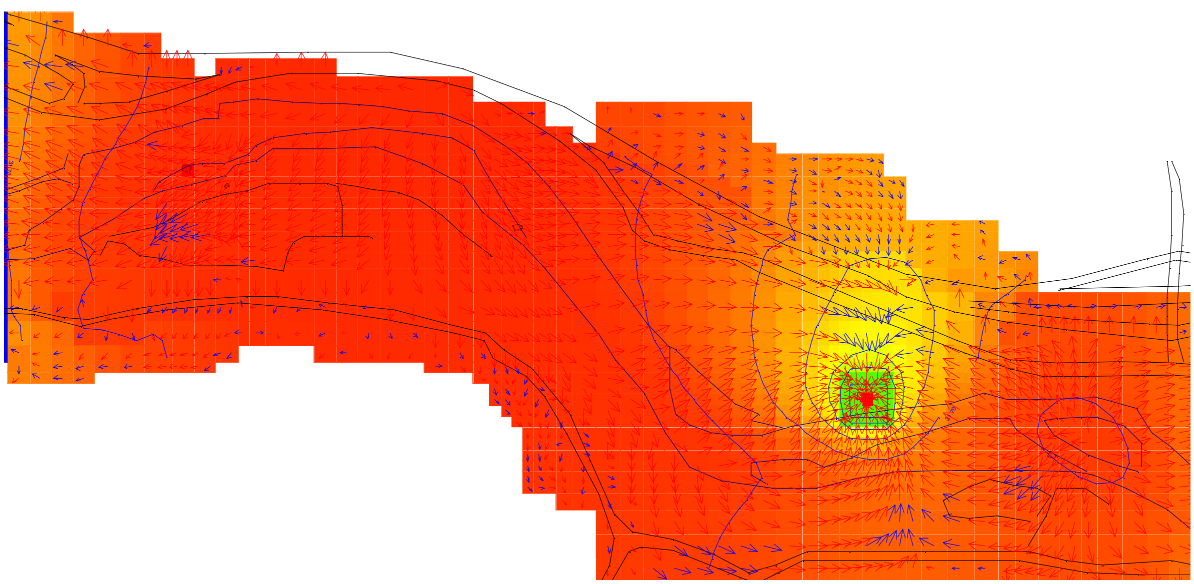
A- 13. Model Results, Scenario 2, Layer 6 - PS-2, 6MGD, HBMWD Groundwater Study



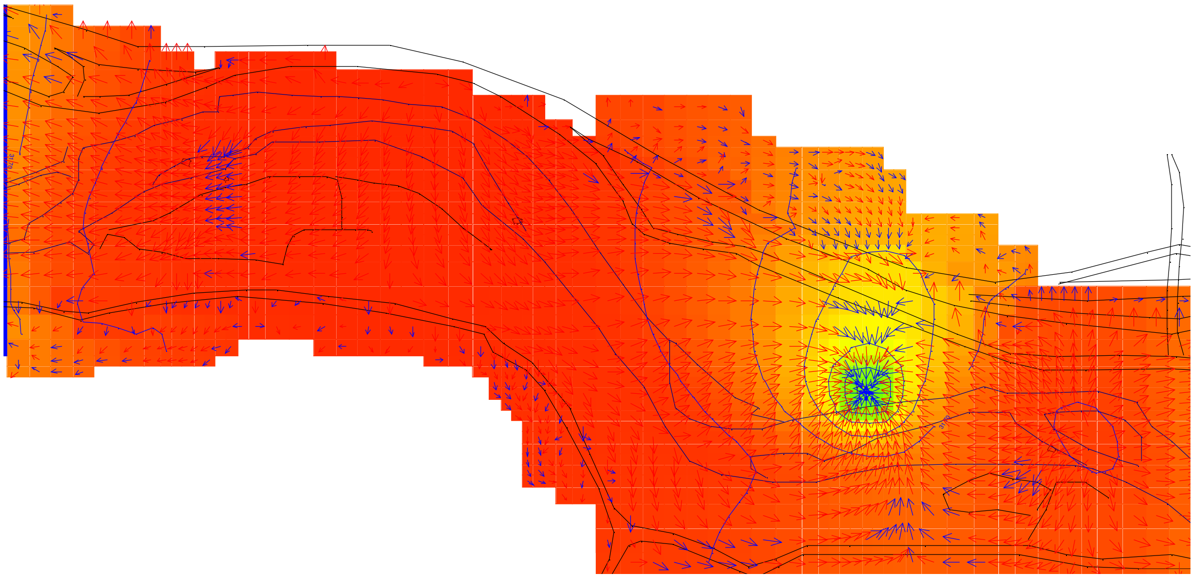
A- 14. Model Results, Scenario 2, Layer 7 - PS-2, 6MGD, HBMWD Groundwater Study



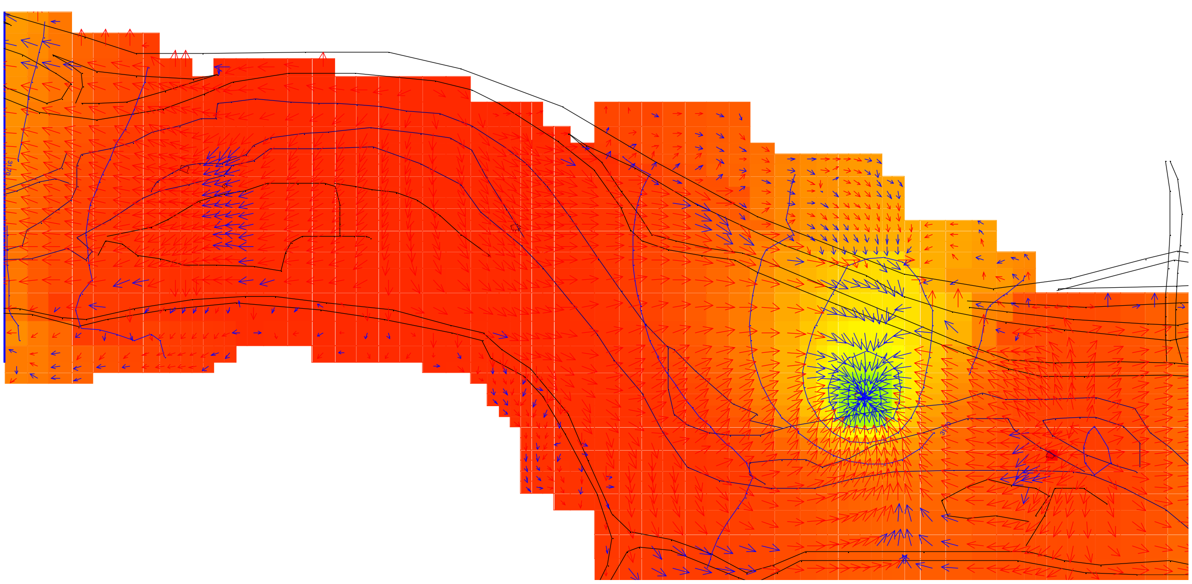
A- 15. Model Results, Scenario 3, Layer 1 - PS-3, 4MGD, HBMWD Groundwater Study



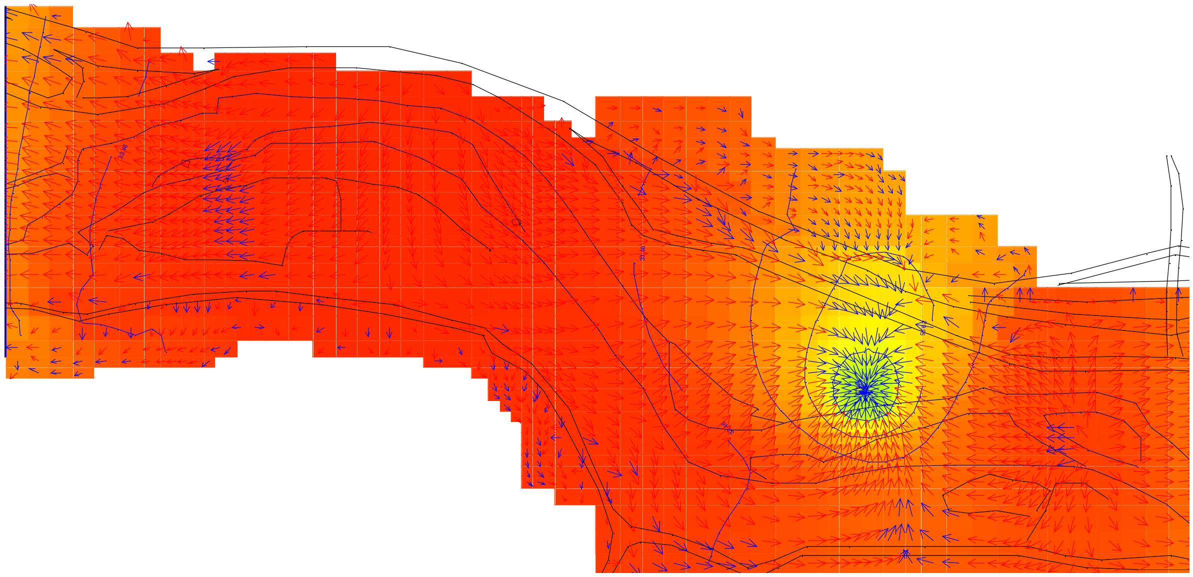
A- 16. Model Results, Scenario 3, Layer 2 - PS-3, 4MGD, HBMWD Groundwater Study



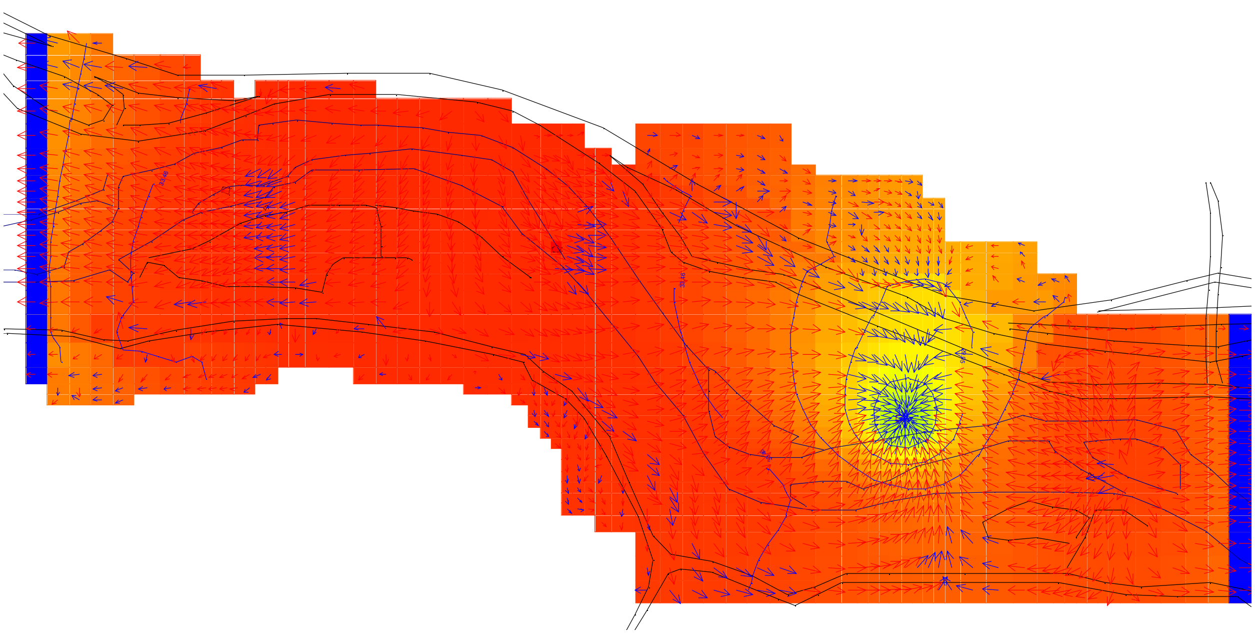
A- 17. Model Results, Scenario 3, Layer 3 - PS-3, 4MGD, HBMWD Groundwater Study



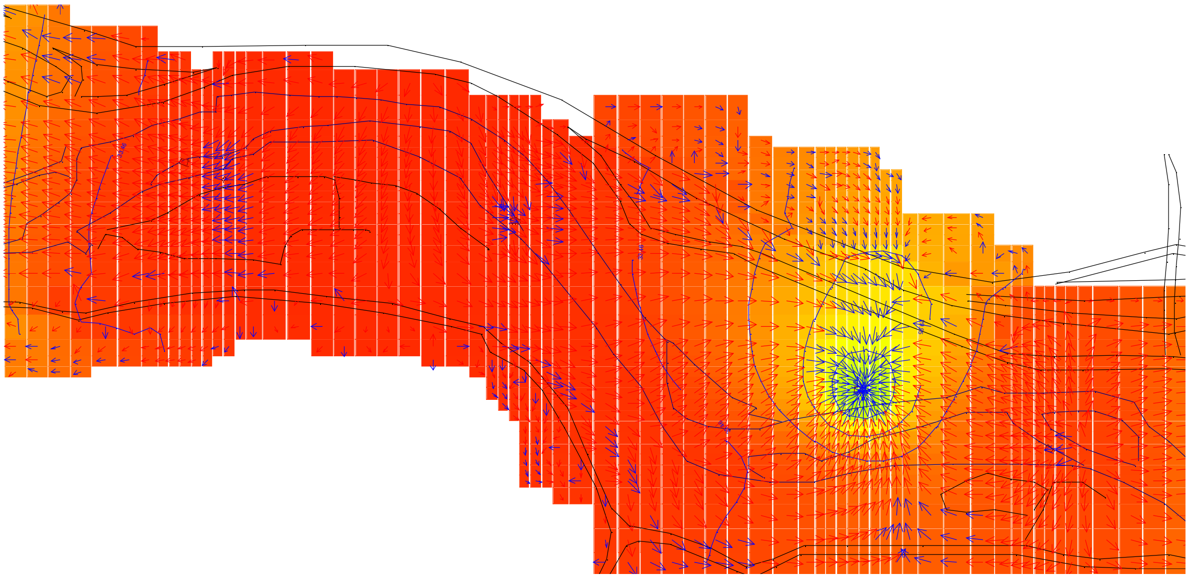
A- 18. Model Results, Scenario 3, Layer 4 - PS-3, 4MGD, HBMWD Groundwater Study



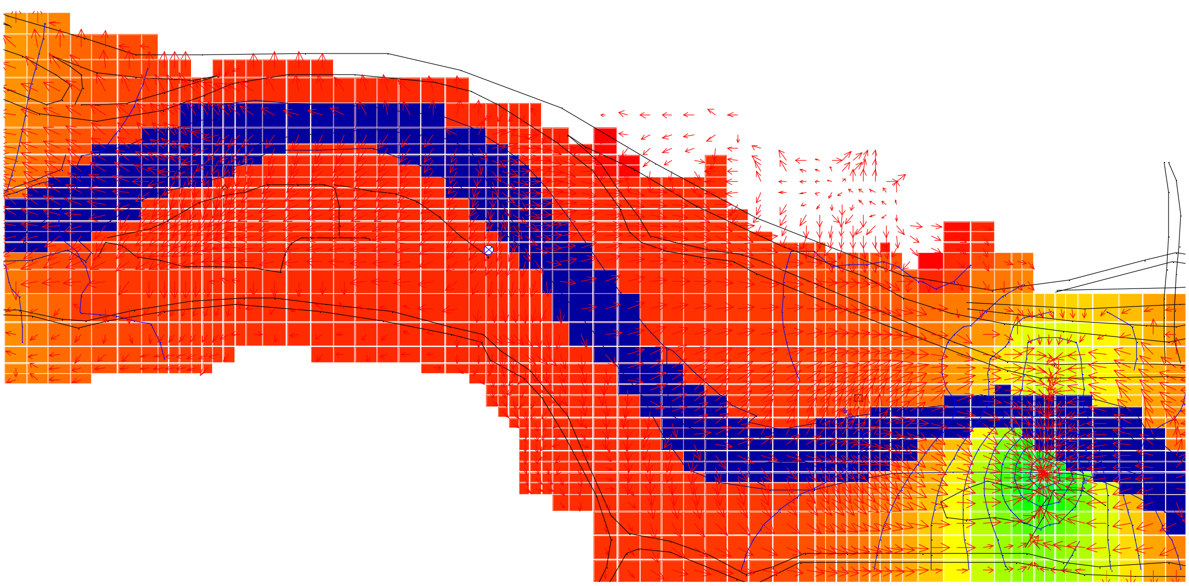
A- 19. Model Results, Scenario 3, Layer 5 - PS-3, 4MGD, HBMWD Groundwater Study



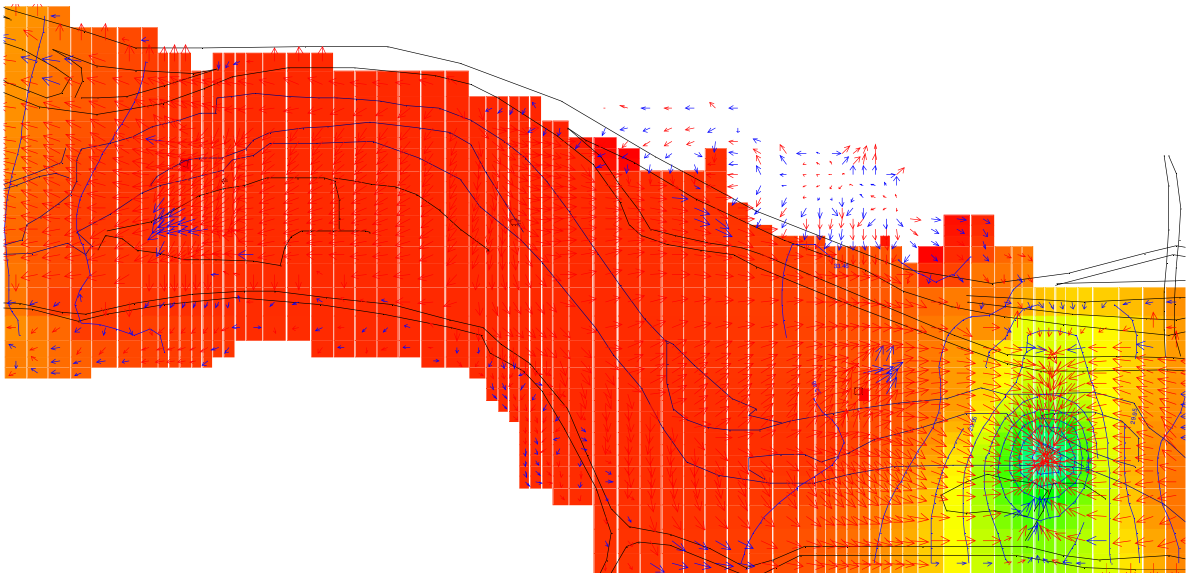
A- 20. Model Results, Scenario 3, Layer 6 - PS-3, 4MGD, HBMWD Groundwater Study



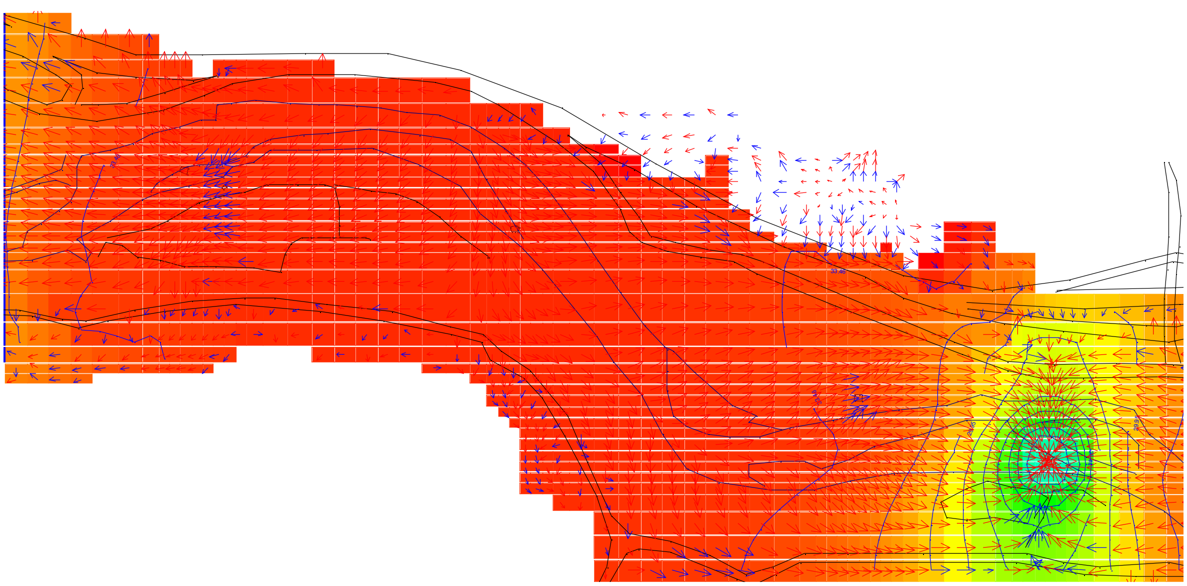
A- 21. Model Results, Scenario 3, Layer 7 - PS-3, 4MGD, HBMWD Groundwater Study



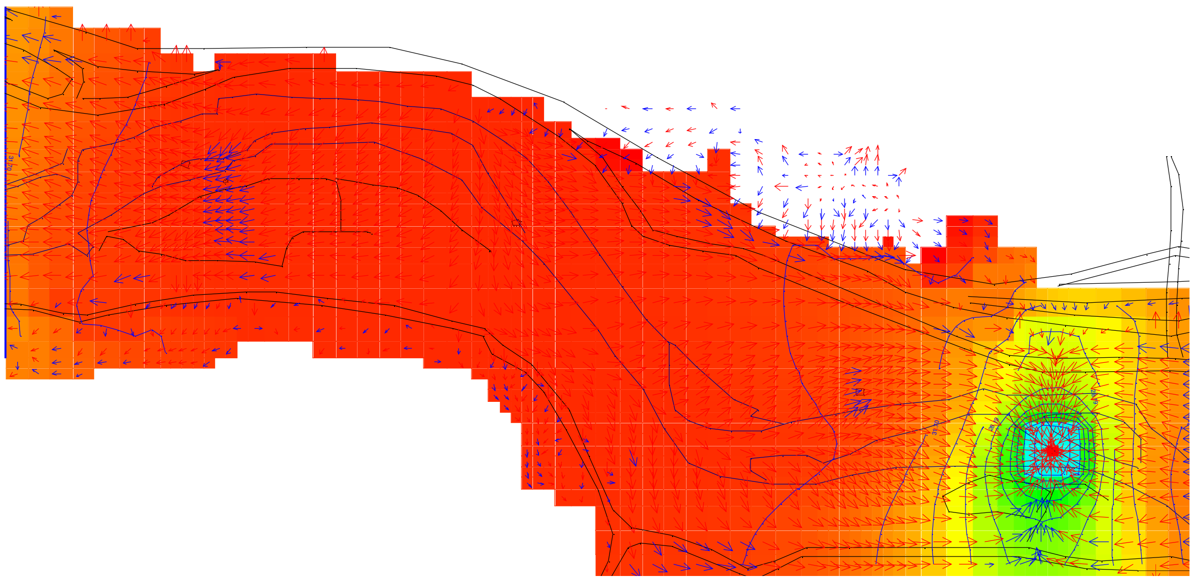
A- 22. Model Results, Scenario 4, Layer 1 - PS-4, 6MGD, HBMWD Groundwater Study



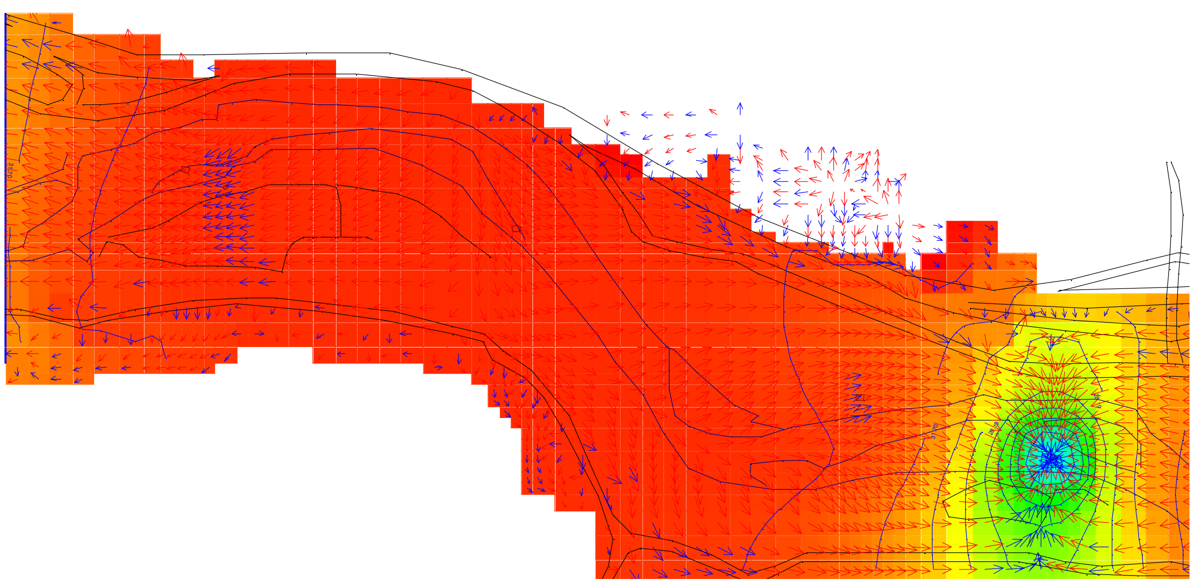
A- 23. Model Results, Scenario 4, Layer 2 - PS-4, 6MGD, HBMWD Groundwater Study



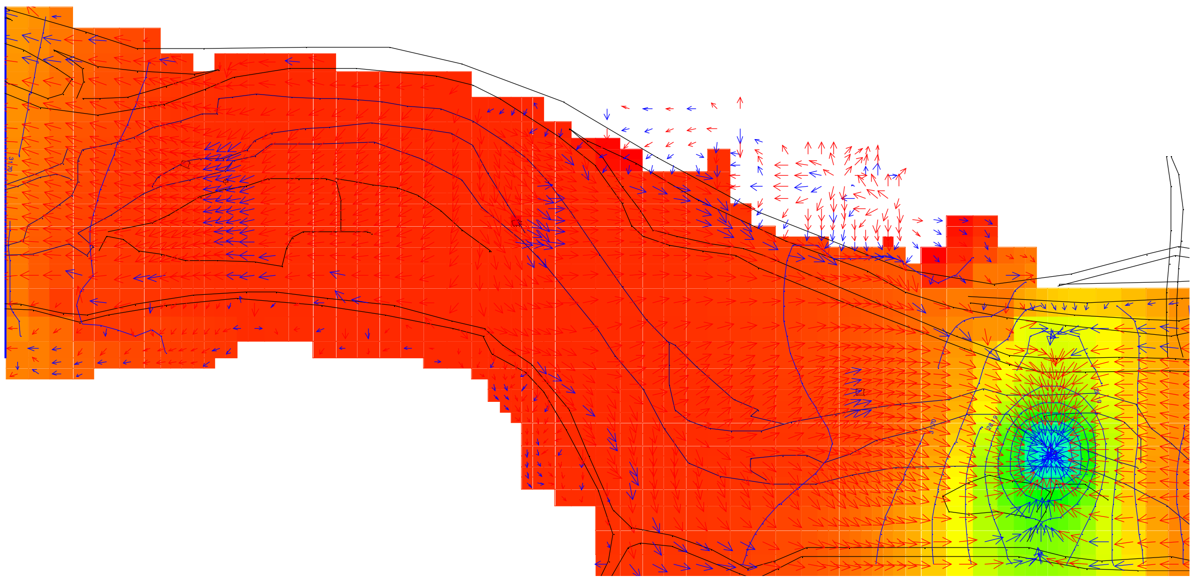
A- 24. Model Results, Scenario 4, Layer 3 - PS-4, 6MGD, HBMWD Groundwater Study



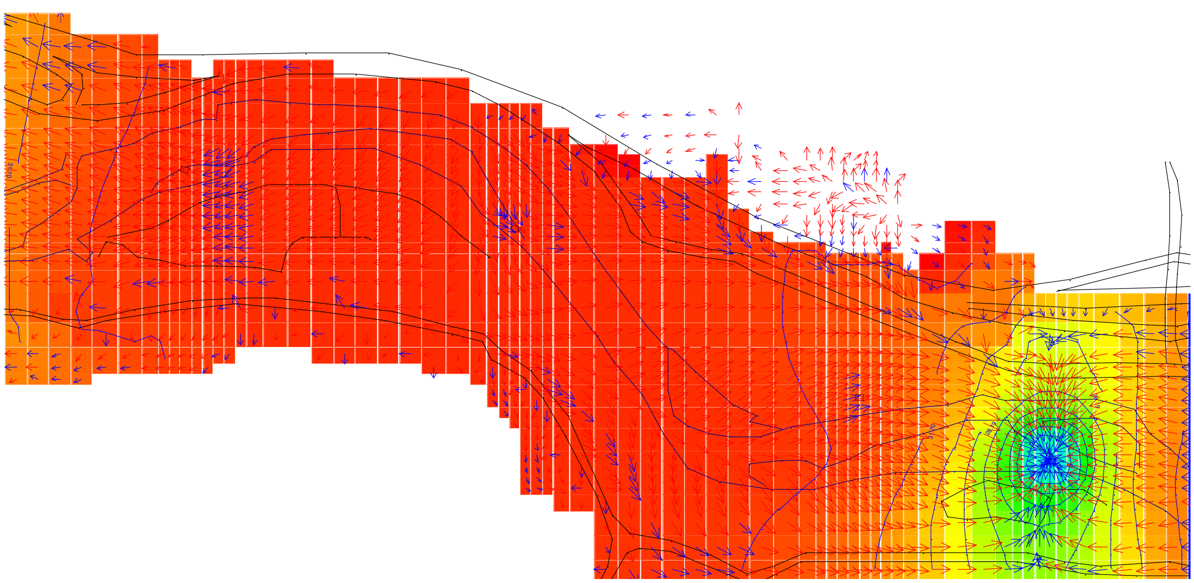
A- 25. Model Results, Scenario 4, Layer 4 - PS-4, 6MGD, HBMWD Groundwater Study



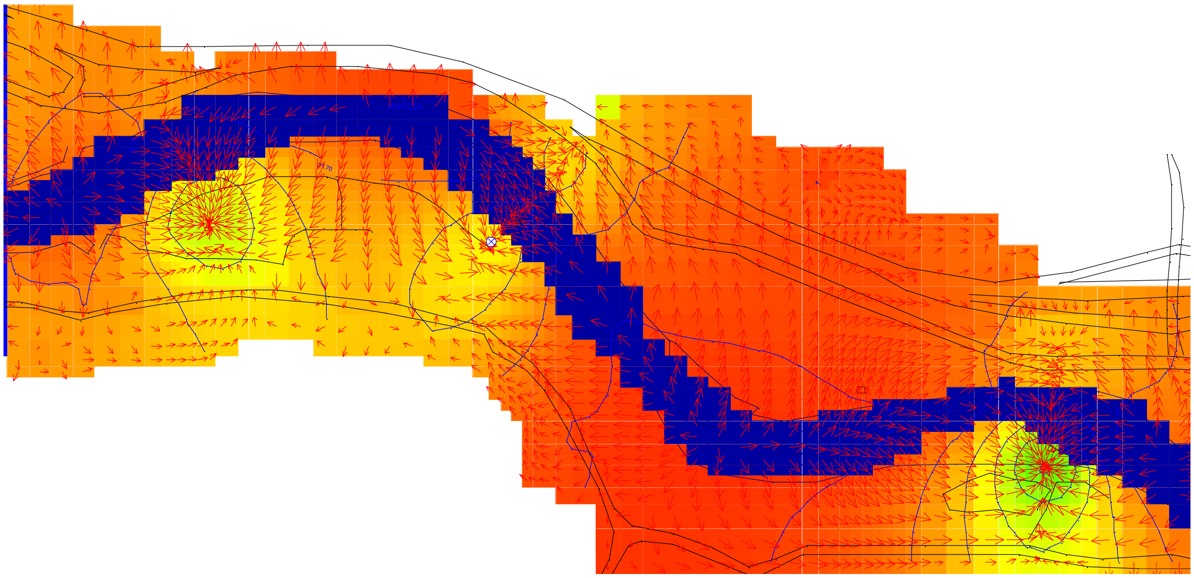
A- 26. Model Results, Scenario 4, Layer 5 - PS-4, 6MGD, HBMWD Groundwater Study



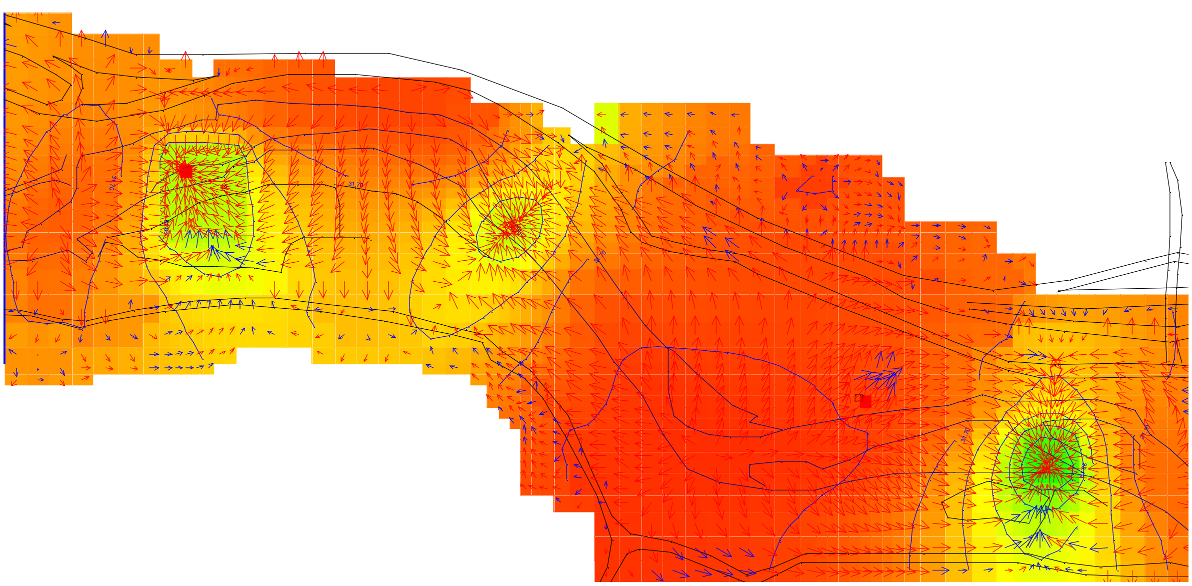
A- 27. Model Results, Scenario 4, Layer 6 - PS-4, 6MGD, HBMWD Groundwater Study



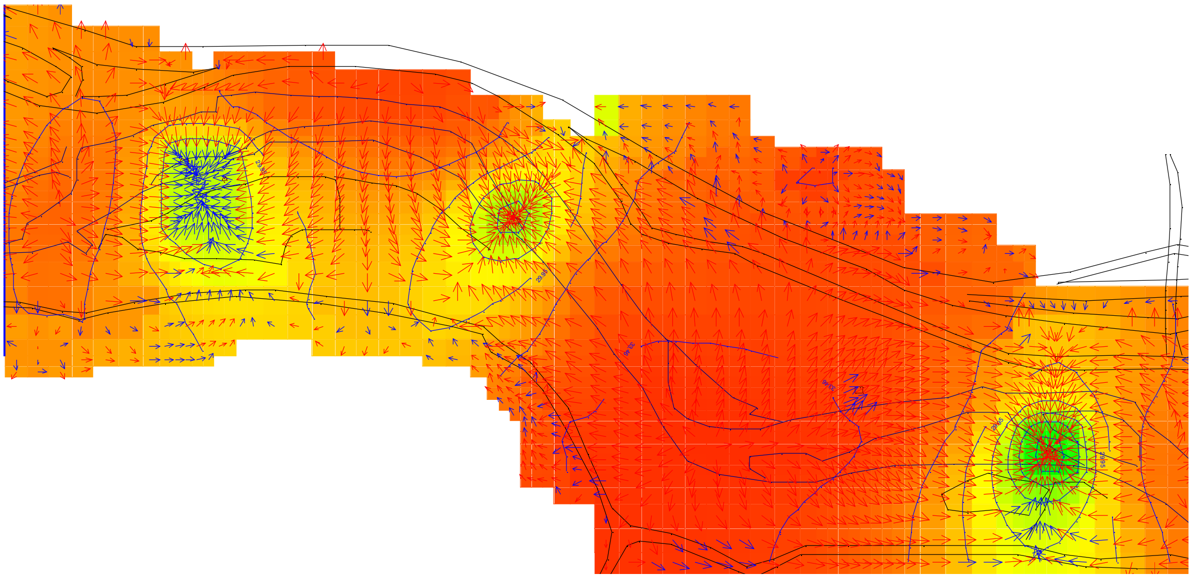
A- 28. Model Results, Scenario 4, Layer 7 - PS-4, 6MGD, HBMWD Groundwater Study



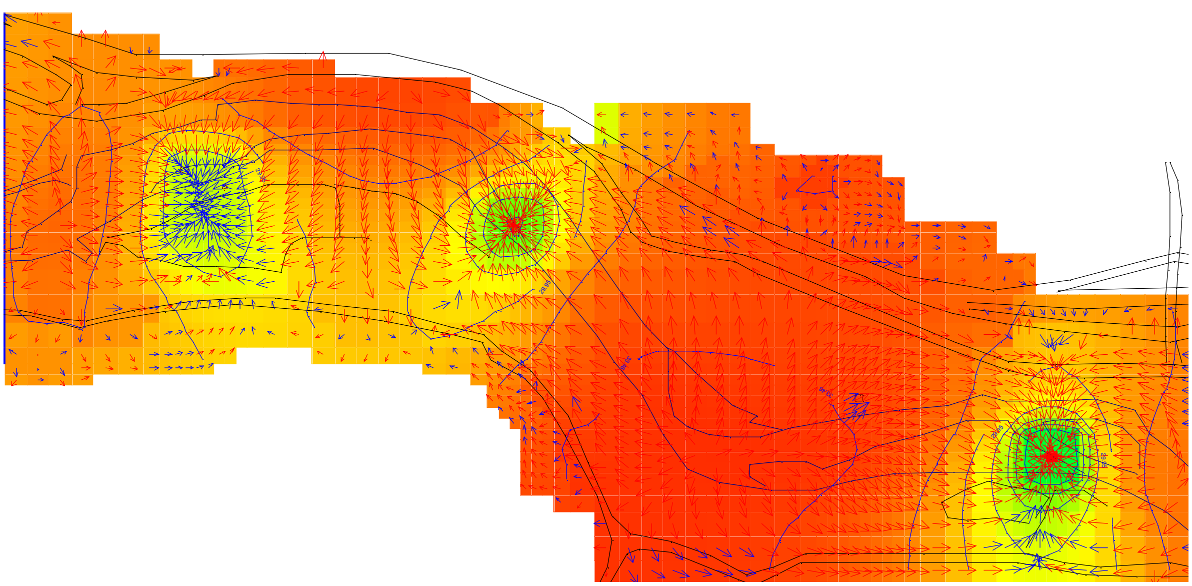
A- 29. Model Results, Scenario 5, Layer 1 - PS-1/1A, PS-2, & PS-4, 4.8MGD, HBMWD Groundwater Study



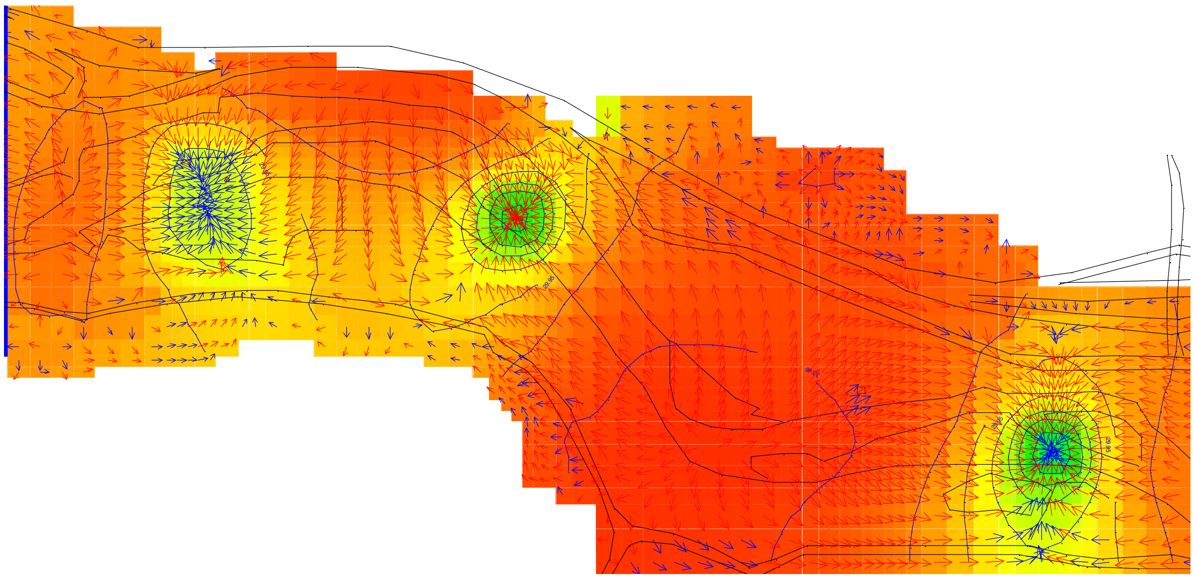
A- 30. Model Results, Scenario 5, Layer 2 - PS-1/1A, PS-2, & PS-4, 4.8MGD, HBMWD Groundwater Study



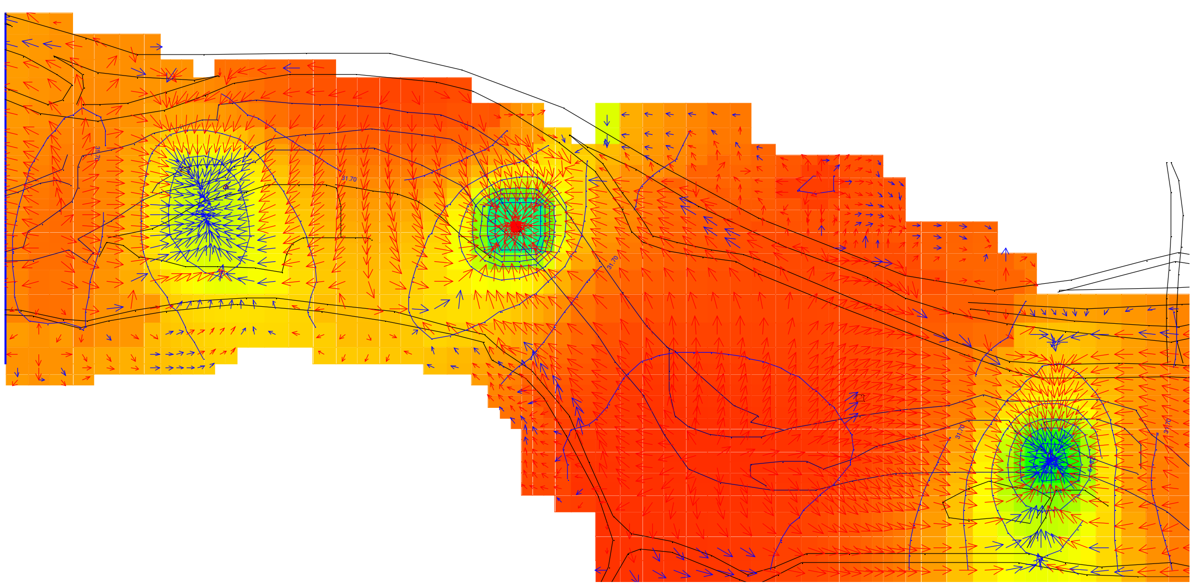
A- 31. Model Results, Scenario 5, Layer 3 - PS-1/1A, PS-2, & PS-4, 4.8MGD, HBMWD Groundwater Study



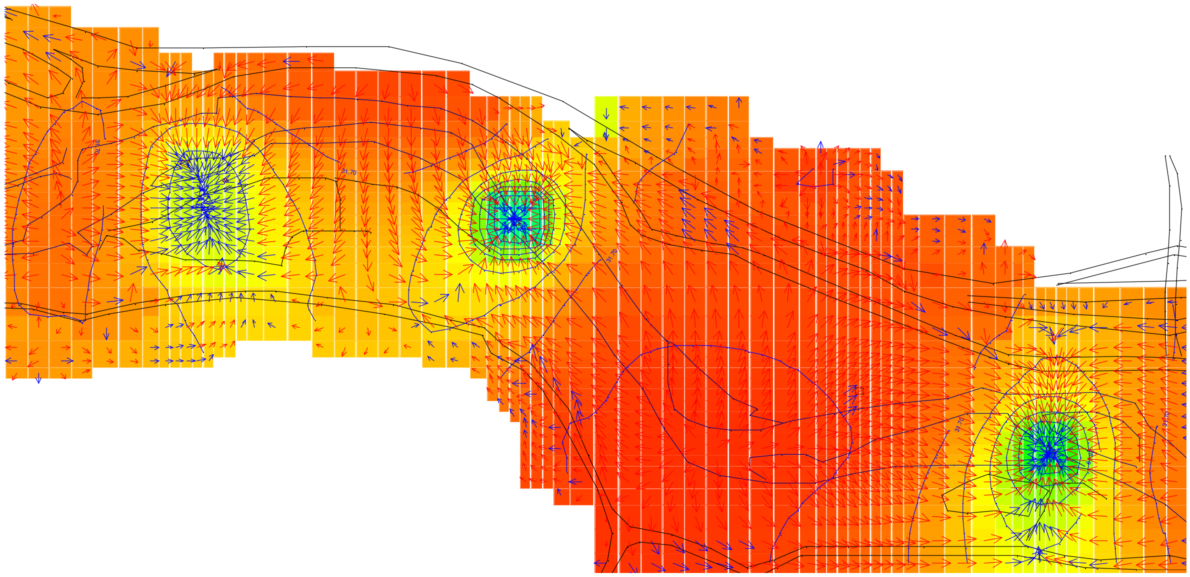
A- 32. Model Results, Scenario 5, Layer 4 - PS-1/1A, PS-2, & PS-4, 4.8MGD, HBMWD Groundwater Study



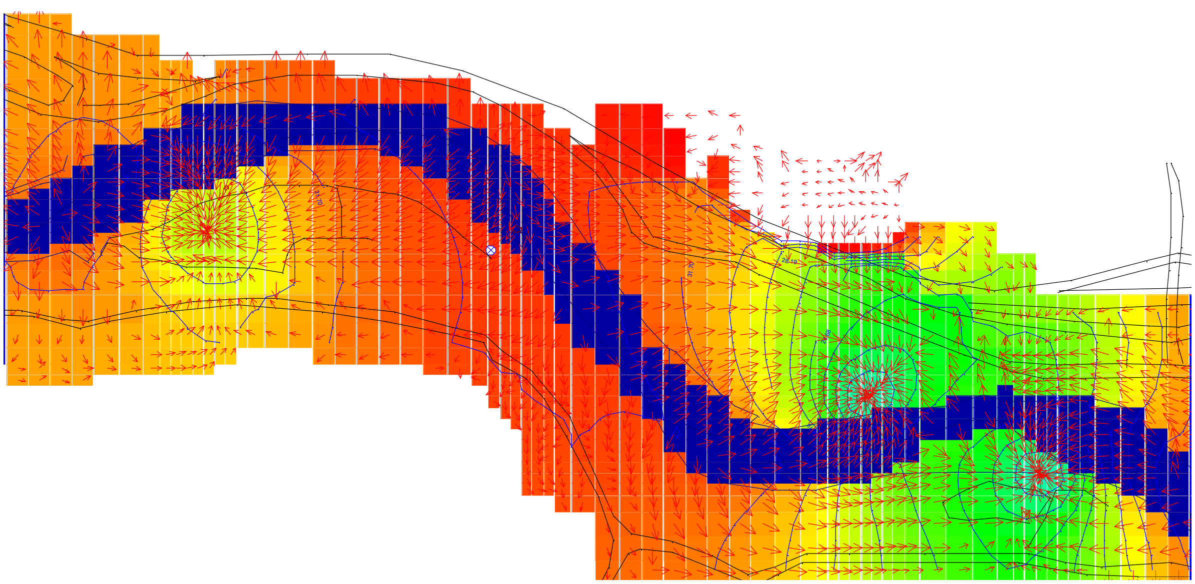
A- 33. Model Results, Scenario 5, Layer 5 - PS-1/1A, PS-2, & PS-4, 4.8MGD, HBMWD Groundwater Study



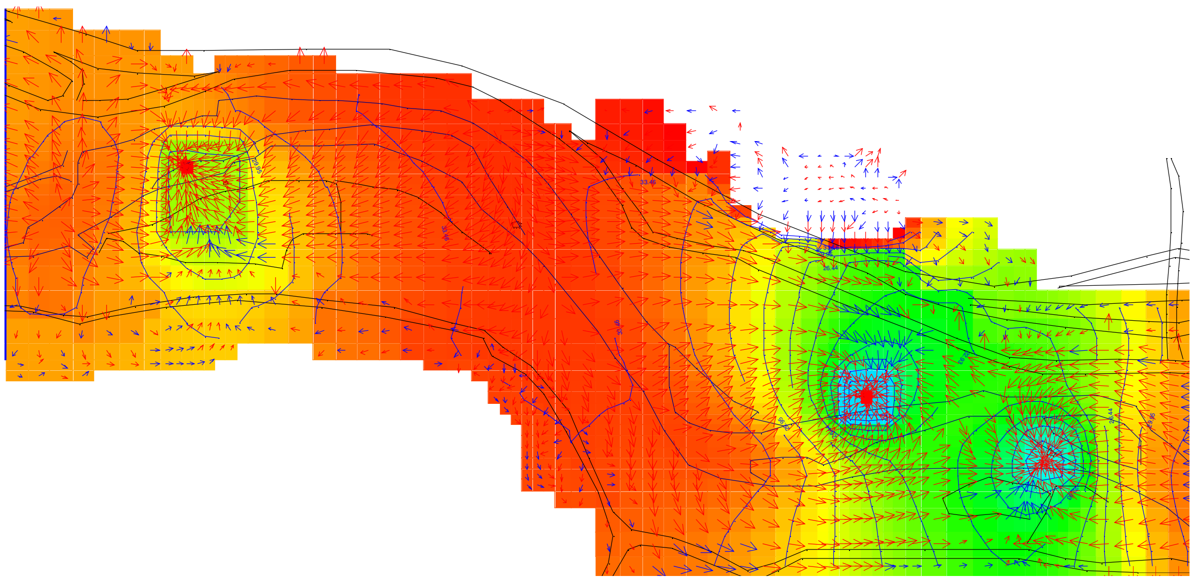
A- 34. Model Results, Scenario 5, Layer 6 - PS-1/1A, PS-2, & PS-4, 4.8MGD, HBMWD Groundwater Study



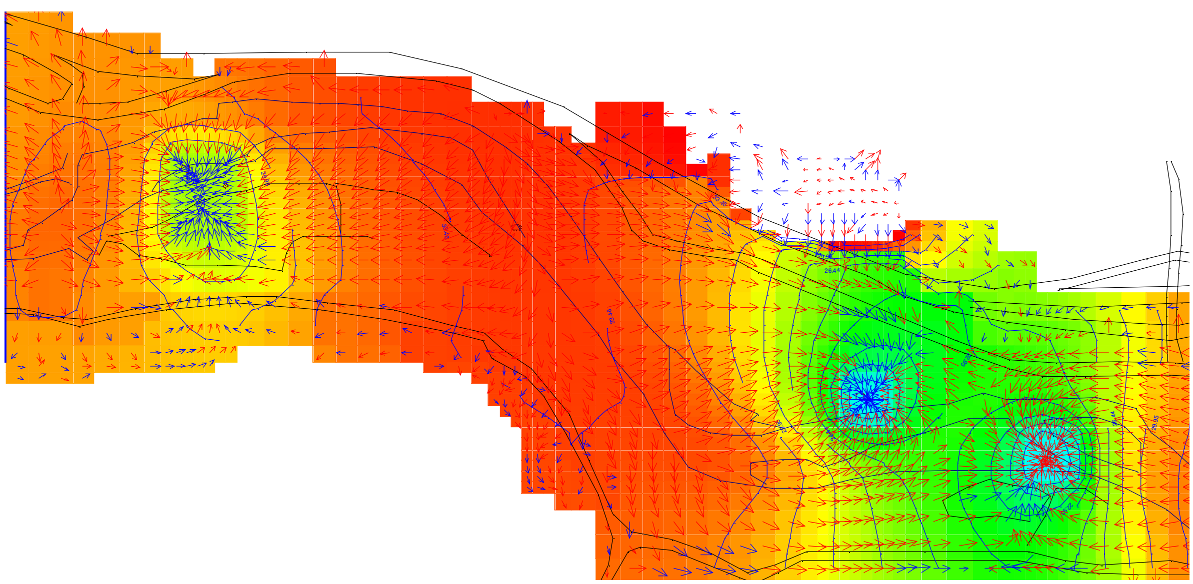
A- 35. Model Results, Scenario 5, Layer 7 - PS-1/1A, PS-2, & PS-4, 4.8MGD, HBMWD Groundwater Study



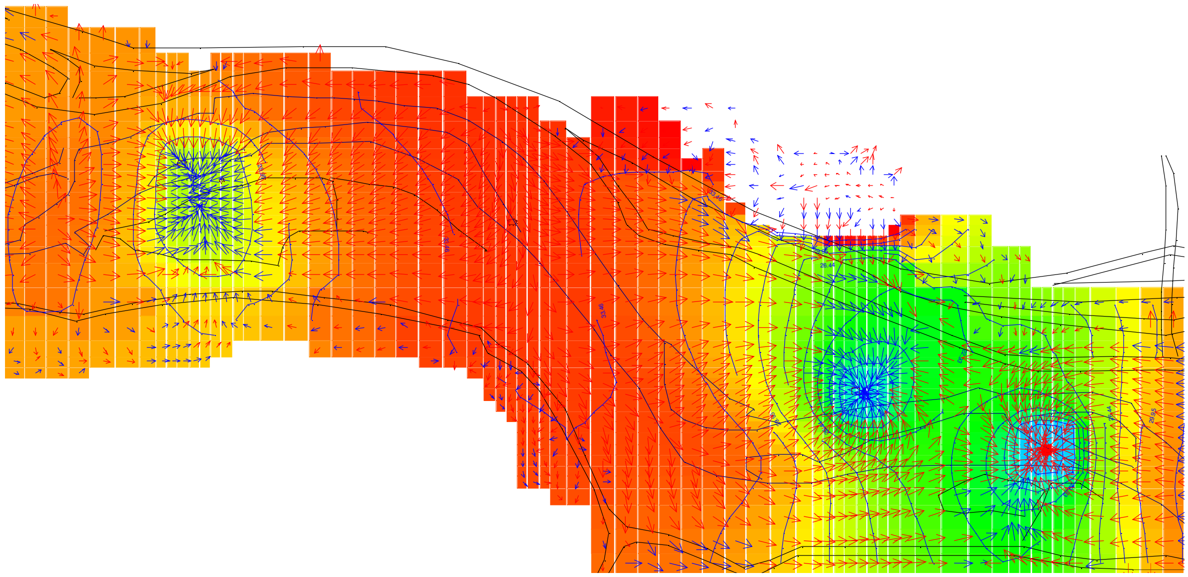
A- 36. Model Results, Scenario 6, Layer 1 - PS-1/1A, PS-3, & PS-4, 5.2MGD, HBMWD Groundwater Study



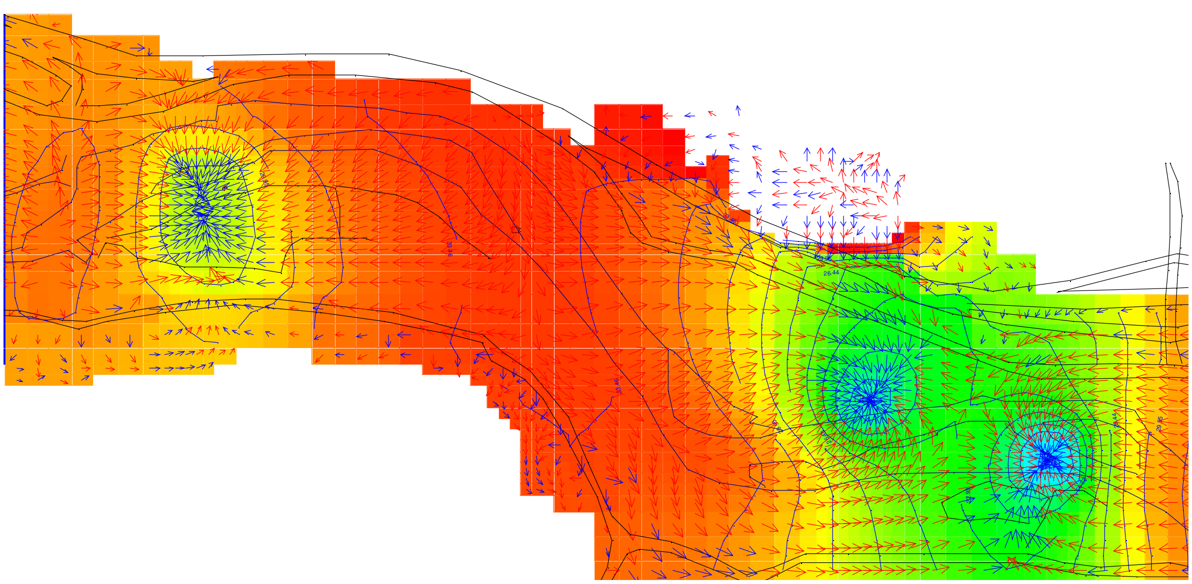
A- 37. Model Results, Scenario 6, Layer 2 - PS-1/1A, PS-3, & PS-4, 5.2MGD, HBMWD Groundwater Study



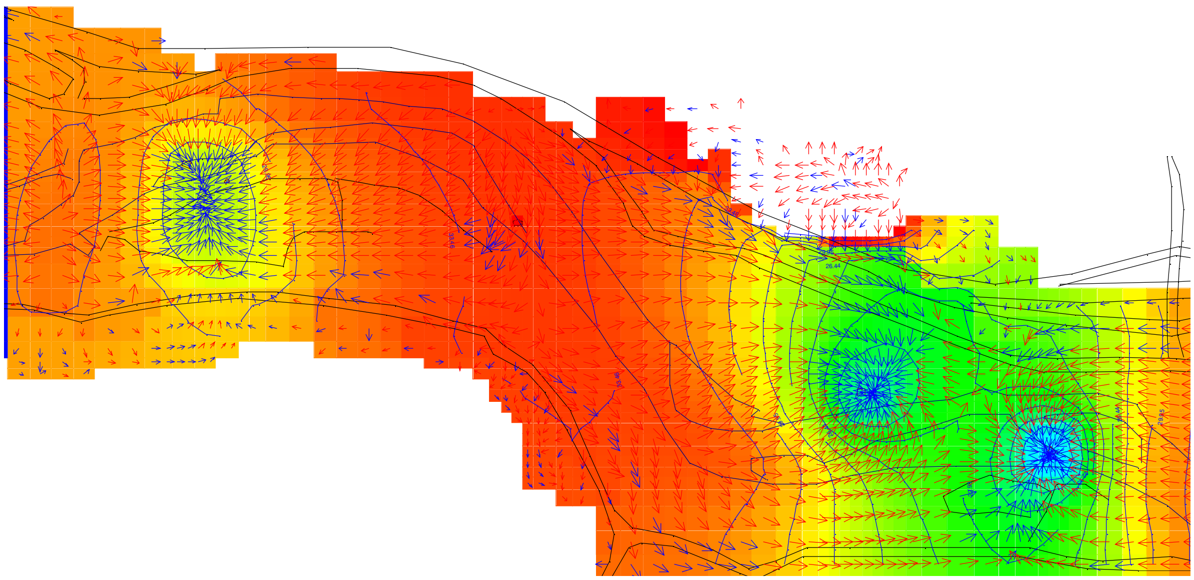
A- 38. Model Results, Scenario 6, Layer 3 - PS-1/1A, PS-3, & PS-4, 5.2MGD, HBMWD Groundwater Study



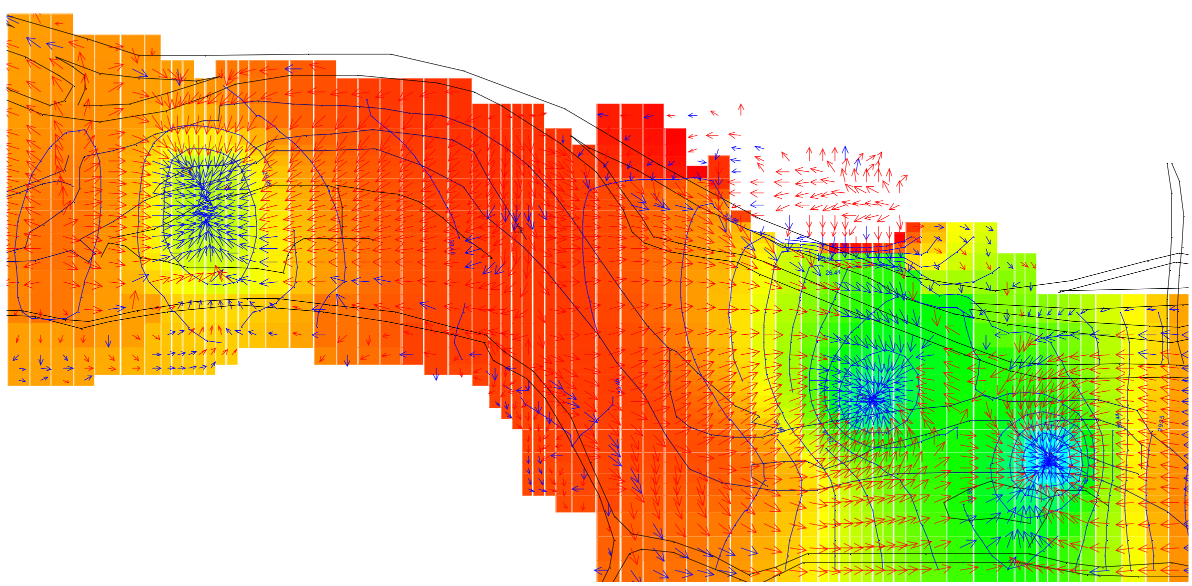
A- 39. Model Results, Scenario 6, Layer 4 - PS-1/1A, PS-3, & PS-4, 5.2MGD, HBMWD Groundwater Study



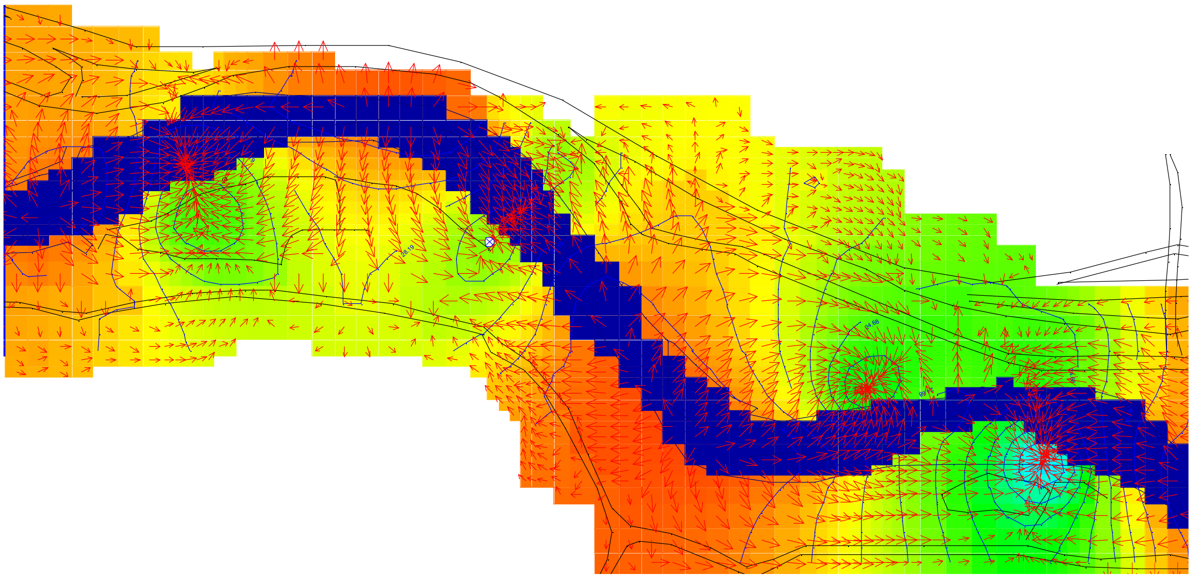
A- 40. Model Results, Scenario 6, Layer 5 - PS-1/1A, PS-3, & PS-4, 5.2MGD, HBMWD Groundwater Study



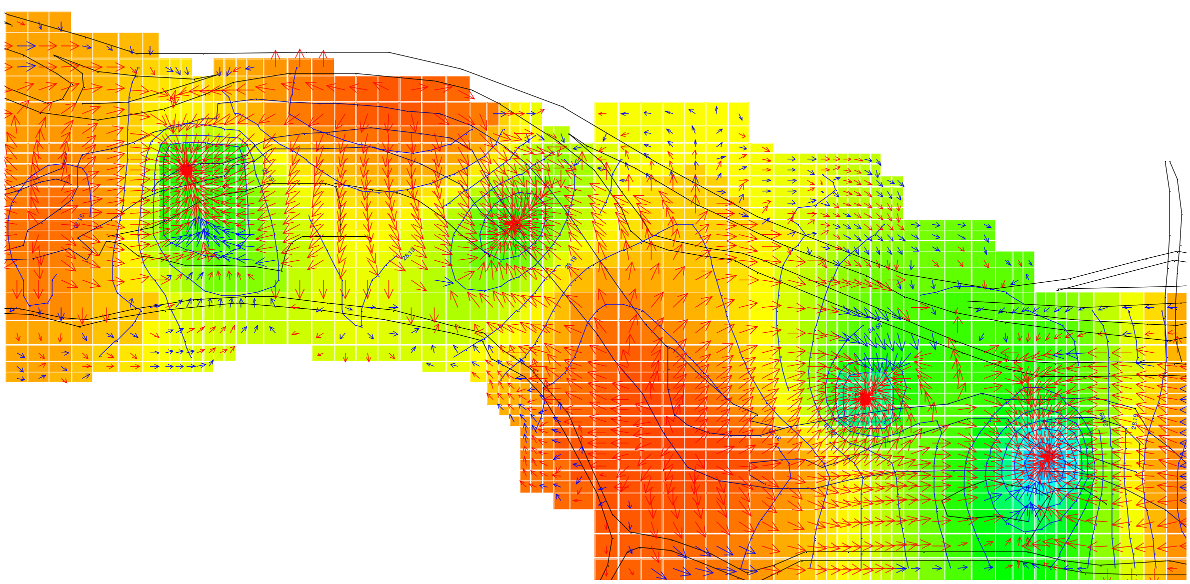
A- 41. Model Results, Scenario 6, Layer 6 - PS-1/1A, PS-3, & PS-4, 5.2MGD, HBMWD Groundwater Study



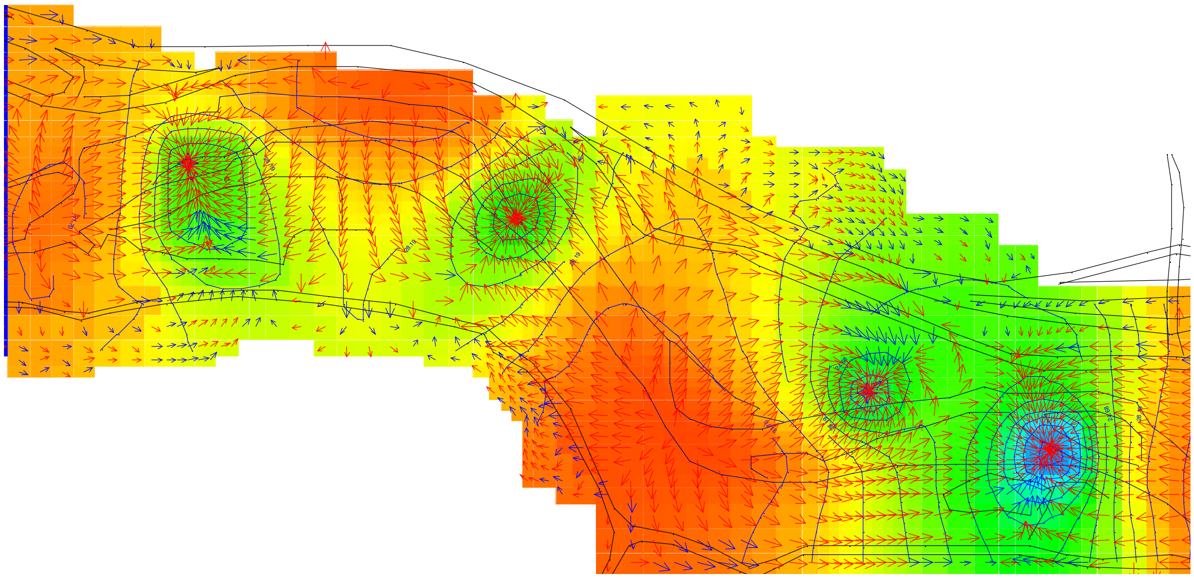
A- 42. Model Results, Scenario 6, Layer 7 - PS-1/1A, PS-3, & PS-4, 5.2MGD, HBMWD Groundwater Study



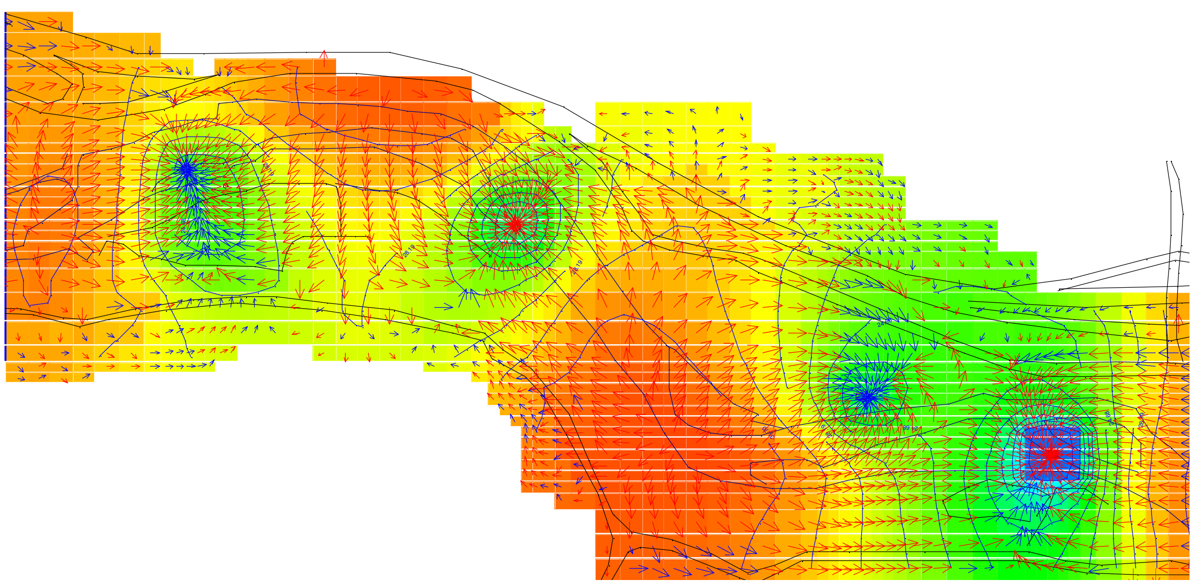
A- 43. Model Results, Scenario 7, Layer 1 - PS-1/1A, PS-2, PS-3, & PS-4, 5MGD, HBMWD Groundwater Study



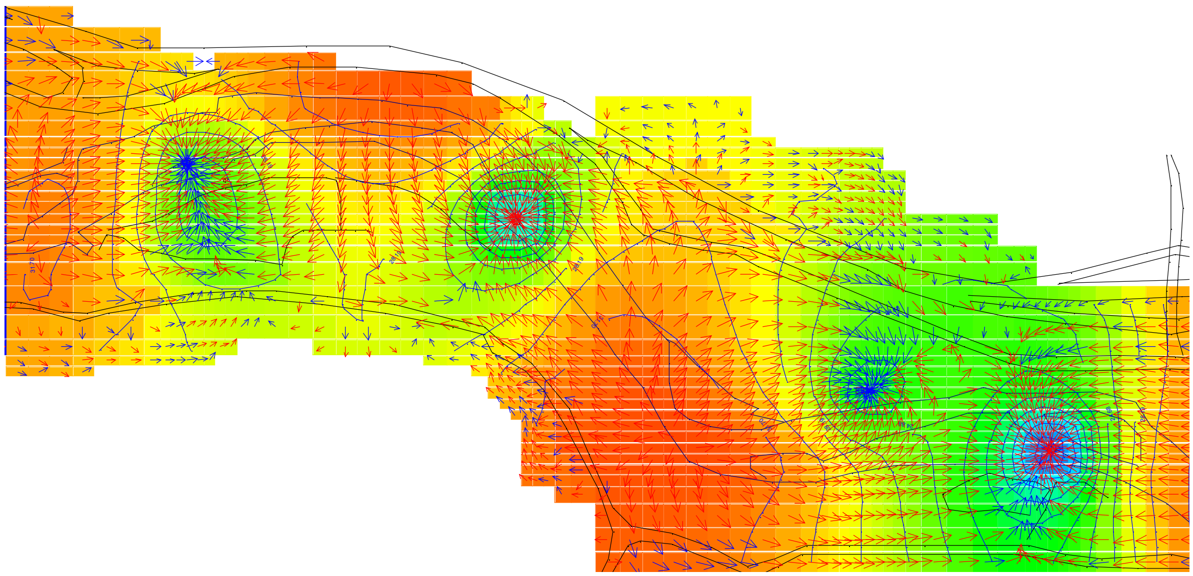
A- 44. Model Results, Scenario 7, Layer 2 - PS-1/1A, PS-2, PS-3, & PS-4, 5MGD, HBMWD Groundwater Study



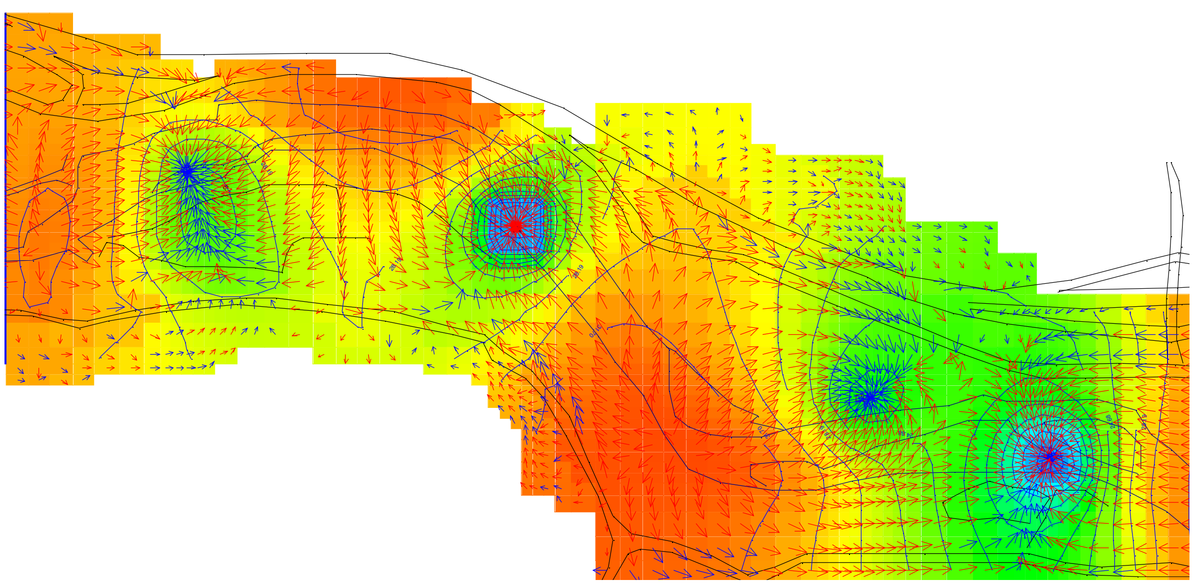
A- 45. Model Results, Scenario 7, Layer 3 - PS-1/1A, PS-2, PS-3, & PS-4, 5MGD, HBMWD Groundwater Study



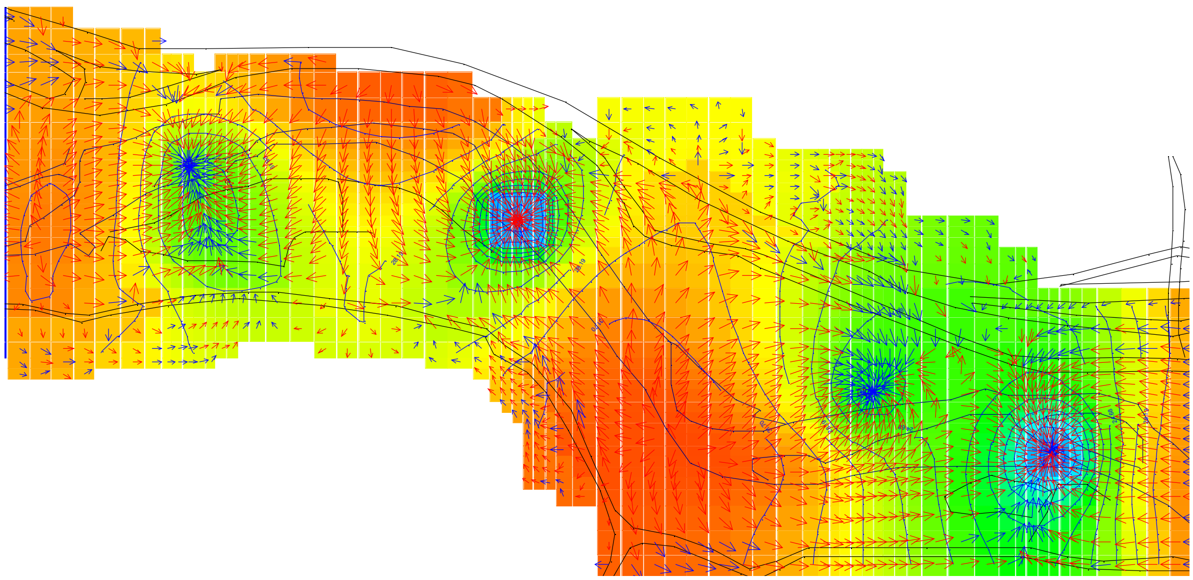
A- 46. Model Results, Scenario 7, Layer 4 - PS-1/1A, PS-2, PS-3, & PS-4, 5MGD, HBMWD Groundwater Study



A- 47. Model Results, Scenario 7, Layer 5 - PS-1/1A, PS-2, PS-3, & PS-4, 5MGD, HBMWD Groundwater Study



A- 48. Model Results, Scenario 7, Layer 6 - PS-1/1A, PS-2, PS-3, & PS-4, 5MGD, HBMWD Groundwater Study



A- 49. Model Results, Scenario 7, Layer 7 - PS-1/1A, PS-2, PS-3, & PS-4, 5MGD, HBMWD Groundwater Study

Appendix B
Seismic Refractions Study Report and Monitoring Well Boring Logs

Appendix B
Seismic Refractions Study Report and Monitoring Well Boring Logs

December 14, 2004

Mr. Kenneth Thiessen
Winzler & Kelley Consulting Engineers
633 Third Street
Eureka, CA 95501-0417

Subject: Seismic Refraction Survey
Humboldt Bay Municipal Water District, Mad River, Humboldt County, CA
NORCAL Job # 04-319.04

Dear Mr. Thiessen:

This report presents the findings of a seismic refraction (SR) survey performed by NORCAL Geophysical Consultants, Inc. on Humboldt Bay Municipal Water District property along the Mad River in Humboldt County, CA. The survey was performed on December 6 - 8, 2004 by NORCAL geophysicist Donald J. Kirker and geophysical technician Chris Blom. Logistical support was provided by Kenneth Thiessen of Winzler & Kelley Consulting Engineers.

SCOPE OF WORK

The scope of work for this project consisted of obtaining SR data along seven profiles, as designated by Winzler & Kelley. Our scope of work also included processing and interpreting these data and presenting the results in a written report.

PURPOSE

The purpose of the SR survey was to obtain subsurface information that will aid in determining the depth to bedrock and to assess the thickness of the saturated alluvium overlying bedrock. We understand that this information will be incorporated with geologic and hydrologic data obtained by Winzler & Kelley to evaluate the groundwater-bearing potential of the area.

SITE DESCRIPTION

The Humboldt Bay Municipal Water District properties are located on the south and north banks of the Mad River northeast of Arcata, California. The survey area is characterized by river cut terraces, channels, sand bars, dense vegetation, and level, grass covered parcels. Site elevations range from about 25 feet above mean sea level (msl) at the rivers edge to over 59 feet above msl at the highest point.

Borehole data, from borings drilled by others in the general area, were obtained from Winzler & Kelley. This data indicates that the subsurface consists of fluvial sediments over Franciscan bedrock that was encountered at elevations of 4 to 70 feet below mean sea level (msl). The fluvial sediments consists primarily of gravel with some interbedded clay. These data, however, do not show specific information regarding the bedrock lithology. It has been our experience that Franciscan bedrock in this area typically consists of consolidated sediments (shale, sandstone, etc.) and/or indurated rock such as graywacke, greenstone, or other basalt.

METHODOLOGY

The SR method is used to determine the seismic velocity of subsurface materials. The seismic velocity of fill, sediments, and rock are dependent on physical properties such as compaction, density, hardness, and induration. However, other factors such as bedding, fracturing, and saturation also effect seismic velocity. Typically, low velocities are indicative of loose soil, poorly compacted fill material, and poorly to semi-consolidated sediments. Higher velocities are indicative of consolidated or dense sediments, highly compacted fill, and moderate to highly weathered and fractured bedrock. The highest velocities are measured in unweathered rock with few fractures. A more detailed description of the SR methodology including data acquisition and analysis procedures and limitations is provided in Appendix A.

FIELD INVESTIGATION

Seismic Refraction Geometry

Seismic refraction data were obtained along seven profiles, as shown on Plate 1. The profiles are designated as Lines 1 through 7 and range in length from 360 to 480 feet. The location of each line was determined by Winzler & Kelley prior to the geophysical survey. Lines 1 through 5 were located south of the river, Lines 6 and 7 were located north of the river.

Each line comprised of one seismic spread which consisted of 18 to 24 geophones and three shot points. The length of the spread was dictated by topography. The geophones were coupled to the ground surface at 20-foot intervals in a collinear array. Shot points were located approximately 10 feet beyond each end and in the center of each spread. The location of each shot point was surveyed using a Trimble global positioning system (GPS).

Seismic Source

We produced seismic energy at each shot point using a Digipulse accelerated weight drop (AWD-1). This device consists of a vertically mounted, cylindrically shaped, 100 lb. weight that is accelerated by large elastic bands from a height of approximately 24 inches onto an aluminum plate on the ground surface. An accelerometer attached to the strike plate transmits a triggering pulse to the seismograph each time the weight strikes the plate. The resulting travel time data were recorded on a seismograph and processed to generate seismic velocity cross-sections.

RESULTS

The results of the seismic refraction survey along Lines 1 through 7, are represented by the seismic velocity cross-sections shown on Plates 2 through 8. We have differentiated the subsurface into a surficial layer (V1), an intermediate layer (V2), and a deeper layer (V3). These layers are labeled V1 through V3 in order of increasing velocity and depth, and range from 900 to 10,000 feet per second (ft/s).The direction of each line and the velocity and depth range to the top of the respective velocity layer is presented in Table A, below.

Table A: Seismic Velocity Profile Data, Mad River, Humboldt County, CA

PROFILE	DIRECTION	SEISMIC LAYER	VELOCITY (ft/s)	DEPTH (ft)*	ELEVATION (ft)*
Line 1	SW-NE	V1 V2 V3	1,900 5,800 7,300	0 1-48 25-71	23 to 46 22 to 0 -43 to 0
Line 2	S-N	V1 V2 V3	1,000 6,400 9,100	0 9-20 62-103	23 to 49 12 to 29 -57 to -9
Line 3	S-N	V1 V2 V3	900 4,800 7,000	0 8-17 34-54	36 to 48 23 to 35 -7 to 14
Line 4	S-N	V1 V2 V3	900 5,300 10,000	0 8-22 40-76	39 to 59 29 to 45 -22 to 20
Line 5	S-N	V1 V2 V3	1,000 4,900 9,300	0 3-20 40-60	30 to 49 24 to 36 -17 to 6
Line 6	S-N	V1 V2 V3	1,300 4,700 7,200	0 16-26 40-73	49 to 59 30 to 34 -14 to 10
Line 7	NW-SE	V1 V2 V3	900 5,000 9,400	0 8-18 70-97	33 to 49 21 to 36 -50 to -31

* Depth and elevation to top of layer

Seismic layer V1 (900-1,900 ft/s) has velocities that are consistent with surficial soils and unsaturated alluvium. Velocities near the low end of the range indicate loose (unconsolidated) material. Velocities near the upper end probably indicate material that is more consolidated Seismic layer V2 (4,700-6,400 ft/s) has velocities that are consistent with saturated, unconsolidated alluvium consisting of interbedded silt, sand, and gravel. The range in V2 values is probably indicative of the degree of consolidation of the saturated materials, as well as the variation in lithology.
Seismic Layer V3 (7,000-10,000 ft/s) has velocities that are consistent with Franciscan bedrock that

exhibits varying degrees of weathering. The range in velocities is indirectly proportional to the degree of bedrock weathering. The less weathering, the higher the apparent velocity of the bedrock. Also, the range of velocities may be indicative of varying bedrock lithology. For example, indurated rock (graywacke, greenstone) and volcanic rock (basalt) typically exhibit higher velocities than sedimentary rock (shale, sandstone, etc.).

The seismic refraction profiles (Plates 2-8) show that the V3 surface ranges in elevation from 20 above msl to 57 feet below msl. The down-river profiles, Lines 1, 2, and 7, define bedrock at elevations of 40 to 57 feet below msl. Whereas, the up-river profiles (Lines 3-6) indicate that bedrock is shallower, and is about 20 above to 22 feet below msl.

STANDARD CARE AND WARRANTY

The scope of NORCAL's services for this project consisted of using geophysical methods to characterize the subsurface. The accuracy of our findings is subject to specific site conditions and limitations inherent to the techniques used. We performed our services in a manner consistent with the standard of care ordinarily exercised by members of the profession currently employing similar methods. No warranty, with respect to the performance of services or products delivered under this agreement, expressed or implied, is made by NORCAL.

We appreciate having the opportunity to provide you with this information.

Respectfully,

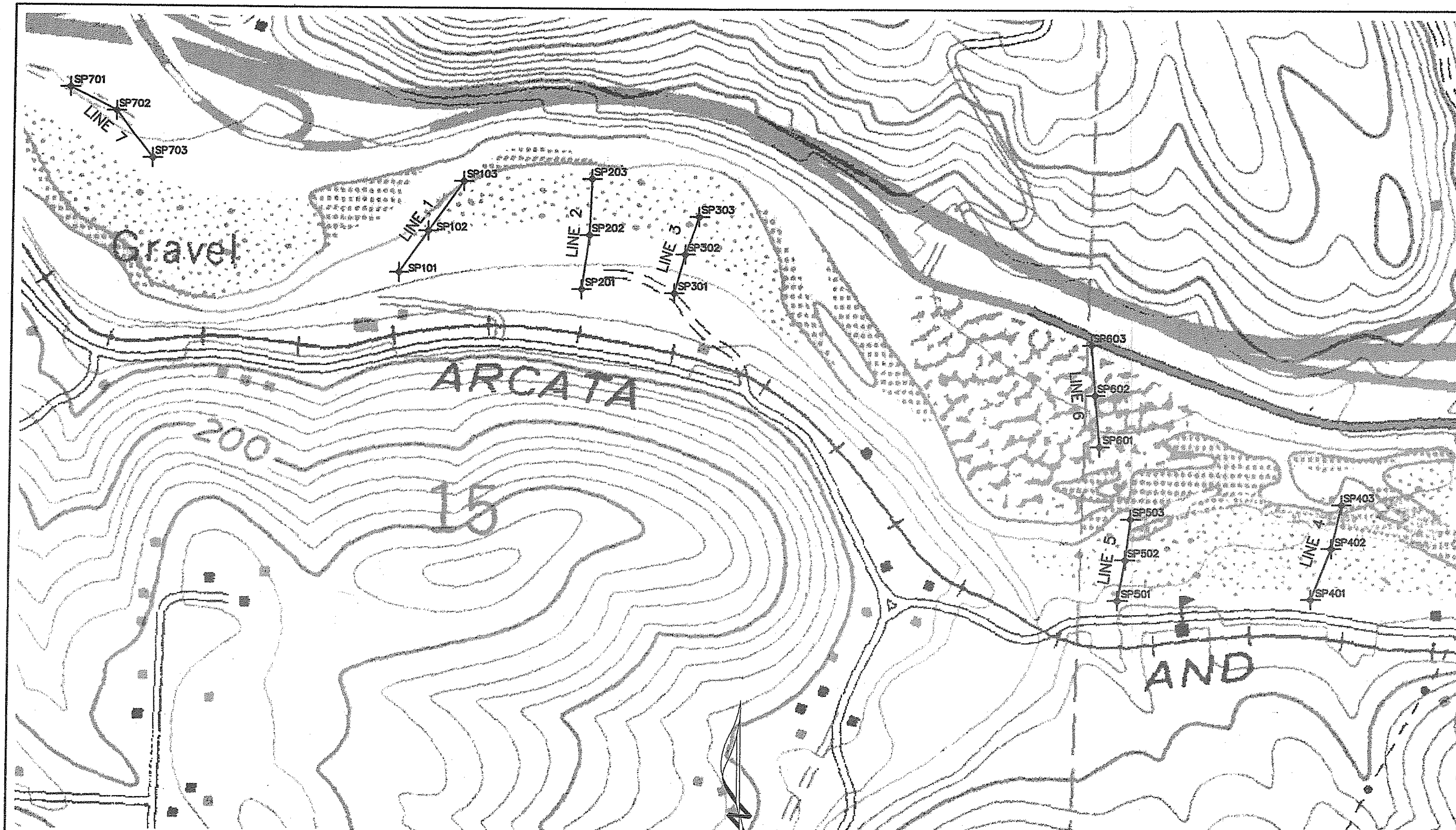
NORCAL Geophysical Consultants, Inc.

Donald J. Kirker

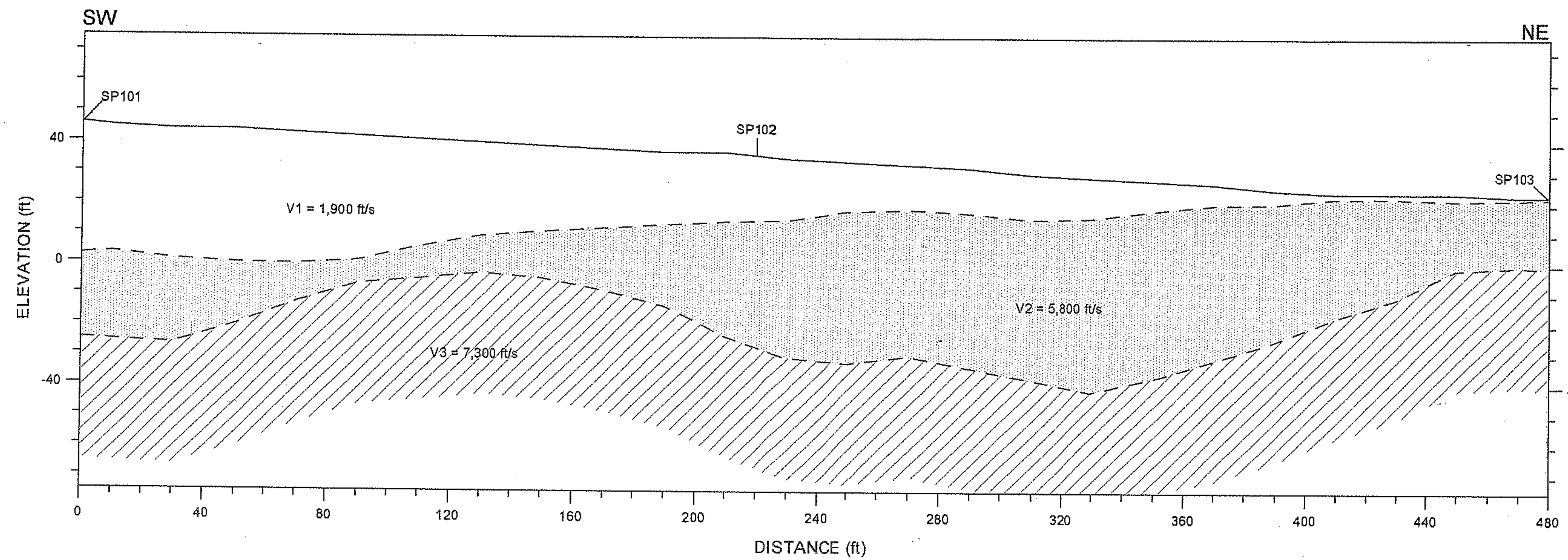
Donald J. Kirker
Geophysicist, GP-997

DJK/tt

Enclosures: Plates 1 through 8
Appendix A Seismic Refraction Survey



NORCAL	SITE LOCATION MAP SEISMIC REFRACTION SURVEY HUMBOLDT BAY MUNICIPAL WATER DISTRICT	
	LOCATION: ARCATA, CALIFORNIA	
	CLIENT: WINZLER & KELLEY	PLATE
JOB #: 04-319.04	NORCAL GEOPHYSICAL CONSULTANTS INC.	1
DATE: DEC. 2004	DRAWN BY: G.RANDALL / APPROVED BY: DJK	



LEGEND

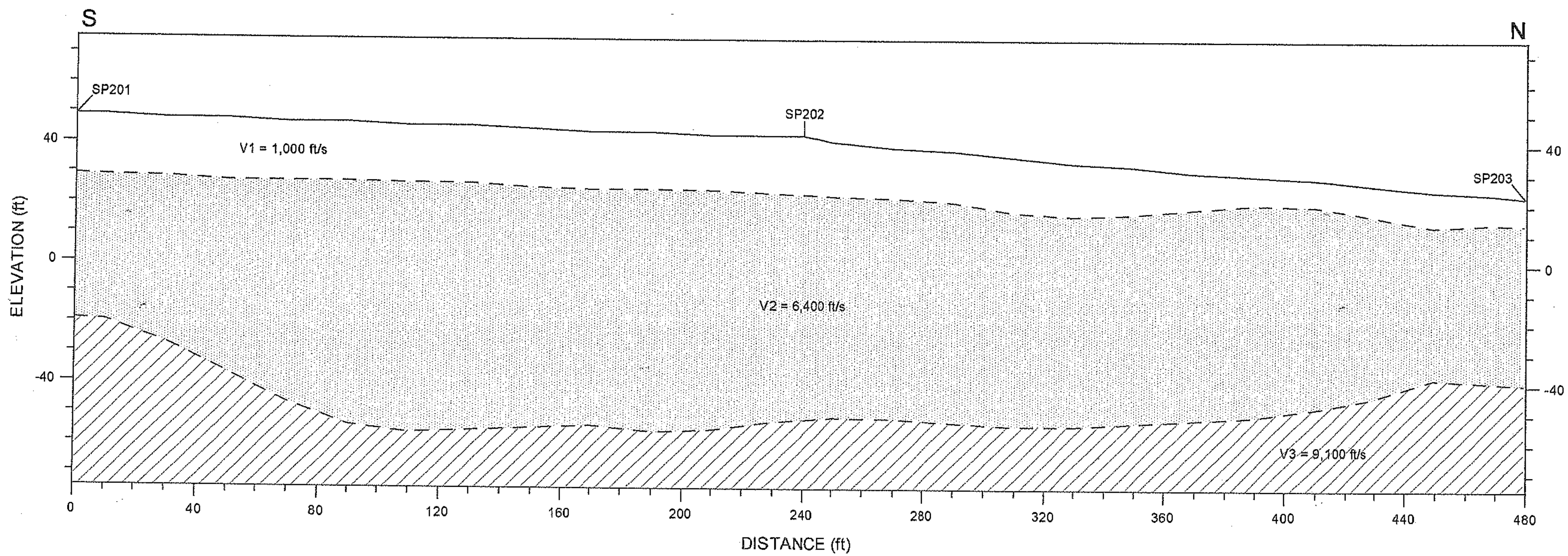
SP101	SHOT POINT LOCATION
V1 = 1,000 ft/s	VELOCITY OF LAYER IN FEET PER SECOND
— — —	VELOCITY INTERFACE

SCALE: 1 INCH = 40 FEET

NORCAL

SEISMIC REFRACTION PROFILE
LINE 1
HUMBOLDT BAY MUNICIPAL WATER DISTRICT

LOCATION: ARCATA, CALIFORNIA		PLATE
CLIENT: WINZLER & KELLEY		2
JOB #: 04-319.04	NORCAL GEOPHYSICAL CONSULTANTS INC.	
DATE: DEC. 2004	DRAWN BY: G. RANDALL	APPROVED BY: DJK



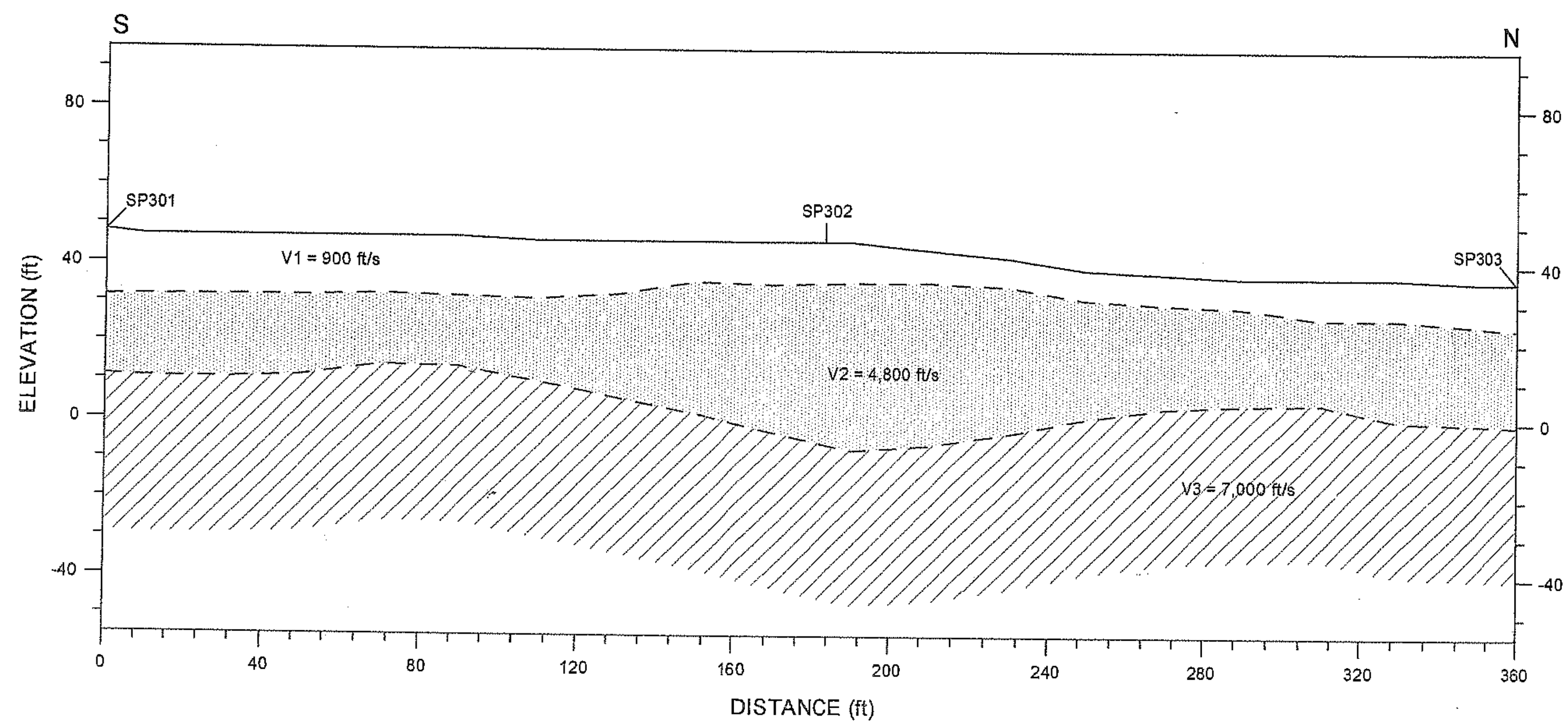
LEGEND

SP101	SHOT POINT LOCATION
V1 = 1,000 ft/s	VELOCITY OF LAYER IN FEET PER SECOND
— — —	VELOCITY INTERFACE

SCALE: 1 INCH = 40 FEET

NORCAL

	SEISMIC REFRACTION PROFILE LINE 2 HUMBOLDT BAY MUNICIPAL WATER DISTRICT		
	LOCATION: ARCATA, CALIFORNIA		
	CLIENT: WINZLER & KELLEY		PLATE
JOB #: 04-319.04	NORCAL GEOPHYSICAL CONSULTANTS INC.		3
DATE: DEC. 2004	DRAWN BY: G. RANDALL	APPROVED BY: DJK	

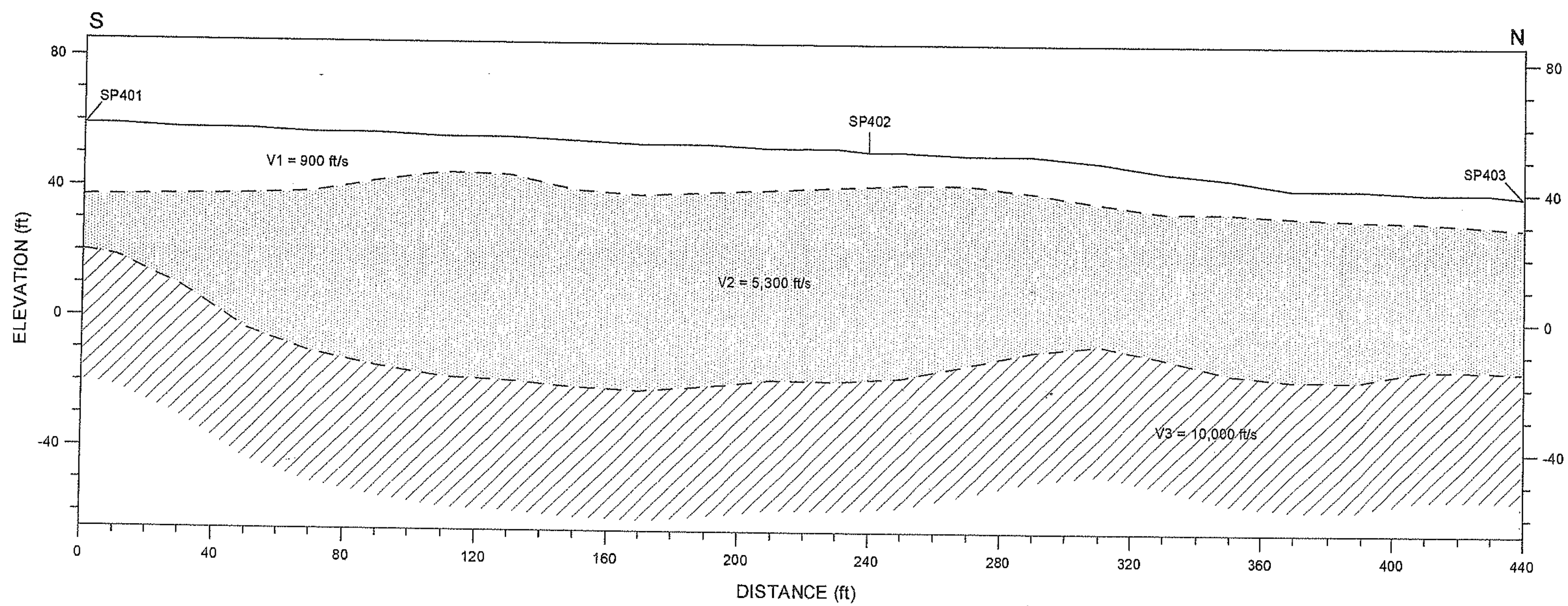


LEGEND

SP101	SHOT POINT LOCATION
V1 = 1,000 ft/s	VELOCITY OF LAYER IN FEET PER SECOND
— — —	VELOCITY INTERFACE

SCALE: 1 INCH = 40 FEET

NORCAL	SEISMIC REFRACTION PROFILE LINE 3 HUMBOLDT BAY MUNICIPAL WATER DISTRICT	
	LOCATION: ARCATA, CALIFORNIA	
	CLIENT: WINZLER & KELLEY	PLATE
JOB #: 04-319.04	NORCAL GEOPHYSICAL CONSULTANTS INC.	4
DATE: DEC. 2004	DRAWN BY: G. RANDALL — APPROVED BY: DJK	

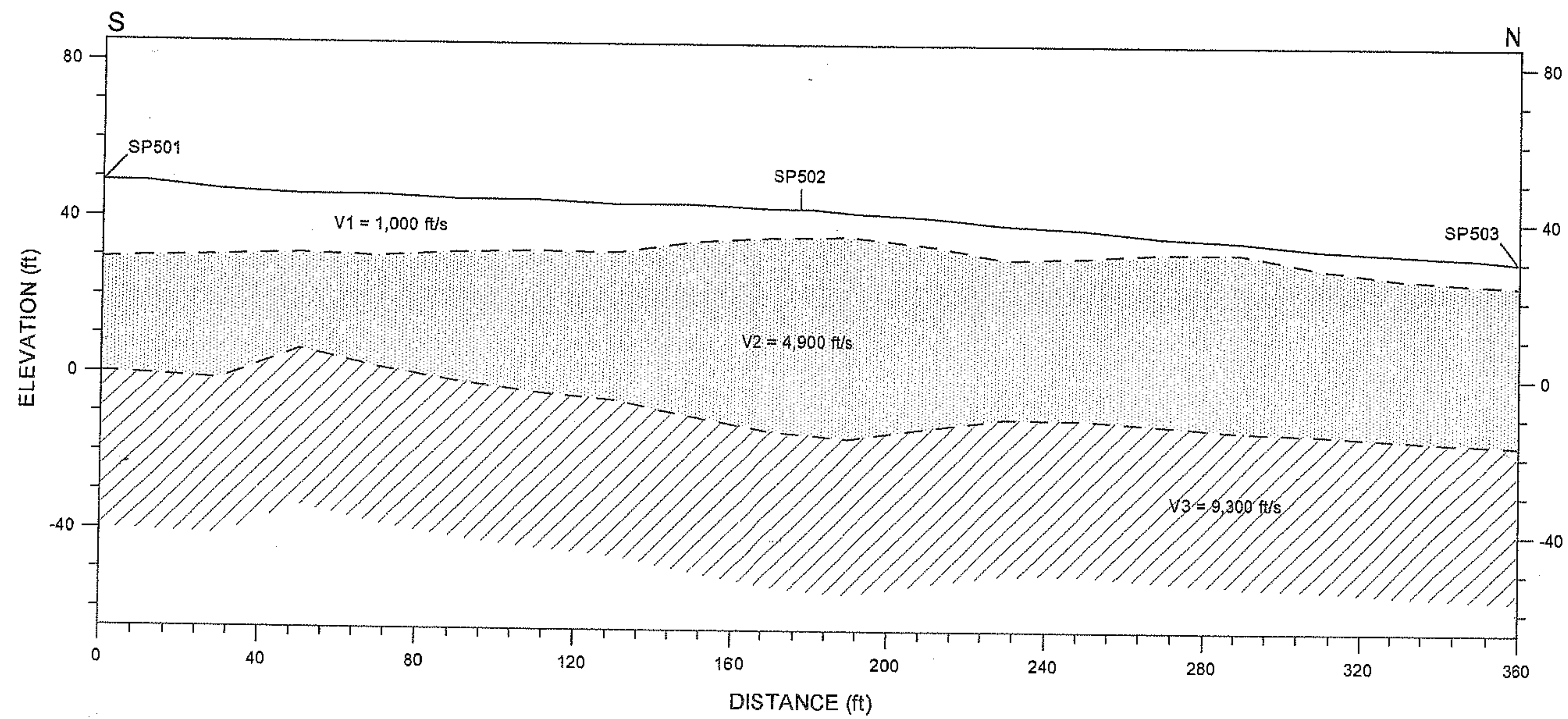


LEGEND

SP101	SHOT POINT LOCATION
V1 = 1,000 ft/s	VELOCITY OF LAYER IN FEET PER SECOND
— — —	VELOCITY INTERFACE

SCALE: 1 INCH = 40 FEET

NORCAL	SEISMIC REFRACTION PROFILE LINE 4 HUMBOLDT BAY MUNICIPAL WATER DISTRICT	
	LOCATION: ARCATA, CALIFORNIA	
	CLIENT: WINZLER & KELLEY	PLATE
JOB #: 04-319.04	NORCAL GEOPHYSICAL CONSULTANTS INC.	5
DATE: DEC. 2004	DRAWN BY: G. RANDALL / APPROVED BY: DJK	

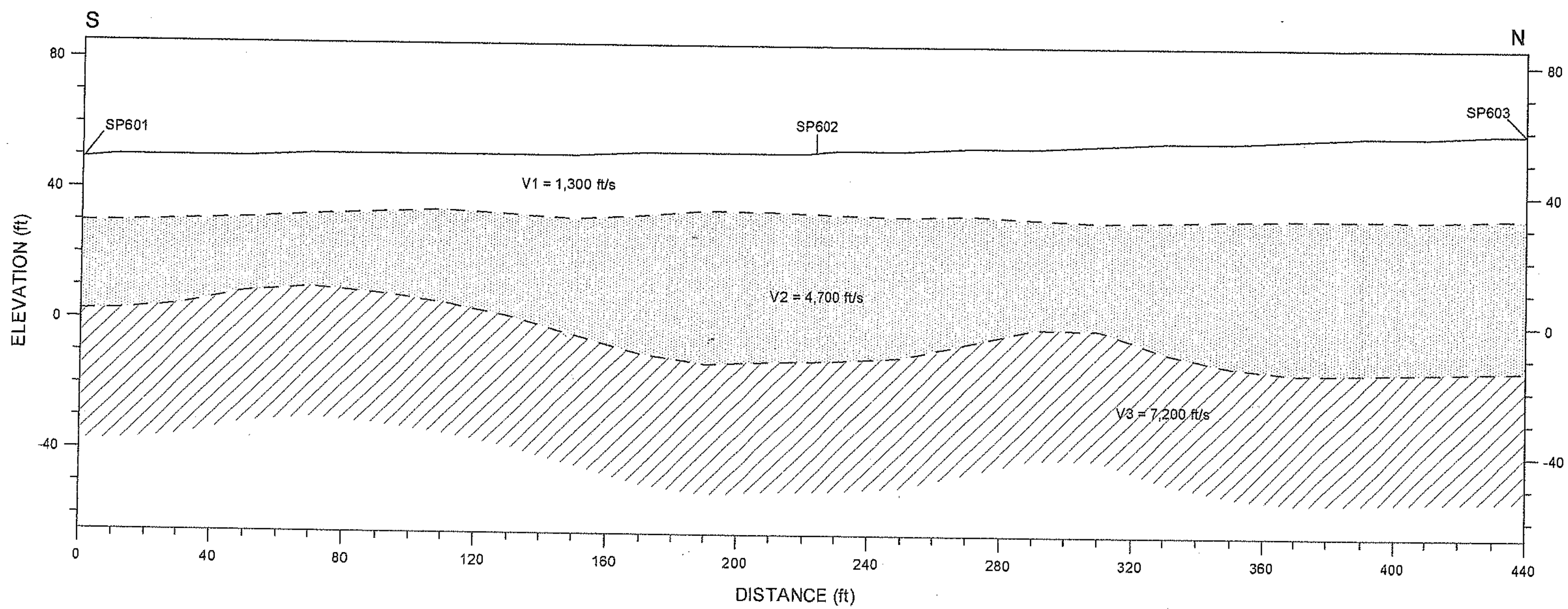


LEGEND

SP101	SHOT POINT LOCATION
V1 = 1,000 ft/s	VELOCITY OF LAYER IN FEET PER SECOND
— — —	VELOCITY INTERFACE

SCALE: 1 INCH = 40 FEET

NORCAL	SEISMIC REFRACTION PROFILE LINE 5 HUMBOLDT BAY MUNICIPAL WATER DISTRICT	
	LOCATION: ARCATA, CALIFORNIA	
	CLIENT: WINZLER & KELLEY	PLATE
JOB #: 04-319.04	NORCAL GEOPHYSICAL CONSULTANTS INC.	6
DATE: DEC. 2004	DRAWN BY: G. RANDALL / APPROVED BY: DJK	



LEGEND

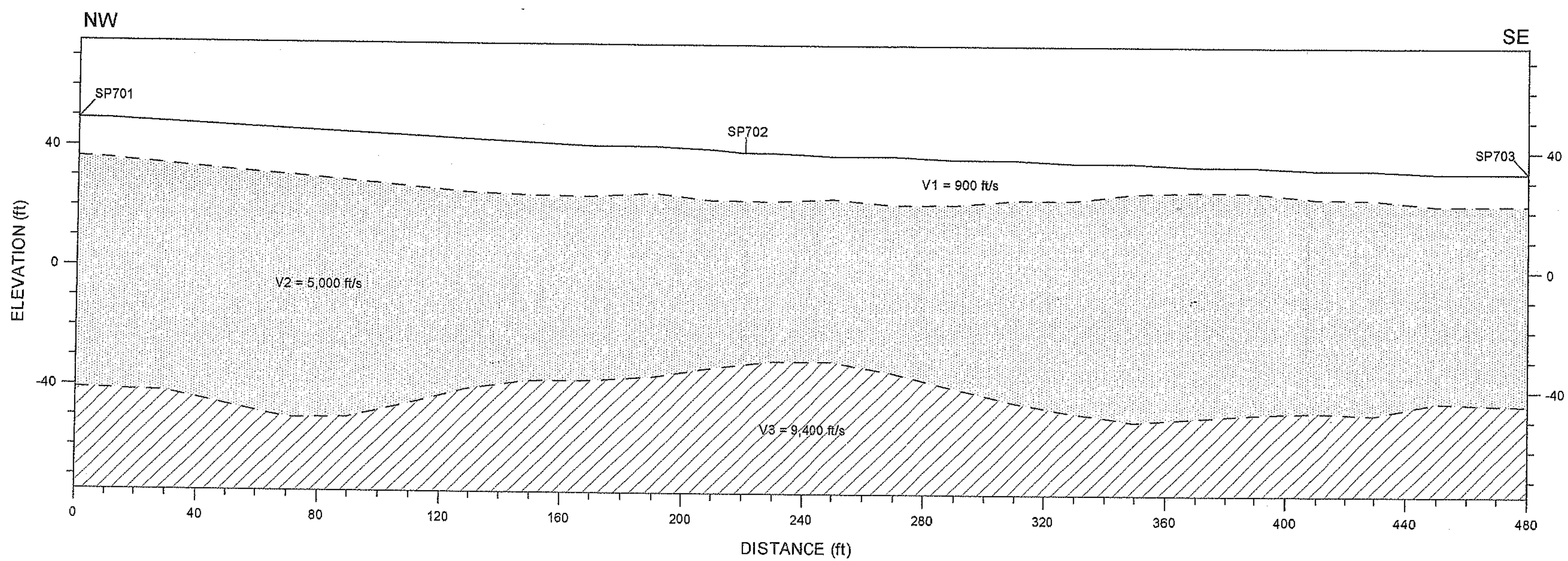
SP101	SHOT POINT LOCATION
V1 = 1,000 ft/s	VELOCITY OF LAYER IN FEET PER SECOND
— — —	VELOCITY INTERFACE

SCALE: 1 INCH = 40 FEET

NORCAL

SEISMIC REFRACTION PROFILE
LINE 6
HUMBOLDT BAY MUNICIPAL WATER DISTRICT

	LOCATION: ARCATA, CALIFORNIA	
	CLIENT: WINZLER & KELLEY	PLATE
JOB #: 04-319.04	NORCAL GEOPHYSICAL CONSULTANTS INC.	7
DATE: DEC. 2004	DRAWN BY: G. RANDALL / APPROVED BY: DJK	



LEGEND

SP101	SHOT POINT LOCATION
V1 = 1,000 ft/s	VELOCITY OF LAYER IN FEET PER SECOND
— — —	VELOCITY INTERFACE

SCALE: 1 INCH = 40 FEET

NORCAL	SEISMIC REFRACTION PROFILE LINE 7 HUMBOLDT BAY MUNICIPAL WATER DISTRICT	
	LOCATION: ARCATA, CALIFORNIA	
	CLIENT: WINZLER & KELLEY	PLATE
JOB #: 04-319.04	NORCAL GEOPHYSICAL CONSULTANTS INC.	8
DATE: DEC. 2004	DRAWN BY: G. RANDALL / APPROVED BY: DJK	

Appendix A

SEISMIC REFRACTION SURVEY

Appendix A

SEISMIC REFRACTION (SR)

Methodology

The seismic refraction method provides information regarding the seismic velocity structure of the subsurface. An impulsive (mechanical or explosive) source is used to produce compressional (P) wave seismic energy. The P-waves propagate into the earth and are refracted along interfaces caused by an increase in velocity. A portion of the P-wave energy is refracted back to the surface where it is detected by sensors (geophones) that are coupled to the ground surface in a collinear array (spread). The detected signals are recorded on a multi-channel seismograph and are analyzed to determine the shot point-to-geophone travel times. These data can be used along with the corresponding shot point-to-geophone distances to determine the depth, thickness, and velocity of subsurface seismic layers.

The seismic refraction technique is based on several assumptions. Paramount among these are:

1) that seismic velocity increases with depth, and,
2) that the velocity of each seismic layer is uniform over the length of the given spread.

In cases where these assumptions do not hold, the accuracy of the technique decreases. For example, if a low velocity layer occurs between two layers of higher velocity, the low velocity layer will not be detected and the depth to the underlying high velocity layer will be erroneously large. Also, if the velocity of a seismic layer varies laterally within a spread, those variations will be interpreted as fluctuations in the elevation of the underlying seismic layer.

Instrumentation

Data acquisition is initiated along each SR line by producing seismic energy using mechanical source. Mechanical sources produce energy by impacting a metal strike plate on the ground surface with either a 12-16 pound sledge hammer or an elastic-band driven weight drop. The resulting seismic wave forms are recorded using a Geometrics 24-channel engineering seismograph and Mark Products geophones with a natural frequency of 10 Hz. The data are recorded on hard copy records (seismograms) as well as on computer disks for future processing. The seismograms display the amount of time it takes for a compression (P) wave to travel from a given shot point to each geophone in a spread.

Data Analysis

The seismic data are downloaded to a computer and processed using the program SIPIK by Rimrock Geophysics to determine the shot point to geophone travel times. These values versus the shot point to geophone distances are then plotted to form time versus distance graphs. By fitting straight lines to the data points, the number of seismic velocity layers and the travel times associated with each layer are determined. These values, the travel times, and the location of each shot point and geophone are then entered into the computer program SIPT2 (also by Rimrock Geophysics). When applicable, the elevation of each shot point and geophone is also entered into this program. Specific elevations (above mean sea level) are determined by topography maps that are typically provided by the client. However, if a topography map is not available, the relative elevation of each shot point and geophone is determined by hand-level techniques and/or a global positioning system (GPS).

SIPT2 uses a variation of the time-delay method to compute a preliminary model listing the depth to each seismic layer beneath each shot point and geophone. The program then uses a ray tracing routine to check the validity of this model and adjust it as necessary to fit the observed data. The final output consists of a cross-section showing the surface topography, the elevation and configuration of the seismic layers, the velocity of each layer, and the locations of the shot points.

Limitations

In general, there are limitations unique to the SR method. These limitations are primarily based on assumptions that are made by the data analysis routine. First, the data analysis routine assumes that the velocities along the length of each spread are uniform. If there are localized zones within each layer where the velocities are higher or lower than indicated, the analysis routine will interpret these zones as changes in the surface topography of the underlying layer. A zone of higher velocity material would be interpreted as a low in the surface of the underlying layer. Zones of lower velocity material would be interpreted as a high in the underlying layer.

Second, the data analysis routine assumes that the velocity of subsurface materials increase with depth. Therefore, if a layer exhibits velocities that are slower than those of the material above it, the slower layer will not be resolved. Also, a velocity layer may simply be too thin to be detected. Due to these and other limitations inherent to the SR method, the results of the SR survey should be considered only as approximations of the subsurface conditions. The actual conditions may vary locally.

ORIGINAL
File with DWR

Page ____ of ____

Owner's Well No. COLLECTOR 3, MW-1

Date Work Began 4/11/06, Ended 4/13/06

Local Permit Agency HUMBOLDT CO. DIV. ENVIRONMENTAL HEALTH

Permit No. 504-151-010 Permit Date 4/10/06

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 797306

DWR USE ONLY — DO NOT FILL IN

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DRILLING METHOD SONIC FLUID Ø

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION Describe material, grain size, color, etc.
0	2	TOP SOIL
2	9	SILTY GRAVEL
9	16	PEA GRAVEL WITH SILT HORIZONS
16	17	CLEAN COARSE GRAVEL
17	18	STIFF CLAYEY SILT
18	38	SILTY GRAVEL
38	58	GRAVEL AND SAND WITH SILT
58	63	VERY COARSE GRAVEL, MINOR SILT
63	68	VERY COARSE SAND
68	75	COARSE GRAVEL
75	77	COARSE SAND AND GRAVEL (NO FINES)
77	78	CLASTS TO 1½"
78	93	NO SAMPLES (PRESUME FLOWING SAND/GRAVEL)
93	95½	COARSE SAND
95½	100	GRAVEL TO ½"
100	108	SAND AND GRAVEL WITH FINES INCREASING WITH DEPTH

TOTAL DEPTH OF BORING 108 (Feet)

TOTAL DEPTH OF COMPLETED WELL 108 (Feet)

WELL OWNER

Name HUMBOLDT BAY MUNI. WATER DISTRICT

Mailing Address 7270 WEST END ROAD

ARCATA, CA 95521

CITY STATE ZIP

WELL LOCATION

Address GLENDALE ROAD

City ESSEX

County HUMBOLDT

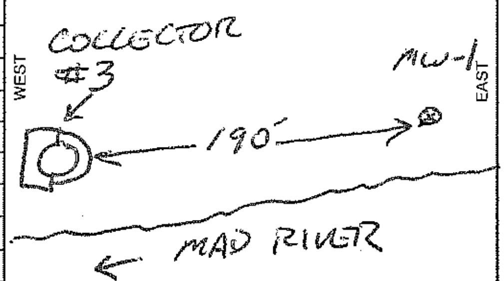
APN Book 504 Page 151 Parcel 010

Township 6N Range 1E Section 15

Latitude 40 54 20 NORTH Longitude 124 02 28 WEST

DEG. MIN. SEC. DEG. MIN. SEC.

LOCATION SKETCH



Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)

___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USES (✓)

WATER SUPPLY
___ Domestic ___ Public
___ Irrigation ___ Industrial

MONITORING X
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER ____ (Ft.) BELOW SURFACE

DEPTH OF STATIC WATER LEVEL 15.2 (Ft.) & DATE MEASURED 4/14/06

ESTIMATED YIELD * ____ (GPM) & TEST TYPE ____

TEST LENGTH ____ (Hrs.) TOTAL DRAWDOWN ____ (Ft.) NOT TESTED

* *May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
+2	-8	10	X				PVC SCH 40	2	0.218"	Ø
-8	-108	8		X			PVC SCH 40	2	0.218"	0.020

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	2	X			
2	6		X		
6	108				2/12 SAND

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other ____

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME ____
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

ADDRESS ____ CITY ____ STATE ____ ZIP ____

Signed ____
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 11-97

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

ORIGINAL
File with DWR

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

Page ____ of ____

Owner's Well No. COLLECTOR 3, BORING 1

No. 797307

Date Work Began 4/13/06, Ended 4/15/06

Local Permit Agency HUMBOLDT CO. DIV. ENVIRONMENTAL HEALTH

Permit No. 504-151-010 Permit Date 4/12/06

DWR USE ONLY — DO NOT FILL IN

STATE WELL NO./STATION NO.

LATITUDE | LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ____ HORIZONTAL ____ ANGLE ____ (SPECIFY)

DRILLING METHOD SONIC FLUID Ø

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION Describe material, grain size, color, etc.
0	3½	IMPORTED BASE ROCK
3½	11	SILT WITH SAND
11	20	SAND WITH SILT AND GRAVEL
20	31	SANDY GRAVEL WITH SILT
31	36½	SILTY SAND
36½	40	SANDY GRAVEL WITH SILT
40	49	GRAVEL WITH MINOR SAND AND SILT
49	69	GRAVEL WITH SAND AND SILT
69	86	SANDY GRAVEL
86	88	GRAVEL WITH SAND AND SILT
		BORING ABANDONED WITH
		HYDRATED BENTONITE AND
		GROUT ON 4/15/06
		FOLLOWING LITHOLOGIC
		LOGGING AND AQUIFER
		TESTING

TOTAL DEPTH OF BORING 88 (Feet)

TOTAL DEPTH OF COMPLETED WELL Ø (Feet)

WELL OWNER

Name HUMBOLDT BAY MUNI. WATER DIST.

Mailing Address 7270 WEST END ROAD

ARCATA, CA 95521

CITY STATE ZIP

WELL LOCATION

Address GLENDALE ROAD

City ESSEX

County HUMBOLDT

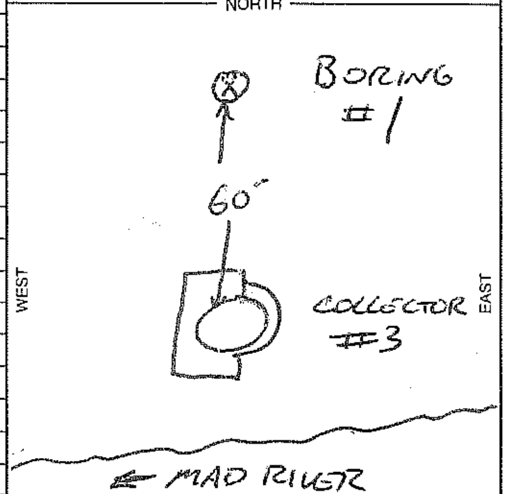
APN Book 504 Page 151 Parcel 010

Township 6N Range 1E Section 15

Latitude 40 54 20 NORTH (DEG. MIN. SEC.) Longitude 124 02 29 WEST (DEG. MIN. SEC.)

LOCATION SKETCH

NORTH



SOUTH

Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR
____ Deepen
____ Other (Specify)

____ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USES (✓)

WATER SUPPLY
____ Domestic ____ Public
____ Irrigation ____ Industrial

MONITORING ____
TEST WELL X
CATHODIC PROTECTION ____
HEAT EXCHANGE ____
DIRECT PUSH ____
INJECTION ____
VAPOR EXTRACTION ____
SPARGING ____
REMEDIATION ____
OTHER (SPECIFY) ____

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER 19.8 (Ft.) BELOW SURFACE

DEPTH OF STATIC WATER LEVEL 18.68 (Ft.) & DATE MEASURED 4/14/06

ESTIMATED YIELD * 71+ (GPM) & TEST TYPE STEP DRAWDOWN

TEST LENGTH 2 (Hrs.) TOTAL DRAWDOWN 1.81 (Ft.)

** May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	88	8	X							N/A

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)

ATTACHMENTS (✓)

____ Geologic Log
____ Well Construction Diagram
____ Geophysical Log(s)
____ Soil/Water Chemical Analyses
____ Other ____

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME ____ (PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

ADDRESS ____ CITY ____ STATE ____ ZIP ____

Signed ____ WELL DRILLER/AUTHORIZED REPRESENTATIVE ____ DATE SIGNED ____ C-57 LICENSE NUMBER ____

DWR 188 REV. 11-97

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

TRIPLICATE
Owner's Copy

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 1087252

DWR USE ONLY — DO NOT FILL IN

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

Page 1 of 1

Owner's Well No. MW-1

Date Work Began 2-24-05, Ended 2-26-05

Local Permit Agency Humboldt County Environmental Health

Permit No. 504-201-011 Permit Date 1-20-05

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DRILLING METHOD air rotary FLUID water

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	5	Silt and fine sand
5	10	Sand and gravel
10	40	Gravel w/sand, minor fines
40	50	Clayey silty sand w/gravel
50	100	Sand and gravel, minor fines
100	105	Clayey silty sand w/gravel
105	112	Franciscan bedrock
	107	Depth to competent bedrock

CONFIDENTIAL
NOT FOR PUBLIC USE
WATER CODE SEC. 13752

RECEIVED
MAY 10 2005
WK-EUREKA

TOTAL DEPTH OF BORING 112 (Feet)

TOTAL DEPTH OF COMPLETED WELL 106 (Feet)

WELL OWNER

Name Humboldt Bay Municipal Water Dist.

Mailing Address c/o Winzler & Kelly Engineers

633 Third Street, Eureka, CA 95501

CITY STATE ZIP

WELL LOCATION

Address 7270 Westend Road, Arcata

City Arcata

County Humboldt

APN Book 504 Page 201 Parcel 011

Township 6N Range 1E Section 15

Lat 40 54 49 N Long 124 03 12 W
DEG. MIN. SEC. DEG. MIN. SEC.

LOCATION SKETCH

NORTH

WEST

See attached map

EAST

SOUTH

Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)

___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

USES (✓)

WATER SUPPLY
___ Domestic ___ Public
___ Irrigation ___ Industrial

MONITORING X
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER 35 (Ft.) BELOW SURFACE

DEPTH OF STATIC WATER LEVEL n/a (Ft.) & DATE MEASURED ___

ESTIMATED YIELD * 170+ (GPM) & TEST TYPE air lift

TEST LENGTH ½ (Hrs.) TOTAL DRAWDOWN n/a (Ft.)

* *May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	11	11¾	x				Steel	6	.188	
11	20	7⅞	x				Steel	6	.188	
20	40	7⅞		x			Steel	6	.188	1/8
40	70	7⅞	x				Steel	6	.188	
70	100	7⅞		x			Steel	6	.188	1/8
100	106	7⅞	x				Steel	6	.188	
106	112	6¼					Open hole			

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	2	x			Concrete
2	14		x		Granular & Chips

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
X Other site map

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Diamond Core Drilling, Inc.
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

P.O. Box 491925 Redding CA 96049
ADDRESS CITY STATE ZIP

Signed [signature] 4-27-05 512406
C-57 LICENSED WATER WELL CONTRACTOR DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 05-03

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

TRIPLICATE
Owner's Copy

Page 1 of 1

Owner's Well No. MW-2

Date Work Began 2-23-05, Ended 2-24-05

Local Permit Agency Humboldt County Environmental Health

Permit No. 504-201-011 Permit Date 1-20-05

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 1087253

DWR USE ONLY — DO NOT FILL IN

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DRILLING METHOD air rotary FLUID water

DEPTH FROM SURFACE Ft. to Ft.		DESCRIPTION Describe material, grain size, color, etc.
0	15	Sandy gravel
15	25	Silty sand and gravel
25	35	Sand and gravel
35	40	Silty sand
40	50	Silty sand w/gravel
50	70	Sand w/gravel, minor fines
70	100	Silty sandy gravel
100	104	Clay and sand w/gravel
104	106	Competent Franciscan bedrock

TOTAL DEPTH OF BORING 106 (Feet)

TOTAL DEPTH OF COMPLETED WELL 104 (Feet)

WELL OWNER

Name Humboldt Bay Municipal Water Dist.

Mailing Address c/o Winzler & Kelly Engineers

633 Third Street, Eureka, CA 95501

CITY STATE ZIP

WELL LOCATION

Address X270 Westend Road,

City Arcata

County Humboldt

APN Book 504 Page 201 Parcel 011

Township 6N Range 1E Section 15

Lat 40 54 50 N (DEG. MIN. SEC.) Long 124 03 06 W (DEG. MIN. SEC.)

LOCATION SKETCH

NORTH

WEST

See attached map

EAST

SOUTH

Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. ***PLEASE BE ACCURATE & COMPLETE.***

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)

___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

USES (✓)

WATER SUPPLY
___ Domestic ___ Public
___ Irrigation ___ Industrial

MONITORING X
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER n/a (Ft.) BELOW SURFACE

DEPTH OF STATIC WATER LEVEL n/a (Ft.) & DATE MEASURED ___

ESTIMATED YIELD * 150+ (GPM) & TEST TYPE air lift

TEST LENGTH n/a (Hrs.) TOTAL DRAWDOWN n/a (Ft.)

* *May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	11	11½	X				Steel	6	.188	
11	18	7½	X				Steel	6	.188	
18	50	7½		X			Steel	6	.188	1/8
50	70	7½	X				Steel	6	.188	
70	95	7½		X			Steel	6	.188	1/8
95	104	7½	X				Steel	6	.188	
104	106	6½					Open hole			

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	2	X			Concrete
2	14		X		Granular & Chips

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
X Other site map

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Diamond Core Drilling, Inc.
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

P.O. Box 491925 Redding CA 96049
ADDRESS CITY STATE ZIP

Signed [signature] 4-27-05 512406
C-57 LICENSED WATER WELL CONTRACTOR DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 05-03

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

TRIPLICATE
Owner's Copy

Page 1 of 1

Owner's Well No. MW-3

Date Work Began 2-22-05, Ended 2-23-05

Local Permit Agency Humboldt County Environmental Health

Permit No. 504-201-011 Permit Date 1-20-05

STATE OF CALIFORNIA
WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 1087254

DWR USE ONLY — DO NOT FILL IN

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) x VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DRILLING METHOD air rotary FLUID water

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	15	Sand and gravel
15	25	Sandy gravel, minor fines
25	70	Sand and gravel w/fines
70	75	Clay w/sand and gravel
75	90	Sandy gravel w/fines
90	100	Sand and gravel w/fines
100	105	Clay w/sand and gravel
105	108	Clay w/sand and gravel
108	110	Competent Franciscan bedrock

TOTAL DEPTH OF BORING 110 (Feet)

TOTAL DEPTH OF COMPLETED WELL 108 (Feet)

WELL OWNER

Name Humboldt Bay Municipal Water Dist.

Mailing Address c/o Winzler & Kelly Engineers

633 Third Street, Eureka, CA 95501

CITY STATE ZIP

WELL LOCATION

Address 7270 Westend Road

City Arcata

County Humboldt

APN Book 504 Page 201 Parcel 011

Township 6N Range 1E Section 15

Lat 40 54 48 N (DEG. MIN. SEC.) Long 124 02 07 W (DEG. MIN. SEC.)

LOCATION SKETCH

NORTH

WEST See attached map EAST

SOUTH

Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

x NEW WELL

MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)

___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

USES (✓)

WATER SUPPLY
___ Domestic ___ Public
___ Irrigation ___ Industrial

MONITORING x
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER ___ (Ft.) BELOW SURFACE not able to be measured

DEPTH OF STATIC WATER LEVEL ___ (Ft.) & DATE MEASURED ___

ESTIMATED YIELD * ___ (GPM) & TEST TYPE ___

TEST LENGTH ___ (Hrs.) TOTAL DRAWDOWN ___ (Ft.)

* *May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	11	11¼					Steel	6	.188	
11	18	7⅞	x				Steel	6	.188	
18	70	7⅞		x			Steel	6	.188	1/8
70	80	7⅞	x				Steel	6	.188	
80	100	7⅞		x			Steel	6	.188	1/8
100	108	7⅞	x				Steel	6	.188	
108	110	6¼					Open hole			

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	2	x			Concrete
2	14		x		Granular & Chips

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
x Other site map

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Diamond Core Drilling, Inc.
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

P.O. Box 491925 Redding CA 96049
ADDRESS CITY STATE ZIP

Signed [signature] 4-27-05 512406
C-57 LICENSED WATER WELL CONTRACTOR DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 05-03

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

TRIPLICATE
Owner's Copy

Page 1 of 1

Owner's Well No. MW-4

Date Work Began 2-21-05, Ended 2-22-05

Local Permit Agency Humboldt County Environmental Health

Permit No. 504-201-011 Permit Date 1-20-05

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 1087255

DWR USE ONLY — DO NOT FILL IN

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DRILLING METHOD air rotary FLUID water

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION Describe material, grain size, color, etc.
0	10	Sandy gravel, minor fines
10	30	Silty sandy gravel
30	40	Silty sand w/gravel
40	55	Sandy gravel w/fines
55	65	Silty sand w/gravel
65	82	Silty sand and gravel
82	93	Franciscan bedrock

TOTAL DEPTH OF BORING 93 (Feet)

TOTAL DEPTH OF COMPLETED WELL 93 (Feet)

WELL OWNER

Name Humboldt Bay Municipal Water Dist.

Mailing Address c/o Winzler & Kelly Engineers

633 Third Street, Eureka, CA 95501

CITY STATE ZIP

WELL LOCATION

Address 7270 Westend Road

City Arcata

County Humboldt

APN Book 504 Page 201 Parcel 011

Township 06N Range 1E Section 15

Lat 40 54 63 N Long 124 02 70 W

DEG. MIN. SEC. DEG. MIN. SEC.

LOCATION SKETCH

NORTH

WEST See attached map EAST

SOUTH

Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)

___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

USES (✓)

WATER SUPPLY
___ Domestic ___ Public
___ Irrigation ___ Industrial

MONITORING X
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER n/a (Ft.) BELOW SURFACE

DEPTH OF STATIC WATER LEVEL 14 (Ft.) & DATE MEASURED 2-22-05

ESTIMATED YIELD * n/a (GPM) & TEST TYPE ___

TEST LENGTH ___ (Hrs.) TOTAL DRAWDOWN ___ (Ft.)

* *May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	11	11½	x				Steel	6	.188	
11	15	7½	x				Steel	6	.188	
15	30	7½		x			Steel	6	.188	1/8
30	45	7½	x				Steel	6	.188	
45	80	7½		x			Steel	6	.188	1/8
80	93	7½	x				Steel	6	.188	

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	2	x			Concrete
2	11½		x		Granular & Chips

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
X Other site map

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

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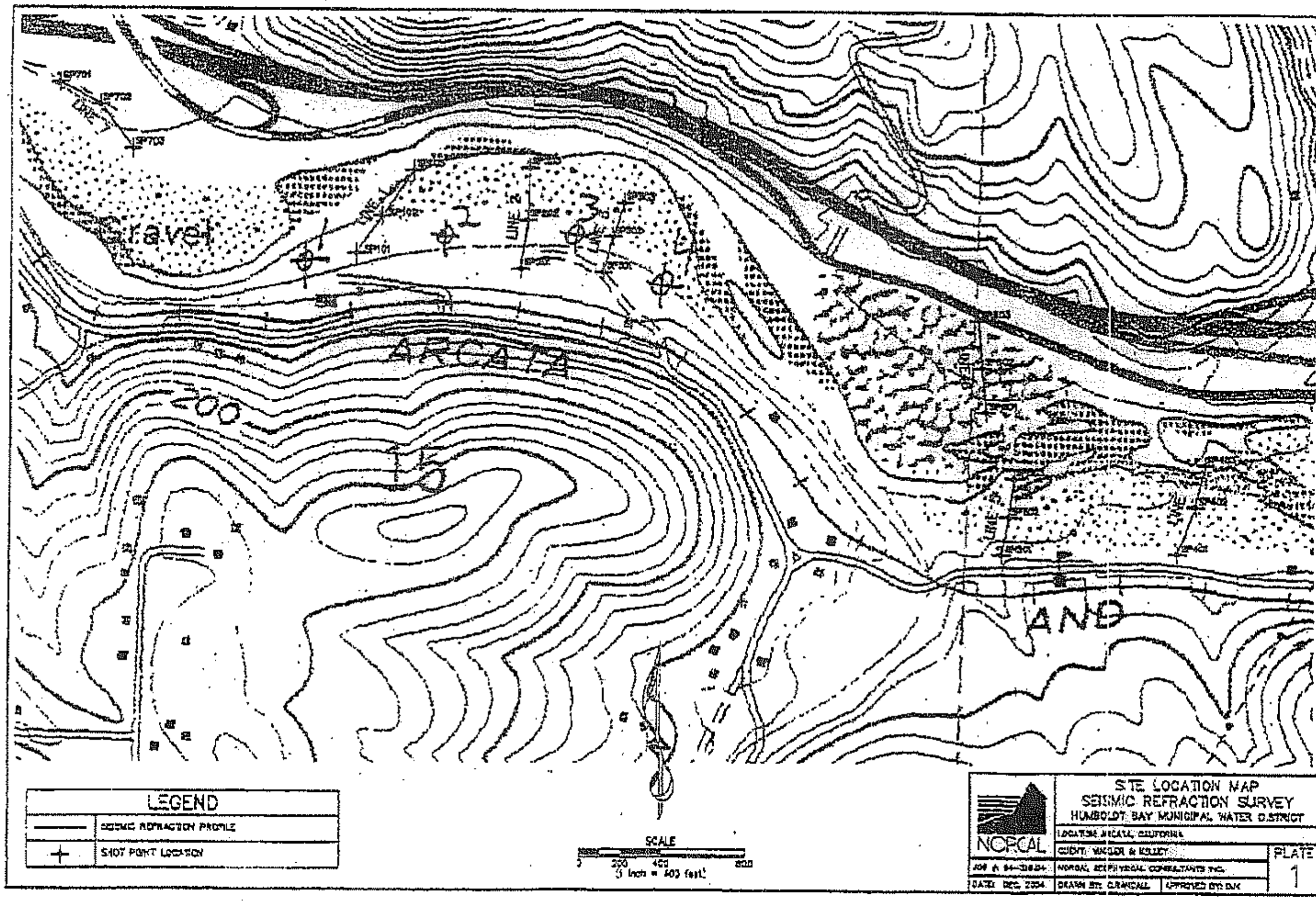
DWR 188 REV. 05-03

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM


Gravel
ARCATA
200
15
AND
LEGEND
SHOT POINT LOCATION
SCALE
0
200
400
800
SITE LOCATION MAP
SEISMIC REFRACTION SURVEY
HUMBOLDT BAY MUNICIPAL WATER DISTRICT
NORCAL
PLATE
1

Appendix B
Boring Logs for New Monitoring Wells

BORING LOG

PROJ. NAME: HBMWD PS #4		PROJECT NO.: 0105507003.11010	Sheet 1 of 3
METHOD OF DRILL: SONIC		LOCATION: PUMP STATION #4	
SAMPLER: 20'x 6" ND CORE BARREL OD: 6.0" ID:		LOGGED BY: P. JONES	BORING #: MW-5
BORING DIAMETER: 8.625"		DATE STARTED: 10/08/07	TIME: 1100
DRILLING CO.: CASCADE DRILLING		DATE COMPLETED: 10/09/07	TIME: 1645
C57 LIC. #: 717510		TOTAL DEPTH OF BORING: 98.0 ft.	
DRILLER: CARL TREECE		DEPTH TO GROUNDWATER: 4.0 ft.	
HAMMER WGT.: lbs.	HAMMER DROP: inches	SURFACE CONDITIONS: BARE SILT/SAND, RIVER BANK	

DEPTH	GRAPHIC SYMBOL	RECOVERY	BLOWS	SAMPLE NO.	USCS SYMBOL	SOIL DESCRIPTION	COLOR	MOISTURE	CONSISTENCY	PID (ppm)	WELL CONSTR.	WELL DESCRIPTION
1–3					GW							PORTLAND CEMENT 0.0'-42.0'
4–7						FIRST WATER @4.0'. GRAVEL & SAND (COARSE TO VERY COARSE), WITH <5% SILT. WELL ROUNDED POORLY SORTED.	5Y 4/1 DARK GRAY	MOIST WET	LOOSE SOFT			BLANK ASTM A53B ERW BPE ND 6" X .250" HEAT NO. 1-9850" 0.0'-47.0'.
8–13							5Y 3/2 DARK OLIVE GRAY	WET	LOOSE/SOFT			NATIVE GRAVEL AS FILTER PACK (ALLOWED TO CAVE) 42.0'-98.0'
14–15						GRADES AS ABOVE.						0.040 SLOTS "ASTM A53B ERW BPE ND 6" X .250" HEAT NO. 1-9850" 47'-67'.
16–19						GRADES ~50% MED. SAND, 50% GRAVEL >1/2", 8-9% SMALL GRAVEL, 1-2% SILT & CLAY.						
20						CLEANER WITH MORE FINE SAND.	2.5Y 4/3 OLIVE BROWN					
21–22						20' GRADES SILTIER (~5% SILT), AND LESS FINER SAND. SAND IS MOSTLY COARSE TO VERY COARSE WITH AN EVEN RANGE OF GRAIN SIZES FROM GRAVEL TO COARSE SAND.	5Y 3/1 VERY DARK GRAY					
23–26					ML	SILT-LITTLE OR NO SAND & CLAY.		WET	SOFT			
26–32					SP	SAND, FINE GRAINED, LITTLE OR NO CLAY. GRADES.	5Y 3/2 DK OLIVE GRAY		SOFT			
32–35					GW	CLEAN GRAVEL/SAND, SAND IS MOSTLY COARSE TO VERY COARSE. CLAY & SILT <5% BUT COLORS SAMPLE.	5YR 3/2 DARK REDDISH BROWN	WET	LOOSE			

WINZLER & KELLY
CONSULTING ENGINEERS

BORING LOG

PROJ. NAME: HBMWD PS #4	PROJECT NO.: 0105507003.11010	Sheet 2 of 3
	LOGGED BY: P. JONES	BORING #: MW-5

DEPTH	GRAPHIC SYMBOL	RECOVERY	BLOWS	SAMPLE NO.	USCS SYMBOL	SOIL DESCRIPTION	COLOR	MOISTURE	CONSISTENCY	PID (ppm)	WELL CONSTR.	WELL DESCRIPTION
36–37												
38–42						GRADES GRAVEL, VERY CLEAN ONLY TRACE OF FINES, MOSTLY SMALLER GRAVEL WITH COARSE SAND. GRAVEL UP TO 1" MOST IS SMALLER.	2.5Y 3/2 DARK OLIVE BROWN					
45–47						GRADES WITH ~2% SILT, GRAVEL IS LARGER (UP TO 2") AT 45.0'.	2.5Y 4/2 DARK GRAYISH BROWN					
48						GRADES WITH 2% SILT AT 46.0'.	GRADES 7.5YR 3/1 VERY DARK GRAY					
49–52					GW	48' GRADES WITH LITTLE TO NO FINES. SAND IS COARSE TO VERY COARSE, GRAVEL UP TO 3".						
56						GRADES.	GRADES					
66						GRADES.						
67–70						67' GRADES SILTY, SANDY GRAVEL WITH <5% CLAY. 10% SILT.	GRADES 2.5Y 3/1 VERY DARK GRAYISH BROWN	WET	LOOSE HARD HARD			
70–71					GM	GRADES WITH ~10% FINES			LOOSE			
72–74							5Y 4/2 OLIVE GRAY		LOOSE			
75					GW							

WINZLER & KELLY
CONSULTING ENGINEERS

BORING LOG

PROJ. NAME: HBMWD PS #4	PROJECT NO.: 0105507003.11010	Sheet 3 of 3
	LOGGED BY: P. JONES	BORING #: MW-5

DEPTH	GRAPHIC SYMBOL	RECOVERY	BLOWS	SAMPLE NO.	USCS SYMBOL	SOIL DESCRIPTION	COLOR	MOISTURE	CONSISTENCY	PID (ppm)	WELL CONSTR.	WELL DESCRIPTION
76–79					GW	75' GRADES WITH 35% FINES (MOSTLY SILT) CLEAN, FINE TO COARSE SAND & DISTINCT GRAY COLOR CHANGE.	GLEY 2 10BG 3/1 DARK GREENISH GRAY	WET	LOOSE			
79–84						GRADES.						
84–88						GRADES MOSTLY GRAVEL ONLY ~20% SAND 83'-85'.	GLEY 2 10BG 3/1 DARK GREENISH GRAY					
88–92					GM	SILTY SANDY GRAVEL, AVE ~30% SILT (20%) & CLAY (10%), 55% GRAVEL, 15% SAND.		WET	VERY SOFT			
92–96						GRADES ~ 70%, SILT & CLAY IN ~4" LENSES.	GLEY 2 5B 4/1 DARK BLUISH GRAY					
96–98					ROCK	96' VERY HARD & SLOW DRILLING. NO RECOVERY 96'-98', DRILLED THROUGH ROCK.						

WINZLER & KELLY
CONSULTING ENGINEERS

BORING LOG

PROJ. NAME: HBMWD PS #4	PROJECT NO.: 0105507003.11010 — Sheet 1 of 3
METHOD OF DRILL: SONIC	LOCATION: PUMP STATION #4
SAMPLER: 20'x 6" ND CORE BARREL OD: 6.0" ID:	LOGGED BY: P. JONES — BORING #: MW-6
BORING DIAMETER: 8.625"	DATE STARTED: 10/10/07 TIME: 0745
DRILLING CO.: CASCADE DRILLING	DATE COMPLETED: 10/11/07 TIME: 1000
C57 LIC. #: 717510	TOTAL DEPTH OF BORING: 95.0 ft.
DRILLER: CARL TREECE	DEPTH TO GROUNDWATER: 30.0 ft.
HAMMER WGT.: lbs. — HAMMER DROP: inches	SURFACE CONDITIONS: GRASS ON SHOULDER OF ACCESS ROAD

DEPTH	GRAPHIC SYMBOL	RECOVERY	BLOWS	SAMPLE NO.	USCS SYMBOL	SOIL DESCRIPTION	COLOR	MOISTURE	CONSISTENCY	PID (ppm)	WELL CONSTR.	WELL DESCRIPTION
1						GRAVEL, SANDY WITH <1% SILT & CLAY, SAND MED TO COARSE.	2.5Y 3/1 V. DARK GRAY	MOIST	LOOSE			
2												PORTLAND CEMENT 0.0'-70.0'
3												
4												
5												BLANK ASTM A53B ERW BPE ND 6" X .250" HEAT NO. I-9850" 0.0'-75.0'.
6												
7												
8						SANDY GRAVEL GRADES WITH SAND, VERY FINE TO V. COARSE, ~ 2% SILT.	GRADES	MOIST				NATIVE GRAVEL AS FILTER PACK (ALLOWED TO CAVE) 70.0'-95.0'
9												
10												
11												
12						GRADES WITH 3% SILT & CLAY.	2.5Y 4/2 DARK GRAYISH BROWN	MOIST				
13												
14												0.040 SLOTS "ASTM A53B ERW BPE ND 6" X .250" HEAT NO. I-9850" 75'-85'.
15					GW							
16												
17												
18												
19												
20												
21												
22						GRADES <1% FINES.	2.5Y 3/1 VERY DARK GRAY	MOIST				
23												
24						GRADES.						
25												
26												
27							GRADES					
28						GRADES.		MOIST				
29												
30											▼	
31												
32					SP	CLEAN SAND, MED. TO FINE GRAINED, WELL SORTED, WITH <1% SILT & CLAY.	2.5Y 4/2 DARK GRAYISH BROWN	WET	LOOSE			
33												
34												
35					SW	CLEAN GRAVELLY SAND, POORLY SORTED, <1% FINES, ~30% GRAVELS, FINE TO VERY COARSE.	GRADES	WET	LOOSE			

WINZLER & KELLY
CONSULTING ENGINEERS

BORING LOG

PROJ. NAME: HBMWD PS #4	PROJECT NO.: 0105507003.11010	Sheet 2 of 3
	LOGGED BY: P. JONES	BORING #: MW-6

DEPTH	GRAPHIC SYMBOL	RECOVERY	BLOWS	SAMPLE NO.	USCS SYMBOL	SOIL DESCRIPTION	COLOR	MOISTURE	CONSISTENCY	PID (ppm)	WELL CONSTR.	WELL DESCRIPTION
36–43					SW	GRADES ~50% GRAVEL & SAND IS MED TO VERY COARSE.						
						GRADES W/ 10% GRAVEL/SAND, 5% FINES.	GRADES	WET	LOOSE			
43–45					GM	43' SILTY, SANDY GRAVEL, ~10% SILT & CLAY, ~60% GRAVEL, 30% SAND.	GRADES	WET	LOOSE			
45–53					ML	SILT WITH <5% CLAY & <5 % SAND.	5Y 3/1 VERY DARK GRAY	WET	SOFT			
						GRADES.						
						48'–58' NO RECOVERY, SAMPLE SLID OUT OF CORE BARREL. WHEN CASING CLEANED OUT WITH MUD SHOE, DISTURBED & MIXED MATERIAL CONSISTED OF SILTY SAND & SILT, MINOR CLAY.						
53–58					SM	FINE TO MED SILTY SAND W/ MINOR CLAY.						
58–70					SP	CLEAN SAND, WELL SORTED, <1% FINES.	GLEY 1 N 3/0 VERY DARK GRAY	WET	SOFT			
						SAMPLE 58'–68' SLID OUT OF CORE BARREL-BAGGED SAMPLE COLLECTED ~68' REMAINDER OF SAMPLE OBSERVED IN CUTTINGS SIMILAR TO SAMPLE.	GRADES	WET	LOOSE			
						GRADES.						
70–73					GW	GRADES WITH ~10% GRAVEL, MED TO VERY COARSE.						
						SANDY GRAVEL, ~2% SILT & CLAY, SAND ~30%.	2.5Y 3/1 VERY DARK GRAY	WET				
73–75					SW	CLAYEY SILTY SAND, FINE TO COARSE GRAINED, ~5% CLAY, ~5% SILT.		WET	M STIFF			
75					GW				LOOSE			

WINZLER & KELLY
CONSULTING ENGINEERS

BORING LOG

PROJ. NAME: HBMWD PS #4	PROJECT NO.: 0105507003.11010	Sheet 3 of 3
	LOGGED BY: P. JONES	BORING #: MW-6

DEPTH	GRAPHIC SYMBOL	RECOVERY	BLOWS	SAMPLE NO.	USCS SYMBOL	SOIL DESCRIPTION	COLOR	MOISTURE	CONSISTENCY	PID (ppm)	WELL CONSTR.	WELL DESCRIPTION
76–79					GW	CLEAN SANDY GRAVEL, ~2% FINES, SAND MED TO VERY COARSE.						
80–84					GW	GRADES.	2.5Y 3/2 VERY DARK GRAYISH BROWN	WET	STIFF			
85–87					SP	SAND, ~5% FINES, FINE TO VERY FINE GRAINED, WELL SORTED.	GLEY 1 N 3/0 VERY DARK GRAY	WET	STIFF			
87–95					GW	GRADES. 88'-100' CORE BARREL PACKED WITH MUD (FLOWED IN) SO ONLY RECOVERED 93'-95'. DRILLING VERY SLOW AT 95' DUE TO PACKED BARREL. SANDY SILTY GRAVEL, CLAY & SILT ~5%, MINOR CLAY.	2.5Y 3/1 VERY DARK GRAY	WET	LOOSE			

WINZLER & KELLY
CONSULTING ENGINEERS

BORING LOG

PROJ. NAME: HBMWD PS #3		PROJECT NO.: 0105507003.11010	Sheet 1 of 3
METHOD OF DRILL: SONIC		LOCATION: PUMP STATION #3	
SAMPLER: 20'x 6" ND CORE BARREL OD: 6.0" ID:		LOGGED BY: P. JONES	BORING #: MW-7
BORING DIAMETER: 8.625"		DATE STARTED: 10/11/07	TIME: 1215
DRILLING CO.: CASCADE DRILLING		DATE COMPLETED: 10/12/07	TIME: 1400
C57 LIC. #: 717510		TOTAL DEPTH OF BORING: 96.0 ft.	
DRILLER: CARL TREECE		DEPTH TO GROUNDWATER: 28.0 ft.	
HAMMER WGT.: lbs.	HAMMER DROP: inches	SURFACE CONDITIONS: GRASS ON GRAVEL	

DEPTH	GRAPHIC SYMBOL	RECOVERY	BLOWS	SAMPLE NO.	USCS SYMBOL	SOIL DESCRIPTION	COLOR	MOISTURE	CONSISTENCY	PID (ppm)	WELL CONSTR.	WELL DESCRIPTION
2												PORTLAND CEMENT 0.0'-50.0'
4						SANDY GRAVEL, ~5% SILT, MINOR CLAY, ~60% GRAVEL.	2.5Y 4/1 DARK GRAY	SL MOIST	LOOSE			BLANK ASTM A53B ERW BPE ND 6" X .250" HEAT NO. 1-9850" 0.0'-55.0'.
8						GRADES, ~70% GRAVEL.	GRADES	SL MOIST				NATIVE GRAVEL AS FILTER PACK (ALLOWED TO CAVE) 50.0'-96.0'
10					GW							
12						GRADES ~80% GRAVEL, <2% FINES.	GRADES	SL MOIST	LOOSE			
14												0.040 SLOTS "ASTM A53B ERW BPE ND 6" X .250" HEAT NO. 1-9850" 55'-75'.
18						GRADES.	GRADES	SL MOIST	LOOSE			
20						SILTY CLAYEY SANDY GRAVEL, ~15% FINES.	10YR 3/2 VERY DARK GRAYISH BROWN	MOIST	STIFF			
24					GM	GRADES.		MOIST	STIFF			
28						CLAYEY SILTY SAND, ~70% SAND, 20% SILT, 10% CLAY.	2.5Y 3/2 VERY DARK GRAYISH BROWN	WET	SOFT		▼	
30					SC							
33					GM	SILTY CLAYEY SANDY GRAVEL, ~15% FINES, ~5% CLAY, ~ 50% GRAVEL.	2.5Y 4/2 DARK GRAYISH BROWN	WET	LOOSE			
35												

WINZLER & KELLY
CONSULTING ENGINEERS

BORING LOG

PROJ. NAME: HBMWD PS #3	PROJECT NO.: 0105507003.11010	Sheet 2 of 3
	LOGGED BY: P. JONES	BORING #: MW-7

DEPTH	GRAPHIC SYMBOL	RECOVERY	BLOWS	SAMPLE NO.	USCS SYMBOL	SOIL DESCRIPTION	COLOR	MOISTURE	CONSISTENCY	PID (ppm)	WELL CONSTR.	WELL DESCRIPTION
36					GM	GRAVEL, ~10% SAND, ~3% FINES, SAND IS MOSTLY COARSE TO VERY COARSE.	10YR 3/2 VERY DARK GRAYISH BROWN	WET	LOOSE			
37												
38												
39												
40						GRADES.						
41												
42												
43												
44						GRADES.						
45												
46												
47												
48						GRADES, GRAVEL WITH SOME COARSE TO VERY COARSE SAND (<5%), & ~2% FINES.	2.5Y 3/2 VERY DARK GRAYISH BROWN	WET	LOOSE			
49												
50												
51												
52						GRADES, SANDY GRAVEL, ~40% SAND (MED TO VERY COARSE), ~2% FINES.	2.5Y 3/2 VERY DARK GRAYISH BROWN	WET	LOOSE			
53												
54												
55												
56					GW	GRADES.	GRADES					
57												
58												
59												
60												
61												
62												
63												
64												
65												
66												
67												
68						GRADES.						
69												
70												
71												
72						GRADES.						
73												
74												
75												

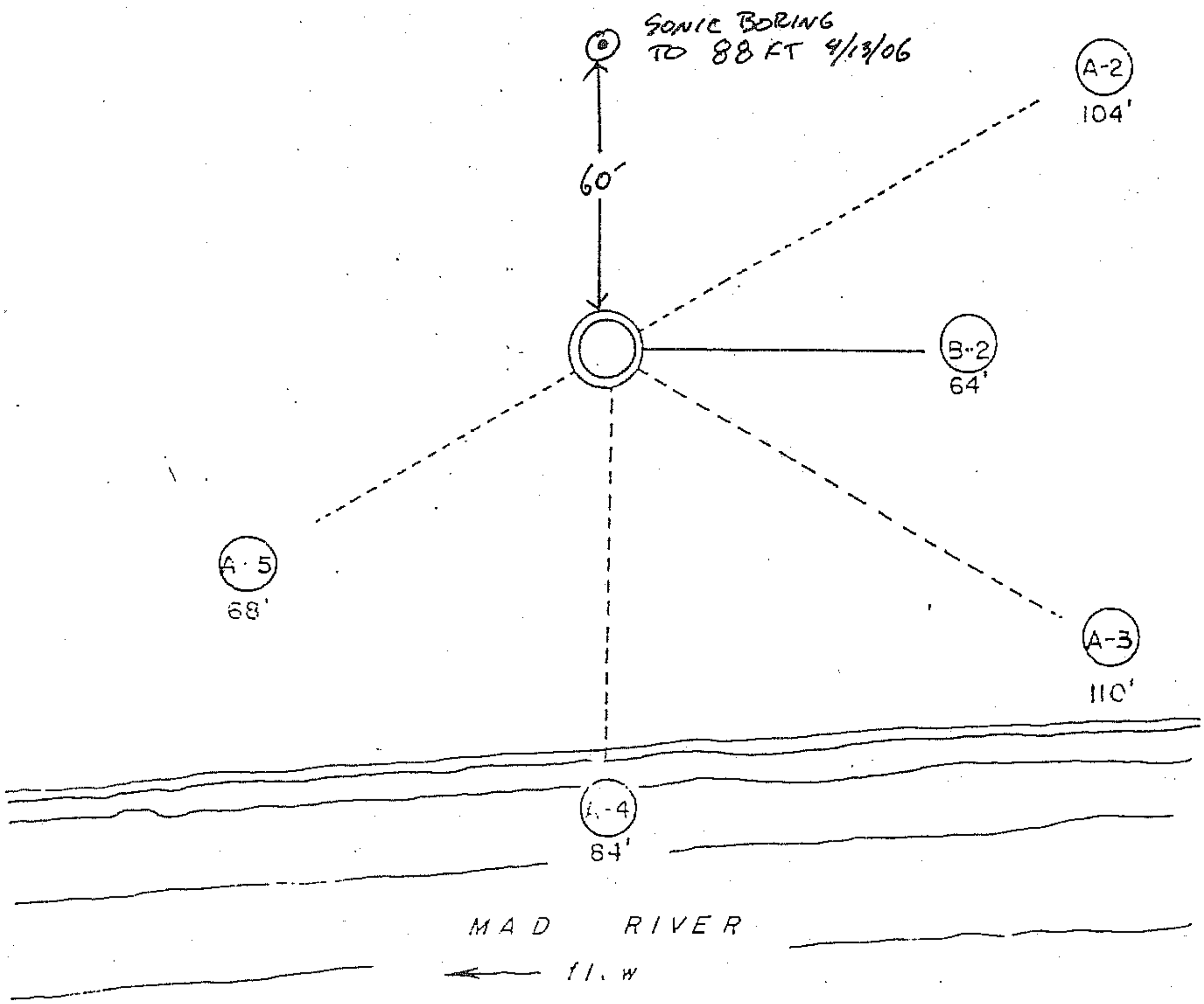
WINZLER & KELLY
CONSULTING ENGINEERS

BORING LOG

PROJ. NAME: HBMWD PS #3	PROJECT NO.: 0105507003.11010	Sheet 3 of 3
	LOGGED BY: P. JONES	BORING #: MW-7

DEPTH	GRAPHIC SYMBOL	RECOVERY	BLOWS	SAMPLE NO.	USCS SYMBOL	SOIL DESCRIPTION	COLOR	MOISTURE	CONSISTENCY	PID (ppm)	WELL CONSTR.	WELL DESCRIPTION
76–77					GW	GRADES WITH <2% FINES.			V STIFF			
78					GM	77.5' GRADES 78' SILTY CLAYEY SANDY GRAVEL, ~10% FINES.						
79–87					GW	GRADES AS ABOVE. GRADES TO 87'.						
87–88					SC	CLAYEY SILTY SAND, FINE TO VERY FINE GRAINED, ~70% SAND, ~5% SILT, 10% CLAY.	GLEY 2 5B 3/0 DARK BLUISH GRAY	WET	SLIGHT PLASTICITY			
88–96					CL	78'-96' GRAVELLY, SANDY, SILTY CLAY, MED. PLASTICITY, POSSIBLE WEATHERED BEDROCK.	GLEY 2 10BG 3/0 DARK BLUISH GRAY	MOIST	STIFF			

WINZLER & KELLY
CONSULTING ENGINEERS



LATERAL PROJECTION DIAGRAM

(Scale 1" = 40')

Total length of laterals = 430 feet (Effective = 430 feet)

—— Tier B

- - - - Tier A

ELEVATIONS

Top of caisson	- 51.00
Ground surface	+ 46.0
℄ of laterals - Tier B	- 26.9
℄ of laterals - Tier A	- 27.9
Top of plug	- 30.9
Cutting shoe	- 37.4

RANNEY METHOD WESTERN OF CALIF., INC.
SACRAMENTO, CALIF.

BECHTEL CORPORATION
CONSULTING ENGINEERS

HUMBOLDT BAY MUNICIPAL WATER DISTRICT

CONSTRUCTION DETAILS
COLLECTOR NO. 3

DRAWN J. S.	APPROVED [illegible]
DATE 5 / 22 / 62	FIGURE UW-17-04

WINZLER & KELLY
CONSULTING ENGINEERS
633 Third Street, Eureka, CA 95501-0417
(707) 443-8326 / FAX (707) 444-8330

By TNICS Date 4/13/6 Client NBMWD Sheet No. ____ of ____

Subject B-1 MK II BORING LOG Job No. ____

DEPTH FEET	% FINES	% SAND	% GRAVEL	TEXTURE	MOISTURE	NOTES	USCS
0-3½	40	40	20	LOOSE	DRY	BASE ROCK	
3½-7½	70	30	0	PARTLY CONSOLIDATED	MOIST	OVERBANK SILT	
7½-9	20	60	20	LOOSE	MOIST		
9-11	60	30	10	PARTLY CONSOLIDATED	MOIST		
11-18	20	60	20	LOOSE	LOW MOISTURE	COBBLES TO 4"	
18-20	40	40	20	LOOSE	MOIST		
20-30	20	30	50	LOOSE	MOIST	CLAST-SUPPORTED CLASTS TO 4"	
30-31	40	20	40	PARTLY CONSOLIDATED	WET	TRANSITION ZONE	
31-36½	20	80	0	LOOSE TO PARTIALLY COHESIVE	WET	MINOR ORGANICS	
36½-40	20	30	50	LOOSE	MOIST		
41-49	10	10	80	LOOSE	WET	MAINLY PEA GRAVEL	
49-60	20	20	60	PARTIALLY COHESIVE	WET		
60-63	5	25	70	LOOSE	WET		
63-~69	20	20	60	~~LOOSE~~ PARTLY COHESIVE	WET	PEA-2" CLEAN GRAVEL	
69-86	0	30	70	LOOSE	WET		
86-88	20	20	60	LOOSE	WET		

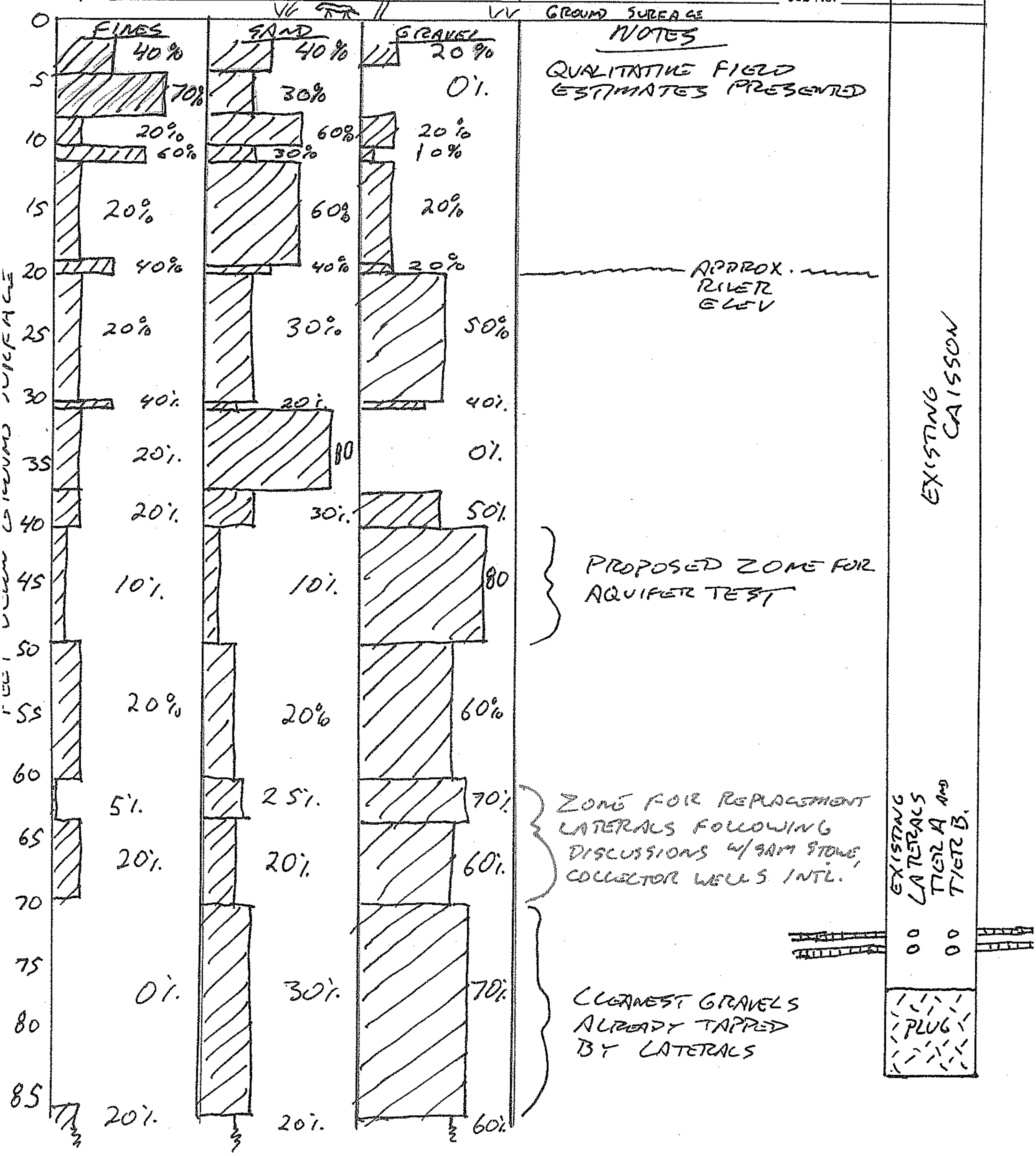
END OF HOLE 88'

NOTE- EXISTING CAISSONS ~74 FT BGS IN CLEAN GRAVELS

WINZLER & KELLY
CONSULTING ENGINEERS
633 Third Street, Eureka, CA 95501-0417
(707) 443-8326 / FAX (707) 444-8330

By THIESSEN Date 4/13/06 Client HUMBOLDT BAY MUN. WATER DIST. Sheet No. ____ of ____

Subject SONIC BORING LOG @ RANNEY COLLECTOR #3 Job No. ____



Appendix C
Cooper-Jacob Results

WELL ID: PS #3 & MW-1

Local ID: HML-Augmentation
Date: 4/19/2000
Time: 10:17

INPUT

Construction:		
Casing dia. (d_c)	6	Inch
Annulus dia. (d_w)	6	Inch
Screen Length (L)	21	Feet
Depths to:		
water level (DTW)	5.21	Feet
Top of Aquifer	0	Feet
Base of Aquifer	63	Feet
Annular Fill:		
across screen --	Open Hole	
above screen --	Cement	
Aquifer Material --	Gravel	
FLOW RATE	3947	GPM

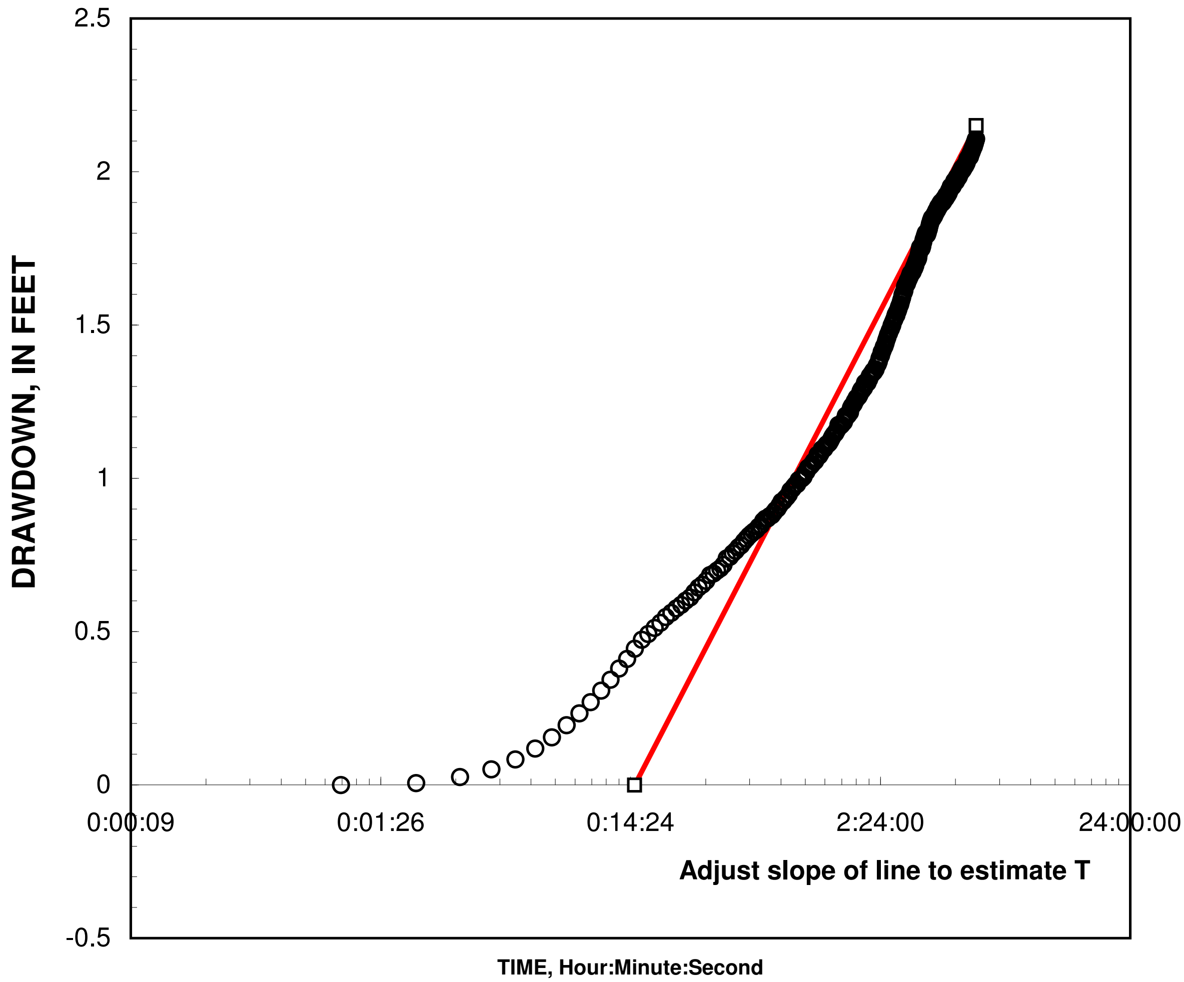
COMPUTED

Aquifer thickness = 32 Feet

Slope = 1.5744939 Feet/log10

Input is consistent.

K = 1500 Feet/Day
T = 88000 Feet²/Day



REMARKS: Cooper-Jacob analysis of single-well aquifer test

HBMWD PS #3 pumping & drawdown in MW-1

WELL ID: PS #3 & MW-4

Local ID: HML-Augmentation
Date: 4/19/2000
Time: 10:17

INPUT

Construction:	
Casing dia. (d_c)	6 Inch
Annulus dia. (d_w)	6 Inch
Screen Length (L)	21 Feet
Depths to:	
water level (DTW)	5.21 Feet
Top of Aquifer	0 Feet
Base of Aquifer	63 Feet
Annular Fill:	
across screen --	Open Hole
above screen --	Cement
Aquifer Material --	Gravel
FLOW RATE	3947 GPM

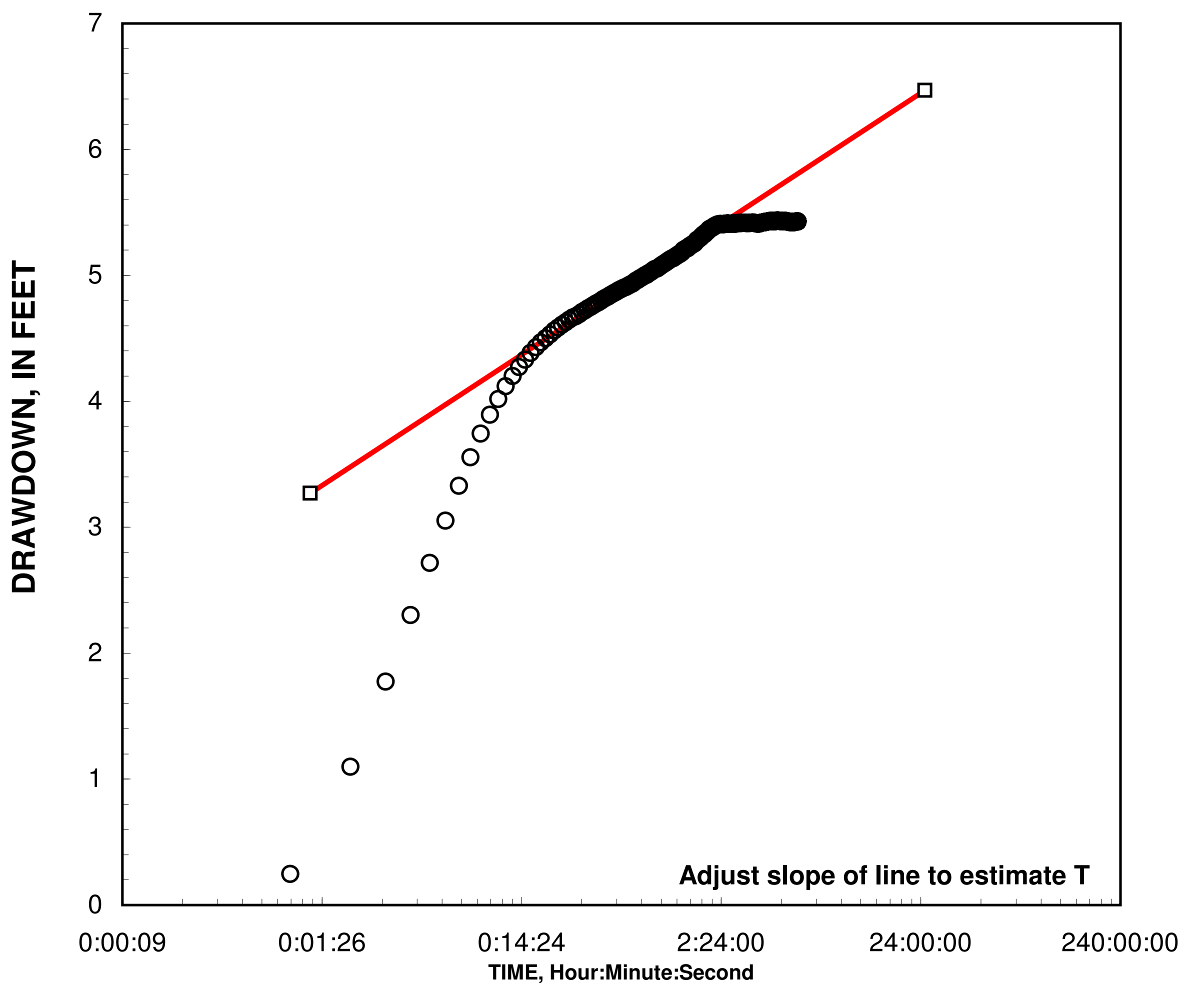
COMPUTED

Aquifer thickness = 58 Feet

Slope = 1.0392985 Feet/log10

Input is consistent.

K = 2300 Feet/Day
T = 130000 Feet²/Day



REMARKS: Cooper-Jacob analysis of single-well aquifer test

HBMWD PS#3 & MW-4

WELL ID: PS #3 & MW-7

Local ID: HML-Augmentation
Date: 4/19/2000
Time: 10:17

INPUT

Construction:	
Casing dia. (d_c)	6 Inch
Annulus dia. (d_w)	6 Inch
Screen Length (L)	21 Feet
Depths to:	
water level (DTW)	5.21 Feet
Top of Aquifer	0 Feet
Base of Aquifer	63 Feet
Annular Fill:	
across screen --	Open Hole
above screen --	Cement
Aquifer Material --	Gravel
FLOW RATE	3947 GPM

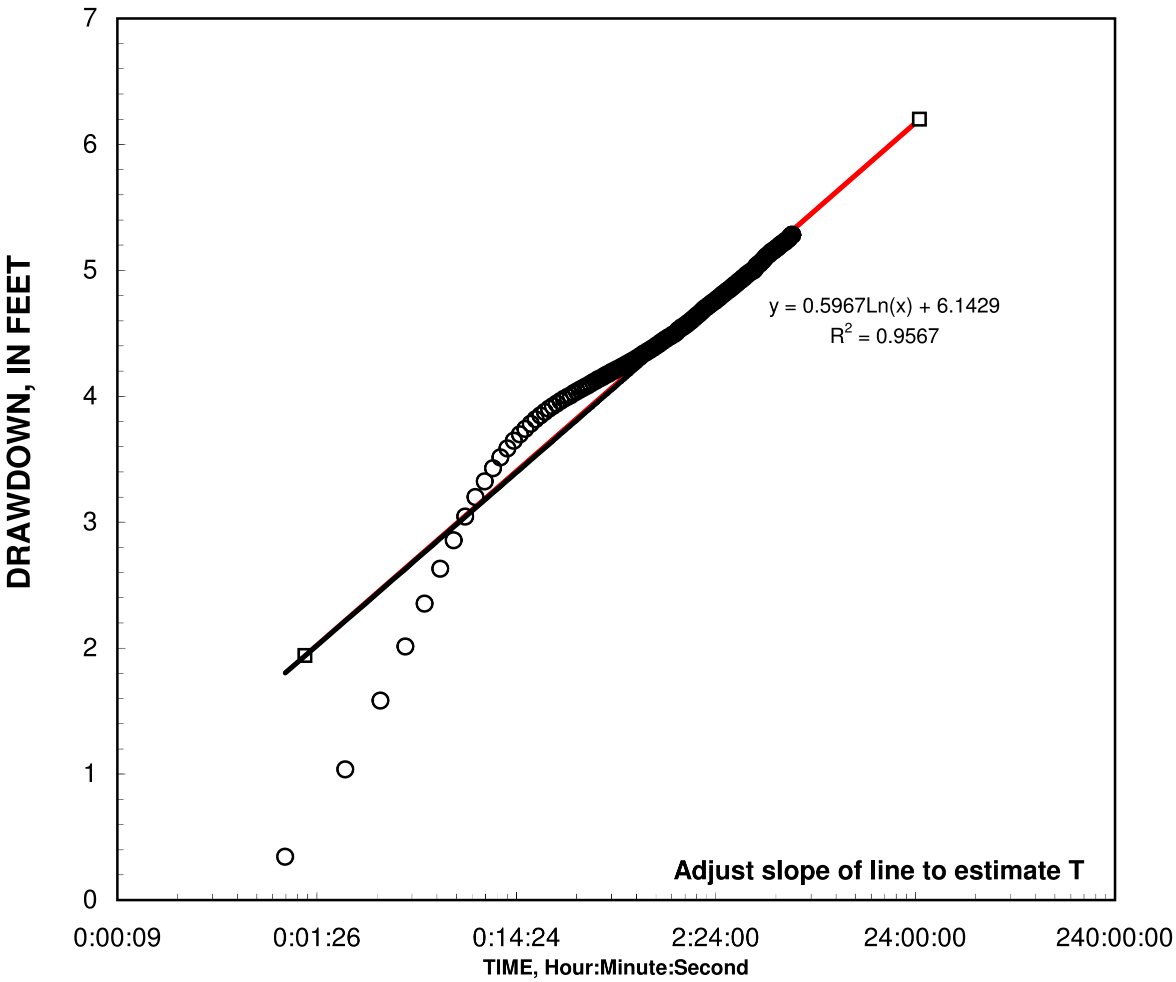
COMPUTED

Aquifer thickness = 58 Feet

Slope = 1.3835661 Feet/log10

Input is consistent.

K = 1700 Feet/Day
T = 100000 Feet²/Day



REMARKS: Cooper-Jacob analysis of single-well aquifer test

HBMWD PS #3 & MW-7

WELL ID: PS #3 & MW-1 Test 2

Local ID: HML-Augmentation
Date: 4/19/2000
Time: 4:57

INPUT

Construction:		
Casing dia. (d_c)	6	Inch
Annulus dia. (d_w)	6	Inch
Screen Length (L)	21	Feet
Depths to:		
water level (DTW)	4.835	Feet
Top of Aquifer	0	Feet
Base of Aquifer	63	Feet
Annular Fill:		
across screen --	Open Hole	
above screen --	Cement	
Aquifer Material --	Gravel	
FLOW RATE	6409	GPM

COMPUTED

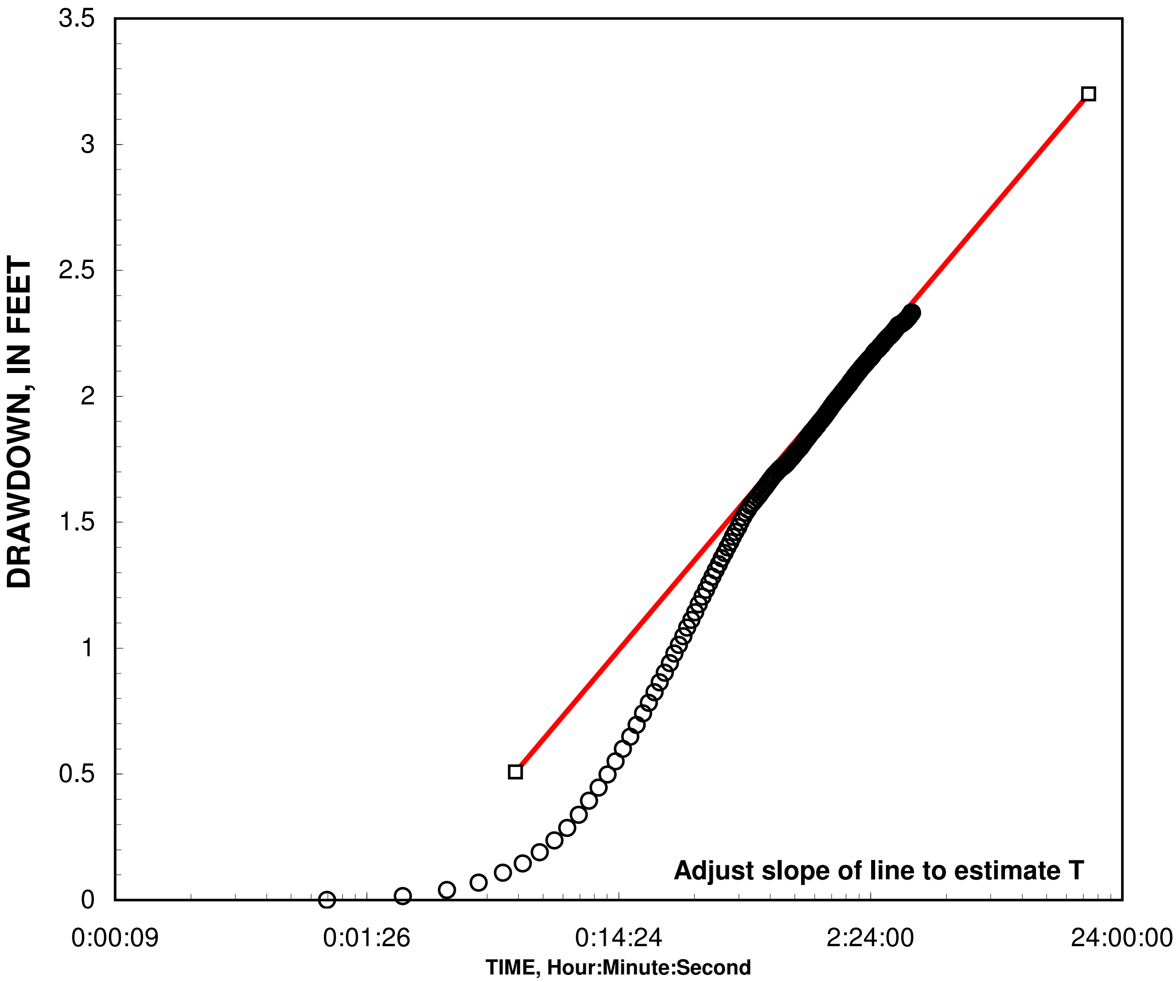
Aquifer thickness = 58 Feet

Slope = 1.1827768 Feet/log10

K= 3300 is greater than extreme maximum of 3000 for Gr

K =	Error	Feet/Day
T =	Error	Feet²/Day

K= 3300 is greater than likely maximum of 3000 for Gravel



REMARKS: Cooper-Jacob analysis of single-well aquifer test

HBMWD PS #3 & MW-1 Test 2

WELL ID: PS #3 & MW-4 Test 2

Local ID: HML-Augmentation
Date: 4/19/2000
Time: 4:57

INPUT

Construction:		
Casing dia. (d_c)	6	Inch
Annulus dia. (d_w)	6	Inch
Screen Length (L)	21	Feet
Depths to:		
water level (DTW)	4.835	Feet
Top of Aquifer	0	Feet
Base of Aquifer	63	Feet
Annular Fill:		
across screen --	Open Hole	
above screen --	Cement	
Aquifer Material --	Gravel	
FLOW RATE	6409	GPM

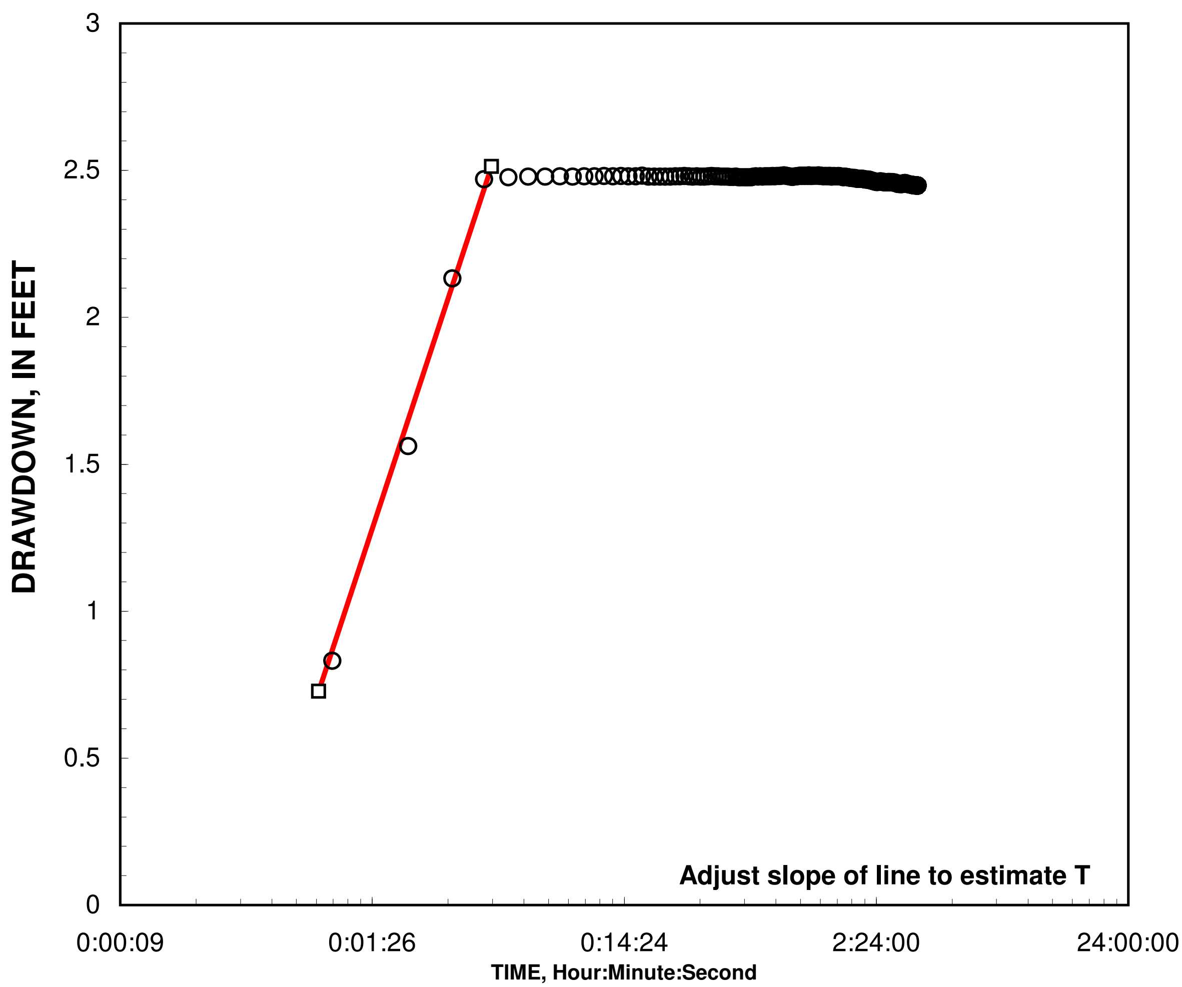
COMPUTED

Aquifer thickness = 58 Feet

Slope = 2.6034985 Feet/log10

Input is consistent.

K =	1500	Feet/Day
T =	87000	$Feet^2$/Day



REMARKS: Cooper-Jacob analysis of single-well aquifer test

HBMWD PS #3 & MW-4 Test 2

WELL ID: PS #3 & MW-7 Test 2

Local ID: HML-Augmentation
Date: 4/19/2000
Time: 4:57

INPUT

Construction:	
Casing dia. (d_c)	6 Inch
Annulus dia. (d_w)	6 Inch
Screen Length (L)	21 Feet
Depths to:	
water level (DTW)	4.835 Feet
Top of Aquifer	0 Feet
Base of Aquifer	63 Feet
Annular Fill:	
across screen --	Open Hole
above screen --	Cement
Aquifer Material --	Gravel
FLOW RATE	6409 GPM

COMPUTED

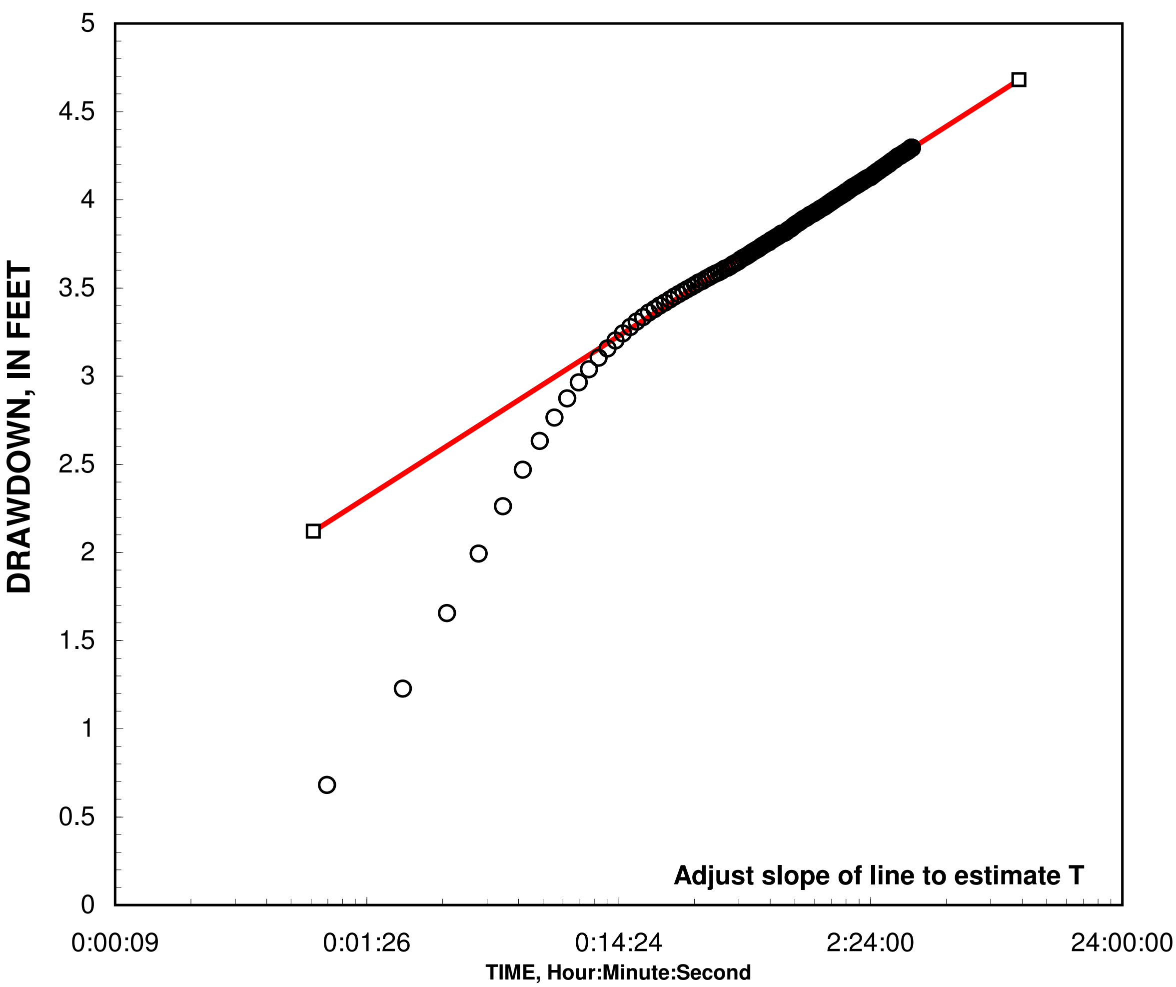
Aquifer thickness = 58 Feet

Slope = 0.9133072 Feet/log10

K= 4300 is greater than extreme maximum of 3000 for Gr

K =	Error	Feet/Day
T =	Error	Feet²/Day

K= 4300 is greater than likely maximum of 3000 for Gravel



REMARKS:

Cooper-Jacob analysis of single-well aquifer test

HBMWD PS #3 & MW-7 Test 2

WELL ID: PS #3 & MW-1 Test 3

Local ID: HML-Augmentation
Date: 4/19/2000
Time: 20:21

INPUT

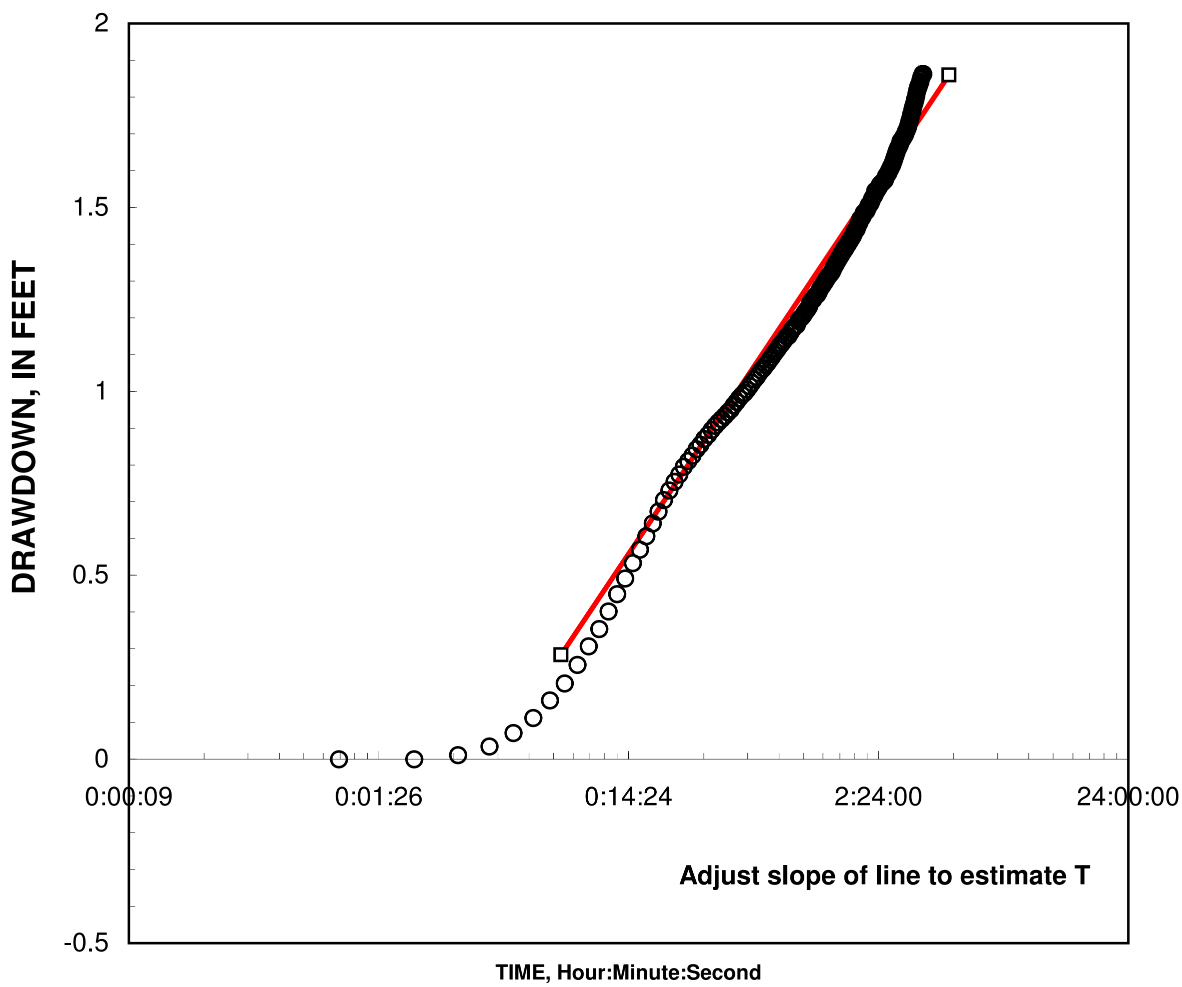
Construction:		
Casing dia. (d_c)	6	Inch
Annulus dia. (d_w)	6	Inch
Screen Length (L)	21	Feet
Depths to:		
water level (DTW)	2.438	Feet
Top of Aquifer	0	Feet
Base of Aquifer	63	Feet
Annular Fill:		
across screen --	Open Hole	
above screen --	Cement	
Aquifer Material --	Gravel	
FLOW RATE	2834	GPM

COMPUTED

Aquifer thickness =	61	Feet
Slope =	1.01481	Feet/log10

Input is consistent.

K =	1600	Feet/Day
T =	98000	Feet²/Day



REMARKS: Cooper-Jacob analysis of single-well aquifer test

HBMWD PS #3 & MW-1 Test 3

WELL ID: PS #3 & MW-4 Test 3

Local ID: HML-Augmentation
Date: 4/19/2000
Time: 20:21

INPUT

Construction:		
Casing dia. (d_c)	6	Inch
Annulus dia. (d_w)	6	Inch
Screen Length (L)	21	Feet
Depths to:		
water level (DTW)	2.438	Feet
Top of Aquifer	0	Feet
Base of Aquifer	63	Feet
Annular Fill:		
across screen --	Open Hole	
above screen --	Cement	
Aquifer Material --	Gravel	
FLOW RATE	2834	GPM

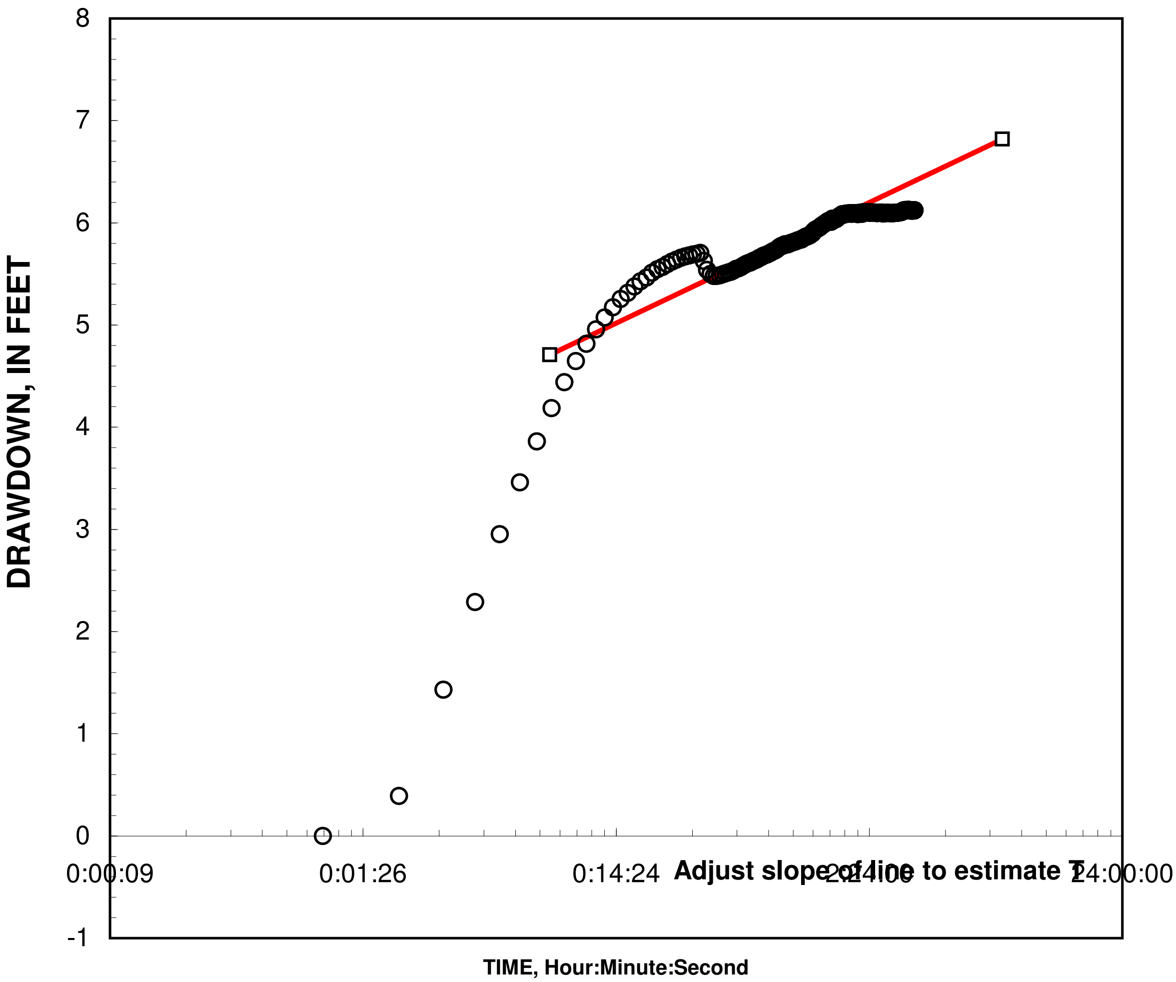
COMPUTED

Aquifer thickness = 61 Feet

Slope = 1.1800895 Feet/log10

Input is consistent.

K =	1400	Feet/Day
T =	85000	Feet²/Day



REMARKS: Cooper-Jacob analysis of single-well aquifer test

HBMWD PS #3 & MW-4 Test 3

WELL ID: PS #3 & MW-7 Test 3

Local ID: HML-Augmentation
Date: 4/19/2000
Time: 20:21

INPUT

Construction:		
Casing dia. (d_c)	6	Inch
Annulus dia. (d_w)	6	Inch
Screen Length (L)	21	Feet
Depths to:		
water level (DTW)	2.438	Feet
Top of Aquifer	0	Feet
Base of Aquifer	63	Feet
Annular Fill:		
across screen --	Open Hole	
above screen --	Cement	
Aquifer Material --	Gravel	
FLOW RATE	2834	GPM

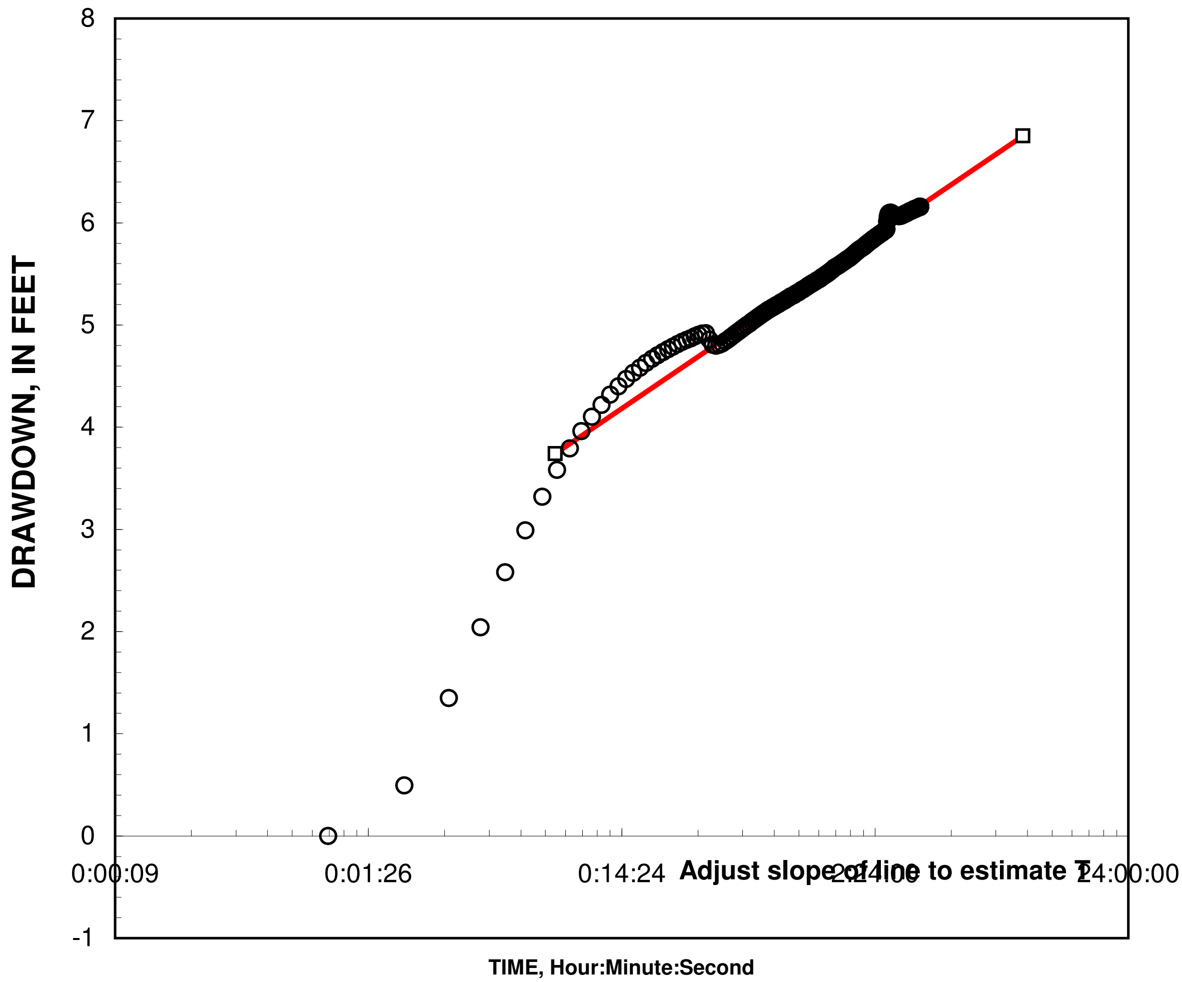
COMPUTED

Aquifer thickness = 61 Feet

Slope = 1.6847237 Feet/log10

Input is consistent.

K =	980	Feet/Day
T =	59000	Feet²/Day



REMARKS: Cooper-Jacob analysis of single-well aquifer test

HBMWD PS #3 & MW-7 Test 3

WELL ID: PS #4 & MW-5

Local ID: HML-Augmentation
Date: 4/19/2000
Time: 13:47

INPUT

Construction:	
Casing dia. (d_c)	6 Inch
Annulus dia. (d_w)	6 Inch
Screen Length (L)	21 Feet
Depths to:	
water level (DTW)	13.401 Feet
Top of Aquifer	0 Feet
Base of Aquifer	75 Feet
Annular Fill:	
across screen --	Open Hole
above screen --	Cement
Aquifer Material --	Gravel
FLOW RATE	4350.4 GPM

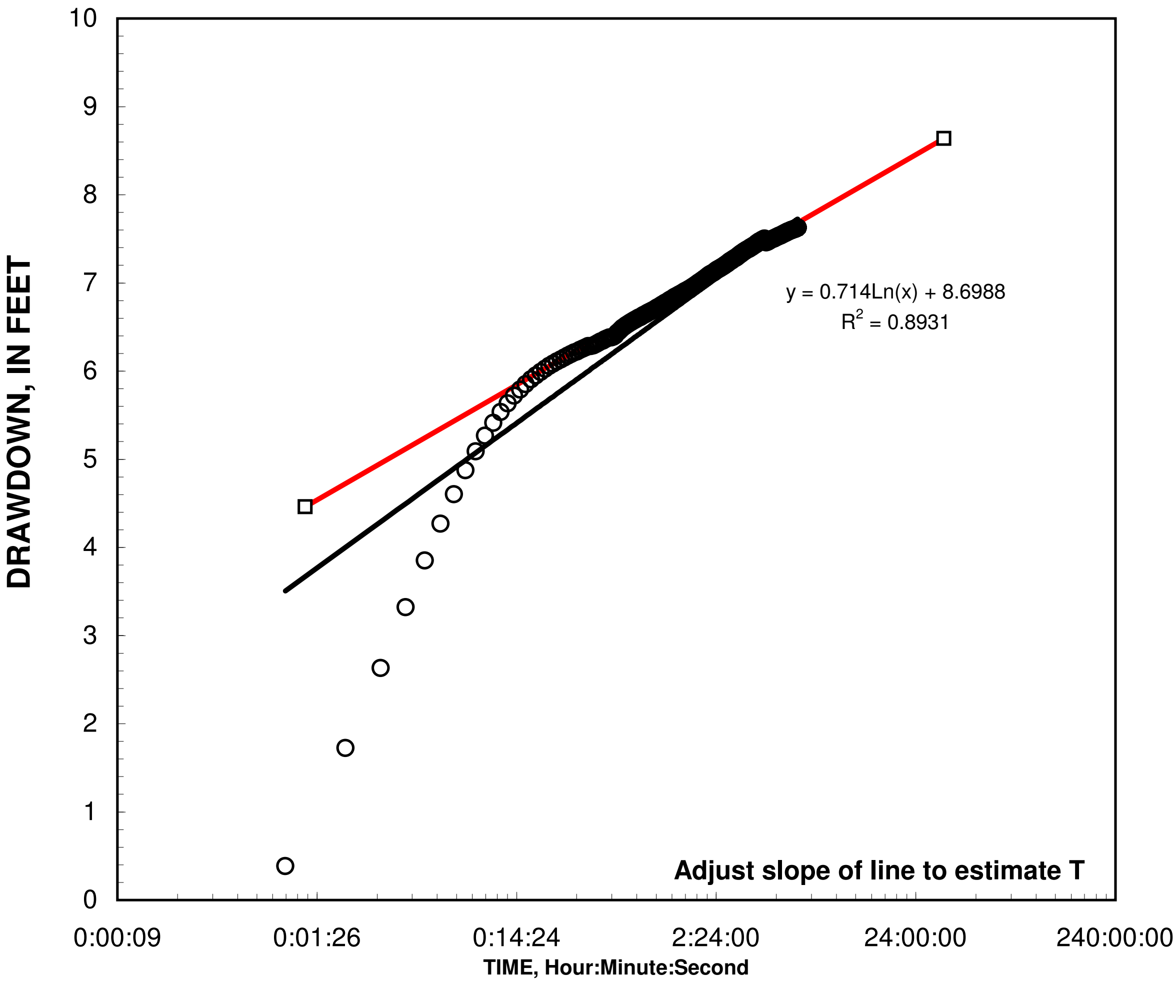
COMPUTED

Aquifer thickness = 62 Feet

Slope = 1.3066583 Feet/log10

Input is consistent.

K =	1900	Feet/Day
T =	120000	Feet²/Day



REMARKS:

Cooper-Jacob analysis of single-well aquifer test

HBMWD PS #4 & MW-5

WELL ID: PS #4 & MW-6

Local ID: HML-Augmentation
Date: 4/19/2000
Time: 13:47

INPUT

Construction:		
Casing dia. (d_c)	6	Inch
Annulus dia. (d_w)	6	Inch
Screen Length (L)	21	Feet
Depths to:		
water level (DTW)	13.401	Feet
Top of Aquifer	0	Feet
Base of Aquifer	75	Feet
Annular Fill:		
across screen --	Open Hole	
above screen --	Cement	
Aquifer Material --	Gravel	
FLOW RATE	4350.4	GPM

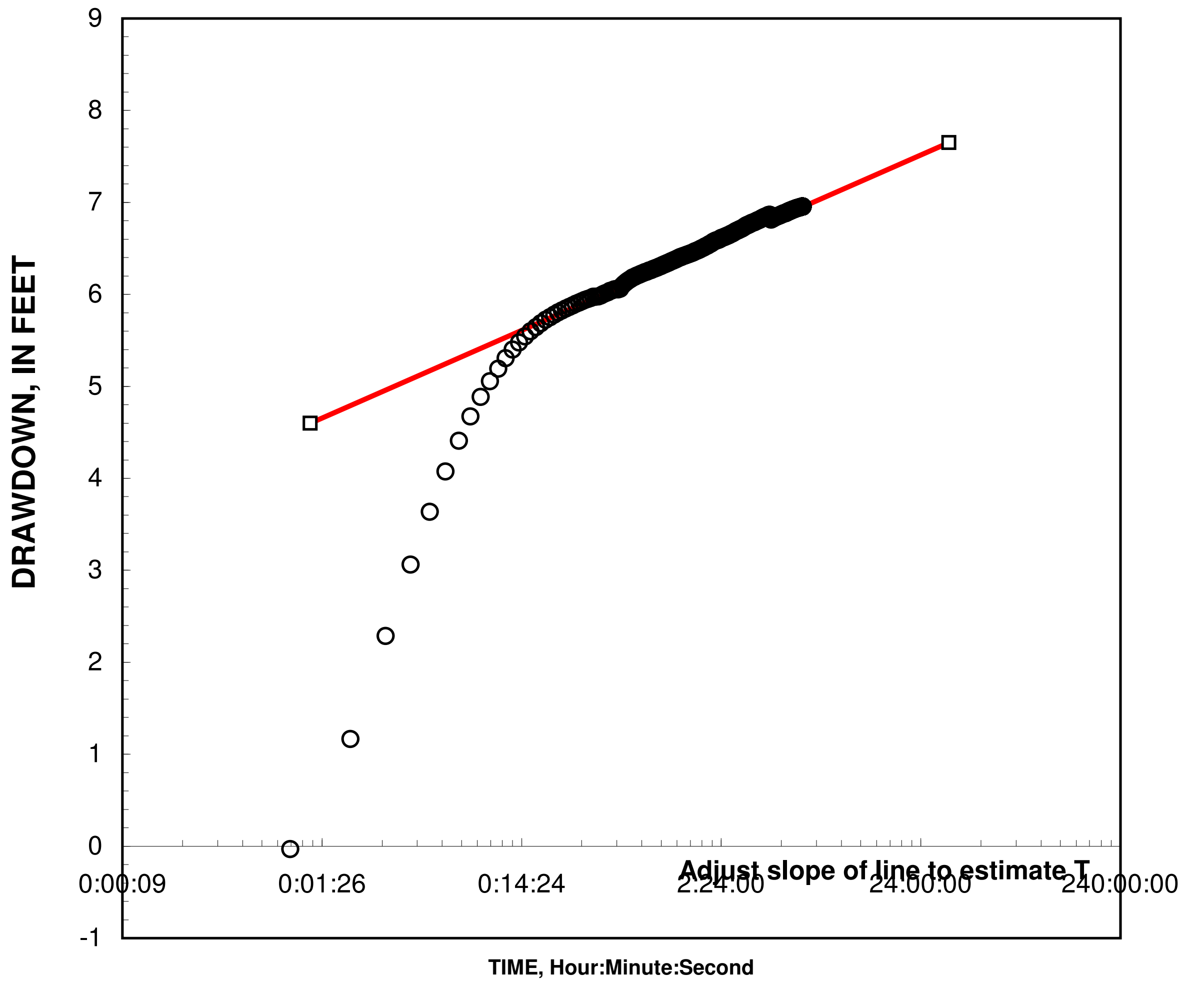
COMPUTED

Aquifer thickness = 62 Feet

Slope = 0.9534229 Feet/log10

Input is consistent.

K =	2600	Feet/Day
T =	160000	$Feet^2$/Day



REMARKS:

Cooper-Jacob analysis of single-well aquifer test

HBMWD PS #4 & MW-6

WELL ID: PS #4 & MW-5 Test 2

Local ID: HML-Augmentation
Date: 4/19/2000
Time: 15:26

INPUT

Construction:		
Casing dia. (d_c)	6	Inch
Annulus dia. (d_w)	6	Inch
Screen Length (L)	21	Feet
Depths to:		
water level (DTW)	10.038	Feet
Top of Aquifer	0	Feet
Base of Aquifer	75	Feet
Annular Fill:		
across screen --	Open Hole	
above screen --	Cement	
Aquifer Material --	Gravel	
FLOW RATE	2806	GPM

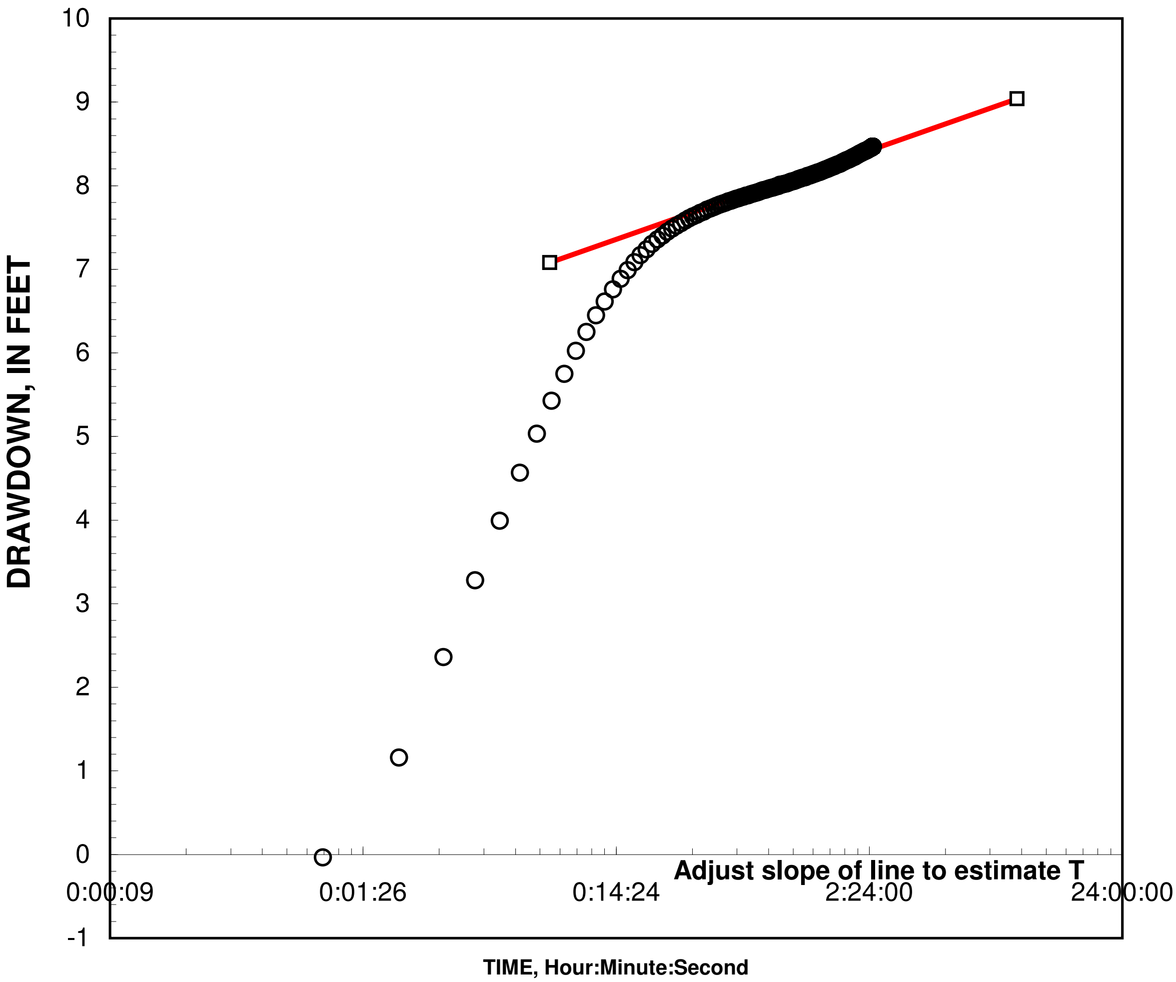
COMPUTED

Aquifer thickness = 65 Feet

Slope = 1.0617551 Feet/log10

Input is consistent.

K	=	1400	Feet/Day
T	=	93000	Feet²/Day



REMARKS: Cooper-Jacob analysis of single-well aquifer test

HBMWD PS #4 & MW-5 Test 2

WELL ID: PS #4 & MW-6 Test 2

Local ID: HML-Augmentation
Date: 4/19/2000
Time: 15:26

INPUT

Construction:		
Casing dia. (d_c)	6	Inch
Annulus dia. (d_w)	6	Inch
Screen Length (L)	21	Feet
Depths to:		
water level (DTW)	10.038	Feet
Top of Aquifer	0	Feet
Base of Aquifer	75	Feet
Annular Fill:		
across screen --	Open Hole	
above screen --	Cement	
Aquifer Material --	Gravel	
FLOW RATE	2806	GPM

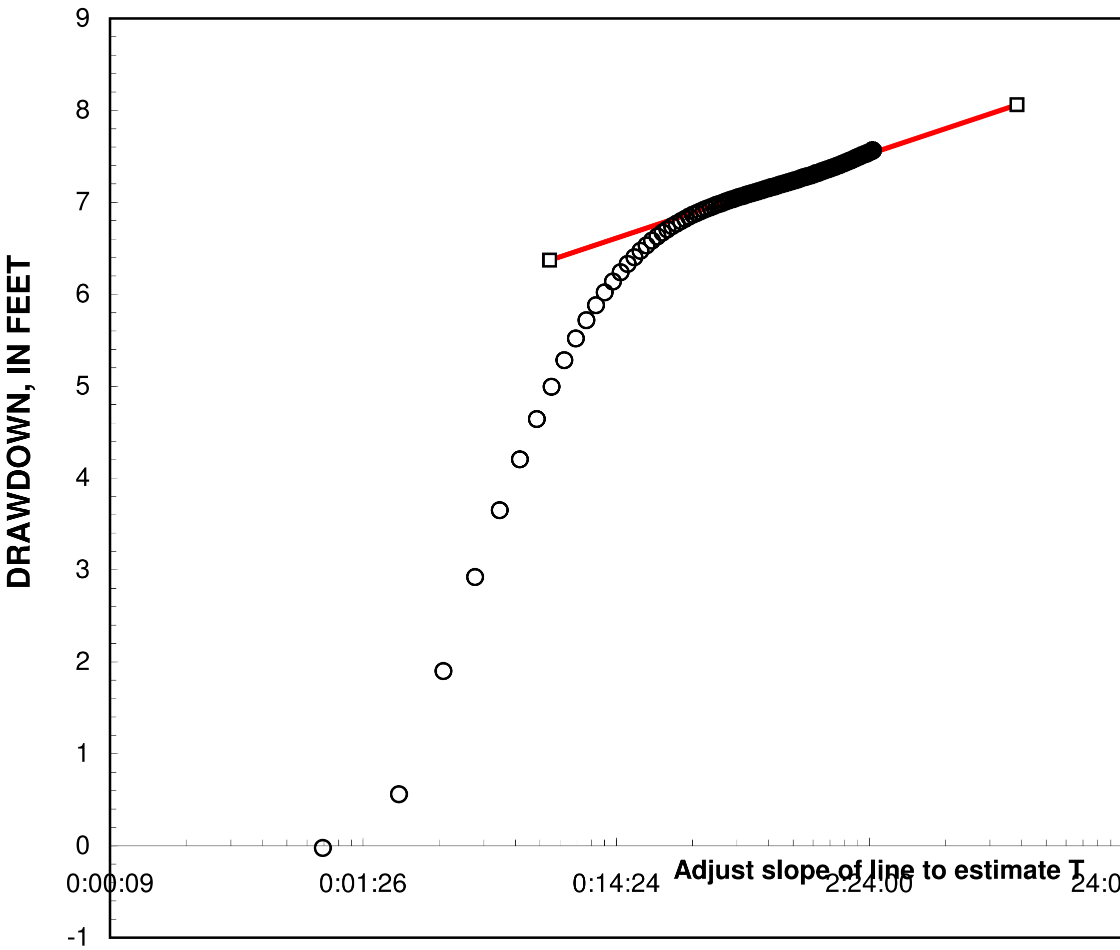
COMPUTED

Aquifer thickness = 65 Feet

Slope = 0.915493 Feet/log10

Input is consistent.

K = 1700 Feet/Day
T = 110000 Feet²/Day



REMARKS: Cooper-Jacob analysis of single-well aquifer test

HBMWD PS #4 & MW-6 Test 2

Ranney Collector No. 3
Maintenance Report
New Lateral Installations

Prepared for:

Humboldt Bay Municipal Water District

Prepared By:

Layne®

Ranney Collector Wells

Columbus, Ohio
August 9, 2012

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1.0 INTRODUCTION

The Layne Christensen Company (d/b/a Ranney Collector Wells), was contracted by the Humboldt Bay Municipal Water District (District) to perform maintenance on the District's Ranney Collector No. 3. The maintenance activities, as completed, included installation of new ports in the caisson wall, installation of six (6) new laterals and pre and post maintenance performance testing of the well. The rehabilitation of the collector well was accomplished during the period from December 2011 through May 2012. Procedures and results for the maintenance activities and testing are included in this report along with recommendations regarding future collector well operations.

1.1 BACKGROUND

The District has six (6) collector wells (1, 1A, 2, 3, 4 and 5) located along the Mad River in Arcata, California (Figure 1). Construction of Ranney Collectors 1, 2, 3 and 4 was begun in 1961 and performance testing was conducted in 1962. Ranney Collector No. 5 is not currently in service.

Each of the District's Ranney Collectors consists of a reinforced concrete caisson with an inner diameter of 13 feet and an outer diameter of 16 feet (Ranney Method Western of California, 1962). The collector wells vary in the numbers and lengths of laterals installed. The laterals in the collector wells were constructed with 12-inch OD, punch-slotted steel well screen with 3/8-inch by 1-1/16-inch rectangular slots.

Ranney Collector No. 3 is located about 3,600 feet east southeast of the water treatment plant on the north side of the Mad River. There are two pumps installed in the collector well, designated 3-1 and 3-2. Ranney Collector No. 3 was originally constructed with five (5) laterals with lengths varying from 64 to 110 feet. Four of the laterals (A-2, A-3, A-4 and A-5) have a centerline elevation at -27.9 feet (A-tier), and one of the laterals (B-2) has a centerline elevation at -26.9 feet (B-tier). The top of the caisson is at an elevation of 51 feet and the floor of the caisson is at an elevation of about -30.9 feet (the floor has an irregular surface) giving a depth of about 81.9 feet from the top of the caisson.

In April 2006, a test boring was drilled adjacent to Collector Well 3 and a short-term pumping test was conducted in this boring. This work was directed by Winzler & Kelly Consulting Engineers of Eureka, California to evaluate the feasibility of the installation of additional laterals in Ranney Collector No. 3. Ranney (d.b.a Collector Wells International, Inc.) performed an inspection of Ranney Collector No. 3 in October 2006 (CWI, 2007). As part of the inspection report an evaluation of the potential yield that could be obtained if five (5) new laterals were installed in Ranney Collector No. 3 at an elevation of -16.0 feet with each new lateral 150 feet in length. It was calculated that Ranney Collector No. 3 could have a sustained yield of up to 8,100 gpm (11.6 MGD) assuming that all of the production would come from the new laterals and neglecting additional potential yield from the existing laterals. It was noted that actual yields would depend on how well the aquifer conditions match the assumed conditions, and would vary with changes in river level and ground water temperature. Also, it was noted that it might be difficult to project the laterals to an average length of 150 feet due to the aquifer characteristics (CWI, 2007).

1.2 LIMITATIONS

This report was prepared for the exclusive use of the Humboldt Bay Municipal Water District for the specific application to the Ranney Collector No. 3 as specified in the report. Conclusions reached in this report are based upon the objective data available at the time of forming our opinions and the accuracy of the report depends upon the accuracy of these data. Every effort is made to evaluate the information by the methods generally recognized to constitute accepted standard practices for groundwater investigations at the time of rendering and the conclusions reached therein to represent our opinions. Ranney cannot be responsible for actual conditions proved to be materially at variance with the data collected or supplied to us, upon which our opinions are based.

2.0 MAINTENANCE AND TESTING PROCEDURES

The collector well maintenance was conducted by Ranney from December 2011 through May 2012. Work accomplished included the following:

- Task 1: Mobilization and set up.
- Task 2: Conduct pre-maintenance performance testing.
- Task 3: Install and develop new laterals.
- Task 4: Conduct post-maintenance performance testing.
- Task 5: Site clean-up and demobilization.
- Task 6: Document new lateral installation and testing results in a report.

TASK 1 – MOBILIZATION/SET-UP

Equipment and personnel were mobilized to the site and the site was secured for work on December 1, 2011. The District had a temporary percolation pond installed at the site to the northwest of the collector well to handle water and sediment discharged from the collector well during the testing and maintenance activities. A temporary discharge line was installed so that the existing well pump could be used for the pre-maintenance pumping test with the discharge directed to the percolation pond. Following the pre-maintenance performance testing, an access port was cored into the side of the caisson to facilitate movement of equipment and materials in and out of the caisson. District personnel removed the well pumps. Then the existing valves were removed by divers and blind flanges were placed over the lateral ports to allow sufficient room for the lateral projection equipment. Ranney then installed a temporary construction pump to dewater the caisson and remove materials during the lateral projection process. Once the well was dewatered, a temporary work platform was installed and preparations to start installation of new laterals were completed.

TASK 2 – PRE-MAINTENANCE PERFORMANCE TESTING

The pre-maintenance pumping test was conducted utilizing one of the existing well pumps. Because the discharged water was directed to the temporary percolation pond, the amount and duration of the pumping was limited by the capacity of the pond. Because of this, the pre-maintenance performance testing was limited to a multiple-rate step pumping test conducted with three steps with lengths of 1 hour, 1.5 hours and 1 hour, respectively. The average pumping rates for the steps were 3,000, 4,470, and 6,000 gpm. During the second step a diver entered the well to conduct lateral flow analyses and measure the water temperature from each of the existing laterals. The second step was extended to allow time for the lateral flow and temperature measurements. At the end of the third step the percolation pond was filled nearly to its maximum capacity and pumping was ended.

A hydrogeologist experienced in testing radial collector wells supervised the pre-maintenance and post-maintenance testing and collected water level and pumping rate data. During the testing, water levels were monitored in the collector well caisson, and in the adjacent observation wells MW-1, MW-2 and MW-7. MW-1 is located approximately 190 feet east of Ranney Collector No. 3 and is reportedly screened from 8 to 108 feet below ground surface. MW-7 is located approximately 220 feet west of Ranney Collector No. 3 and is reportedly screened from 55 to 75 feet below ground surface. MW-2 is located approximately 21 feet west of Ranney Collector Well No. 3 and is reportedly screened from 10 to 30 feet below ground surface. Water levels were monitored using pressure transducers equipped with digital data loggers. Also manual water level measurements were made to calibrate the transducers and confirm that they were functioning properly. All measurements of water level and drawdown were made within 0.01 foot. Pumping rates were measured using an in-line Water Specialties Model ML20-D digital flow meter manufactured by McCrometer, Inc. Mad River level data during the testing period were provided by the District from their telemetry system for their gage at the intake at the water treatment plant (Pumping Station 6).

TASK 3 – NEW LATERAL INSTALLATION

The procedures for the lateral installations were as follows:

Following set up, portal assemblies were installed in circular openings cut in the caisson wall at the selected locations and bonded to the caisson by grouting. Then projection equipment, pipe and tools were lowered into the well and set up. After installation of the portal assemblies, the laterals were constructed by initially projecting 16-inch diameter pipe to the desired length and sampling the aquifer materials as the pipe was projected. Prior to installation of the well screens, the vertical orientation of the projection pipe was determined. The vertical orientation of the projection pipe was determined using a Reflex EZ-DIP Electronic Inclinometer. In addition to the inclinometer measurements, a “Dutch level”, consisting of sufficient small diameter plastic pipe to reach the end of the projection pipe and a manometer tube, was utilized to determine if the far end of the projection pipe was above the centerline at the caisson end. Following selection of the screen slot size distribution based upon sampling, the 12-inch ID diameter stainless steel (type 304) screen assemblage was installed within the projection pipe and the 16-inch pipe hydraulically extracted from the aquifer, exposing the screened lateral to the aquifer. The screen slot sizes were varied depending on the coarseness of the material encountered, which was based upon the samples collected during the projection of the drive pipe. Sieve analyses of samples collected during the drive pipe projection are included in Appendix A. Lateral screen slot sizes were approved by the District prior to installation. The screens were installed using 10-foot long sections, with each section having 9.5 feet of its length screened. In addition to the screen, each lateral was installed with a 5-foot long section of blank pipe extending from the caisson wall. Each lateral is completed with a 12-inch gate valve in the caisson.

Following installation of all laterals, each lateral was fully developed using the BoreBlast II® system. This system provides a high energy pulse to screens and was selected to ensure that development energy penetrated the formation. The BoreBlast II® system uses pressure-pulse technology, delivered by gaseous nitrogen driven Air Impulse Generator (AIG), to agitate and break up bridging in order to develop coarse grained zones around the lateral screens. The high pressure AIG creates a high intensity pressure pulse and associated high frequency acoustic waves that break up and remove fines within the well screen. The system is piston-actuated and discharges automatically delivering pressure pulses of up to 450 psi. The ports on the AIG were angled at 90º to provide pulses to effectively surge out through the screen and allow for strong liquid return, pulling debris from the aquifer into the well.

The AIG was hydraulically advanced through each lateral at a controlled rate. The AIG with angled ports was attached to a “centralizing” sled fabricated to center the AIG in the lateral screen. The sled was advanced using the four-inch diameter sand line, which was also used to flush water and entrained sediments from the well screen. As the development proceeded, water samples were caught from the sand line and measured in an Imhoff Cone to evaluate the quantity of entrained sediment and sand. When no further improvement could be made, the tool was advanced. Sediment removed during the lateral installation and development process was conveyed to the percolation pond for disposal. To determine the adequacy of development, centrifugal sand-separating device manufactured by the Roscoe Moss Company was used to measure sand production. The standard for sand production from the completed collector was specified to be less than 2 parts per million (ppm). Sand content testing was conducted on flow from the individual laterals.

After the development of the new laterals was completed, all sediment remaining on the floor of the caisson was removed. Also, the valve actuator lines on the original laterals were cut off and removed from the caisson. The caisson walls were cleaned and washed with a chlorine solution. Once the walls were cleaned, the caisson was re-watered and additional calcium hypochlorite was added and the resulting chlorine solution was allowed to remain in the caisson.

Prior to the post maintenance performance testing, the temporary construction pump and discharge line in the caisson were removed. Divers entered the well to open the valves on the new laterals, remove the blind flanges and reinstall the valves on the old laterals. The District reinstalled its well pumps, and the discharge line from the well pumps was directed to the temporary percolation ponds.

TASK 4 – POST-MAINTENANCE PERFORMANCE TESTING

The post-maintenance performance testing consisted of a multiple-rate step test and a 24-hour pumping test. The testing procedures generally followed those utilized for the pre-maintenance testing. During post-maintenance testing, water levels were monitored in the collector well caisson, and in the adjacent observation wells MW-1, MW-2 and MW-7. Mad River level data during the testing period were provided by the District from their telemetry system for their gage at the intake at the water treatment plant (Pumping Station 6).

For the post-maintenance multiple-rate step test the discharge water was conveyed to the percolation ponds and the pumping rate was determined using an in-line flow meter on the temporary discharge line. The multiple-rate step pumping test was conducted with four steps with lengths of 1 hour each. The average pumping rates for the steps were 3,050, 4,650, 6,020 and 7,420 gpm.

For the 24-hour pumping test, the discharge was conveyed to the water system and the pumping rate was controlled by the pumps in operation and the system line pressures. Following the multiple-rate step test, the collector well was allowed to recover overnight. Prior to the start of the 24-hour pumping test, a diver entered the well to put screen baskets over the pump intakes. The 24-hour pumping test was started with an initial pumping rate of approximately 3,700 gpm. After the well had been pumping for approximately one hour, a diver entered the well to conduct lateral flow analyses and measure the water temperature from each of the laterals. The diver also obtained water samples from the laterals. The well pumps were off for approximately one half hour for the divers to remove the screen baskets from the pump intakes. For a period of about two and one half hours both well pumps were operated for a combined pumping rate of about 5,600 gpm. For the remainder of the pumping period, the well was pumped with one pump at a rate of about 3,500 gpm.

TASK 5 – SITE CLEAN UP AND DEMOBILIZATION

Following the completion of the lateral installation and maintenance activities, all equipment was removed from the well site and the site returned to original state.

TASK 6 – DOCUMENTATION REPORT

All data/information collected was evaluated, with the findings organized into this report. This report details the lateral installation and redevelopment procedures and results, with recommendation for the continued operation of the collector.

3.0 RESULTS

3.1 NEW LATERAL INSTALLATION

Plan and section views for the rehabilitated collector well are depicted in Figure 2, and construction details are summarized in Table 1. The initial plan called for the installation of four (4) new laterals each having 5-foot blanks and 160 feet of screen for a total of 660 feet of new lateral. Laterals 1 and 3 were planned to be installed 5.75 feet above the existing A-tier laterals (as a new C-tier) and Laterals 2 and 4 were planned to be installed 16.75 feet above the A-tier laterals (as a new D-tier). Laterals 1 and 3 were installed first. Lateral 1 was projected to refusal at 115 feet and Lateral 3 was projected to refusal at 75 feet from the inside caisson wall. Because neither lateral reached the target length, it was decided to install two additional C-tier laterals designated as Laterals 5 and 6. Both of these laterals were successfully projected to lengths of 155 feet. Once Laterals 5 and 6 were completed, the temporary work platform was raised to install the D-tier laterals. Lateral 2 was projected to a length of 105 feet, and Lateral 4 was projected to a length of 85 feet so that the total installed length of the new laterals would be 690 feet or 30 feet more than the original specification of 660 feet.

Information on the screen slot sizes used in the new laterals is presented in Table 2. As listed in the table, screen slot openings varied between 0.100 inches and 0.150 inches. The slot size openings were selected based upon sieve analyses (Appendix A) of samples collected during lateral projection. The total open area of the new screen installed in the collector well, adjusting for couplings and blank sections, is 1,063.9 square feet, which has a mechanical capacity of 7,960 gpm (11.5 MGD) at an entrance velocity of 1 foot per minute (ft/min) assuming no blockage of the screen slots. The original laterals have an open area of 18.6% (Ranney Method Western of California, 1962) so the total open area of the original laterals is approximately 250 square feet assuming no blockage of these laterals.

The specifications called for each new lateral to be installed horizontally in a straight line throughout its full length with the maximum allowable deviation from horizontal being two lateral projection pipe diameters over the entire projected length of the lateral. As the diameter of the projection pipe was 16 inches, the allowable deviation from horizontal is 32 inches. The vertical orientation of the new laterals was determined using a Reflex EZ-DIP Electronic

Inclinometer. The inclinometer measurements were conducted in the projection pipe prior to installation of the lateral screens. In addition to the inclinometer measurements, a “Dutch level” was utilized to determine if the far end of the projection pipe was above the centerline of the projection pipe at the caisson end. The inclinometer measurements indicated that all of the laterals were within the tolerance for vertical alignment except for Laterals 4 and 5. The inclinometer readings for Lateral 5 indicated that it deviated upward by 36.5 inches, 2.5 inches out of tolerance. The Dutch level measurements indicated an upward deviation in Lateral 5 of only 32 inches. In Lateral 4, the inclinometer measurements indicated an upward deviation of 46 inches, 14 inches out of tolerance. However, the Dutch level measurements in Lateral 4 indicated an upward deviation of only 16 inches, well within tolerance. On the other laterals the Dutch level and the inclinometer measurements agreed more closely. In Lateral 4, the superintendent was able to see the back of the digging head from the caisson and the sand line unscrewed from the head without difficulty. Both of these are indications that the projection pipe had not deflected significantly.

3.2 PRE-MAINTENANCE PERFORMANCE TESTING RESULTS

The pre-maintenance performance test was conducted on December 6, 2011. The pre-maintenance test consisted of a multiple-rate step pumping test conducted at rates of 3,000, 4,470, and 6,000 gpm. During the second step, a diver entered the well to measure lateral flow velocities and water temperatures. The pre-maintenance test had to be ended after the third step when the percolation pond reached its capacity.

Hydrographs for the pre-maintenance test depicting the water levels in Ranney Collector No. 3, adjacent monitoring wells and the Mad River area presented in Figure 3. Plots of the observed drawdown with respect to elapsed pumping time for the pre-maintenance test for the collector well and adjacent observation wells are depicted in Figure 4. Table 3 presents a summary of the pre-maintenance test water level changes, and Table 4 presents the results of the lateral flow and temperature measurements during the pre-maintenance test. The water level data collected by the data loggers and pumping rate data during the test are included in Appendix B.

After 1-hour of pumping at rates of 3,000, 4,470, and 6,000 gpm the observed drawdown in Ranney Collector No. 3 for each step in the pre-maintenance test was 10.7, 18.5 and 27.7 feet, respectively. This gives observed pre-maintenance specific capacity values of 280, 241 and 217 gallons per minute per foot of drawdown (gpm/ft). The observed drawdown at the end of step 3 in observation well MW-1 was 15.4 feet, and the observed drawdown in MW-7 was 11.4 feet. The drawdown differential values (i.e. the difference between the water elevation in adjacent observation wells and the water elevation in the collector divided by the pumping rate) at the end of step 3 were 2.1 feet per 1000 gallons per minute (ft/1000 gpm) for MW-1 and 2.7 ft/1000 gpm for MW-7. The Mad River level at PS6 was at an elevation of approximately 21.7 feet during the pre-maintenance testing period.

Lateral flow analyses were conducted on the five original laterals during step 2 of the pre-maintenance test. The flow velocity and water temperature at the caisson end of the laterals were measured by the diver using handheld meters, which were remotely read by the hydrogeologist. The individual flows from the original laterals varied from 11% to 33% of the total with the highest flow observed in Lateral A-2 and the lowest observed in Lateral B-2. The temperature of the water produced from the existing laterals during the flow analyses ranged from 55.5 °F in Lateral A-4 to 57.5 °F in Lateral B-2. The pre-maintenance test lateral flow distribution was similar to that observed during the 2006 inspection of Ranney Collector No. 3, i.e. with Lateral A-2 having the highest flow and Lateral B-2 having the lowest. However, during the 2006 inspection, the valve for Lateral A-3 was only partially opened (CWI, 2006).

3.3 POST-MAINTENANCE PERFORMANCE TESTING RESULTS

Ranney conducted post-maintenance testing to evaluate collector performance following the installation of the new lateral installations. The post-maintenance performance testing was conducted from May 3rd to May 5th, 2012. The post-maintenance multiple-rate step pumping test was conducted on May 3rd with four one hour steps with average pumping rates of 3,050, 4,650, 6,020 and 7,420 gpm. For the multiple-rate step test, the discharge was directed to the percolation ponds and the flow rate was monitored with the in-line flow meter installed on the temporary discharge line. A 24-hour pumping test was started on May 4th with the discharge directed to the water system and system flow rates were obtained from the District's telemetry system. Approximately one hour after the start of the 24-hour pumping test, a diver entered the well to measure lateral flow velocities and water temperatures.

Hydrographs for the post-maintenance multiple-rate step test depicting the water levels in Ranney Collector No. 3, adjacent monitoring wells and the Mad River area presented in Figure 5. Plots of the observed drawdown with respect to elapsed pumping time for the post-maintenance step test for the collector well and adjacent observation wells are depicted in Figure 6. Table 5 presents a summary of the post-maintenance multiple-rate step test water level changes. Hydrographs for the post-maintenance 24-hour pumping test are presented in Figure 7. Table 6 presents the results of the post-maintenance lateral flow and temperature measurements. The water level data collected by the data loggers and pumping rate data during the post-maintenance testing are included in Appendix C.

After the end of each 1-hour step at pumping at rates of 3,050, 4,650, 6,020 and 7,420 gpm the observed drawdown values in Ranney Collector No. 3 for the post-maintenance step test were 7.8, 12.9, 18.3 and 23.8 feet, respectively. This gives observed post-maintenance specific capacity values of 392, 362, 329 and 312 gpm/ft. These values are 40% to 50% greater than the specific capacity values observed during the pre-maintenance step test at similar pumping rates. The observed drawdown at the end of step 3 in observation well MW-1 was 12.9 feet, and the observed drawdown in MW-7 was 9.9 feet. The drawdown differential values at the end of step 3 were 1.0 ft/1000 gpm for MW-1 and 1.4 ft/1000 gpm for MW-7. These values represent decreases of about 50% from the pre-maintenance drawdown differential values at similar pumping rates. The Mad River level at PS6 was at an elevation of approximately 23.2 feet during the post-maintenance step test, which is approximately 1.6 feet higher than it was during the pre-maintenance step test.

At 9:49 AM on 5/4/12, the 24-hour pumping test was started with an initial pumping rate of approximately 3,700 gpm with pump number 3-2 in operation. After the well had been pumping for approximately one hour, a diver entered the well to conduct lateral flow analyses and measure the water temperature from each of the laterals. The diver also obtained water samples from the laterals. The diver had previously noted that the column pipe for pump 3-1 was very close to the Lateral 4 valve, and apparently the valve wheel on Lateral 4 had been broken during the reinstallation of pump 3-1. At about 12:50 PM, with the diver observing the pump 3-1 column, pump 3-2 was turned off and pump 3-1 was turned on briefly. This allowed the diver to observe that there was very little movement of the pump 3-1 column during start-up and operation so that it did not come into contact with the valve on Lateral 4. After the diver completed the necessary testing and observations, the pump 3-2 was turned off at 1:46 PM for the diver to remove the screen baskets from the pump intakes. At 2:16 PM pump 3-2 was turned back on. At 2:36 PM an attempt was made to run pump 3-1 in addition to pump 3-2, but a fault in the control system prevented both pumps from operating at the same time, and pump 3-2 turned off. At 3:04 PM pump 3-2 was turned on but this caused pump 3-1 to turn off. At 3:14 pump 3-1 was turned on and pump 3-2 remained in operation. For a period of about two and one half hours both well pumps were operated for a combined pumping rate of about 5,600 gpm. At 5:45 PM, pump 3-1 was turned off, and for the remainder of the pumping period, the well was pumped with only 3-2 in operation. The pumping period ended at 10:27 AM on 5/5/12 when pump 3-2 was turned off.

During the 24-hour pumping test, with pump 3-2 in operation, the pumping rate was about 3,500 gpm. However, the pumping rate from Ranney Collector No. 3 varied as the system line pressure changed when the other collector wells were turned on and off. Water levels in the Ranney Collector No. 3 were also affected by pumping interference with the other collector wells. The pumping rate changes in Ranney Collector No. 3 due to system line pressure changes tended to have more influence on the water levels in Ranney Collector No. 3 than did pumping interference from the other collector wells. Prior to the start of the 24-hour pumping test, Ranney Collector No. 2 was turned on at 7:18 AM on 5/4/12. Following this, the water level in Ranney Collector No. 3 decreased by about 0.1 to 0.2 foot, apparently due to drawdown from Ranney Collector No. 2. Ranney Collector No. 4 was turned on at 9:14 on 5/4/12, and following this, the water level in Ranney Collector No. 3 decreased by about 0.4 foot, apparently due to drawdown from Ranney Collector No. 4. During the 24-hour pumping test, Ranney Collector No. 1 was turned off at 9:56 PM on 5/4/12. After Ranney Collector No. 1 was turned off, the water level in Ranney Collector No. 3 decreased by about 0.7 foot, apparently due to an increase in the Ranney Collector No. 3 pumping rate due to a decrease in the system line pressure.

Similarly, when Ranney Collector No. 2 was turned off at 2:08 AM on 5/5/12, the water level in Ranney Collector No. 3 decreased by about 0.3 foot. When Ranney Collector No. 4 was turned on at 6:02 AM on 5/5/12, the water level in Ranney Collector Well No. 3 increased by about 0.7 foot. This was apparently due to a decrease in the Ranney Collector Well No. 3 pumping rate due to an increase in the system line pressure. Similarly, when Ranney Collector No. 2 was turned on at 9:30 AM on 5/5/12, the water level in Ranney Collector Well No. 3 again increased by about 0.7 foot. During the period from about 1:10 AM to 6:00 AM on 5/5/12, Ranney Collector No. 3 was the only collector well in operation. The average pumping rate during this period was approximately 3,490 gpm (5.02 MGD), and the pumping level in the Ranney Collector No. 3 was relatively stable at an elevation of about 17.0 feet, which is about 28 feet above the upper tier (D-tier) of the new laterals.

During the 24-hour pumping test, lateral flow analyses and water temperature measurements were conducted on the laterals. Because the pump 3-1 column is very close to the end of Lateral 4, the flow and temperature from this lateral could not be measured. For the lateral flow analysis, it was assumed that flow in Lateral 4 is proportional to the flow in Lateral 2 relative to the lengths of the two laterals. It was assumed that the flow in Lateral 4 would be similar to the flow in Lateral 2 because these are the two laterals installed on the upper tier (D-tier). With this assumption, the flow analysis indicated the flow from Lateral 2 was 9% of the total and the estimated flow from Lateral 4 is 7% of the total. The individual flows from all of the laterals varied from 2% to 24% of the total with the highest flow observed in the new Lateral 6 and the lowest observed in the original Lateral B-2. The new laterals account for 73% of the total flow. The distribution of the flow among the original laterals after the installation of the new laterals is similar to the pre-maintenance distribution with A-2 having the highest proportion and B-2 having the lowest proportion of the flow from the original laterals. However, Lateral A-5, which previously had the second highest proportion of the flow, had the second lowest proportion of the flow from the original laterals. Lateral A-5 is the western most of the original laterals and previously had less interference from the other laterals. With the installation of the new laterals, Lateral A-5 is between Laterals 1 and 3 and nearly parallel and below Lateral 2, and consequently has substantially more interference from the adjacent laterals. The temperature of the water produced from the laterals during the flow analyses varied from 48.6 °F in Lateral 6 to 50.4 °F in Lateral 2.

3.5 SAND CONTENT TESTING

Following development of the new laterals, sand content testing was conducted on the individual laterals while the caisson was dewatered. The sand production was measured using a centrifugal sand-separating device manufactured by the Roscoe Moss Company. For each test a reducer was attached to the valve on the lateral being tested, and an 8-inch diameter pipe with an in-line flow meter was attached to the reducer. The sand tester was attached to a port in the side of the 8-inch pipe. The lateral valve was opened and adjusted so that there was a discharge of 1,200 gpm from the lateral. The tests were conducted for durations of 15 to 25 minutes. The results of the sand testing are summarized in Table 7. None of the sand test results from the post-maintenance test exceeded 1.1 ppm, and consequently all were well within the sand specification of 2 ppm.

4.0 COLLECTOR WELL YIELD PROJECTIONS

As called for in the specifications for the installation of the new laterals, estimated yields for Ranney Collector No. 3 were calculated for both the conditions prior to the installation of the new laterals and following the installation of the new laterals. The long-term yield of a collector well is dependent upon length of pumping, efficiency, available drawdown and aquifer hydraulics. Aquifer hydraulics are related to saturated thickness, hydraulic conductivity and recharge. It is possible to project the yield of a collector well for varying aquifer water levels and water temperature using the following equation:

$$Q_2 = \frac{Q_1}{m_1} \frac{m_2}{s_1} \frac{s_2}{V_2} V_1$$

Where:

Q = Yield (gpm) of collector well under test (Q_1) and design (Q_2) conditions;
s = Drawdown (ft) in collector well under test (s_1) and design (s_2) conditions;
m = Aquifer thickness (ft) corrected for dewatering under test (m_1) and design (m_2) conditions; and
V = Viscosity coefficient under test (V_1) and design (V_2) temperature conditions.

Using the post-maintenance performance testing results (test conditions) and the above equation it is possible to estimate the maximum yield of the collector well under the test conditions. For the estimation, the following values were assumed:

Top of Aquifer Elevation	10.0 Feet msl
Base of Aquifer Elevation	-40.0 Feet msl
Static Water Level	
Pre Maintenance Performance Test	27.1 Feet msl
Post Maintenance Performance Test	28.1 Feet msl
Assumed High River Conditions	29.4 Feet msl
Assumed Low River Conditions	23.0 Feet msl
Pumping Levels	
Pre Maintenance Performance Test (Projected for 3,000 gpm)	12.0 Feet msl
Post Maintenance Performance Test (3,490 gpm)	17.0 Feet msl

Pre Maintenance	
Minimum Recommended Pumping Level (10 feet above B-tier lateral)	-16.9 Feet msl
Post Maintenance	
Minimum Recommended Pumping Level (10 feet above new D-tier laterals)	-1.0 Feet msl

Water Temperature / Viscosity Coefficient	
Pre Maintenance Performance Test	56 ^{o} F / 1.06
Post Maintenance Performance Test	49 ^{o} F / 1.18
Assumed High River Conditions	55 ^{o} F / 1.08
Assumed Low River Conditions	45 ^{o} F / 1.26

To estimate the minimum and maximum recharge conditions, the daily mean stream flow values were obtained for the USGS stream gage station number 11481000 for the period from September 1, 1990 through June 20, 2012 (USGS, 2012). For this record period the minimum flow that was recorded was 4.5 cubic feet per second (cfs). The minimum flow value on the current rating table is 6.8 cfs, and this is associated with a stage of 3.9 feet and an elevation of 16.7 feet. For the purposes of estimating collector well yield, an elevation of 16.0 feet at the stream gage is assumed for the low river condition. The flow for the record period that was exceeded for only 10% of the records was 3,660 cfs. Based on the current rating table and gage datum, this flow corresponds to a river elevation at the gage station of 22.4 feet. The data from the pre and post maintenance tests indicates that the static water level at Ranney Collector No. 3 is about 7 feet above the river elevation at the USGS gage. Based on these values, the static water level at Ranney Collector No. 3 under low river conditions is assumed to be at an elevation of 23.0 feet, and the static water level under high river conditions is assumed to be at an elevation of 29.4 feet.

During the post-maintenance 24-hour pumping test, the water level in Ranney Collector No. 3 was relatively stable at an elevation of 17.0 feet when the pumping rate was 3,490 gpm for several hours. Because of the short duration of the pre-maintenance pumping test, stabilized pumping levels were not observed. Based on the results of the post-maintenance testing, it appears that pumping levels stabilize within 24 hours. Projecting the trend of the observed drawdown from the first step of the pre-maintenance test to 24 hours gives an estimate of 12 feet of drawdown for a stabilized pumping level at an elevation of 13.9 feet for the pumping rate of 3000 gpm.

Based upon the available data, the discharge temperature for the collector well is likely to range from about 45^o to 65^o F. For the low river conditions it was assumed that the water temperature would be 45^o as this would give the least favorable recharge conditions. For the high river conditions the water temperature was assumed to be 55^o to simulate high river conditions during late spring, which would probably represent the most favorable recharge conditions.

Prior to installation of the new laterals, the centerline elevation of the highest tier of laterals was -26.9 feet. To maintain ten (10) feet of water over the top of the upper tier of laterals the minimum recommended pumping level prior to installation of the new laterals would have been at an elevation of -16.9 feet. Given that the centerline of the upper tier of the new laterals is at an elevation of -11.2 feet, the minimum pumping level should be an elevation of -1.0 feet, to maintain a minimum of ten feet of water over the top of the new upper tier laterals.

Using the above equation and assumptions, the estimated yields for Ranney Collector No. 3 were calculated for the pre-maintenance and post-maintenance conditions. The results of the pre-maintenance estimates are presented in Figure 8, and the results of the post-maintenance estimates are presented in Figure 9. The maximum yields under the assumed conditions are as follows:

Conditions for Yield Estimates	Pre-Maintenance Minimum Pumping Level at -16.9 feet	Pre-Maintenance Minimum Pumping Level at -1.0 feet	Post-Maintenance Minimum Pumping Level at -1.0 feet
Test	10.8 (MGD)	8.3 (MGD)	11.0 (MGD)
Low River	8.5 (MGD)	6.2 (MGD)	8.5 (MGD)
High River	11.5 (MGD)	9.2 (MGD)	12.5 (MGD)

For comparability, the maximum pre-maintenance yields were calculated with minimum pumping levels at both -16.9 feet and -1.0 feet. As indicated, the maximum yields after the installation of the new laterals are the same for the low river conditions and 1.0 MGD higher for the high river conditions than the pre-maintenance estimates with the pumping level at -16.9 feet. The maximum yields after the installation of the new laterals are 2.3 MGD and 3.3 MGD higher, for the low river conditions and high river conditions, respectively than the pre-maintenance estimates with the pumping level at -1.0 feet. Although there has been a decrease in the available drawdown, the improvement in the specific capacity since the installation of the new laterals gives Ranney Collector No. 3 additional capacity under most conditions.

The estimated yields for Ranney Collector No. 3 are dependent on how well the assumed conditions match the actual conditions. The actual day to day yield of this well will vary under differing conditions and pumping durations. The yield estimates assume that there is sufficient flow in the river to provide sufficient recharge to the collector wells and also do not consider pumping interference from the other collector wells.

5.0 SUMMARY AND RECOMMENDATIONS

Ranney Collector Wells recently completed the rehabilitation of the Humboldt Bay Municipal Water District Ranney Collector No. 3. The work included the installation of six (6) new 12-inch diameter laterals. The new laterals were installed in two tiers with centerline elevations of -22.2 feet and -11.2 feet. The lengths of the new laterals vary from 75 feet to 155 feet, and the total length of the newly installed laterals is 690 feet. Each lateral is constructed from stainless steel, wire-wrapped well screen with 5 feet of blank pipe at the caisson end. The total open area of the new lateral well screens is 1063.9 square feet. Assuming a maximum entrance velocity of 1 ft/min and no blockage of the screen slots, the mechanical capacity of the new laterals is 7,960 gpm (11.5 MGD). This is in addition to the capacity of the originally installed laterals.

The pre-maintenance multiple-rate step test indicated that the collector well had observed specific capacity values of 280, 241 and 217 gpm/ft when pumped at rates of 3,000, 4,470, and 6,000 gpm, respectively. The post-maintenance multiple-rate step test indicated that the collector well had observed specific capacity values of 392, 362, 329 and 312 gpm/ft when pumped at rates of 3,050, 4,650, 6,020 and 7,420 gpm, respectively. The observed post-maintenance specific capacity values are approximately 50% higher than those observed during the pre-maintenance test at similar pumping rates. The pre-maintenance lateral flow analysis indicated that Lateral A-2 had the highest flow rate and Lateral B-2 had the lowest flow rate. The post maintenance lateral flow analysis indicated that Lateral 6 had the highest flow rate and Lateral B-2 had the lowest. The new laterals were producing 73% of the total flow. Analysis of the testing results indicates that the new laterals are efficiently providing the water that is available.

Calculated yield estimates indicate that Ranney Collector No. 3 should be capable of producing up to 8.5 MGD under the assumed low river conditions and up to 12.5 MGD under the assumed high river conditions. The actual yields from the collector well will depend on how well the actual conditions match the assumed conditions and will vary with changes in river level and water temperatures.

It is recommended that the City's monitoring program include such essential data as: (1) Pumping Rates, (2) Pumping levels in the collector and observation wells, (3) Static water levels in the collector and observation wells, (4) Water temperature of the pumped water and Mad River, and (5) Mad River level. Initially this information should be collected at least monthly and reviewed on a 6-month basis by a person experienced in the analysis and evaluation of this type of operational data. This program will provide current and accurate determination of the operating trend of the collector enabling the tracking of the efficiency and yield potential of the well under varying recharge conditions. The operation trends will be tracked primarily on the specific capacity and drawdown differential values of the collector well under operating conditions. This will allow future maintenance requirements to be easily assessed and scheduled at opportune times.

6.0 REFERENCES

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Ranney Method Western of California, Inc., May 31, 1962. Report on Performance Tests – Ranney Collector System, Prepared for Bechtel Corporation Consulting Engineers and Humboldt Bay Municipal Water District, Eureka, California, Prepared by Ranney Method Western of California, Inc., Sacramento, California.

US Geological Survey (USGS), 2012. Internet Web Site: USGS 11481000 MAD R NR ARCATA CA, http://waterdata.usgs.gov/ca/nwis/nwisman/?site_no=11481000&agency_cd=USGS , accessed 6/20/2012.

FIGURES

Layne
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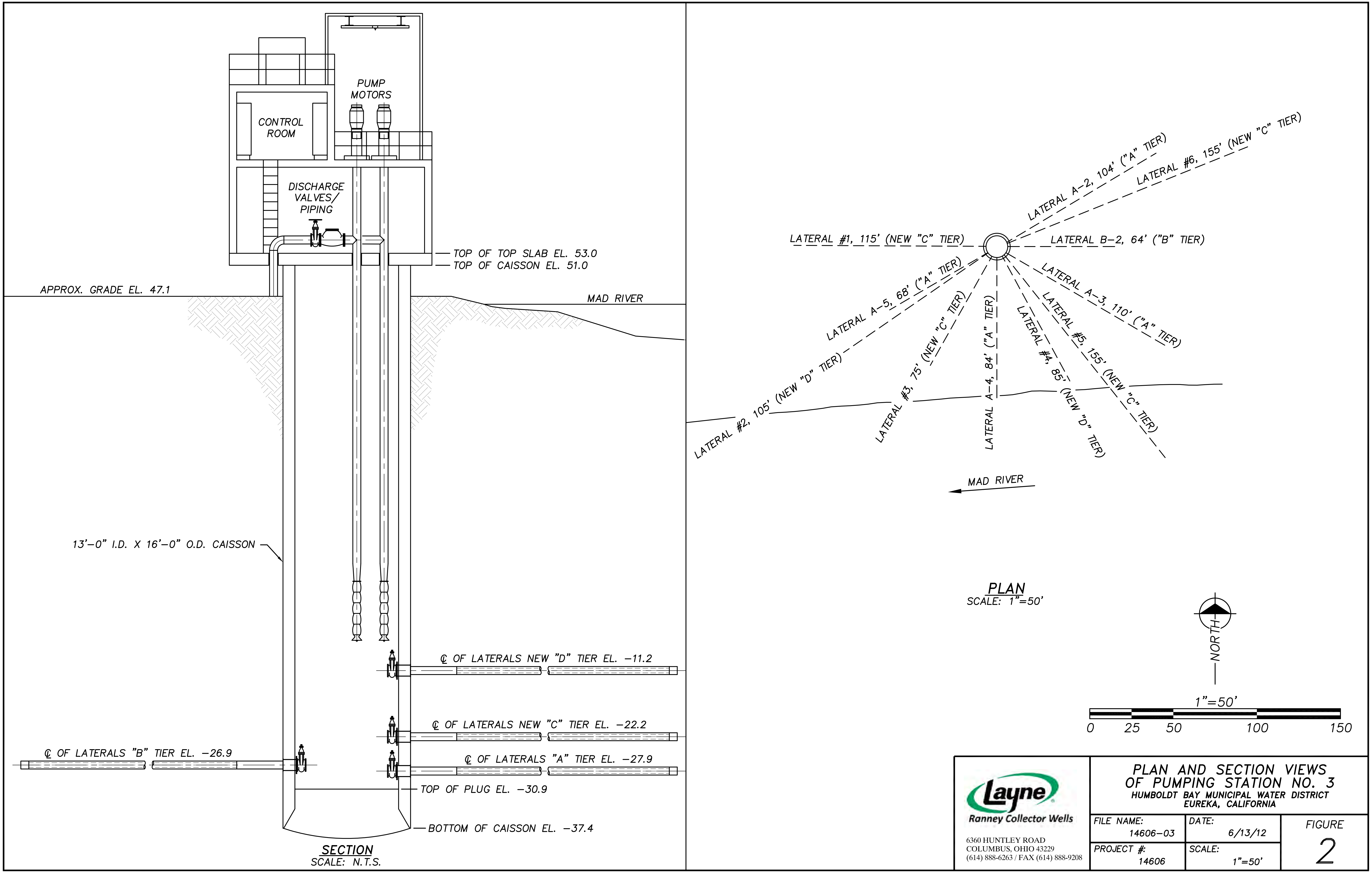
PROJECT LOCATION MAP
HUMBOLDT BAY MUNICIPAL WATER DISTRICT
ARCATA, CALIFORNIA

FIGURE 1

PROJECT NUMBER	DATE	FILE NAME	SCALE
14606	06/08/2012	7303-01	1" = 2500'



Layne Ranney Collector Wells

6360 HUNTLEY ROAD
COLUMBUS, OHIO 43229
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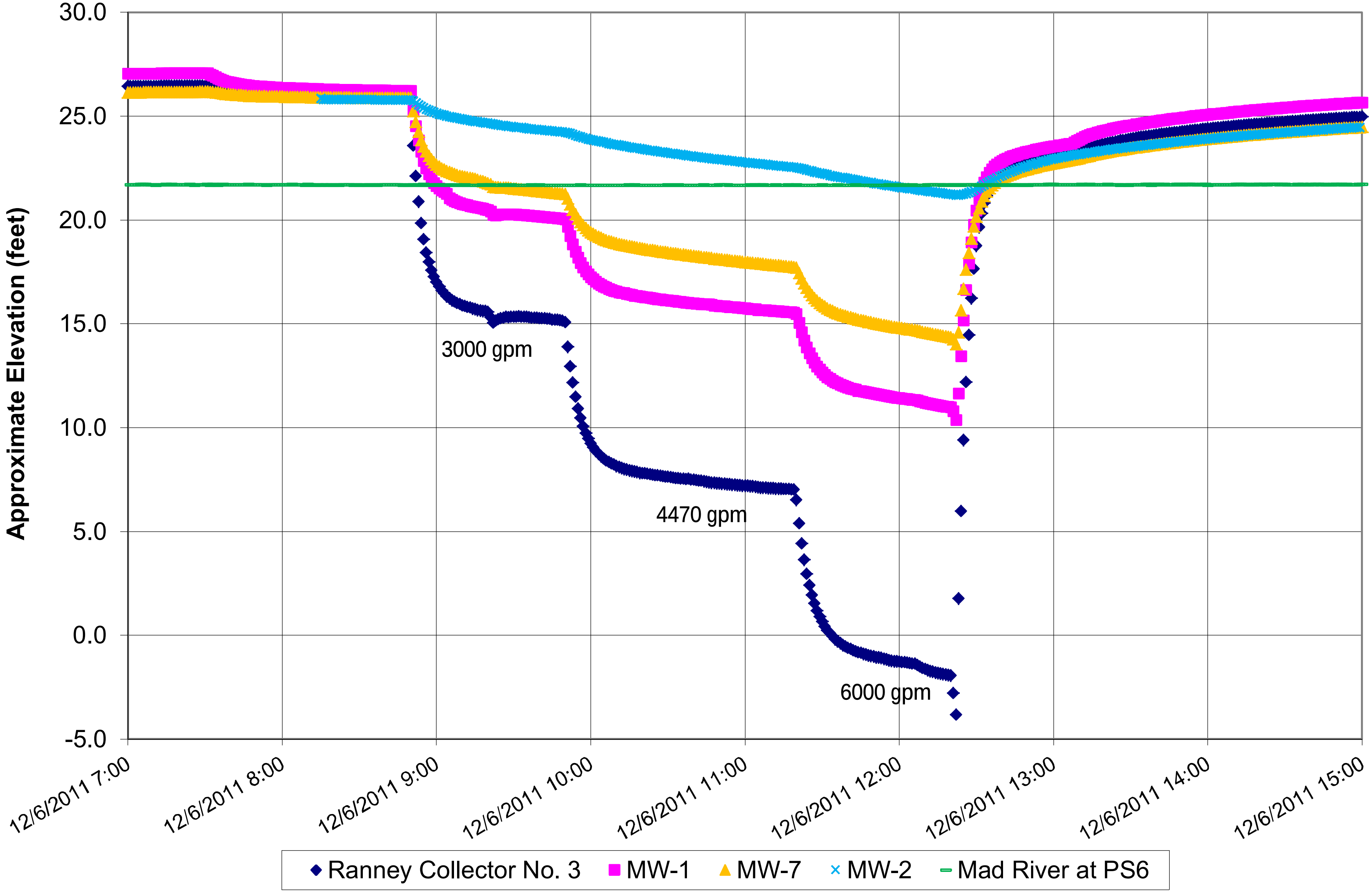
PLAN AND SECTION VIEWS OF PUMPING STATION NO. 3
HUMBOLDT BAY MUNICIPAL WATER DISTRICT
EUREKA, CALIFORNIA

FILE NAME: 14606-03	DATE: 6/13/12	FIGURE 2
PROJECT #: 14606	SCALE: 1"=50'	

FIGURE 3
Pre-Maintenance Multiple-Rate Step Test Hydrographs
HBMWD Ranney Collector No. 3

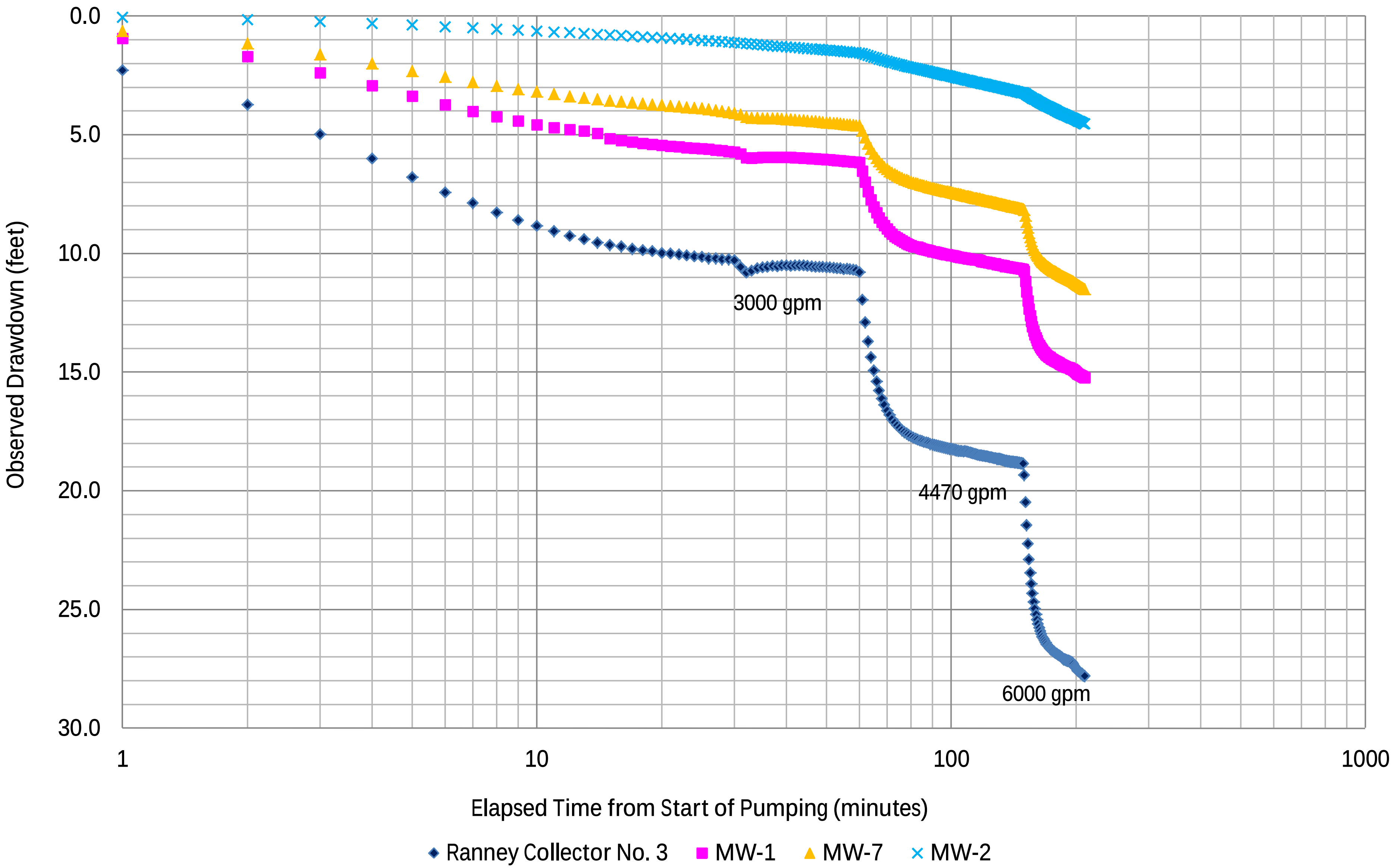


File: HBMWD CW3 Pre-Maintenance Test All Data.xlsx Print Date: 7/2/2012

FIGURE 4

Pre-Maintenance Step Test Observed Drawdown with Respect to Elapsed Pumping Time

HBMWD Ranney Collector No. 3

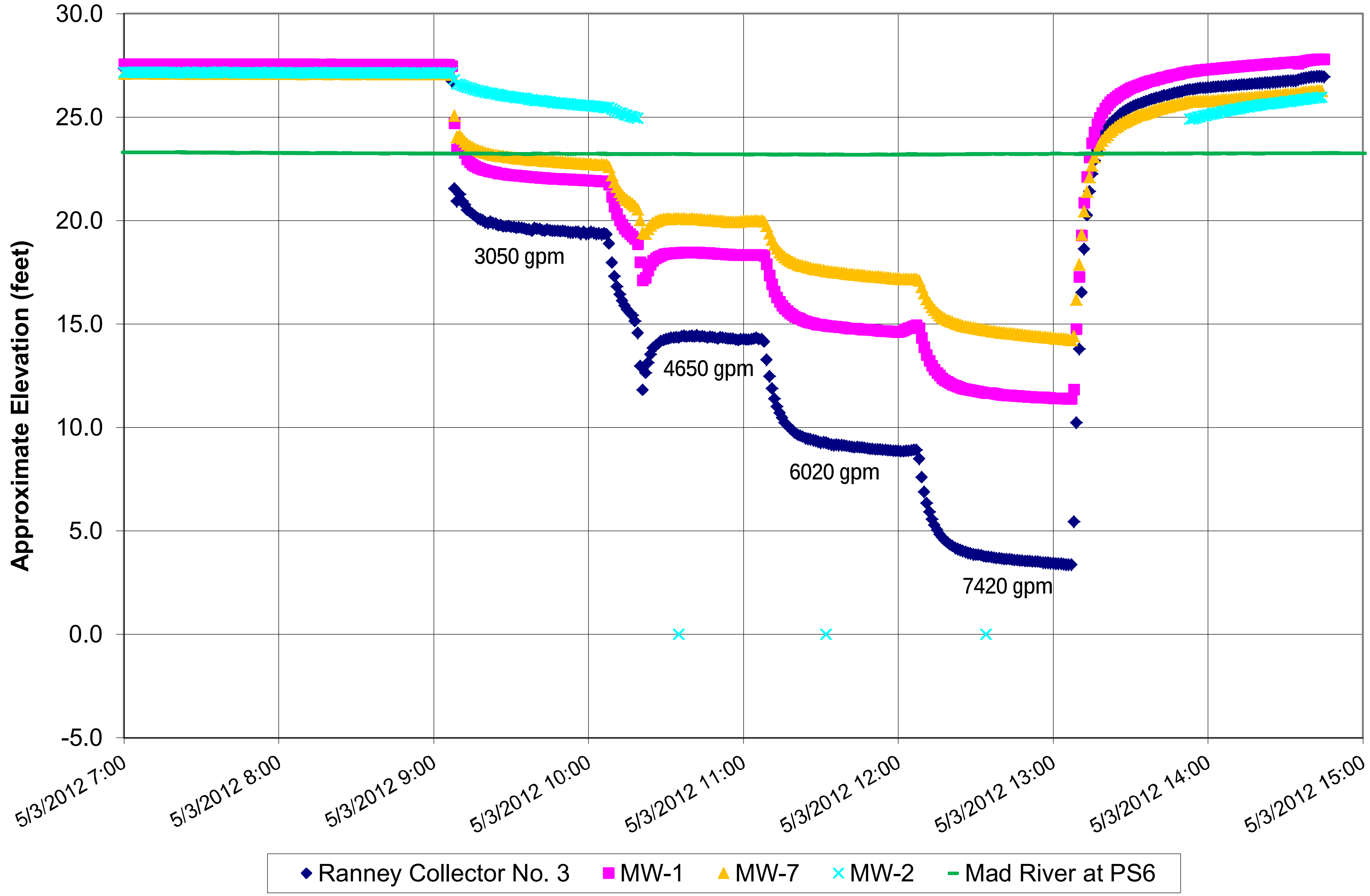


File: HBMWD CW3 Pre-Maintenance Test All Data.xlsx Print Date: 7/2/2012

FIGURE 5

Post-Maintenance Multiple-Rate Step Test Hydrographs

HBMWD Ranney Collector No. 3

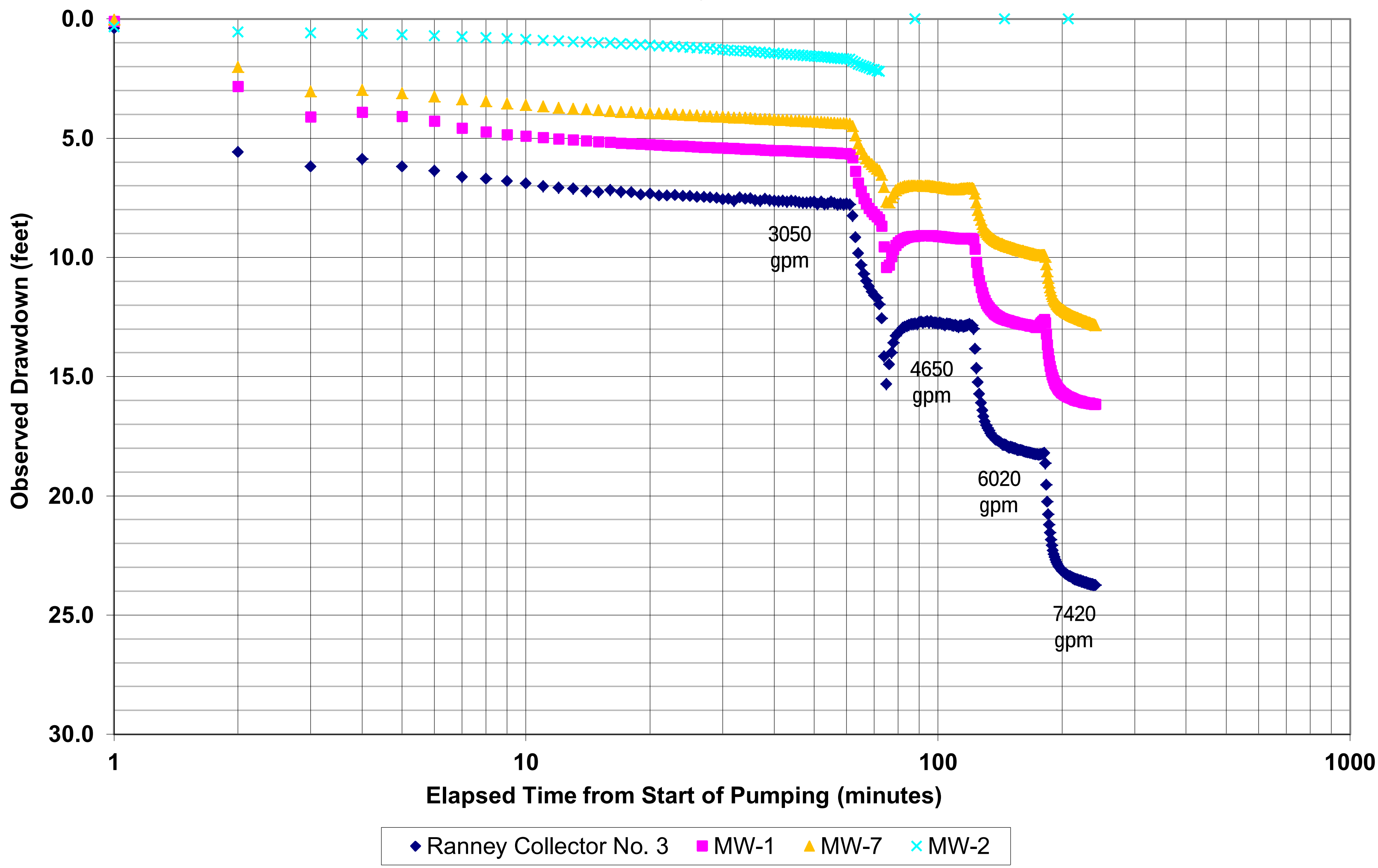


File: HBWD CW3 Post Maintenance Test All Data.xlsx Print Date: 7/2/2012

FIGURE 6

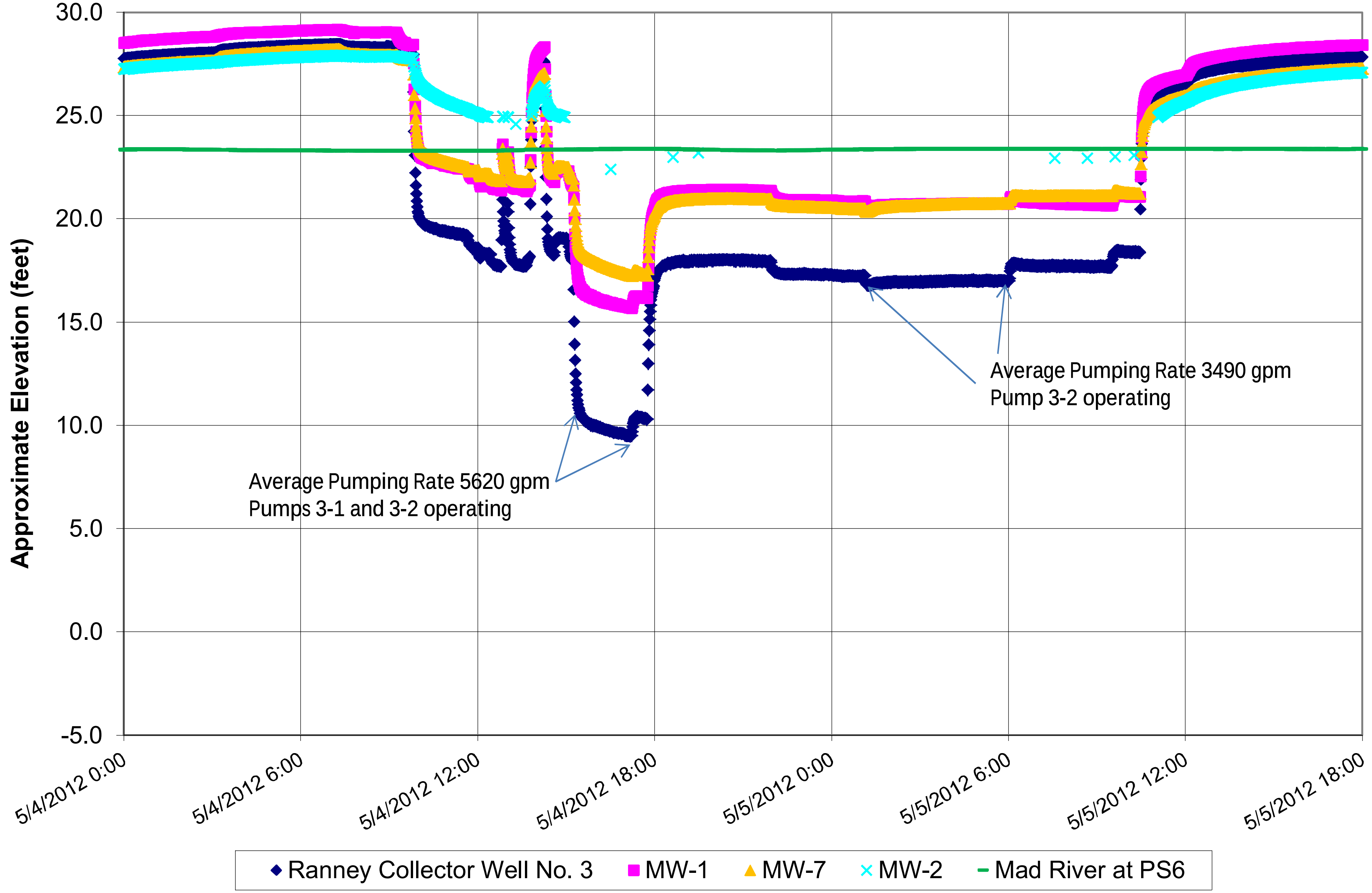
Post-Maintenance Step Test Observed Drawdown with Respect to Elapsed Pumping Time

HBMWD Ranney Collector No. 3



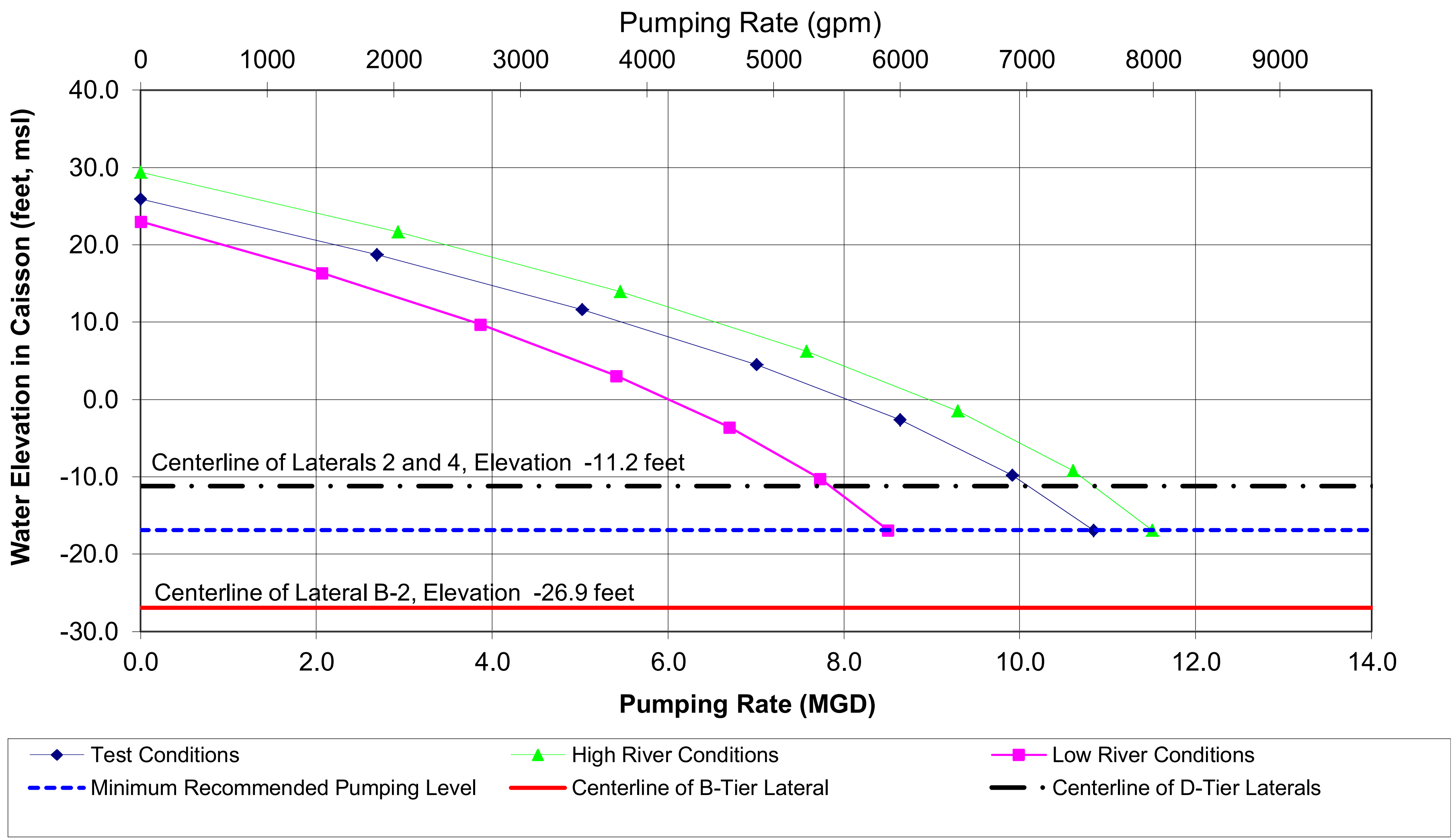
File: HBWD CW3 Post Maintenance Test All Data.xlsx Print Date: 7/2/2012

FIGURE 7
Post-Maintenance 24-Hour Pumping Test Hydrographs
HBMWD Ranney Collector Well No. 3



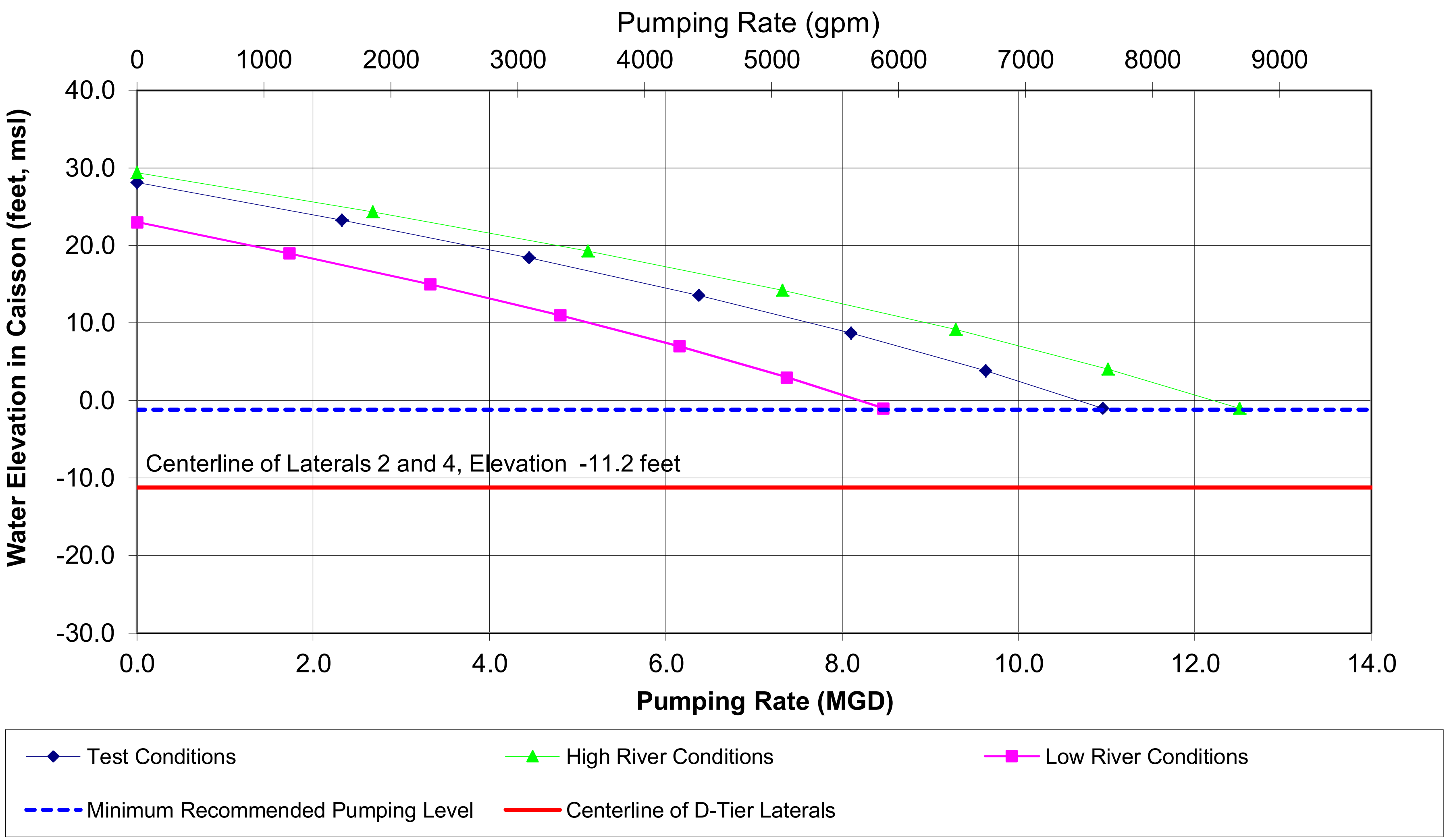
File: HBWD CW3 Post Maintenance Test All Data.xlsx Print Date: 7/2/2012

Figure 8
Ranney Collector No. 3 Yield Projections Pre-Maintenance Conditions
Humboldt Bay Municipay Water District



File: Pre-maintenance HBMWD RC3 Collector Well Yield Adjustments.xlsx Print Date: 7/2/2012

Figure 9
Ranney Collector No. 3 Yield Projections Post-Maintenance Conditions
Humboldt Bay Municipay Water District



File: Post-maintenance HBMWD RC3 Collector Well Yield Adjustments.xlsx   Print Date: 7/2/2012

TABLES

TABLE 1

Ranney Collector No. 3 As-Built Design Summary
Humboldt Bay Municipal Water Authority - Arcata, California

CAISSON AND LATERAL DESIGN

CAISSON INSIDE DIAMETER	13	feet
CAISSON OUTSIDE DIAMETER	16	feet
TOP OF TOP SLAB ELEVATION	53.0	feet, msl.
TOP OF CAISSON ELEVATION	51.0	feet, msl.
GRADE ELEVATION	47.1	feet, msl.
TOP OF PLUG (caisson floor) ELEVATION	-30.9	feet, msl.
CAISSON DEPTH (top of caisson to top of plug)	81.9	feet
CENTER LINE OF LATERAL ELEVATION A-tier (original installation))	-27.9	feet, msl.
CENTER LINE OF LATERAL ELEVATION B-tier (original installation)	-26.9	feet, msl.
CENTER LINE OF LATERAL ELEVATION C-tier (Installed 2012)	-22.2	feet, msl.
CENTER LINE OF LATERAL ELEVATION D-tier (Installed 2012)	-11.2	feet, msl.
MINIMUM RECOMMENDED PUMPING ELEVATION	-1.0	feet, msl.
LATERAL DIAMETER	12.0	inches

LATERAL LENGTH AND OPEN AREA

LATERAL NUMBER	TIER		BLANK LENGTH (feet)	LATERAL SCREEN LENGTH (feet)	TOTAL LATERAL LENGTH (feet)	Screen Slot Open Area (square feet)
A-2	A	Original	0	104	104	57.7
A-3	A	Original	0	110	110	61.1
A-4	A	Original	0	84	84	46.6
A-5	A	Original	0	68	68	37.7
B-2	B	Original	0	64	64	35.5
1	C	Installed 2012	5	110	115	179.5
2	D	Installed 2012	5	100	105	164.0
3	C	Installed 2012	5	70	75	112.0
4	D	Installed 2012	5	80	85	125.7
5	C	Installed 2012	5	150	155	240.5
6	C	Installed 2012	5	150	155	242.3
TOTAL ORIGINAL LATERALS			0	430	430	238.7
TOTAL NEW LATERALS			30	660	690	1063.9
TOTAL ALL LATERALS			30	1,090	1,120	1,302.6

TABLE 2

Ranney Collector No. 3 New Lateral Well Screen Slot Size and Placement
Humboldt Bay Municipal Water District - Arcata, California

Lateral	Distance (1)	0 - 5	5 - 15	15 - 25	25 - 35	35 - 45	45 - 55	55 - 65	65 - 75	75 - 85	85 - 95	95 - 105	105 - 115
1	Slot Size (2)	Blank	100	125	125	150	150	150	150	150	150	150	150

Lateral	Distance (1)	0 - 5	5 - 15	15 - 25	25 - 35	35 - 45	45 - 55	55 - 65	65 - 75	75 - 85	85 - 95	95 - 105
2	Slot Size (2)	Blank	100	125	150	150	150	150	150	150	150	150

Lateral	Distance (1)	0 - 5	5 - 15	15 - 25	25 - 35	35 - 45	45 - 55	55 - 65	65 - 75
3	Slot Size (2)	Blank	100	125	125	150	150	150	150

Lateral	Distance (1)	0 - 5	5 - 15	15 - 25	25 - 35	35 - 45	45 - 55	55 - 65	65 - 75	75 - 85
4	Slot Size (2)	Blank	100	100	125	150	150	150	150	125

Lateral	Distance (1)	0 - 5	5 - 15	15 - 25	25 - 35	35 - 45	45 - 55	55 - 65	65 - 75	75 - 85	85 - 95	95 - 105	105 - 115	115 - 125	125 - 135	135 - 145	145 - 155
5	Slot Size (2)	Blank	100	100	125	100	125	150	150	150	150	150	150	150	150	150	150

Lateral	Distance (1)	0 - 5	5 - 15	15 - 25	25 - 35	35 - 45	45 - 55	55 - 65	65 - 75	75 - 85	85 - 95	95 - 105	105 - 115	115 - 125	125 - 135	135 - 145	145 - 155
6	Slot Size (2)	Blank	100	100	125	125	125	150	150	150	150	150	150	150	150	150	150

1) Distance in feet from inside wall of caisson

2) Well screen slot opening size in thousandths of an inch

TABLE 3

Ranney Collector No. 3 Pre-Maintenance Multiple-Rate Step Pumping Test Summary
Humboldt Bay Municipal Water District - Arcata, California

Pre-Maintenance Test Conducted - December 6, 2011

		Observed Static Water Level		Observed Step 1 Pumping Water Levels		Observed Step 1 Well Performance			
Well	Measuring Point Elevation (feet msl.)	Depth to Water (feet)	Approximate Water Elevation (feet)	Depth to Water (feet)	Approximate Water Elevation (feet)	Pumping Rate (gpm)	Observed Drawdown (feet)	Differential (feet/1000 gpm)	Observed Specific Capacity (gal/min/ft)
Ranney Collector No. 3	53.50 (1)	27.64	25.86	38.35	15.15	3,000	10.71		280.1
MW-1	49.25 (2)	23.03	26.22	29.20	20.05		6.17	1.63	
MW-7	48.85 (2)	22.99	25.86	27.59	21.26		4.60	2.0	
Mad River at PS6	(3)		21.69		21.66				

		Observed Static Water Level		Observed Step 2 Pumping Water Levels		Observed Step 2 Well Performance			
Well	Measuring Point Elevation (feet msl.)	Depth to Water (feet)	Approximate Water Elevation (feet)	Depth to Water (feet)	Approximate Water Elevation (feet)	Pumping Rate (gpm)	Observed Drawdown (feet)	Differential (feet/1000 gpm)	Observed Specific Capacity (gal/min/ft)
Ranney Collector No. 3	53.50 (1)	27.64	25.86	46.16	7.34	4,470	18.52		241.4
MW-1	49.25 (2)	23.03	26.22	33.38	15.87		10.35	1.9	
MW-7	48.85 (2)	22.98	25.87	30.74	18.11		7.76	2.4	
Mad River at PS6	(3)		21.69		21.68				

		Observed Static Water Level		Observed Step 3 Pumping Water Levels		Observed Step 3 Well Performance			
Well	Measuring Point Elevation (feet msl.)	Depth to Water (feet)	Approximate Water Elevation (feet)	Depth to Water (feet)	Approximate Water Elevation (feet)	Pumping Rate (gpm)	Observed Drawdown (feet)	Differential (feet/1000 gpm)	Observed Specific Capacity (gal/min/ft)
Ranney Collector No. 3	53.50 (1)	27.64	25.86	55.31	-1.81	6,000	27.67		216.8
MW-1	49.25 (2)	23.03	26.22	38.17	11.08		15.14	2.1	
MW-7	48.85 (2)	22.98	25.87	34.39	14.46		11.41	2.7	
Mad River at PS6	(3)		21.69		21.70				

Notes:
1) Caisson water levels measured from the top of access hatch, 0.5 feet above top slab.
2) Observation well water levels measured from the top of the protective steel casing in MW-1 and the top of the steel casing in MW-7.
MW-1 approx. ground elev. 45.1' + 4.15' pro casing stickup = 49.25'; MW-7 approx. ground elev. 46.6' + 2.25' casing stickup = 48.85'
3) Mad River Elevations at PS6 provided by HBMWD.

TABLE 4
Ranney Collector No. 3 Pre-Maintenance Lateral Flow Analysis
Humboldt Bay Municipal Water District - Arcata, California

Lateral No.	Tier	Orientation East of North (degrees)	Total Lateral Length from inside wall (feet)	Total Lateral Screen Length (feet)	Relative Water Velocity at End of Lateral [1] (kilometers/hour)	Water Temperature [1] ($^\circ$ F)	Percent of Total Flow (percent)	Approximate Flow Per Lateral (gpm)	Approximate Flow Per Foot of Screen (gpm/ft)
A-2	A	59	104	104	4.50	55.7	32.7%	1,453	14.0
A-3	A	120	110	110	2.50	55.7	18.2%	807	7.3
A-4	A	180	84	84	2.40	55.5	17.5%	775	9.2
A-5	A	240	68	68	2.80	56.3	20.4%	904	13.3
B-2	B	90	64	64	1.55	57.5	11.3%	501	7.8
TOTAL			430	430			100.0%	4,440	
AVERAGE			86	86		56.0 [2]			10.3

Pumping Rate During Flow Measurements = 4,440 gpm

Notes:
1) Lateral velocity and water temperature are the average of two readings.
2) Average temperature weighted for lateral flow

Lateral Tier A Elevation = -27.9 feet
Lateral Tier B Elevation = -26.9 feet

TABLE 5

Ranney Collector No. 3 Post-Maintenance Multiple-Rate Step Pumping Test Summary
Humboldt Bay Municipal Water District - Arcata, California

Post-Maintenance Test Conducted - May 3, 2012

		Observed Static Water Level		Observed Step 1 Pumping Water Levels		Observed Step 1 Well Performance			
Well	Measuring Point Elevation (feet msl.)	Depth to Water (feet)	Approximate Water Elevation (feet)	Depth to Water (feet)	Approximate Water Elevation (feet)	Pumping Rate (gpm)	Observed Drawdown (feet)	Differential (feet/1000 gpm)	Observed Specific Capacity (gal/min/ft)
Ranney Collector No. 3	53.50 [1]	26.37	27.13	34.16	19.34	3,050	7.79		391.5
MW-1	49.25 [2]	21.70	27.55	27.35	21.90		5.65	0.84	
MW-7	48.85 [2]	21.77	27.08	26.17	22.68		4.40	1.1	
Mad River at PS6	[3]		23.24		23.23				

		Observed Static Water Level		Observed Step 2 Pumping Water Levels		Observed Step 2 Well Performance			
Well	Measuring Point Elevation (feet msl.)	Depth to Water (feet)	Approximate Water Elevation (feet)	Depth to Water (feet)	Approximate Water Elevation (feet)	Pumping Rate (gpm)	Observed Drawdown (feet)	Differential (feet/1000 gpm)	Observed Specific Capacity (gal/min/ft)
Ranney Collector No. 3	53.50 [1]	26.37	27.13	39.23	14.27	4,650	12.86		361.6
MW-1	49.25 [2]	21.70	27.55	30.90	18.35		9.20	0.9	
MW-7	48.85 [2]	21.77	27.08	28.88	19.97		7.11	1.2	
Mad River at PS6	[3]		23.24		23.21				

		Observed Static Water Level		Observed Step 3 Pumping Water Levels		Observed Step 3 Well Performance			
Well	Measuring Point Elevation (feet msl.)	Depth to Water (feet)	Approximate Water Elevation (feet)	Depth to Water (feet)	Approximate Water Elevation (feet)	Pumping Rate (gpm)	Observed Drawdown (feet)	Differential (feet/1000 gpm)	Observed Specific Capacity (gal/min/ft)
Ranney Collector No. 3	53.50 [1]	26.37	27.13	44.65	8.85	6,020	18.28		329.3
MW-1	49.25 [2]	21.70	27.55	34.60	14.65		12.90	1.0	
MW-7	48.85 [2]	21.77	27.08	31.68	17.17		9.91	1.4	
Mad River at PS6	[3]		23.24		23.20				

		Observed Static Water Level		Observed Step 4 Pumping Water Levels		Observed Step 4 Well Performance			
Well	Measuring Point Elevation (feet msl.)	Depth to Water (feet)	Approximate Water Elevation (feet)	Depth to Water (feet)	Approximate Water Elevation (feet)	Pumping Rate (gpm)	Observed Drawdown (feet)	Differential (feet/1000 gpm)	Observed Specific Capacity (gal/min/ft)
Ranney Collector No. 3	53.50 [1]	26.37	27.13	50.12	3.38	7,420	23.75		312.4
MW-1	49.25 [2]	21.70	27.55	37.86	11.39		16.16	1.1	
MW-7	48.85 [2]	21.77	27.08	34.61	14.24		12.84	1.5	
Mad River at PS6	[3]		23.24		23.24				

Notes:

1) Caisson water levels measured from the top of access hatch, 0.5 feet above top slab.
2) Observation well water levels measured from the top of the protective steel casing in MW-1 and the top of the steel casing in MW-7.
   MW-1 approx. ground elev. 45.1' + 4.15' pro casing stickup = 49.25'; MW-7 approx. ground elev. 46.6' + 2.25' casing stickup = 48.85'
3) Mad River Elevations at PS6 provided by HBMWD.

TABLE 6

Ranney Collector No. 3 Post-Maintenance Lateral Flow Analysis
Humboldt Bay Municipal Water District - Arcata, California

Lateral No.	Tier	Orientation East of North (degrees)	Total Lateral Length from inside wall (feet)	Total Lateral Screen Length (feet)	Relative Water Velocity at End of Lateral (1) (kilometers/hour)	Water Temperature (1) (^{o} F)	Percent of Total Flow (percent)	Approximate Flow Per Lateral (gpm)	Approximate Flow Per Foot of Screen (gpm/ft)
A-2	A	59	104	104	1.00	49.0	11.9%	436	4.2
A-3	A	120	110	110	0.55	48.7	6.5%	240	2.2
A-4	A	180	84	84	0.30	50.2	3.6%	131	1.6
A-5	A	240	68	68	0.25	49.3	3.0%	109	1.6
B-2	B	90	64	64	0.15	48.8	1.8%	65	1.0
1	C	270	115	110	1.40	49.5	16.7%	610	5.5
2	D	235	105	100	0.75	50.4	8.9%	327	3.3
3	C	209	75	70	0.20	49.6	2.4%	87	1.2
4	D	152	85	80	n/a (3)	n/a (3)	7.2% (3)	261	3.3
5	C	142	155	150	1.20	49.4	14.3%	523	3.5
6	C	68	155	150	2.00	48.6	23.8%	871	5.8
TOTAL			1,120	1,090			100.0%	3,660	
AVERAGE			102	99		49.2 (2)			3.0

Pumping Rate During Flow Measurements = 3,660 gpm

<u>Notes:</u>
1) Lateral velocity and water temperature are the average of two readings.
2) Average temperature weighted for lateral flow
3) Velocity and water temperature in Lateral 4 could not be measured because the pump column obstructs the end of the lateral. Percentage of flow in Lateral 4 was assumed based on flow from Lateral 2 adjusted for lateral lengths.

Lateral Tier A Elevation = -27.9 feet

Lateral Tier B Elevation = -26.9 feet

Lateral Tier C Elevation = -22.2 feet

Lateral Tier D Elevation = -11.2 feet

TABLE 7

Sand Content Testing Results - New Laterals

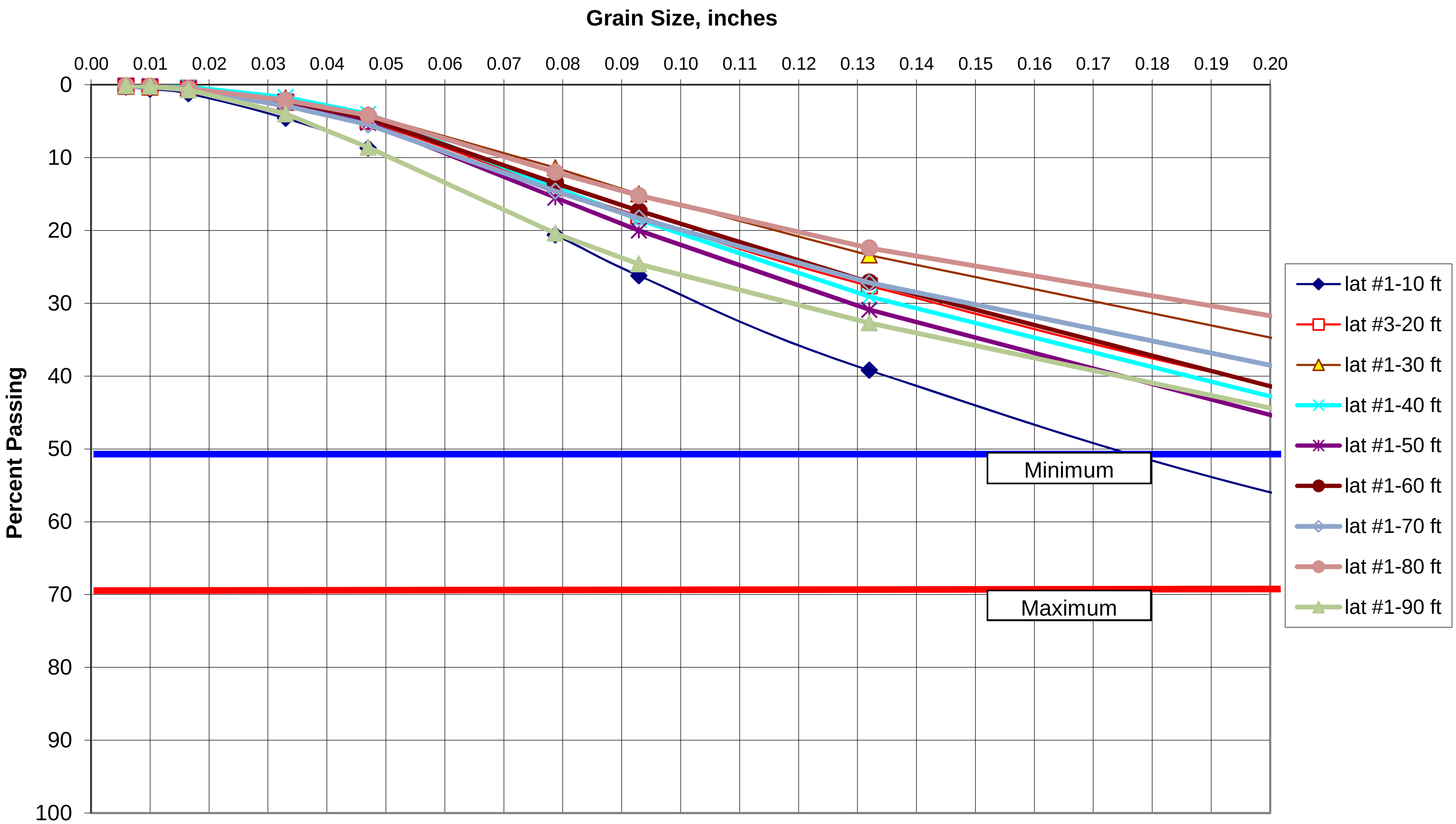
Humboldt Bay Municipal Water District - Arcata, California

Lateral	Date	Discharge Rate (gpm)	Start Time of Sand Test	Time of Reading	Elapsed Time of Reading from Start of Sand Test (minutes)	Volume in Sample Tube [1] (ml)	Sand Content (ppm) [2]
1	4/13/2012	1200	4:00	4:15	15	< 0.05	< 1.8
				4:20	20	< 0.05	< 1.3
				4:25	25	< 0.05	< 1.1
2	4/9/2012	1200	11:30	11:50	20	< 0.05	< 1.3
				11:55	25	< 0.05	< 1.1
				12:00	30	< 0.05	< 0.9
3	4/13/2012	1200	3:00	3:15	15	< 0.05	< 1.8
				3:20	20	< 0.05	< 1.3
				3:25	25	< 0.05	< 1.1
4	4/9/2012	1200	10:00	10:15	15	< 0.05	< 1.8
				10:20	20	< 0.05	< 1.3
				10:25	25	< 0.05	< 1.1
5	4/13/2012	1200	2:00	2:15	15	< 0.05	< 1.8
				2:20	20	< 0.05	< 1.3
				2:25	25	< 0.05	< 1.1
6	4/13/2012	1200	1:00	1:15	15	< 0.05	< 1.8
				1:20	20	< 0.05	< 1.3
				1:25	25	< 0.05	< 1.1

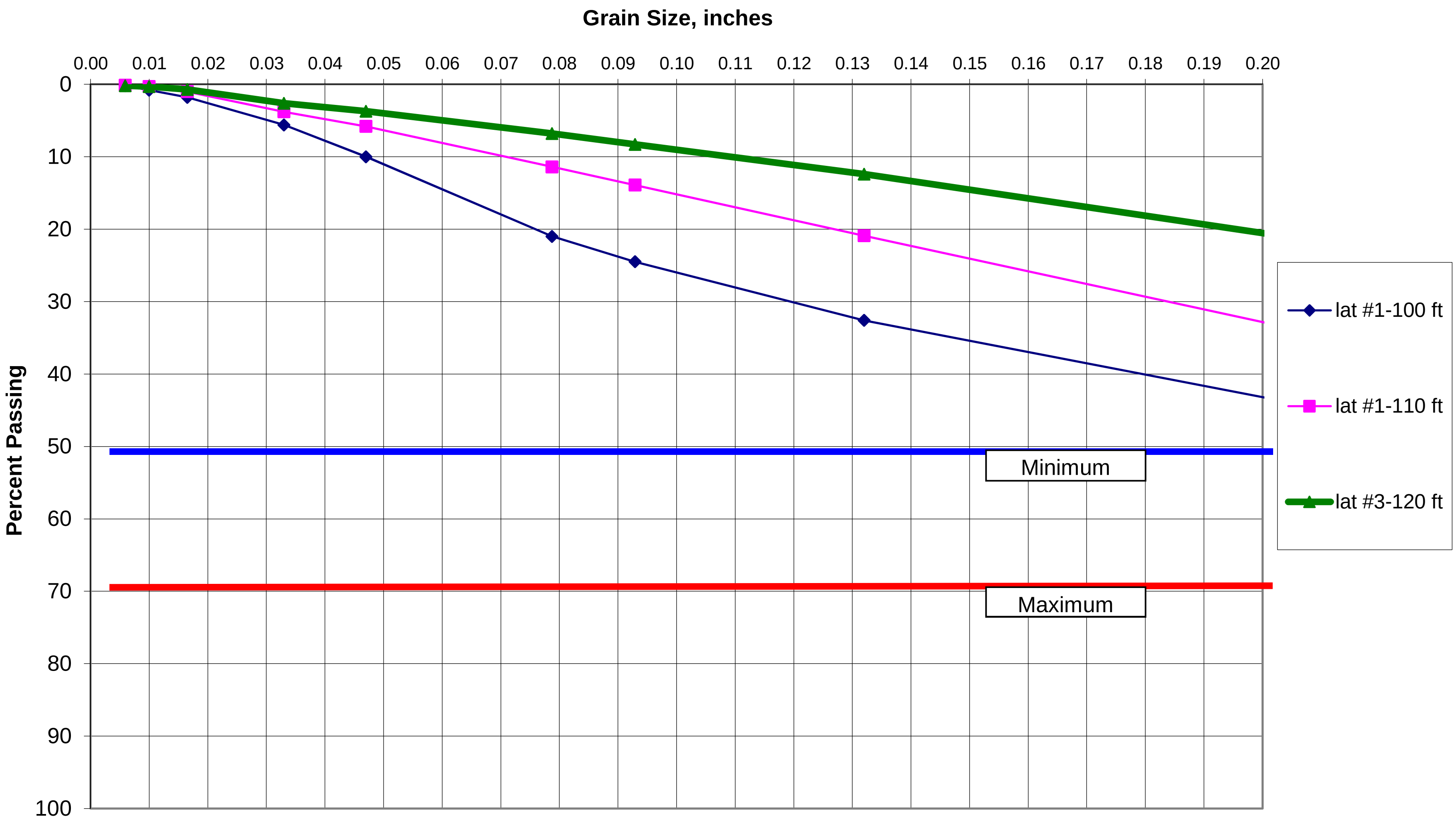
(1) All sand volumes were less than the first mark on the sampling tube (0.1 ml).
Trace amounts were assumed to be less than 0.05 ml for sand content calculations.
(2) Sand Content = [Sand Volume] / [Elapsed Time] x 528

APPENDIX A
LATERAL SIEVE ANALYSES

Sieve Analyses-Collector Well
Humboldt Bay
New Lateral Installation
Ranney Well 3 - Job No. 14606
Lateral #1



Sieve Analyses-Collector Well
Humboldt Bay
New Lateral Installation
Ranney Well 3 - Job No. 14606
Lateral #1



Sieve Analysis Results

Client: **Humboldt Bay**		**Job No.:**	**14606**
Well Number: **Ranney Well #3**			
Lateral Number: **1**			
Interval: **10**	**Feet**	**Pipe No.**	**2**

Initial Wt. **1929** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	357	357	18.6%	81.4%
3.5	5.600	0.223	413	770	40.2%	59.8%
6	3.353	0.132	394	1164	60.8%	39.2%
8	2.360	0.094	249	1413	73.8%	26.2%
10	1.999	0.079	107	1520	79.4%	20.6%
16	1.194	0.047	228	1748	91.3%	8.7%
20	0.838	0.033	78	1826	95.4%	4.6%
40	0.419	0.017	66	1892	98.8%	1.2%
60	0.254	0.010	12	1904	99.4%	0.6%
100	0.150	0.006	5	1909	99.7%	0.3%
Pan			6	1915	100.0%	0.0%
		Total	1915	grams		
		Difference	0.7%			

Client: **Humboldt Bay**		**Job No.:**	**14606**
Well Number: **Ranney Well #3**			
Lateral Number: **1**			
Interval: **20**	**Feet**	**Pipe No.**	**4**

Initial Wt. **2095** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	721	721	34.5%	65.5%
3.5	5.600	0.223	436	1157	55.4%	44.6%
6	3.353	0.132	355	1512	72.4%	27.6%
8	2.360	0.094	201	1713	82.0%	18.0%
10	1.999	0.079	81	1794	85.9%	14.1%
16	1.194	0.047	189	1983	95.0%	5.0%
20	0.838	0.033	54	2037	97.6%	2.4%
40	0.419	0.017	40	2077	99.5%	0.5%
60	0.254	0.010	5	2082	99.7%	0.3%
100	0.150	0.006	2	2084	99.8%	0.2%
Pan			4	2088	100.0%	0.0%
		Total	2088			
		Difference	0.3%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client:	**Humboldt Bay**		**Job No.:**	**14606**
Well Number:	**Ranney Well #3**			
Lateral Number:	**1**			
Interval:	**30**	**Feet**	**Pipe No.**	**6**

Initial Wt. **1982** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	854	854	43.4%	56.6%
3.5	5.600	0.223	365	1219	61.9%	38.1%
6	3.353	0.132	289	1508	76.6%	23.4%
8	2.360	0.094	166	1674	85.0%	15.0%
10	1.999	0.079	71	1745	88.6%	11.4%
16	1.194	0.047	143	1888	95.9%	4.1%
20	0.838	0.033	45	1933	98.2%	1.8%
40	0.419	0.017	26	1959	99.5%	0.5%
60	0.254	0.010	5	1964	99.7%	0.3%
100	0.150	0.006	2	1966	99.8%	0.2%
Pan			3	1969	100.0%	0.0%
		Total	1969	grams		
		Difference	0.7%			

Client:	**Humboldt Bay**		**Job No.:**	**14606**
Well Number:	**Ranney Well #3**			
Lateral Number:	**1**			
Interval:	**40**	**Feet**	**Pipe No.**	**8**

Initial Wt. **1817** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	628	628	34.9%	65.1%
3.5	5.664	0.223	326	954	53.1%	46.9%
6	3.353	0.132	320	1274	70.9%	29.1%
8	2.388	0.094	192	1466	81.5%	18.5%
10	1.999	0.079	78	1544	85.9%	14.1%
16	1.194	0.047	182	1726	96.0%	4.0%
20	0.838	0.033	41	1767	98.3%	1.7%
40	0.419	0.017	25	1792	99.7%	0.3%
60	0.254	0.010	3	1795	99.8%	0.2%
100	0.150	0.006	2	1797	99.9%	0.1%
Pan			1	1798	100.0%	0.0%
		Total	1798			
		Difference	1.0%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client: Humboldt Bay		**Job No.:**	**14606**
Well Number: Ranney Well #3			
Lateral Number: 1			
Interval: 50	**Feet**	**Pipe No.**	**10**

Initial Wt. **1636** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	503	503	30.9%	69.1%
3.5	5.600	0.223	315	818	50.3%	49.7%
6	3.353	0.132	307	1125	69.1%	30.9%
8	2.360	0.094	177	1302	80.0%	20.0%
10	1.999	0.079	73	1375	84.5%	15.5%
16	1.194	0.047	168	1543	94.8%	5.2%
20	0.838	0.033	46	1589	97.7%	2.3%
40	0.419	0.017	30	1619	99.5%	0.5%
60	0.254	0.010	4	1623	99.8%	0.2%
100	0.150	0.006	2	1625	99.9%	0.1%
Pan			2	1627	100.0%	0.0%
		Total	1627	grams		
		Difference	0.6%			

Client: Humboldt Bay		**Job No.:**	**14606**
Well Number: Ranney Well #3			
Lateral Number: 1			
Interval: 60	**Feet**	**Pipe No.**	**12**

Initial Wt. **1808** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	565	565	31.4%	68.6%
3.5	5.600	0.223	411	976	54.3%	45.7%
6	3.353	0.132	334	1310	72.9%	27.1%
8	2.360	0.094	176	1486	82.7%	17.3%
10	1.999	0.079	69	1555	86.5%	13.5%
16	1.194	0.047	160	1715	95.4%	4.6%
20	0.838	0.033	43	1758	97.8%	2.2%
40	0.419	0.017	30	1788	99.5%	0.5%
60	0.254	0.010	5	1793	99.8%	0.2%
100	0.150	0.006	2	1795	99.9%	0.1%
Pan			2	1797	100.0%	0.0%
		Total	1797			
		Difference	0.6%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**1**		
Interval:	**70** **Feet**	**Pipe No.**	**14**

Initial Wt. **1687** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	658	658	39.3%	60.7%
3.5	5.600	0.223	316	974	58.1%	41.9%
6	3.353	0.132	246	1220	72.8%	27.2%
8	2.360	0.094	150	1370	81.7%	18.3%
10	1.999	0.079	62	1432	85.4%	14.6%
16	1.194	0.047	152	1584	94.5%	5.5%
20	0.838	0.033	44	1628	97.1%	2.9%
40	0.419	0.017	36	1664	99.3%	0.7%
60	0.254	0.010	7	1671	99.7%	0.3%
100	0.150	0.006	2	1673	99.8%	0.2%
Pan			3	1676	100.0%	0.0%
		Total	1676	grams		
		Difference	0.7%			

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**1**		
Interval:	**80** **Feet**	**Pipe No.**	**16**

Initial Wt. **2175** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	1097	1097	50.6%	49.4%
3.5	5.600	0.223	322	1419	65.5%	34.5%
6	3.353	0.132	261	1680	77.6%	22.4%
8	2.360	0.094	156	1836	84.8%	15.2%
10	1.999	0.079	69	1905	88.0%	12.0%
16	1.194	0.047	169	2074	95.8%	4.2%
20	0.838	0.033	47	2121	97.9%	2.1%
40	0.419	0.017	35	2156	99.5%	0.5%
60	0.254	0.010	6	2162	99.8%	0.2%
100	0.150	0.006	2	2164	99.9%	0.1%
Pan			2	2166	100.0%	0.0%
		Total	2166			
		Difference	0.4%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client: **Humboldt Bay**		**Job No.:**	**14606**
Well Number: **Ranney Well #3**			
Lateral Number: **1**			
Interval: **90**	**Feet**	**Pipe No.**	**18**

Initial Wt. **1992** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	645	645	32.5%	67.5%
3.5	5.600	0.223	391	1036	52.1%	47.9%
6	3.353	0.132	301	1337	67.3%	32.7%
8	2.360	0.094	161	1498	75.4%	24.6%
10	1.999	0.079	84	1582	79.6%	20.4%
16	1.194	0.047	235	1817	91.4%	8.6%
20	0.838	0.033	90	1907	96.0%	4.0%
40	0.419	0.017	67	1974	99.3%	0.7%
60	0.254	0.010	10	1984	99.8%	0.2%
100	0.150	0.006	2	1986	99.9%	0.1%
Pan			1	1987	100.0%	0.0%
		Total	1987	grams		
		Difference	0.3%			

Client: **Humboldt Bay**		**Job No.:**	**14606**
Well Number: **Ranney Well #3**			
Lateral Number: **1**			
Interval: **100**	**Feet**	**Pipe No.**	**20**

Initial Wt. **1624** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	584	584	36.1%	63.9%
3.5	5.600	0.223	284	868	53.6%	46.4%
6	3.353	0.132	222	1090	67.4%	32.6%
8	2.360	0.094	131	1221	75.5%	24.5%
10	1.999	0.079	57	1278	79.0%	21.0%
16	1.194	0.047	178	1456	90.0%	10.0%
20	0.838	0.033	72	1528	94.4%	5.6%
40	0.419	0.017	61	1589	98.2%	1.8%
60	0.254	0.010	16	1605	99.2%	0.8%
100	0.150	0.006	9	1614	99.8%	0.2%
Pan			4	1618	100.0%	0.0%
		Total	1618			
		Difference	0.4%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**1**		
Interval:	**110 Feet**	**Pipe No.**	**22**

Initial Wt. **1988** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	767	767	38.9%	61.1%
3.5	5.600	0.223	488	1255	63.6%	36.4%
6	3.353	0.132	306	1561	79.1%	20.9%
8	2.360	0.094	138	1699	86.1%	13.9%
10	1.999	0.079	49	1748	88.6%	11.4%
16	1.194	0.047	110	1858	94.2%	5.8%
20	0.838	0.033	41	1899	96.2%	3.8%
40	0.419	0.017	55	1954	99.0%	1.0%
60	0.254	0.010	14	1968	99.7%	0.3%
100	0.150	0.006	3	1971	99.9%	0.1%
Pan			2	1973	100.0%	0.0%
		Total	1973	grams		
		Difference	0.8%			

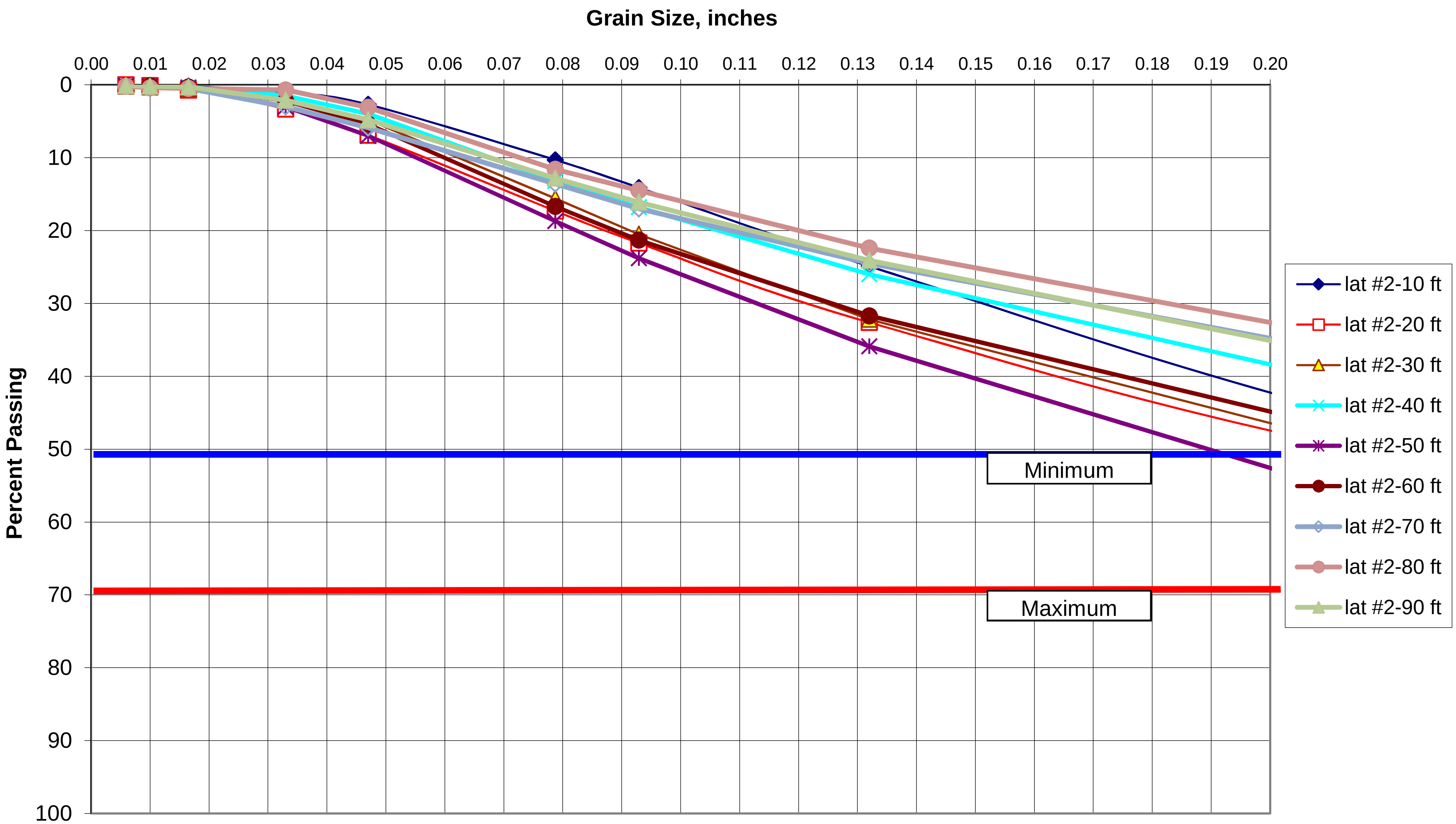
Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**1**		
Interval:	**120 Feet**	**Pipe No.**	**24**

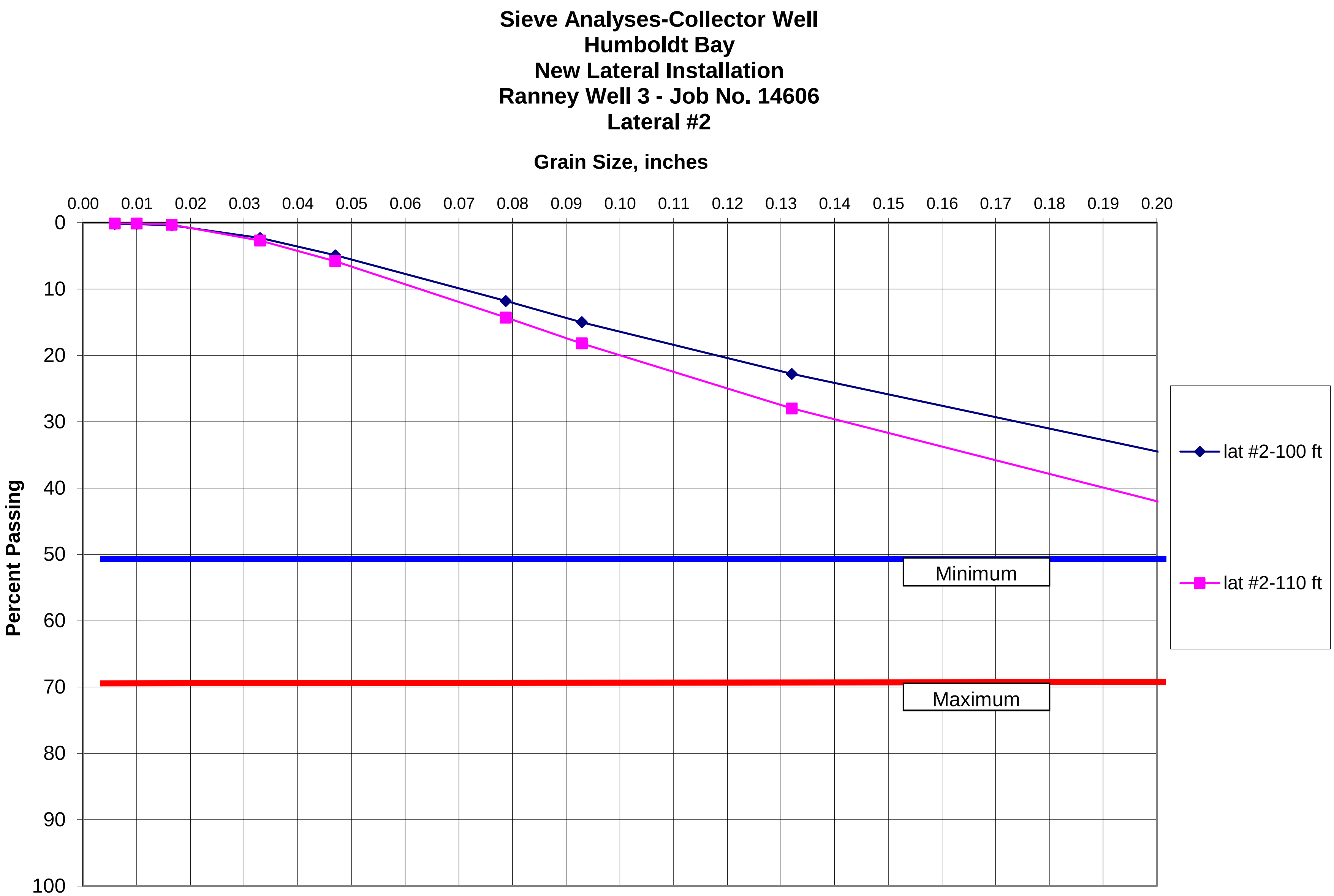
Initial Wt. **1887** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	1093	1093	58.2%	41.8%
3.5	5.600	0.223	354	1447	77.0%	23.0%
6	3.353	0.132	199	1646	87.6%	12.4%
8	2.360	0.094	77	1723	91.7%	8.3%
10	1.999	0.079	28	1751	93.2%	6.8%
16	1.194	0.047	58	1809	96.3%	3.7%
20	0.838	0.033	22	1831	97.4%	2.6%
40	0.419	0.017	34	1865	99.3%	0.7%
60	0.254	0.010	8	1873	99.7%	0.3%
100	0.150	0.006	3	1876	99.8%	0.2%
Pan			3	1879	100.0%	0.0%
		Total	1879			
		Difference	0.4%			

Layne Ranney Collector Wells

Sieve Analyses-Collector Well
Humboldt Bay
New Lateral Installation
Ranney Well 3 - Job No. 14606
Lateral #2




Sieve Analyses-Collector Well
Humboldt Bay
New Lateral Installation
Ranney Well 3 - Job No. 14606
Lateral #2
Grain Size, inches
0.00 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.10 0.11 0.12 0.13 0.14 0.15 0.16 0.17 0.18 0.19 0.20
Percent Passing
0 10 20 30 40 50 60 70 80 90 100
Minimum
Maximum
lat #2-100 ft
lat #2-110 ft

Sieve Analysis Results

Client: Humboldt Bay		**Job No.:**	**14606**
Well Number: Ranney Well #3			
Lateral Number:	**2**		
Interval:	**10**	**Feet**	**Pipe No.** **2**

Initial Wt. **2073** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	506	506	24.6%	75.4%
3.5	5.600	0.223	591	1097	53.3%	46.7%
6	3.353	0.132	449	1546	75.1%	24.9%
8	2.360	0.094	222	1768	85.9%	14.1%
10	1.999	0.079	79	1847	89.7%	10.3%
16	1.194	0.047	156	2003	97.3%	2.7%
20	0.838	0.033	35	2038	99.0%	1.0%
40	0.419	0.017	16	2054	99.8%	0.2%
60	0.254	0.010	1	2055	99.9%	0.1%
100	0.150	0.006	1	2056	99.9%	0.1%
Pan			2	2058	100.0%	0.0%
		Total	2058	grams		
		Difference	0.7%			

Client: Humboldt Bay		**Job No.:**	**14606**
Well Number: Ranney Well #3			
Lateral Number:	**2**		
Interval:	**20**	**Feet**	**Pipe No.** **4**

Initial Wt. **2208** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	615	615	28.0%	72.0%
3.5	5.600	0.223	463	1078	49.0%	51.0%
6	3.353	0.132	405	1483	67.4%	32.6%
8	2.360	0.094	240	1723	78.3%	21.7%
10	1.999	0.079	97	1820	82.7%	17.3%
16	1.194	0.047	229	2049	93.1%	6.9%
20	0.838	0.033	78	2127	96.7%	3.3%
40	0.419	0.017	58	2185	99.3%	0.7%
60	0.254	0.010	13	2198	99.9%	0.1%
100	0.150	0.006	1	2199	100.0%	0.0%
Pan			1	2200	100.0%	0.0%
		Total	2200			
		Difference	0.4%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client: Humboldt Bay		**Job No.:**	**14606**
Well Number: Ranney Well #3			
Lateral Number:	**2**		
Interval:	**30**	**Feet**	**Pipe No.** **6**

Initial Wt. **2150** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	637	637	29.9%	70.1%
3.5	5.600	0.223	414	1051	49.3%	50.7%
6	3.353	0.132	396	1447	67.8%	32.2%
8	2.360	0.094	250	1697	79.5%	20.5%
10	1.999	0.079	104	1801	84.4%	15.6%
16	1.194	0.047	231	2032	95.2%	4.8%
20	0.838	0.033	60	2092	98.0%	2.0%
40	0.419	0.017	32	2124	99.5%	0.5%
60	0.254	0.010	3	2127	99.7%	0.3%
100	0.150	0.006	2	2129	99.8%	0.2%
Pan			5	2134	100.0%	0.0%
		Total	2134	grams		
		Difference	0.7%			

Client: Humboldt Bay		**Job No.:**	**14606**
Well Number: Ranney Well #3			
Lateral Number:	**2**		
Interval:	**40**	**Feet**	**Pipe No.** **8**

Initial Wt. **2144** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	786	786	36.9%	63.1%
3.5	5.664	0.223	447	1233	57.9%	42.1%
6	3.353	0.132	345	1578	74.0%	26.0%
8	2.388	0.094	195	1773	83.2%	16.8%
10	1.999	0.079	77	1850	86.8%	13.2%
16	1.194	0.047	196	2046	96.0%	4.0%
20	0.838	0.033	52	2098	98.5%	1.5%
40	0.419	0.017	26	2124	99.7%	0.3%
60	0.254	0.010	3	2127	99.8%	0.2%
100	0.150	0.006	1	2128	99.9%	0.1%
Pan			3	2131	100.0%	0.0%
		Total	2131			
		Difference	0.6%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client: **Humboldt Bay** **Job No.:** **14606**
Well Number: **Ranney Well #3**
Lateral Number: **2**
Interval: **50** **Feet** **Pipe No.** **10**

Initial Wt. **2033** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	388	388	19.2%	80.8%
3.5	5.600	0.223	469	857	42.4%	57.6%
6	3.353	0.132	438	1295	64.1%	35.9%
8	2.360	0.094	245	1540	76.2%	23.8%
10	1.999	0.079	104	1644	81.3%	18.7%
16	1.194	0.047	235	1879	93.0%	7.0%
20	0.838	0.033	82	1961	97.0%	3.0%
40	0.419	0.017	51	2012	99.6%	0.4%
60	0.254	0.010	5	2017	99.8%	0.2%
100	0.150	0.006	2	2019	99.9%	0.1%
Pan			2	2021	100.0%	0.0%
		Total	2021	grams		
		Difference	0.6%			

Client: **Humboldt Bay** **Job No.:** **14606**
Well Number: **Ranney Well #3**
Lateral Number: **2**
Interval: **60** **Feet** **Pipe No.** **12**

Initial Wt. **1962** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	634	634	32.6%	67.4%
3.5	5.600	0.223	362	996	51.2%	48.8%
6	3.353	0.132	333	1329	68.3%	31.7%
8	2.360	0.094	202	1531	78.7%	21.3%
10	1.999	0.079	89	1620	83.3%	16.7%
16	1.194	0.047	220	1840	94.6%	5.4%
20	0.838	0.033	62	1902	97.8%	2.2%
40	0.419	0.017	38	1940	99.7%	0.3%
60	0.254	0.010	3	1943	99.9%	0.1%
100	0.150	0.006	1	1944	99.9%	0.1%
Pan			1	1945	100.0%	0.0%
		Total	1945			
		Difference	0.9%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client: Humboldt Bay		**Job No.:**	**14606**
Well Number: Ranney Well #3			
Lateral Number: 2			
Interval: 70	**Feet**	**Pipe No.**	**14**

Initial Wt. **1864** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	763	763	41.0%	59.0%
3.5	5.600	0.223	392	1155	62.1%	37.9%
6	3.353	0.132	250	1405	75.5%	24.5%
8	2.360	0.094	140	1545	83.0%	17.0%
10	1.999	0.079	63	1608	86.4%	13.6%
16	1.194	0.047	143	1751	94.1%	5.9%
20	0.838	0.033	54	1805	97.0%	3.0%
40	0.419	0.017	46	1851	99.5%	0.5%
60	0.254	0.010	5	1856	99.7%	0.3%
100	0.150	0.006	2	1858	99.8%	0.2%
Pan			3	1861	100.0%	0.0%
		Total	1861	grams		
		Difference	0.2%			

Client: Humboldt Bay		**Job No.:**	**14606**
Well Number: Ranney Well #3			
Lateral Number: 2			
Interval: 80	**Feet**	**Pipe No.**	**16**

Initial Wt. **1697** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	771	771	45.7%	54.3%
3.5	5.600	0.223	313	1084	64.3%	35.7%
6	3.353	0.132	225	1309	77.6%	22.4%
8	2.360	0.094	132	1441	85.5%	14.5%
10	1.999	0.079	50	1491	88.4%	11.6%
16	1.194	0.047	143	1634	96.9%	3.1%
20	0.838	0.033	40	1674	99.3%	0.7%
40	0.419	0.017	4	1678	99.5%	0.5%
60	0.254	0.010	2	1680	99.6%	0.4%
100	0.150	0.006	3	1683	99.8%	0.2%
Pan			3	1686	100.0%	0.0%
		Total	1686			
		Difference	0.6%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client: **Humboldt Bay** **Job No.:** **14606**
Well Number: **Ranney Well #3**
Lateral Number: **2**
Interval: **90** **Feet** **Pipe No.** **18**

Initial Wt. **1772** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	690	690	39.1%	60.9%
3.5	5.600	0.223	396	1086	61.6%	38.4%
6	3.353	0.132	253	1339	75.9%	24.1%
8	2.360	0.094	141	1480	83.9%	16.1%
10	1.999	0.079	58	1538	87.2%	12.8%
16	1.194	0.047	142	1680	95.2%	4.8%
20	0.838	0.033	47	1727	97.9%	2.1%
40	0.419	0.017	31	1758	99.7%	0.3%
60	0.254	0.010	3	1761	99.8%	0.2%
100	0.150	0.006	1	1762	99.9%	0.1%
Pan			2	1764	100.0%	0.0%
		Total	1764	grams		
		Difference	0.5%			

Client: **Humboldt Bay** **Job No.:** **14606**
Well Number: **Ranney Well #3**
Lateral Number: **2**
Interval: **100** **Feet** **Pipe No.** **20**

Initial Wt. **1717** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	701	701	41.0%	59.0%
3.5	5.600	0.223	359	1060	62.0%	38.0%
6	3.353	0.132	260	1320	77.2%	22.8%
8	2.360	0.094	134	1454	85.0%	15.0%
10	1.999	0.079	54	1508	88.2%	11.8%
16	1.194	0.047	118	1626	95.1%	4.9%
20	0.838	0.033	45	1671	97.7%	2.3%
40	0.419	0.017	32	1703	99.6%	0.4%
60	0.254	0.010	3	1706	99.8%	0.2%
100	0.150	0.006	1	1707	99.8%	0.2%
Pan			3	1710	100.0%	0.0%
		Total	1710			
		Difference	0.4%			

Layne
Ranney Collector Wells

Sieve Analysis Results

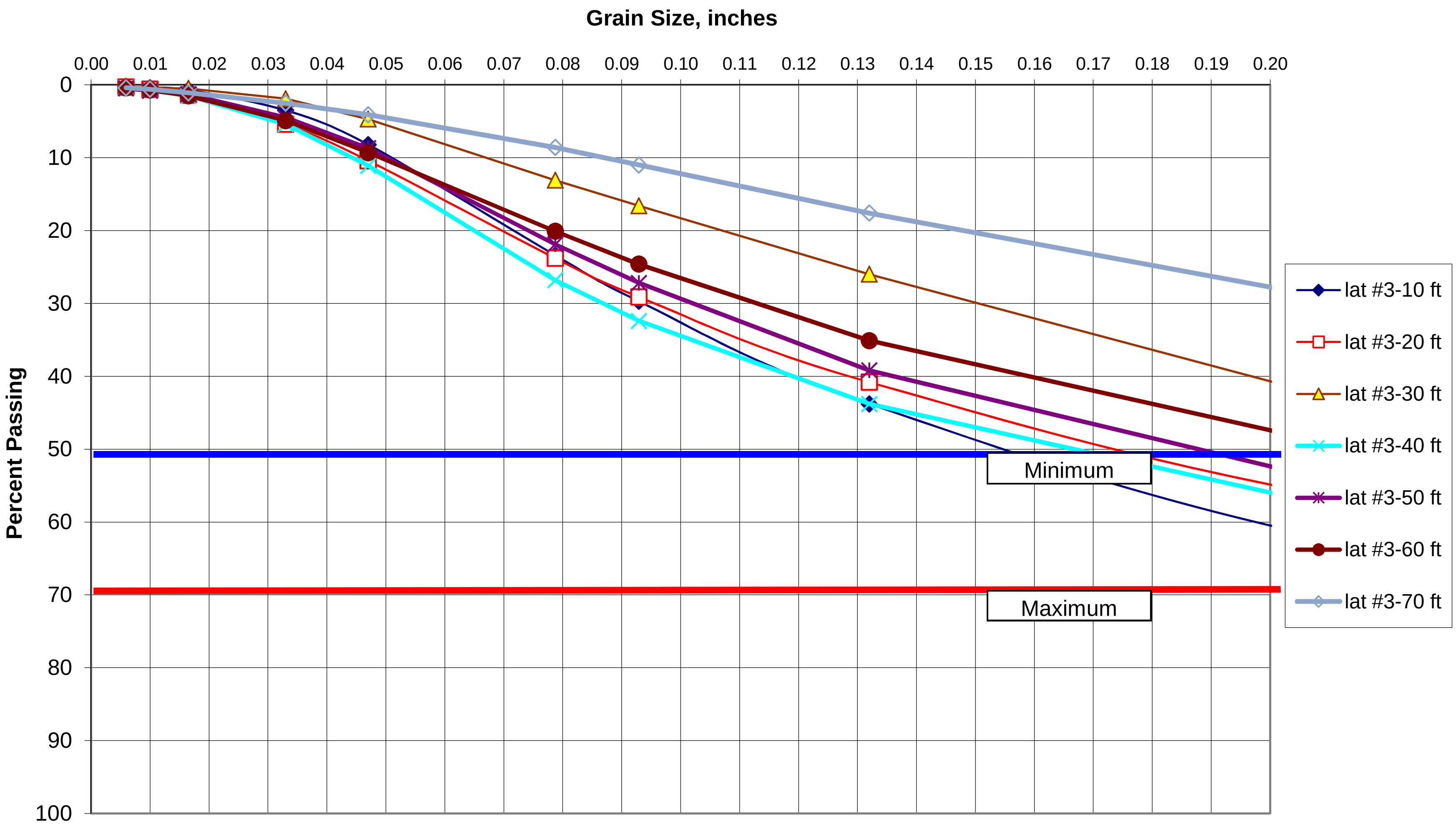
Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**2**		
Interval:	**110** **Feet**	**Pipe No.**	**22**

Initial Wt. **2082** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	659	659	31.7%	68.3%
3.5	5.600	0.223	458	1117	53.8%	46.2%
6	3.353	0.132	380	1497	72.0%	28.0%
8	2.360	0.094	203	1700	81.8%	18.2%
10	1.999	0.079	80	1780	85.7%	14.3%
16	1.194	0.047	178	1958	94.2%	5.8%
20	0.838	0.033	63	2021	97.3%	2.7%
40	0.419	0.017	50	2071	99.7%	0.3%
60	0.254	0.010	4	2075	99.9%	0.1%
100	0.150	0.006	1	2076	99.9%	0.1%
Pan			2	2078	100.0%	0.0%
		Total	2078	grams		
		Difference	0.2%			

Layne
Ranney Collector Wells

Sieve Analyses-Collector Well
Humboldt Bay
New Lateral Installation
Ranney Well 3 - Job No. 14606
Latral #3



Sieve Analysis Results

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**3**		
Interval:	**10** **Feet**	**Pipe No.**	**2**

Initial Wt. **1812** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	337	337	18.6%	81.4%
3.5	5.600	0.223	314	651	36.0%	64.0%
6	3.353	0.132	367	1018	56.2%	43.8%
8	2.360	0.094	255	1273	70.3%	29.7%
10	1.999	0.079	114	1387	76.6%	23.4%
16	1.194	0.047	275	1662	91.8%	8.2%
20	0.838	0.033	85	1747	96.5%	3.5%
40	0.419	0.017	50	1797	99.3%	0.7%
60	0.254	0.010	6	1803	99.6%	0.4%
100	0.150	0.006	2	1805	99.7%	0.3%
Pan			5	1810	100.0%	0.0%
		Total	1810	grams		
		Difference	0.1%			

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**3**		
Interval:	**20** **Feet**	**Pipe No.**	**4**

Initial Wt. **2165** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	568	568	26.3%	73.7%
3.5	5.600	0.223	341	909	42.1%	57.9%
6	3.353	0.132	369	1278	59.2%	40.8%
8	2.360	0.094	254	1532	70.9%	29.1%
10	1.999	0.079	113	1645	76.2%	23.8%
16	1.194	0.047	291	1936	89.6%	10.4%
20	0.838	0.033	107	2043	94.6%	5.4%
40	0.419	0.017	86	2129	98.6%	1.4%
60	0.254	0.010	18	2147	99.4%	0.6%
100	0.150	0.006	6	2153	99.7%	0.3%
Pan			7	2160	100.0%	0.0%
		Total	2160			
		Difference	0.2%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client: **Humboldt Bay** **Job No.:** **14606**

Well Number: **Ranney Well #3**

Lateral Number: **3**

Interval: **30** **Feet** **Pipe No.** **6**

Initial Wt. **1921** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	606	606	31.7%	68.3%
3.5	5.600	0.223	445	1051	54.9%	45.1%
6	3.353	0.132	364	1415	74.0%	26.0%
8	2.360	0.094	181	1596	83.4%	16.6%
10	1.999	0.079	66	1662	86.9%	13.1%
16	1.194	0.047	161	1823	95.3%	4.7%
20	0.838	0.033	53	1876	98.1%	1.9%
40	0.419	0.017	28	1904	99.5%	0.5%
60	0.254	0.010	2	1906	99.6%	0.4%
100	0.150	0.006	3	1909	99.8%	0.2%
Pan			4	1913	100.0%	0.0%
		Total	1913	grams		
		Difference	0.4%			

Client: **Humboldt Bay** **Job No.:** **14606**

Well Number: **Ranney Well #3**

Lateral Number: **3**

Interval: **40** **Feet** **Pipe No.** **8**

Initial Wt. **1648** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	444	444	27.0%	73.0%
3.5	5.664	0.223	220	664	40.4%	59.6%
6	3.353	0.132	259	923	56.2%	43.8%
8	2.388	0.094	187	1110	67.6%	32.4%
10	1.999	0.079	92	1202	73.2%	26.8%
16	1.194	0.047	258	1460	88.9%	11.1%
20	0.838	0.033	94	1554	94.6%	5.4%
40	0.419	0.017	64	1618	98.5%	1.5%
60	0.254	0.010	12	1630	99.2%	0.8%
100	0.150	0.006	6	1636	99.6%	0.4%
Pan			7	1643	100.0%	0.0%
		Total	1643			
		Difference	0.3%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client: **Humboldt Bay** **Job No.:** **14606**

Well Number: Ranney Well #3

Lateral Number: 3

Interval: 50 Feet **Pipe No. 10**

Initial Wt. **2224** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	635	635	28.6%	71.4%
3.5	5.600	0.223	336	971	43.7%	56.3%
6	3.353	0.132	381	1352	60.8%	39.2%
8	2.360	0.094	266	1618	72.8%	27.2%
10	1.999	0.079	118	1736	78.1%	21.9%
16	1.194	0.047	292	2028	91.3%	8.7%
20	0.838	0.033	94	2122	95.5%	4.5%
40	0.419	0.017	71	2193	98.7%	1.3%
60	0.254	0.010	12	2205	99.2%	0.8%
100	0.150	0.006	6	2211	99.5%	0.5%
Pan			11	2222	100.0%	0.0%
		Total	2222	grams		
		Difference	0.1%			

Client: **Humboldt Bay** **Job No.:** **14606**

Well Number: Ranney Well #3

Lateral Number: 3

Interval: 60 Feet **Pipe No. 12**

Initial Wt. **1852** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	584	584	31.5%	68.5%
3.5	5.600	0.223	323	907	48.9%	51.1%
6	3.353	0.132	297	1204	64.9%	35.1%
8	2.360	0.094	194	1398	75.4%	24.6%
10	1.999	0.079	83	1481	79.9%	20.1%
16	1.194	0.047	201	1682	90.7%	9.3%
20	0.838	0.033	81	1763	95.1%	4.9%
40	0.419	0.017	63	1826	98.5%	1.5%
60	0.254	0.010	15	1841	99.3%	0.7%
100	0.150	0.006	6	1847	99.6%	0.4%
Pan			7	1854	100.0%	0.0%
		Total	1854			
		Difference	-0.1%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client: **Humboldt Bay** **Job No.:** **14606**

Well Number: Ranney Well #3

Lateral Number: **3**

Interval: **70** **Feet** **Pipe No.** **14**

Initial Wt. ______ grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375			52.8%	47.2%
3.5	5.600	0.223			69.2%	30.8%
6	3.353	0.132			82.4%	17.6%
8	2.360	0.094			89.0%	11.0%
10	1.999	0.079			91.4%	8.6%
16	1.194	0.047			95.9%	4.1%
20	0.838	0.033			97.5%	2.5%
40	0.419	0.017			98.9%	1.1%
60	0.254	0.010			99.4%	0.6%
100	0.150	0.006			99.6%	0.4%
Pan					100.0%	0.0%
		Total		grams		
		Difference				

Layne
Ranney Collector Wells

Sieve Analyses-Collector Well
Humboldt Bay
New Lateral Installation
Ranney Well 3 - Job No. 14606
Lateral #4

Sieve Analysis Results

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**4**		
Interval:	**10** **Feet**	**Pipe No.**	**2**

Initial Wt. **1310** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	224	224	17.1%	82.9%
3.5	5.600	0.223	270	494	37.8%	62.2%
6	3.353	0.132	270	764	58.5%	41.5%
8	2.360	0.094	189	953	72.9%	27.1%
10	1.999	0.079	84	1037	79.3%	20.7%
16	1.194	0.047	142	1179	90.2%	9.8%
20	0.838	0.033	71	1250	95.6%	4.4%
40	0.419	0.017	50	1300	99.5%	0.5%
60	0.254	0.010	6	1306	99.9%	0.1%
100	0.150	0.006	0	1306	99.9%	0.1%
Pan			1	1307	100.0%	0.0%
		Total	1307	grams		
		Difference	0.2%			

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**4**		
Interval:	**20** **Feet**	**Pipe No.**	**4**

Initial Wt. **1387** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	124	124	9.0%	91.0%
3.5	5.600	0.223	225	349	25.2%	74.8%
6	3.353	0.132	210	559	40.4%	59.6%
8	2.360	0.094	209	768	55.5%	44.5%
10	1.999	0.079	98	866	62.6%	37.4%
16	1.194	0.047	299	1165	84.2%	15.8%
20	0.838	0.033	118	1283	92.8%	7.2%
40	0.419	0.017	89	1372	99.2%	0.8%
60	0.254	0.010	9	1381	99.9%	0.1%
100	0.150	0.006	2	1383	100.0%	0.0%
Pan			0	1383	100.0%	0.0%
		Total	1383			
		Difference	0.3%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client: **Humboldt Bay** **Job No.:** **14606**
Well Number: Ranney Well #3
Lateral Number: **4**
Interval: **30** **Feet** **Pipe No.** **6**

Initial Wt. **1701** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	440	440	26.0%	74.0%
3.5	5.600	0.223	236	676	39.9%	60.1%
6	3.353	0.132	240	916	54.1%	45.9%
8	2.360	0.094	170	1086	64.1%	35.9%
10	1.999	0.079	78	1164	68.7%	31.3%
16	1.194	0.047	252	1416	83.6%	16.4%
20	0.838	0.033	111	1527	90.1%	9.9%
40	0.419	0.017	115	1642	96.9%	3.1%
60	0.254	0.010	30	1672	98.7%	1.3%
100	0.150	0.006	13	1685	99.5%	0.5%
Pan			9	1694	100.0%	0.0%
		Total	1694	grams		
		Difference	0.4%			

Client: **Humboldt Bay** **Job No.:** **14606**
Well Number: Ranney Well #3
Lateral Number: **4**
Interval: **40** **Feet** **Pipe No.** **8**

Initial Wt. **1715** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	271	271	15.8%	84.2%
3.5	5.664	0.223	329	600	35.0%	65.0%
6	3.353	0.132	376	976	57.0%	43.0%
8	2.388	0.094	224	1200	70.1%	29.9%
10	1.999	0.079	98	1298	75.8%	24.2%
16	1.194	0.047	256	1554	90.8%	9.2%
20	0.838	0.033	84	1638	95.7%	4.3%
40	0.419	0.017	62	1700	99.3%	0.7%
60	0.254	0.010	9	1709	99.8%	0.2%
100	0.150	0.006	3	1712	100.0%	0.0%
Pan			0	1712	100.0%	0.0%
		Total	1712			
		Difference	0.2%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**4**		
Interval:	**50** **Feet**	**Pipe No.**	**10**

Initial Wt. **1950** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	478	478	24.6%	75.4%
3.5	5.600	0.223	406	884	45.5%	54.5%
6	3.353	0.132	363	1247	64.2%	35.8%
8	2.360	0.094	221	1468	75.6%	24.4%
10	1.999	0.079	93	1561	80.3%	19.7%
16	1.194	0.047	234	1795	92.4%	7.6%
20	0.838	0.033	80	1875	96.5%	3.5%
40	0.419	0.017	59	1934	99.5%	0.5%
60	0.254	0.010	7	1941	99.9%	0.1%
100	0.150	0.006	0	1941	99.9%	0.1%
Pan			2	1943	100.0%	0.0%
		Total	1943	grams		
		Difference	0.4%			

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**4**		
Interval:	**60** **Feet**	**Pipe No.**	**12**

Initial Wt. **1780** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	321	321	18.1%	81.9%
3.5	5.600	0.223	299	620	34.9%	65.1%
6	3.353	0.132	350	970	54.6%	45.4%
8	2.360	0.094	249	1219	68.7%	31.3%
10	1.999	0.079	108	1327	74.8%	25.2%
16	1.194	0.047	286	1613	90.9%	9.1%
20	0.838	0.033	91	1704	96.0%	4.0%
40	0.419	0.017	61	1765	99.4%	0.6%
60	0.254	0.010	6	1771	99.8%	0.2%
100	0.150	0.006	2	1773	99.9%	0.1%
Pan			2	1775	100.0%	0.0%
		Total	1775			
		Difference	0.3%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client: **Humboldt Bay** **Job No.:** **14606**
Well Number: **Ranney Well #3**
Lateral Number: **4**
Interval: **70** **Feet** **Pipe No.** **14**

Initial Wt. **1608** grams

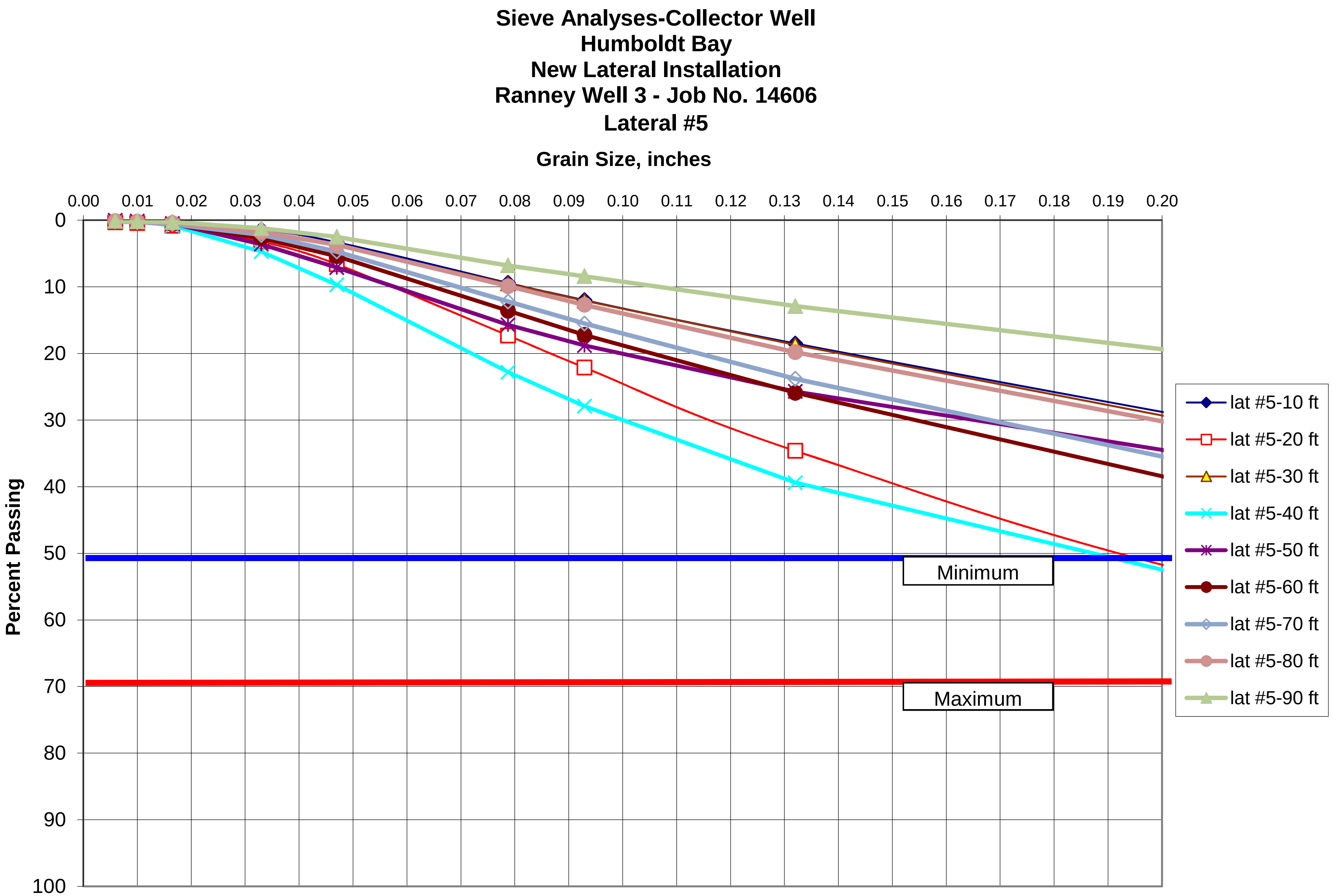
Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	301	301	18.8%	81.2%
3.5	5.600	0.223	319	620	38.8%	61.3%
6	3.353	0.132	308	928	58.0%	42.0%
8	2.360	0.094	192	1120	70.0%	30.0%
10	1.999	0.079	86	1206	75.4%	24.6%
16	1.194	0.047	223	1429	89.3%	10.7%
20	0.838	0.033	84	1513	94.6%	5.4%
40	0.419	0.017	77	1590	99.4%	0.6%
60	0.254	0.010	8	1598	99.9%	0.1%
100	0.150	0.006	2	1600	100.0%	0.0%
Pan			0	1600	100.0%	0.0%
		Total	1600	grams		
		Difference	0.5%			

Client: **Humboldt Bay** **Job No.:** **14606**
Well Number: **Ranney Well #3**
Lateral Number: **4**
Interval: **80** **Feet** **Pipe No.** **16**

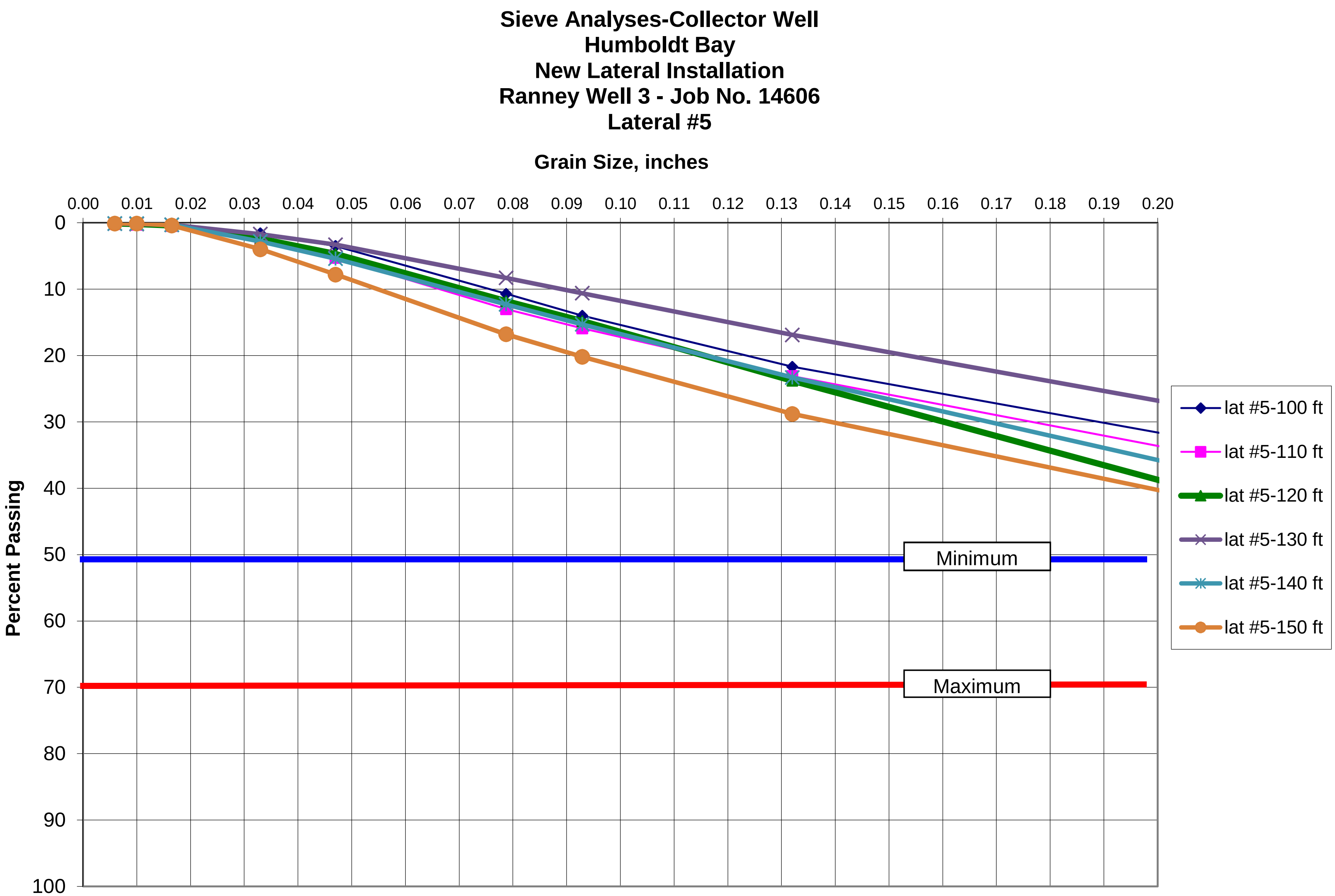
Initial Wt. **1771** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	350	350	19.8%	80.2%
3.5	5.600	0.223	255	605	34.2%	65.8%
6	3.353	0.132	304	909	51.4%	48.6%
8	2.360	0.094	223	1132	64.0%	36.0%
10	1.999	0.079	105	1237	69.9%	30.1%
16	1.194	0.047	299	1536	86.8%	13.2%
20	0.838	0.033	112	1648	93.2%	6.8%
40	0.419	0.017	109	1757	99.3%	0.7%
60	0.254	0.010	9	1766	99.8%	0.2%
100	0.150	0.006	0	1766	99.8%	0.2%
Pan			3	1769	100.0%	0.0%
		Total	1769			
		Difference	0.1%			

Layne
Ranney Collector Wells



Sieve Analyses-Collector Well
Humboldt Bay
New Lateral Installation
Ranney Well 3 - Job No. 14606
Lateral #5
Grain Size, inches
0.00 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.10 0.11 0.12 0.13 0.14 0.15 0.16 0.17 0.18 0.19 0.20
Percent Passing
0 10 20 30 40 50 60 70 80 90 100
Minimum
Maximum
lat #5-10 ft
lat #5-20 ft
lat #5-30 ft
lat #5-40 ft
lat #5-50 ft
lat #5-60 ft
lat #5-70 ft
lat #5-80 ft
lat #5-90 ft


Sieve Analyses-Collector Well
Humboldt Bay
New Lateral Installation
Ranney Well 3 - Job No. 14606
Lateral #5
Grain Size, inches
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.10
0.11
0.12
0.13
0.14
0.15
0.16
0.17
0.18
0.19
0.20
Percent Passing
0
10
20
30
40
50
60
70
80
90
100
Minimum
Maximum
lat #5-100 ft
lat #5-110 ft
lat #5-120 ft
lat #5-130 ft
lat #5-140 ft
lat #5-150 ft

Sieve Analysis Results

Client: Humboldt Bay **Job No.:** 14606
Well Number: Ranney Well #3
Lateral Number: 5
Interval: 10 **Feet** **Pipe No.** 2

Initial Wt. **1999** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	906	906	45.7%	54.3%
3.5	5.600	0.223	446	1352	68.2%	31.8%
6	3.353	0.132	263	1615	81.5%	18.5%
8	2.360	0.094	128	1743	88.0%	12.0%
10	1.999	0.079	51	1794	90.6%	9.4%
16	1.194	0.047	121	1915	96.7%	3.3%
20	0.838	0.033	38	1953	98.6%	1.4%
40	0.419	0.017	22	1975	99.7%	0.3%
60	0.254	0.010	3	1978	99.8%	0.2%
100	0.150	0.006	1	1979	99.9%	0.1%
Pan			2	1981	100.0%	0.0%
		Total	1981	grams		
		Difference	0.9%			

Client: Humboldt Bay **Job No.:** 14606
Well Number: Ranney Well #3
Lateral Number: 5
Interval: 20 **Feet** **Pipe No.** 4

Initial Wt. **1909** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	441	441	23.2%	76.8%
3.5	5.600	0.223	405	846	44.4%	55.6%
6	3.353	0.132	400	1246	65.4%	34.6%
8	2.360	0.094	237	1483	77.9%	22.1%
10	1.999	0.079	92	1575	82.7%	17.3%
16	1.194	0.047	204	1779	93.4%	6.6%
20	0.838	0.033	64	1843	96.8%	3.2%
40	0.419	0.017	45	1888	99.2%	0.8%
60	0.254	0.010	8	1896	99.6%	0.4%
100	0.150	0.006	3	1899	99.7%	0.3%
Pan			5	1904	100.0%	0.0%
		Total	1904			
		Difference	0.3%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client: **Humboldt Bay** **Job No.:** **14606**

Well Number: Ranney Well #3

Lateral Number: **5**

Interval: **30** **Feet** **Pipe No.** **6**

Initial Wt. **2143** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	1025	1025	48.2%	51.8%
3.5	5.600	0.223	409	1434	67.5%	32.5%
6	3.353	0.132	294	1728	81.3%	18.7%
8	2.360	0.094	141	1869	87.9%	12.1%
10	1.999	0.079	55	1924	90.5%	9.5%
16	1.194	0.047	124	2048	96.3%	3.7%
20	0.838	0.033	40	2088	98.2%	1.8%
40	0.419	0.017	30	2118	99.6%	0.4%
60	0.254	0.010	4	2122	99.8%	0.2%
100	0.150	0.006	2	2124	99.9%	0.1%
Pan			2	2126	100.0%	0.0%
		Total	2126	grams		
		Difference	0.8%			

Client: **Humboldt Bay** **Job No.:** **14606**

Well Number: Ranney Well #3

Lateral Number: **5**

Interval: **40** **Feet** **Pipe No.** **8**

Initial Wt. **1863** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	483	483	26.0%	74.0%
3.5	5.664	0.223	327	810	43.6%	56.4%
6	3.353	0.132	316	1126	60.6%	39.4%
8	2.388	0.094	214	1340	72.1%	27.9%
10	1.999	0.079	96	1436	77.2%	22.8%
16	1.194	0.047	242	1678	90.3%	9.7%
20	0.838	0.033	94	1772	95.3%	4.7%
40	0.419	0.017	73	1845	99.2%	0.8%
60	0.254	0.010	10	1855	99.8%	0.2%
100	0.150	0.006	2	1857	99.9%	0.1%
Pan			2	1859	100.0%	0.0%
		Total	1859			
		Difference	0.2%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client: **Humboldt Bay** **Job No.:** **14606**

Well Number: **Ranney Well #3**

Lateral Number: **5**

Interval: **50** **Feet** **Pipe No.** **10**

Initial Wt. **2247** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	1029	1029	46.1%	53.9%
3.5	5.600	0.223	374	1403	62.9%	37.1%
6	3.353	0.132	253	1656	74.3%	25.7%
8	2.360	0.094	154	1810	81.2%	18.8%
10	1.999	0.079	69	1879	84.3%	15.7%
16	1.194	0.047	193	2072	92.9%	7.1%
20	0.838	0.033	77	2149	96.4%	3.6%
40	0.419	0.017	69	2218	99.5%	0.5%
60	0.254	0.010	10	2228	99.9%	0.1%
100	0.150	0.006	1	2229	100.0%	0.0%
Pan			1	2230	100.0%	0.0%
		Total	2230	grams		
		Difference	0.8%			

Client: **Humboldt Bay** **Job No.:** **14606**

Well Number: **Ranney Well #3**

Lateral Number: **5**

Interval: **60** **Feet** **Pipe No.** **12**

Initial Wt. **1928** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	733	733	38.0%	62.0%
3.5	5.600	0.223	381	1114	57.8%	42.2%
6	3.353	0.132	315	1429	74.1%	25.9%
8	2.360	0.094	167	1596	82.8%	17.2%
10	1.999	0.079	69	1665	86.4%	13.6%
16	1.194	0.047	158	1823	94.6%	5.4%
20	0.838	0.033	52	1875	97.3%	2.7%
40	0.419	0.017	42	1917	99.4%	0.6%
60	0.254	0.010	6	1923	99.7%	0.3%
100	0.150	0.006	2	1925	99.8%	0.2%
Pan			3	1928	100.0%	0.0%
		Total	1928			
		Difference	0.0%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client: **Humboldt Bay** **Job No.:** **14606**

Well Number: **Ranney Well #3**

Lateral Number: **5**

Interval: **70** **Feet** **Pipe No.** **14**

Initial Wt. **2063** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	874	874	42.3%	57.7%
3.5	5.600	0.223	385	1259	61.0%	39.0%
6	3.353	0.132	313	1572	76.2%	23.8%
8	2.360	0.094	173	1745	84.5%	15.5%
10	1.999	0.079	68	1813	87.8%	12.2%
16	1.194	0.047	155	1968	95.3%	4.7%
20	0.838	0.033	51	2019	97.8%	2.2%
40	0.419	0.017	33	2052	99.4%	0.6%
60	0.254	0.010	5	2057	99.7%	0.3%
100	0.150	0.006	2	2059	99.8%	0.2%
Pan			5	2064	100.0%	0.0%
		Total	2064	grams		
		Difference	0.0%			

Client: **Humboldt Bay** **Job No.:** **14606**

Well Number: **Ranney Well #3**

Lateral Number: **5**

Interval: **80** **Feet** **Pipe No.** **16**

Initial Wt. **1807** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	877	877	48.7%	51.3%
3.5	5.600	0.223	324	1201	66.7%	33.3%
6	3.353	0.132	242	1443	80.2%	19.8%
8	2.360	0.094	129	1572	87.3%	12.7%
10	1.999	0.079	50	1622	90.1%	9.9%
16	1.194	0.047	112	1734	96.3%	3.7%
20	0.838	0.033	34	1768	98.2%	1.8%
40	0.419	0.017	24	1792	99.6%	0.4%
60	0.254	0.010	4	1796	99.8%	0.2%
100	0.150	0.006	2	1798	99.9%	0.1%
Pan			2	1800	100.0%	0.0%
		Total	1800			
		Difference	0.4%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client: **Humboldt Bay** **Job No.:** **14606**

Well Number: **Ranney Well #3**

Lateral Number: **5**

Interval: **90** **Feet** **Pipe No.** **18**

Initial Wt. **2013** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	1292	1292	64.5%	35.5%
3.5	5.600	0.223	286	1578	78.7%	21.3%
6	3.353	0.132	167	1745	87.1%	12.9%
8	2.360	0.094	90	1835	91.6%	8.4%
10	1.999	0.079	33	1868	93.2%	6.8%
16	1.194	0.047	85	1953	97.5%	2.5%
20	0.838	0.033	27	1980	98.8%	1.2%
40	0.419	0.017	17	1997	99.7%	0.3%
60	0.254	0.010	2	1999	99.8%	0.2%
100	0.150	0.006	2	2001	99.9%	0.1%
Pan			3	2004	100.0%	0.0%
		Total	2004	grams		
		Difference	0.4%			

Client: **Humboldt Bay** **Job No.:** **14606**

Well Number: **Ranney Well #3**

Lateral Number: **5**

Interval: **100** **Feet** **Pipe No.** **20**

Initial Wt. **1959** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	966	966	49.7%	50.3%
3.5	5.600	0.223	304	1270	65.4%	34.6%
6	3.353	0.132	251	1521	78.3%	21.7%
8	2.360	0.094	150	1671	86.0%	14.0%
10	1.999	0.079	63	1734	89.3%	10.7%
16	1.194	0.047	141	1875	96.5%	3.5%
20	0.838	0.033	35	1910	98.4%	1.6%
40	0.419	0.017	25	1935	99.6%	0.4%
60	0.254	0.010	3	1938	99.8%	0.2%
100	0.150	0.006	2	1940	99.9%	0.1%
Pan			2	1942	100.0%	0.0%
		Total	1942			
		Difference	0.9%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**5**		
Interval:	**110** **Feet**	**Pipe No.**	**22**

Initial Wt. **2022** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	875	875	43.3%	56.7%
3.5	5.600	0.223	403	1278	63.2%	36.8%
6	3.353	0.132	276	1554	76.9%	23.1%
8	2.360	0.094	147	1701	84.1%	15.9%
10	1.999	0.079	59	1760	87.0%	13.0%
16	1.194	0.047	154	1914	94.7%	5.3%
20	0.838	0.033	56	1970	97.4%	2.6%
40	0.419	0.017	41	2011	99.5%	0.5%
60	0.254	0.010	5	2016	99.7%	0.3%
100	0.150	0.006	2	2018	99.8%	0.2%
Pan			4	2022	100.0%	0.0%
		Total	2022	grams		
		Difference	0.0%			

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**5**		
Interval:	**120** **Feet**	**Pipe No.**	**24**

Initial Wt. **1890** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	602	602	31.9%	68.1%
3.5	5.600	0.223	470	1072	56.8%	43.2%
6	3.353	0.132	365	1437	76.2%	23.8%
8	2.360	0.094	170	1607	85.2%	14.8%
10	1.999	0.079	58	1665	88.2%	11.8%
16	1.194	0.047	133	1798	95.3%	4.7%
20	0.838	0.033	44	1842	97.6%	2.4%
40	0.419	0.017	38	1880	99.6%	0.4%
60	0.254	0.010	4	1884	99.8%	0.2%
100	0.150	0.006	2	1886	99.9%	0.1%
Pan			1	1887	100.0%	0.0%
		Total	1887			
		Difference	0.2%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**5**		
Interval:	**130** **Feet**	**Pipe No.**	**26**

Initial Wt. **1540** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	744	744	48.5%	51.5%
3.5	5.600	0.223	333	1077	70.2%	29.8%
6	3.353	0.132	199	1276	83.1%	16.9%
8	2.360	0.094	97	1373	89.4%	10.6%
10	1.999	0.079	35	1408	91.7%	8.3%
16	1.194	0.047	76	1484	96.7%	3.3%
20	0.838	0.033	25	1509	98.3%	1.7%
40	0.419	0.017	21	1530	99.7%	0.3%
60	0.254	0.010	2	1532	99.8%	0.2%
100	0.150	0.006	2	1534	99.9%	0.1%
Pan			1	1535	100.0%	0.0%
		Total	1535	grams		
		Difference	0.3%			

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**5**		
Interval:	**140** **Feet**	**Pipe No.**	**28**

Initial Wt. **1554** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	602	602	39.0%	61.0%
3.5	5.600	0.223	331	933	60.5%	39.5%
6	3.353	0.132	249	1182	76.7%	23.3%
8	2.360	0.094	124	1306	84.7%	15.3%
10	1.999	0.079	47	1353	87.7%	12.3%
16	1.194	0.047	106	1459	94.6%	5.4%
20	0.838	0.033	40	1499	97.2%	2.8%
40	0.419	0.017	38	1537	99.7%	0.3%
60	0.254	0.010	3	1540	99.9%	0.1%
100	0.150	0.006	1	1541	99.9%	0.1%
Pan			1	1542	100.0%	0.0%
		Total	1542			
		Difference	0.8%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client: **Humboldt Bay** **Job No.:** **14606**

Well Number: **Ranney Well #3**

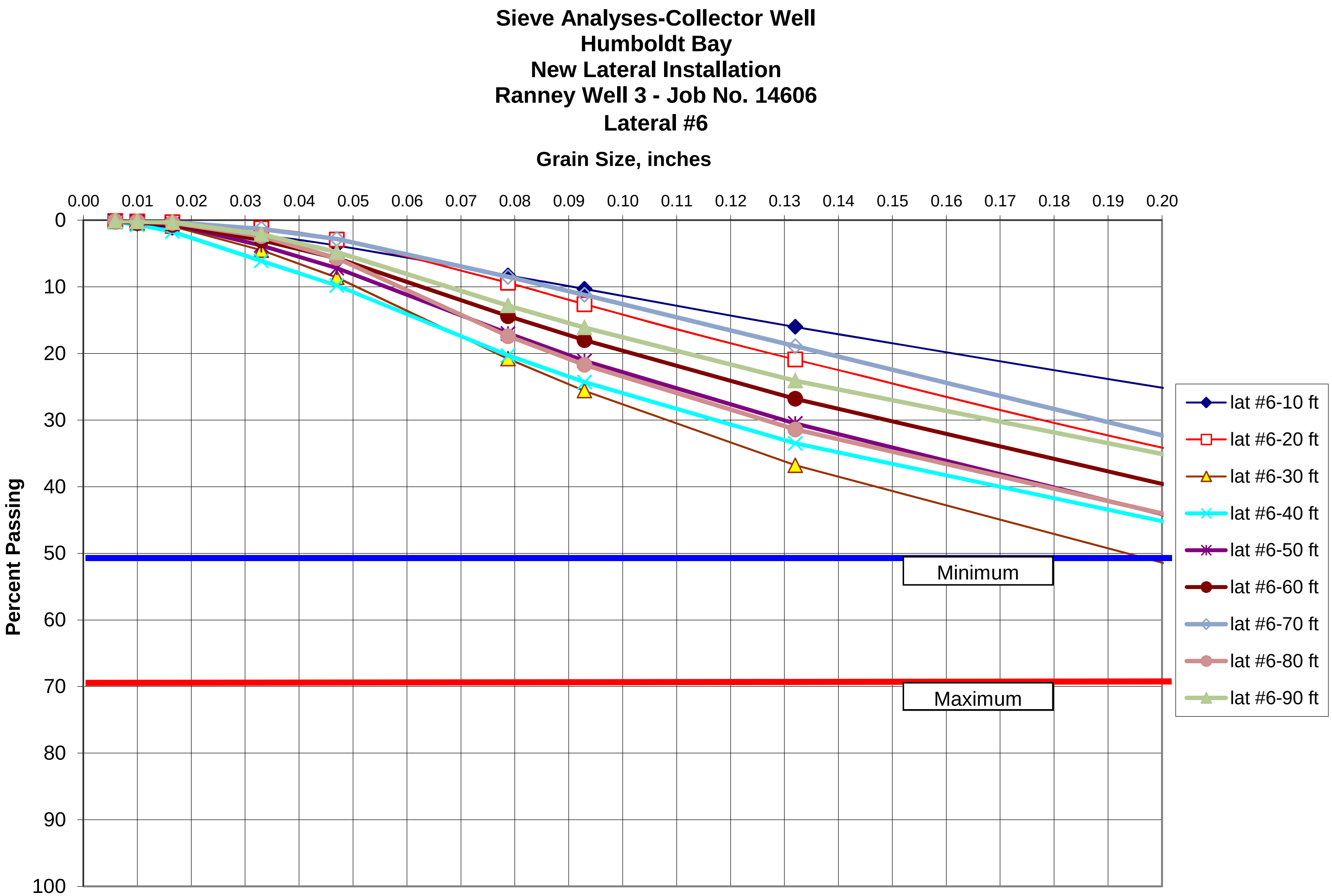
Lateral Number: **5**

Interval: **150** **Feet** **Pipe No.** **30**

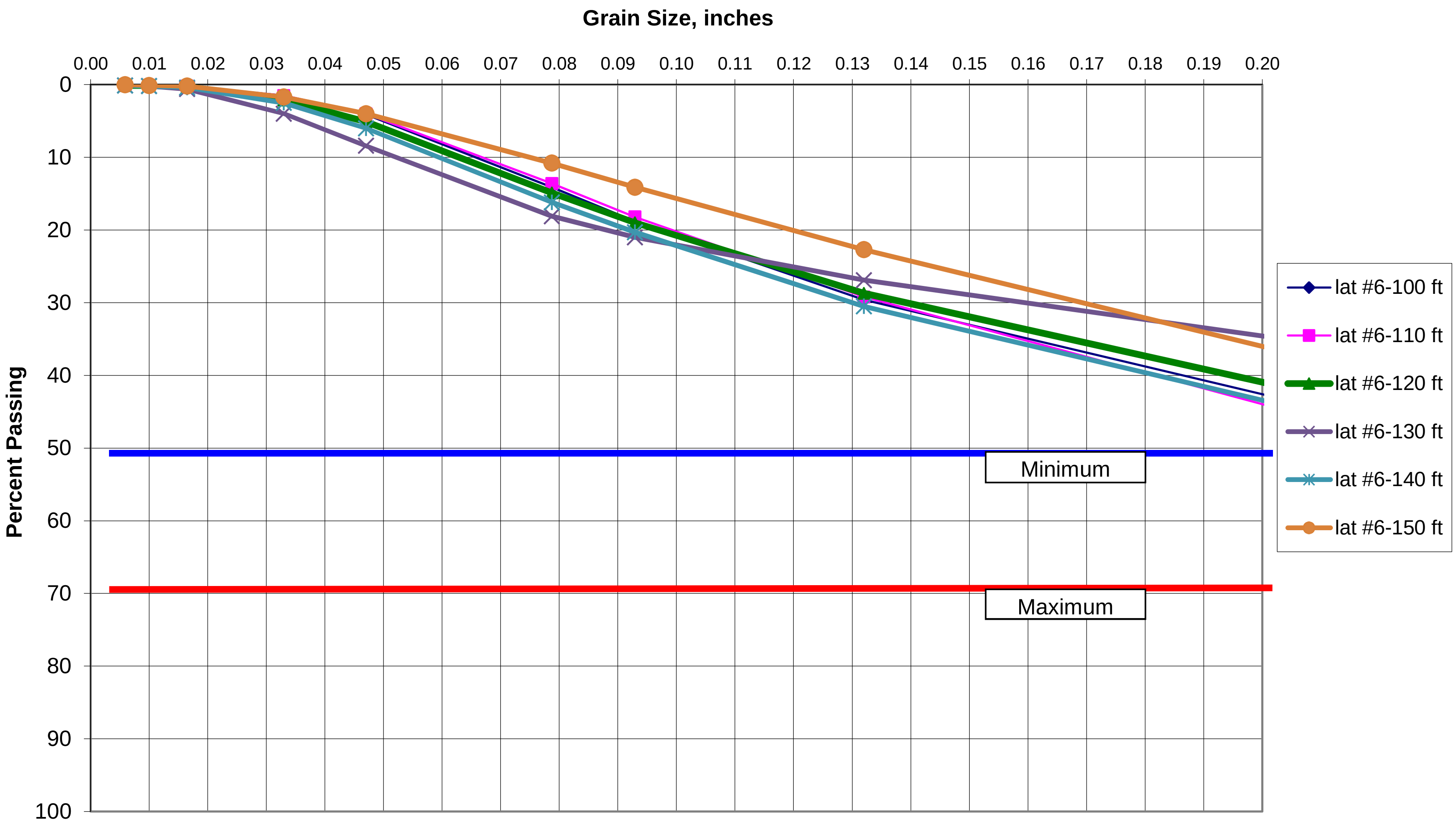
Initial Wt. **1955** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	681	681	34.9%	65.1%
3.5	5.600	0.223	417	1098	56.3%	43.7%
6	3.353	0.132	292	1390	71.2%	28.8%
8	2.360	0.094	167	1557	79.8%	20.2%
10	1.999	0.079	67	1624	83.2%	16.8%
16	1.194	0.047	175	1799	92.2%	7.8%
20	0.838	0.033	74	1873	96.0%	4.0%
40	0.419	0.017	71	1944	99.6%	0.4%
60	0.254	0.010	5	1949	99.9%	0.1%
100	0.150	0.006	1	1950	99.9%	0.1%
Pan			1	1951	100.0%	0.0%
		Total	1951	grams		
		Difference	0.2%			

Layne Ranney Collector Wells


Sieve Analyses-Collector Well
Humboldt Bay
New Lateral Installation
Ranney Well 3 - Job No. 14606
Lateral #6
Grain Size, inches
0.00 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.10 0.11 0.12 0.13 0.14 0.15 0.16 0.17 0.18 0.19 0.20
Percent Passing
0 10 20 30 40 50 60 70 80 90 100
Minimum
Maximum
lat #6-10 ft
lat #6-20 ft
lat #6-30 ft
lat #6-40 ft
lat #6-50 ft
lat #6-60 ft
lat #6-70 ft
lat #6-80 ft
lat #6-90 ft

Sieve Analyses-Collector Well
Humboldt Bay
New Lateral Installation
Ranney Well 3 - Job No. 14606
Lateral #6



Sieve Analysis Results

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**6**		
Interval:	**10**	**Feet**	**Pipe No.** **2**

Initial Wt. **1843** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	965	965	52.8%	47.2%
3.5	5.600	0.223	356	1321	72.2%	27.8%
6	3.353	0.132	216	1537	84.0%	16.0%
8	2.360	0.094	104	1641	89.7%	10.3%
10	1.999	0.079	37	1678	91.7%	8.3%
16	1.194	0.047	81	1759	96.2%	3.8%
20	0.838	0.033	28	1787	97.7%	2.3%
40	0.419	0.017	22	1809	98.9%	1.1%
60	0.254	0.010	11	1820	99.5%	0.5%
100	0.150	0.006	8	1828	99.9%	0.1%
Pan			1	1829	100.0%	0.0%
		Total	1829	grams		
		Difference	0.8%			

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**6**		
Interval:	**20**	**Feet**	**Pipe No.** **4**

Initial Wt. **2284** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	863	863	38.1%	61.9%
3.5	5.600	0.223	550	1413	62.3%	37.7%
6	3.353	0.132	381	1794	79.1%	20.9%
8	2.360	0.094	188	1982	87.4%	12.6%
10	1.999	0.079	72	2054	90.6%	9.4%
16	1.194	0.047	147	2201	97.1%	2.9%
20	0.838	0.033	39	2240	98.8%	1.2%
40	0.419	0.017	21	2261	99.7%	0.3%
60	0.254	0.010	2	2263	99.8%	0.2%
100	0.150	0.006	1	2264	99.9%	0.1%
Pan			3	2267	100.0%	0.0%
		Total	2267			
		Difference	0.7%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client: **Humboldt Bay** **Job No.:** **14606**
Well Number: **Ranney Well #3**
Lateral Number: **6**
Interval: **30** **Feet** **Pipe No.** **6**

Initial Wt. **2031** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	411	411	20.4%	79.6%
3.5	5.600	0.223	478	889	44.2%	55.8%
6	3.353	0.132	383	1272	63.2%	36.8%
8	2.360	0.094	226	1498	74.4%	25.6%
10	1.999	0.079	97	1595	79.2%	20.8%
16	1.194	0.047	244	1839	91.4%	8.6%
20	0.838	0.033	83	1922	95.5%	4.5%
40	0.419	0.017	72	1994	99.1%	0.9%
60	0.254	0.010	11	2005	99.6%	0.4%
100	0.150	0.006	4	2009	99.8%	0.2%
Pan			4	2013	100.0%	0.0%
		Total	2013	grams		
		Difference	0.9%			

Client: **Humboldt Bay** **Job No.:** **14606**
Well Number: **Ranney Well #3**
Lateral Number: **6**
Interval: **40** **Feet** **Pipe No.** **8**

Initial Wt. **2231** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	638	638	28.8%	71.2%
3.5	5.664	0.223	498	1136	51.3%	48.7%
6	3.353	0.132	337	1473	66.5%	33.5%
8	2.388	0.094	204	1677	75.7%	24.3%
10	1.999	0.079	89	1766	79.7%	20.3%
16	1.194	0.047	233	1999	90.2%	9.8%
20	0.838	0.033	81	2080	93.9%	6.1%
40	0.419	0.017	99	2179	98.3%	1.7%
60	0.254	0.010	22	2201	99.3%	0.7%
100	0.150	0.006	8	2209	99.7%	0.3%
Pan			7	2216	100.0%	0.0%
		Total	2216			
		Difference	0.7%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client: **Humboldt Bay** **Job No.:** **14606**
Well Number: **Ranney Well #3**
Lateral Number: **6**
Interval: **50** **Feet** **Pipe No.** **10**

Initial Wt. **2031** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	628	628	31.1%	68.9%
3.5	5.600	0.223	418	1046	51.8%	48.2%
6	3.353	0.132	357	1403	69.5%	30.5%
8	2.360	0.094	191	1594	78.9%	21.1%
10	1.999	0.079	82	1676	83.0%	17.0%
16	1.194	0.047	198	1874	92.8%	7.2%
20	0.838	0.033	70	1944	96.2%	3.8%
40	0.419	0.017	63	2007	99.4%	0.6%
60	0.254	0.010	8	2015	99.8%	0.2%
100	0.150	0.006	3	2018	99.9%	0.1%
Pan			2	2020	100.0%	0.0%
		Total	2020	grams		
		Difference	0.5%			

Client: **Humboldt Bay** **Job No.:** **14606**
Well Number: **Ranney Well #3**
Lateral Number: **6**
Interval: **60** **Feet** **Pipe No.** **12**

Initial Wt. **2005** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	646	646	32.4%	67.6%
3.5	5.600	0.223	484	1130	56.6%	43.4%
6	3.353	0.132	331	1461	73.2%	26.8%
8	2.360	0.094	175	1636	82.0%	18.0%
10	1.999	0.079	73	1709	85.6%	14.4%
16	1.194	0.047	173	1882	94.3%	5.7%
20	0.838	0.033	55	1937	97.0%	3.0%
40	0.419	0.017	45	1982	99.3%	0.7%
60	0.254	0.010	7	1989	99.6%	0.4%
100	0.150	0.006	3	1992	99.8%	0.2%
Pan			4	1996	100.0%	0.0%
		Total	1996			
		Difference	0.4%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**6**		
Interval:	**70** **Feet**	**Pipe No.**	**14**

Initial Wt. **1752** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	635	635	36.5%	63.5%
3.5	5.600	0.223	473	1108	63.7%	36.3%
6	3.353	0.132	303	1411	81.1%	18.9%
8	2.360	0.094	133	1544	88.8%	11.2%
10	1.999	0.079	48	1592	91.5%	8.5%
16	1.194	0.047	99	1691	97.2%	2.8%
20	0.838	0.033	26	1717	98.7%	1.3%
40	0.419	0.017	16	1733	99.7%	0.3%
60	0.254	0.010	3	1736	99.8%	0.2%
100	0.150	0.006	1	1737	99.9%	0.1%
Pan			2	1739	100.0%	0.0%
		Total	1739	grams		
		Difference	0.7%			

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**6**		
Interval:	**80** **Feet**	**Pipe No.**	**16**

Initial Wt. **1750** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	533	533	30.6%	69.4%
3.5	5.600	0.223	375	908	52.2%	47.8%
6	3.353	0.132	285	1193	68.6%	31.4%
8	2.360	0.094	169	1362	78.3%	21.7%
10	1.999	0.079	76	1438	82.6%	17.4%
16	1.194	0.047	203	1641	94.3%	5.7%
20	0.838	0.033	58	1699	97.6%	2.4%
40	0.419	0.017	34	1733	99.6%	0.4%
60	0.254	0.010	4	1737	99.8%	0.2%
100	0.150	0.006	1	1738	99.9%	0.1%
Pan			2	1740	100.0%	0.0%
		Total	1740			
		Difference	0.6%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**6**		
Interval:	**90**	**Feet**	**Pipe No.** **18**

Initial Wt. **1772** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	690	690	39.1%	60.9%
3.5	5.600	0.223	396	1086	61.6%	38.4%
6	3.353	0.132	253	1339	75.9%	24.1%
8	2.360	0.094	141	1480	83.9%	16.1%
10	1.999	0.079	58	1538	87.2%	12.8%
16	1.194	0.047	142	1680	95.2%	4.8%
20	0.838	0.033	47	1727	97.9%	2.1%
40	0.419	0.017	31	1758	99.7%	0.3%
60	0.254	0.010	3	1761	99.8%	0.2%
100	0.150	0.006	1	1762	99.9%	0.1%
Pan			2	1764	100.0%	0.0%
		Total	1764	grams		
		Difference	0.5%			

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**6**		
Interval:	**100**	**Feet**	**Pipe No.** **20**

Initial Wt. **1771** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	675	675	38.3%	61.7%
3.5	5.600	0.223	268	943	53.5%	46.5%
6	3.353	0.132	296	1239	70.4%	29.6%
8	2.360	0.094	191	1430	81.2%	18.8%
10	1.999	0.079	82	1512	85.9%	14.1%
16	1.194	0.047	177	1689	95.9%	4.1%
20	0.838	0.033	45	1734	98.5%	1.5%
40	0.419	0.017	23	1757	99.8%	0.2%
60	0.254	0.010	2	1759	99.9%	0.1%
100	0.150	0.006	1	1760	99.9%	0.1%
Pan			1	1761	100.0%	0.0%
		Total	1761			
		Difference	0.6%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**6**		
Interval:	**110** **Feet**	**Pipe No.**	**22**

Initial Wt. **1917** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	560	560	29.3%	70.7%
3.5	5.600	0.223	425	985	51.6%	48.4%
6	3.353	0.132	366	1351	70.8%	29.2%
8	2.360	0.094	210	1561	81.8%	18.2%
10	1.999	0.079	88	1649	86.4%	13.6%
16	1.194	0.047	183	1832	96.0%	4.0%
20	0.838	0.033	48	1880	98.5%	1.5%
40	0.419	0.017	25	1905	99.8%	0.2%
60	0.254	0.010	2	1907	99.9%	0.1%
100	0.150	0.006	1	1908	99.9%	0.1%
Pan			1	1909	100.0%	0.0%
		Total	1909	grams		
		Difference	0.4%			

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**6**		
Interval:	**120** **Feet**	**Pipe No.**	**24**

Initial Wt. **1874** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	661	661	35.4%	64.6%
3.5	5.600	0.223	374	1035	55.4%	44.6%
6	3.353	0.132	297	1332	71.3%	28.7%
8	2.360	0.094	180	1512	81.0%	19.0%
10	1.999	0.079	76	1588	85.1%	14.9%
16	1.194	0.047	183	1771	94.9%	5.1%
20	0.838	0.033	57	1828	97.9%	2.1%
40	0.419	0.017	34	1862	99.7%	0.3%
60	0.254	0.010	3	1865	99.9%	0.1%
100	0.150	0.006	1	1866	99.9%	0.1%
Pan			1	1867	100.0%	0.0%
		Total	1867			
		Difference	0.4%			

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Ranney Collector Wells

Sieve Analysis Results

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**6**		
Interval:	**130**	**Feet**	**Pipe No.** **26**

Initial Wt. **1732** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	850	850	49.4%	50.6%
3.5	5.600	0.223	235	1085	63.1%	36.9%
6	3.353	0.132	172	1257	73.1%	26.9%
8	2.360	0.094	102	1359	79.0%	21.0%
10	1.999	0.079	50	1409	81.9%	18.1%
16	1.194	0.047	166	1575	91.6%	8.4%
20	0.838	0.033	76	1651	96.0%	4.0%
40	0.419	0.017	59	1710	99.4%	0.6%
60	0.254	0.010	7	1717	99.8%	0.2%
100	0.150	0.006	2	1719	99.9%	0.1%
Pan			1	1720	100.0%	0.0%
		Total	1720	grams		
		Difference	0.7%			

Client:	**Humboldt Bay**	**Job No.:**	**14606**
Well Number:	**Ranney Well #3**		
Lateral Number:	**6**		
Interval:	**140**	**Feet**	**Pipe No.** **28**

Initial Wt. **2025** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	704	704	34.8%	65.2%
3.5	5.600	0.223	361	1065	52.7%	47.3%
6	3.353	0.132	339	1404	69.5%	30.5%
8	2.360	0.094	206	1610	79.7%	20.3%
10	1.999	0.079	83	1693	83.8%	16.2%
16	1.194	0.047	207	1900	94.0%	6.0%
20	0.838	0.033	70	1970	97.5%	2.5%
40	0.419	0.017	43	2013	99.6%	0.4%
60	0.254	0.010	4	2017	99.8%	0.2%
100	0.150	0.006	2	2019	99.9%	0.1%
Pan			2	2021	100.0%	0.0%
		Total	2021			
		Difference	0.2%			

Layne
Ranney Collector Wells

Sieve Analysis Results

Client: **Humboldt Bay** **Job No.:** **14606**

Well Number: **Ranney Well #3**

Lateral Number: **6**

Interval: **150** **Feet** **Pipe No.** **30**

Initial Wt. **2095** grams

Sieve No.	Sieve size (mm)	Sieve size (inches)	Weight Retained (grams)	Cumulative Weight (grams)	Cumulative % Retained	Cumulative % Passing
3/8	9.525	0.375	732	732	34.9%	65.1%
3.5	5.600	0.223	525	1257	60.0%	40.0%
6	3.353	0.132	362	1619	77.3%	22.7%
8	2.360	0.094	181	1800	85.9%	14.1%
10	1.999	0.079	69	1869	89.2%	10.8%
16	1.194	0.047	143	2012	96.0%	4.0%
20	0.838	0.033	48	2060	98.3%	1.7%
40	0.419	0.017	30	2090	99.8%	0.2%
60	0.254	0.010	3	2093	99.9%	0.1%
100	0.150	0.006	1	2094	100.0%	0.0%
Pan			1	2095	100.0%	0.0%
		Total	2095	grams		
		Difference	0.0%			

Layne
Ranney Collector Wells

APPENDIX B
PRE-MAINTENANCE TESTING DATA

Humboldt Bay Municipal Water District Ranney Collector No. 3 Job No. : 14606
Pre-Maintenance Test Transducer Data

Date/Time	Ranney Collector No. 3 Depth to Water (feet)	Ranney Collector No. 3 Water Temperature (degrees F)	MW-1 Depth to Water (feet)	MW-1 Water Temperature (degrees F)	MW-7 Depth to Water (feet)	MW-7 Water Temperature (degrees F)	MW-2 Depth to Water (feet)	MW-2 Water Temperature (degrees F)	SCADA River Elevation (feet)
12/5/11 0:01									21.76
12/5/11 1:00									21.79
12/5/11 2:00									21.77
12/5/11 3:00									21.78
12/5/11 4:00									21.77
12/5/11 5:00									21.77
12/5/11 6:00									21.80
12/5/11 7:00									21.77
12/5/11 8:00									21.75
12/5/11 9:00									21.76
12/5/11 10:00									21.74
12/5/11 11:00									21.74
12/5/11 12:00									21.74
12/5/11 13:00									21.74
12/5/11 14:00									21.77
12/5/11 15:00									21.77
12/5/11 15:51	32.28	55.76			24.31	61.08			21.76
12/5/11 15:52	37.17	55.76			25.76	61.08			21.75
12/5/11 15:53	38.86	55.78			26.75	61.08			21.77
12/5/11 15:54	37.86	55.80			26.74	61.06			21.76
12/5/11 15:55	39.11	55.80			27.14	61.03			21.76
12/5/11 15:56	38.90	55.80			27.23	61.01			21.77
12/5/11 15:57	38.81	55.83			27.26	61.01			21.76
12/5/11 15:58	38.90	55.83			27.29	60.99			21.75
12/5/11 15:59	36.51	55.83			26.97	60.99			21.74
12/5/11 16:00	34.45	55.80			26.34	60.99			21.76
12/5/11 16:01	32.84	55.69			25.76	60.97			21.74
12/5/11 16:02	31.70	55.64			25.30	60.97			21.76
12/5/11 16:03	30.84	55.62			24.93	60.97			21.75
12/5/11 16:04	30.20	55.60			24.65	60.97			21.77
12/5/11 16:05	29.72	55.60			24.41	60.94			21.77
12/5/11 16:06	29.37	55.58			24.24	60.94			21.77
12/5/11 16:07	29.12	55.58			24.11	60.94			21.77
12/5/11 16:08	28.93	55.60			24.01	60.94			21.75
12/5/11 16:09	28.79	55.60			23.92	60.94			21.75
12/5/11 16:10	28.68	55.60			23.87	60.94			21.76
12/5/11 16:11	28.61	55.60			23.82	60.94			21.75
12/5/11 16:12	28.55	55.60			23.78	60.94			21.77
12/5/11 17:00	28.42	55.60	23.87	52.32	23.78	60.99			21.77
12/5/11 18:00	28.04	55.62	23.30	52.25	23.58	61.15			21.75
12/5/11 19:00	28.08	55.62	23.45	52.30	23.58	61.26			21.74
12/5/11 20:00	28.27	55.64	23.68	52.30	23.68	61.19			21.71
12/5/11 21:00	28.33	55.64	23.76	52.27	23.73	61.22			21.70
12/5/11 22:00	28.37	55.64	23.76	52.25	23.76	61.17			21.69
12/5/11 23:00	27.89	55.64	23.11	52.21	23.50	61.33			21.69
12/6/11 0:00	27.73	55.64	22.89	52.18	23.39	61.35			21.71
12/6/11 1:00	27.62	55.64	22.76	52.18	23.32	61.35			21.70
12/6/11 2:00	27.55	55.67	22.66	52.21	23.27	61.37			21.72
12/6/11 3:00	27.50	55.64	22.59	52.21	23.23	61.37			21.70
12/6/11 4:00	27.45	55.67	22.54	52.21	23.21	61.40			21.71
12/6/11 5:00	27.25	55.67	22.37	52.18	22.94	61.40			21.72
12/6/11 6:00	27.14	55.64	22.27	52.16	22.80	61.40			21.71
12/6/11 7:00	27.06	55.64	22.20	52.16	22.71	61.42			21.70
12/6/11 7:50			22.80	52.30	22.88	61.15			21.69
12/6/11 7:54	27.47	55.64	22.85	52.30	22.90	61.17			21.68
12/6/11 8:00	27.51	55.64	22.88	52.30	22.91	61.10			21.68
12/6/11 8:40	27.61	55.64	23.01	52.27	22.97	61.15	20.47		21.68
12/6/11 8:41	27.61	55.64	23.02	52.27	22.98	61.15	20.47		21.69
12/6/11 8:42	27.62	55.62	23.02	52.27	22.98	61.12	20.47		21.69
12/6/11 8:43	27.62	55.64	23.02	52.27	22.98	61.15	20.48		21.69
12/6/11 8:44	27.62	55.64	23.02	52.27	22.97	61.17	20.48		21.69
12/6/11 8:45	27.62	55.62	23.02	52.27	22.98	61.17	20.48		21.69

	Ranney Collector No. 3		MW-1		MW-7		MW-2		SCADA
Date/Time	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	River Elevation (feet)
12/6/11 8:46	27.62	55.62	23.03	52.27	22.99	61.15	20.48		21.69
12/6/11 8:47	27.62	55.62	23.03	52.27	22.98	61.12	20.48		21.68
12/6/11 8:48	27.62	55.62	23.03	52.27	22.99	61.15	20.48		21.67
12/6/11 8:49	27.63	55.64	23.03	52.27	22.98	61.15	20.48		21.68
12/6/11 8:50	27.64	55.64	23.03	52.27	22.99	61.15	20.48		21.70
12/6/11 8:51	29.93	55.64	23.97	52.30	23.62	61.12	20.54		21.69
12/6/11 8:52	31.37	55.64	24.73	52.45	24.14	61.24	20.63		21.68
12/6/11 8:53	32.61	55.64	25.41	52.48	24.61	61.33	20.72		21.68
12/6/11 8:54	33.64	55.64	25.96	52.48	25.00	61.35	20.79		21.68
12/6/11 8:55	34.42	55.64	26.40	52.45	25.31	61.35	20.86		21.71
12/6/11 8:56	35.06	55.58	26.76	52.43	25.56	61.35	20.92		21.68
12/6/11 8:57	35.52	55.60	27.04	52.41	25.77	61.35	20.98		21.68
12/6/11 8:58	35.91	55.58	27.26	52.39	25.93	61.33	21.03		21.68
12/6/11 8:59	36.24	55.53	27.45	52.36	26.07	61.33	21.07		21.70
12/6/11 9:00	36.48	55.46	27.60	52.34	26.18	61.33	21.11		21.68
12/6/11 9:01	36.71	55.39	27.72	52.32	26.28	61.33	21.16		21.69
12/6/11 9:02	36.89	55.39	27.82	52.32	26.37	61.31	21.18		21.68
12/6/11 9:03	37.03	55.42	27.88	52.30	26.44	61.31	21.22		21.68
12/6/11 9:04	37.17	55.39	27.97	52.30	26.50	61.31	21.25		21.70
12/6/11 9:05	37.27	55.39	28.19	52.27	26.55	61.28	21.28		21.68
12/6/11 9:06	37.35	55.37	28.27	52.27	26.60	61.28	21.30		21.68
12/6/11 9:07	37.44	55.37	28.33	52.27	26.65	61.28	21.33		21.68
12/6/11 9:08	37.51	55.37	28.38	52.27	26.68	61.26	21.36		21.69
12/6/11 9:09	37.55	55.37	28.44	52.27	26.72	61.26	21.38		21.66
12/6/11 9:10	37.62	55.39	28.48	52.27	26.75	61.24	21.40		21.68
12/6/11 9:11	37.65	55.42	28.51	52.27	26.78	61.24	21.42		21.69
12/6/11 9:12	37.69	55.42	28.54	52.30	26.80	61.24	21.44		21.68
12/6/11 9:13	37.72	55.42	28.57	52.32	26.83	61.24	21.46		21.67
12/6/11 9:14	37.76	55.42	28.60	52.32	26.85	61.22	21.49		21.68
12/6/11 9:15	37.79	55.44	28.62	52.34	26.88	61.22	21.51		21.67
12/6/11 9:16	37.84	55.46	28.64	52.34	26.92	61.19	21.52		21.67
12/6/11 9:17	37.84	55.46	28.67	52.34	26.96	61.19	21.54		21.67
12/6/11 9:18	37.87	55.49	28.70	52.34	27.00	61.19	21.56		21.69
12/6/11 9:19	37.88	55.49	28.73	52.34	27.04	61.17	21.59		21.67
12/6/11 9:20	37.93	55.49	28.76	52.36	27.08	61.17	21.60		21.69
12/6/11 9:21	38.20	55.51	28.84	52.34	27.14	61.17	21.62		21.69
12/6/11 9:22	38.45	55.51	28.99	52.36	27.25	61.15	21.65		21.68
12/6/11 9:23	38.36	55.53	29.02	52.36	27.28	61.15	21.66		21.68
12/6/11 9:24	38.27	55.53	29.00	52.36	27.29	61.15	21.68		21.67
12/6/11 9:25	38.22	55.55	28.99	52.39	27.29	61.12	21.70		21.68
12/6/11 9:26	38.20	55.55	28.97	52.41	27.30	61.12	21.72		21.69
12/6/11 9:27	38.17	55.55	28.97	52.41	27.30	61.10	21.73		21.68
12/6/11 9:28	38.17	55.58	28.97	52.41	27.31	61.10	21.75		21.68
12/6/11 9:29	38.15	55.58	28.97	52.43	27.32	61.10	21.76		21.69
12/6/11 9:30	38.15	55.58	28.98	52.43	27.34	61.10	21.78		21.68
12/6/11 9:31	38.16	55.60	28.98	52.43	27.34	61.08	21.79		21.67
12/6/11 9:32	38.14	55.60	28.99	52.43	27.36	61.08	21.80		21.67
12/6/11 9:33	38.15	55.62	29.00	52.43	27.37	61.08	21.81		21.67
12/6/11 9:34	38.15	55.64	29.01	52.43	27.38	61.06	21.83		21.67
12/6/11 9:35	38.16	55.62	29.01	52.45	27.40	61.06	21.85		21.66
12/6/11 9:36	38.19	55.62	29.03	52.45	27.42	61.06	21.86		21.68
12/6/11 9:37	38.21	55.64	29.04	52.45	27.42	61.03	21.87		21.69
12/6/11 9:38	38.20	55.67	29.05	52.45	27.44	61.03	21.89		21.67
12/6/11 9:39	38.21	55.64	29.07	52.48	27.45	61.03	21.90		21.66
12/6/11 9:40	38.23	55.67	29.08	52.48	27.47	61.03	21.91		21.68
12/6/11 9:41	38.23	55.67	29.09	52.50	27.49	61.01	21.93		21.66
12/6/11 9:42	38.24	55.69	29.10	52.50	27.50	61.01	21.94		21.66
12/6/11 9:43	38.27	55.64	29.11	52.50	27.51	61.01	21.95		21.66
12/6/11 9:44	38.27	55.67	29.13	52.52	27.52	60.99	21.96		21.67
12/6/11 9:45	38.31	55.69	29.14	52.52	27.54	60.99	21.97		21.68
12/6/11 9:46	38.29	55.69	29.15	52.52	27.55	60.99	21.98		21.67
12/6/11 9:47	38.30	55.71	29.16	52.52	27.57	60.99	22.00		21.67

	Ranney Collector No. 3		MW-1		MW-7		MW-2		SCADA
Date/Time	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	River Elevation (feet)
12/6/11 9:48	38.32	55.71	29.18	52.52	27.58	60.97	22.01		21.67
12/6/11 9:49	38.35	55.69	29.19	52.50	27.59	60.97	22.03		21.68
12/6/11 9:50	38.42	55.71	29.20	52.50	27.61	60.97	22.04		21.66
12/6/11 9:51	39.59	55.69	29.57	52.50	27.82	60.97	22.06		21.68
12/6/11 9:52	40.54	55.73	30.02	52.48	28.10	60.94	22.09		21.68
12/6/11 9:53	41.34	55.71	30.42	52.43	28.36	60.94	22.13		21.68
12/6/11 9:54	42.01	55.73	30.77	52.41	28.59	60.94	22.18		21.68
12/6/11 9:55	42.57	55.76	31.06	52.41	28.78	60.94	22.22		21.66
12/6/11 9:56	43.04	55.76	31.32	52.41	28.96	60.92	22.25		21.68
12/6/11 9:57	43.42	55.78	31.53	52.41	29.10	60.92	22.29		21.68
12/6/11 9:58	43.75	55.80	31.71	52.43	29.24	60.92	22.33		21.67
12/6/11 9:59	44.02	55.78	31.86	52.43	29.34	60.90	22.36		21.68
12/6/11 10:00	44.25	55.80	31.99	52.45	29.44	60.90	22.39		21.68
12/6/11 10:01	44.44	55.80	32.10	52.45	29.52	60.90	22.41		21.67
12/6/11 10:02	44.61	55.80	32.21	52.48	29.60	60.90	22.44		21.68
12/6/11 10:03	44.76	55.83	32.31	52.50	29.66	60.88	22.47		21.67
12/6/11 10:04	44.88	55.83	32.38	52.50	29.72	60.88	22.50		21.66
12/6/11 10:05	44.98	55.83	32.44	52.52	29.77	60.88	22.52		21.68
12/6/11 10:06	45.08	55.85	32.50	52.55	29.82	60.85	22.54		21.68
12/6/11 10:07	45.15	55.87	32.56	52.55	29.87	60.85	22.57		21.68
12/6/11 10:08	45.23	55.89	32.61	52.57	29.90	60.85	22.60		21.66
12/6/11 10:09	45.28	55.89	32.65	52.59	29.94	60.83	22.62		21.67
12/6/11 10:10	45.34	55.92	32.69	52.61	29.97	60.83	22.64		21.67
12/6/11 10:11	45.40	55.92	32.73	52.64	30.01	60.83	22.66		21.67
12/6/11 10:12	45.44	55.92	32.75	52.64	30.04	60.83	22.68		21.67
12/6/11 10:13	45.48	55.94	32.77	52.66	30.06	60.81	22.70		21.68
12/6/11 10:14	45.52	55.94	32.81	52.68	30.09	60.81	22.72		21.67
12/6/11 10:15	45.55	55.94	32.83	52.70	30.11	60.81	22.75		21.69
12/6/11 10:16	45.58	55.96	32.86	52.73	30.14	60.79	22.76		21.68
12/6/11 10:17	45.61	55.96	32.89	52.75	30.16	60.79	22.78		21.68
12/6/11 10:18	45.63	55.98	32.90	52.75	30.19	60.79	22.80		21.67
12/6/11 10:19	45.66	55.98	32.92	52.77	30.21	60.79	22.82		21.67
12/6/11 10:20	45.69	56.01	32.95	52.79	30.23	60.79	22.85		21.68
12/6/11 10:21	45.71	56.01	32.96	52.82	30.25	60.76	22.87		21.67
12/6/11 10:22	45.73	56.03	32.98	52.84	30.27	60.76	22.88		21.67
12/6/11 10:23	45.75	56.01	32.99	52.86	30.29	60.76	22.90		21.68
12/6/11 10:24	45.77	56.01	33.02	52.86	30.31	60.76	22.92		21.68
12/6/11 10:25	45.78	56.03	33.04	52.88	30.33	60.74	22.94		21.66
12/6/11 10:26	45.80	56.05	33.05	52.91	30.35	60.74	22.96		21.66
12/6/11 10:27	45.82	56.05	33.07	52.93	30.37	60.74	22.97		21.68
12/6/11 10:28	45.84	56.03	33.08	52.93	30.39	60.74	22.99		21.66
12/6/11 10:29	45.86	56.05	33.10	52.95	30.40	60.74	23.01		21.68
12/6/11 10:30	45.87	56.05	33.12	52.97	30.42	60.72	23.03		21.69
12/6/11 10:31	45.89	56.05	33.13	53.00	30.44	60.72	23.05		21.66
12/6/11 10:32	45.91	56.08	33.14	53.02	30.45	60.72	23.07		21.68
12/6/11 10:33	45.93	56.08	33.16	53.02	30.47	60.72	23.08		21.67
12/6/11 10:34	45.94	56.10	33.17	53.04	30.49	60.70	23.10		21.69
12/6/11 10:35	45.96	56.10	33.19	53.06	30.50	60.70	23.11		21.66
12/6/11 10:36	45.97	56.12	33.21	53.06	30.52	60.70	23.13		21.67
12/6/11 10:37	45.98	56.12	33.22	53.09	30.54	60.70	23.14		21.67
12/6/11 10:38	45.97	56.10	33.22	53.11	30.55	60.70	23.17		21.68
12/6/11 10:39	45.99	56.10	33.24	53.13	30.57	60.67	23.18		21.68
12/6/11 10:40	46.01	56.12	33.25	53.16	30.58	60.67	23.19		21.67
12/6/11 10:41	46.03	56.10	33.27	53.16	30.60	60.67	23.21		21.68
12/6/11 10:42	46.05	56.10	33.27	53.18	30.62	60.67	23.23		21.68
12/6/11 10:43	46.06	56.12	33.29	53.20	30.63	60.65	23.24		21.67
12/6/11 10:44	46.08	56.12	33.30	53.20	30.65	60.65	23.26		21.69
12/6/11 10:45	46.11	56.12	33.29	53.22	30.65	60.65	23.27		21.67
12/6/11 10:46	46.13	56.14	33.31	53.25	30.67	60.65	23.29		21.67
12/6/11 10:47	46.15	56.17	33.32	53.27	30.68	60.65	23.30		21.66
12/6/11 10:48	46.15	56.17	33.36	53.27	30.71	60.63	23.32		21.66
12/6/11 10:49	46.16	56.14	33.38	53.29	30.73	60.63	23.33		21.67

Date/Time	Ranney Collector No. 3 Depth to Water (feet)	Ranney Collector No. 3 Water Temperature (degrees F)	MW-1 Depth to Water (feet)	MW-1 Water Temperature (degrees F)	MW-7 Depth to Water (feet)	MW-7 Water Temperature (degrees F)	MW-2 Depth to Water (feet)	MW-2 Water Temperature (degrees F)	SCADA River Elevation (feet)
12/6/11 10:50	46.17	56.14	33.38	53.31	30.74	60.63	23.35		21.68
12/6/11 10:51	46.18	56.17	33.40	53.31	30.76	60.63	23.35		21.68
12/6/11 10:52	46.20	56.17	33.40	53.34	30.77	60.63	23.37		21.69
12/6/11 10:53	46.21	56.19	33.41	53.36	30.78	60.63	23.38		21.68
12/6/11 10:54	46.22	56.19	33.43	53.36	30.80	60.61	23.40		21.67
12/6/11 10:55	46.23	56.19	33.44	53.38	30.81	60.61	23.41		21.68
12/6/11 10:56	46.24	56.21	33.45	53.40	30.82	60.61	23.43		21.68
12/6/11 10:57	46.26	56.23	33.46	53.43	30.83	60.61	23.44		21.67
12/6/11 10:58	46.27	56.21	33.47	53.43	30.85	60.61	23.45		21.67
12/6/11 10:59	46.28	56.21	33.49	53.45	30.86	60.61	23.47		21.68
12/6/11 11:00	46.29	56.21	33.50	53.47	30.88	60.61	23.48		21.67
12/6/11 11:01	46.29	56.23	33.51	53.47	30.89	60.58	23.49		21.67
12/6/11 11:02	46.31	56.23	33.53	53.49	30.90	60.58	23.51		21.69
12/6/11 11:03	46.32	56.26	33.53	53.52	30.92	60.58	23.52		21.68
12/6/11 11:04	46.34	56.26	33.55	53.52	30.93	60.58	23.53		21.68
12/6/11 11:05	46.37	56.26	33.57	53.54	30.95	60.58	23.55		21.68
12/6/11 11:06	46.37	56.26	33.57	53.56	30.96	60.58	23.56		21.70
12/6/11 11:07	46.38	56.26	33.59	53.56	30.97	60.56	23.57		21.68
12/6/11 11:08	46.39	56.26	33.59	53.58	30.99	60.56	23.58		21.67
12/6/11 11:09	46.40	56.28	33.60	53.61	31.00	60.56	23.60		21.67
12/6/11 11:10	46.41	56.28	33.61	53.61	31.01	60.56	23.61		21.68
12/6/11 11:11	46.41	56.30	33.63	53.63	31.02	60.56	23.63		21.68
12/6/11 11:12	46.42	56.30	33.63	53.63	31.04	60.56	23.63		21.69
12/6/11 11:13	46.43	56.30	33.63	53.65	31.04	60.56	23.65		21.67
12/6/11 11:14	46.44	56.30	33.65	53.68	31.05	60.54	23.66		21.68
12/6/11 11:15	46.44	56.32	33.66	53.68	31.07	60.54	23.67		21.67
12/6/11 11:16	46.46	56.32	33.67	53.70	31.08	60.54	23.69		21.66
12/6/11 11:17	46.46	56.32	33.68	53.72	31.09	60.54	23.70		21.69
12/6/11 11:18	46.47	56.32	33.69	53.72	31.11	60.54	23.71		21.68
12/6/11 11:19	46.48	56.32	33.70	53.74	31.12	60.54	23.72		21.68
12/6/11 11:20	46.97	56.35	33.78	53.74	31.16	60.54	23.73		21.69
12/6/11 11:21	48.11	56.35	34.20	53.77	31.40	60.54	23.75		21.66
12/6/11 11:22	49.07	56.35	34.64	53.81	31.67	60.52	23.78		21.68
12/6/11 11:23	49.86	56.35	35.04	53.83	31.91	60.52	23.82		21.67
12/6/11 11:24	50.53	56.37	35.37	53.86	32.13	60.52	23.85		21.67
12/6/11 11:25	51.09	56.37	35.65	53.88	32.31	60.52	23.88		21.68
12/6/11 11:26	51.56	56.35	35.90	53.90	32.47	60.52	23.91		21.67
12/6/11 11:27	51.96	56.35	36.12	53.92	32.62	60.52	23.94		21.66
12/6/11 11:28	52.31	56.37	36.29	53.95	32.74	60.52	23.97		21.67
12/6/11 11:29	52.59	56.37	36.45	53.97	32.85	60.52	24.00		21.66
12/6/11 11:30	52.84	56.37	36.58	53.99	32.94	60.49	24.02		21.68
12/6/11 11:31	53.06	56.39	36.70	54.01	33.02	60.49	24.05		21.68
12/6/11 11:32	53.25	56.42	36.81	54.04	33.10	60.49	24.07		21.67
12/6/11 11:33	53.41	56.42	36.89	54.06	33.18	60.49	24.11		21.67
12/6/11 11:34	53.55	56.44	36.98	54.08	33.23	60.49	24.13		21.67
12/6/11 11:35	53.67	56.44	37.05	54.08	33.29	60.49	24.15		21.68
12/6/11 11:36	53.78	56.44	37.11	54.10	33.34	60.49	24.18		21.68
12/6/11 11:37	53.88	56.44	37.18	54.13	33.39	60.47	24.20		21.68
12/6/11 11:38	53.96	56.46	37.22	54.15	33.44	60.47	24.22		21.68
12/6/11 11:39	54.04	56.46	37.27	54.17	33.48	60.47	24.24		21.66
12/6/11 11:40	54.10	56.46	37.32	54.19	33.51	60.47	24.26		21.68
12/6/11 11:41	54.16	56.48	37.36	54.22	33.55	60.47	24.29		21.68
12/6/11 11:42	54.22	56.48	37.39	54.24	33.58	60.47	24.31		21.67
12/6/11 11:43	54.27	56.51	37.41	54.24	33.62	60.45	24.33		21.69
12/6/11 11:44	54.31	56.51	37.47	54.26	33.65	60.45	24.36		21.68
12/6/11 11:45	54.35	56.51	37.48	54.29	33.68	60.45	24.38		21.68
12/6/11 11:46	54.39	56.51	37.51	54.31	33.71	60.45	24.40		21.68
12/6/11 11:47	54.43	56.51	37.54	54.33	33.73	60.45	24.42		21.66
12/6/11 11:48	54.46	56.51	37.56	54.33	33.76	60.45	24.44		21.67
12/6/11 11:49	54.49	56.51	37.58	54.35	33.78	60.45	24.46		21.68
12/6/11 11:50	54.52	56.53	37.61	54.40	33.81	60.45	24.49		21.68
12/6/11 11:51	54.55	56.53	37.63	54.40	33.84	60.43	24.51		21.67

	Ranney Collector No. 3		MW-1		MW-7		MW-2		SCADA
Date/Time	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	River Elevation (feet)
12/6/11 11:52	54.57	56.53	37.64	54.42	33.86	60.43	24.53		21.68
12/6/11 11:53	54.59	56.55	37.67	54.44	33.88	60.43	24.55		21.68
12/6/11 11:54	54.62	56.55	37.69	54.44	33.91	60.43	24.57		21.68
12/6/11 11:55	54.66	56.55	37.73	54.47	33.93	60.43	24.59		21.68
12/6/11 11:56	54.69	56.55	37.73	54.49	33.95	60.43	24.60		21.69
12/6/11 11:57	54.72	56.57	37.77	54.51	33.98	60.43	24.62		21.68
12/6/11 11:58	54.74	56.57	37.78	54.53	34.00	60.43	24.64		21.68
12/6/11 11:59	54.75	56.60	37.80	54.53	34.02	60.40	24.66		21.68
12/6/11 12:00	54.77	56.60	37.82	54.56	34.04	60.40	24.68		21.69
12/6/11 12:01	54.79	56.60	37.83	54.58	34.06	60.40	24.70		21.68
12/6/11 12:02	54.80	56.60	37.85	54.60	34.08	60.40	24.71		21.69
12/6/11 12:03	54.82	56.60	37.85	54.60	34.10	60.40	24.73		21.67
12/6/11 12:04	54.83	56.60	37.88	54.62	34.12	60.40	24.75		21.67
12/6/11 12:05	54.85	56.62	37.91	54.65	34.14	60.40	24.77		21.68
12/6/11 12:06	54.87	56.62	37.91	54.67	34.16	60.40	24.78		21.68
12/6/11 12:07	54.94	56.62	37.94	54.67	34.18	60.40	24.80		21.67
12/6/11 12:08	55.01	56.62	37.97	54.69	34.21	60.38	24.82		21.68
12/6/11 12:09	55.07	56.62	38.01	54.71	34.24	60.38	24.84		21.68
12/6/11 12:10	55.12	56.62	38.04	54.71	34.27	60.38	24.86		21.68
12/6/11 12:11	55.16	56.64	38.08	54.74	34.30	60.38	24.87		21.69
12/6/11 12:12	55.21	56.64	38.10	54.76	34.32	60.38	24.89		21.68
12/6/11 12:13	55.25	56.67	38.12	54.78	34.35	60.38	24.91		21.69
12/6/11 12:14	55.28	56.67	38.15	54.80	34.37	60.38	24.92		21.68
12/6/11 12:15	55.31	56.67	38.17	54.80	34.39	60.38	24.94		21.68
12/6/11 12:16	55.34	56.67	38.19	54.83	34.41	60.38	24.95		21.70
12/6/11 12:17	55.36	56.67	38.21	54.85	34.44	60.38	24.97		21.68
12/6/11 12:18	55.39	56.67	38.23	54.85	34.46	60.36	24.99		21.70
12/6/11 12:19	55.41	56.67	38.25	54.87	34.48	60.38	25.01		21.69
12/6/11 12:20	55.44	56.69	38.26	54.90	34.49	60.36	25.02		21.68
12/6/11 12:21	56.29	56.69	38.46	54.90	34.59	60.36	25.04		21.70
12/6/11 12:22	57.31	56.69	38.87	54.94	34.83	60.36	25.05		21.69
12/6/11 12:23	51.72	56.71	37.59	54.96	34.26	60.36	25.06		21.69
12/6/11 12:24	47.52	56.71	35.80	54.10	33.20	60.36	25.05		21.68
12/6/11 12:25	44.08	56.71	34.08	52.64	32.16	60.33	25.02		21.68
12/6/11 12:26	41.29	56.71	32.60	52.18	31.24	60.33	24.99		21.69
12/6/11 12:27	39.05	56.69	31.34	52.07	30.43	60.31	24.94		21.68
12/6/11 12:28	37.26	56.69	30.31	52.09	29.75	60.31	24.89		21.69
12/6/11 12:29	35.86	56.69	29.47	52.12	29.18	60.31	24.83		21.69
12/6/11 12:30	34.73	56.69	28.78	52.14	28.69	60.31	24.77		21.70
12/6/11 12:31	33.85	56.69	28.22	52.03	28.29	60.31	24.70		21.67
12/6/11 12:32	33.18	56.69	27.78	51.93	27.95	60.31	24.63		21.67
12/6/11 12:33	32.69	56.69	27.44	51.84	27.69	60.31	24.57		21.67
12/6/11 12:34	32.33	56.69	27.18	51.82	27.48	60.31	24.50		21.68
12/6/11 12:35	32.05	56.64	26.97	51.84	27.32	60.31	24.43		21.70
12/6/11 12:36	31.82	56.64	26.81	51.87	27.17	60.31	24.36		21.68
12/6/11 12:37	31.65	56.64	26.67	51.98	27.07	60.31	24.30		21.70
12/6/11 12:38	31.51	56.64	26.57	52.05	26.98	60.31	24.23		21.70
12/6/11 12:39	31.39	56.64	26.47	52.07	26.89	60.31	24.17		21.68
12/6/11 12:40	31.29	56.64	26.40	52.12	26.83	60.31	24.11		21.68
12/6/11 12:41	31.21	56.64	26.33	52.12	26.77	60.31	24.06		21.69
12/6/11 12:42	31.14	56.64	26.27	52.09	26.71	60.31	24.00		21.68
12/6/11 12:43	31.08	56.64	26.22	52.07	26.66	60.33	23.95		21.68
12/6/11 12:44	31.02	56.64	26.18	52.05	26.61	60.33	23.90		21.69
12/6/11 12:45	30.97	56.64	26.14	52.00	26.58	60.33	23.86		21.68
12/6/11 12:46	30.92	56.67	26.09	51.93	26.53	60.33	23.81		21.68
12/6/11 12:47	30.88	56.67	26.06	51.87	26.49	60.33	23.76		21.70
12/6/11 12:48	30.83	56.67	26.02	51.82	26.46	60.36	23.72		21.68
12/6/11 12:49	30.79	56.67	25.98	51.78	26.42	60.36	23.69		21.69
12/6/11 12:50	30.75	56.67	25.95	51.75	26.39	60.36	23.64		21.68
12/6/11 12:51	30.72	56.67	25.92	51.73	26.36	60.36	23.60		21.69
12/6/11 12:52	30.69	56.67	25.90	51.71	26.33	60.36	23.57		21.69
12/6/11 12:53	30.66	56.67	25.87	51.71	26.30	60.38	23.53		21.68

	Ranney Collector No. 3		MW-1		MW-7		MW-2		SCADA
Date/Time	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	River Elevation (feet)
12/6/11 12:54	30.63	56.67	25.84	51.69	26.27	60.38	23.50		21.69
12/6/11 12:55	30.60	56.67	25.81	51.66	26.24	60.38	23.46		21.70
12/6/11 12:56	30.57	56.67	25.79	51.66	26.22	60.38	23.43		21.70
12/6/11 12:57	30.54	56.67	25.77	51.64	26.19	60.40	23.40		21.70
12/6/11 12:58	30.51	56.67	25.75	51.62	26.16	60.40	23.37		21.71
12/6/11 12:59	30.49	56.67	25.72	51.60	26.14	60.40	23.35		21.71
12/6/11 13:00	30.46	56.67	25.70	51.57	26.12	60.40	23.32		21.71
12/6/11 13:05	30.35	56.67	25.60	51.53	26.00	60.43	23.20		21.69
12/6/11 13:10	30.20	56.64	25.37	51.48	25.88	60.45	23.10		21.69
12/6/11 13:15	29.99	56.64	25.11	51.51	25.72	60.45	23.00		21.70
12/6/11 13:20	29.82	56.64	24.94	51.48	25.60	60.47	22.91		21.68
12/6/11 13:25	29.70	56.64	24.80	51.44	25.49	60.49	22.82		21.69
12/6/11 13:30	29.58	56.64	24.69	51.39	25.39	60.52	22.74		21.70
12/6/11 13:35	29.48	56.64	24.58	51.37	25.31	60.52	22.67		21.68
12/6/11 13:40	29.40	56.64	24.49	51.39	25.22	60.54	22.60		21.69
12/6/11 13:45	29.31	56.64	24.40	51.39	25.14	60.56	22.53		21.70
12/6/11 13:50	29.24	56.64	24.32	51.39	25.08	60.58	22.47		21.69
12/6/11 13:55	29.17	56.64	24.24	51.35	25.01	60.58	22.41		21.70
12/6/11 14:00	29.10	56.62	24.18	51.35	24.95	60.61	22.35		21.68
12/6/11 15:00	28.53	56.62	23.58	51.48	24.38	60.72	21.79		21.71
12/6/11 16:00	28.20	56.60	23.24	51.69	24.04	60.79	21.44		21.69
12/6/11 17:00	27.98	56.57	23.02	51.80	23.81	60.85	21.23		21.70
12/6/11 18:00	28.15	56.55	23.40	51.96	23.81	60.90	21.11		21.70
12/6/11 19:00	28.35	56.53	23.68	51.98	23.89	60.90	21.12		21.71
12/6/11 20:00	28.39	56.53	23.75	51.96	23.88	60.85	21.10		21.69
12/6/11 21:00	28.42	56.51	23.81	51.96	23.87	60.90	21.08		21.67
12/6/11 22:00	28.44	56.51	23.86	51.93	23.87	60.88	21.06		21.67
12/6/11 23:00	28.30	56.48	23.76	51.89	23.62	60.94	20.99		21.68
12/7/11 0:00	28.24	56.46	23.73	51.87	23.52	60.92	20.92		21.69
12/7/11 1:00	28.20	56.46	23.73	51.87	23.44	60.94	20.86		21.68
12/7/11 2:00	28.04	56.44	23.48	51.82	23.31	60.88	20.80		21.70
12/7/11 3:00	27.65	56.42	22.99	51.75	23.05	60.92	20.66		21.70
12/7/11 4:00	27.43	56.42	22.71	51.73	22.88	60.94	20.54		21.68
12/7/11 5:00	27.28	56.42	22.53	51.73	22.76	61.01	20.45		21.68
12/7/11 6:00	27.17	56.39	22.41	51.75	22.67	61.01	20.37		21.67
12/7/11 7:00	27.08	56.37	22.30	51.75	22.59	61.03	20.30		21.66
12/7/11 7:57			22.22	51.78			20.25		21.66
12/7/11 8:00			22.22	51.78			20.25		21.68
12/7/11 9:00									21.69
12/7/11 10:00									21.64
12/7/11 11:00									21.65
12/7/11 12:00									21.66

Well ID: Ranney Collector No. 3 **Job No. :** 14606
Client: Humboldt Bay Municipal Water Authority
Location: North side of Mad River approx. 3600 feet southeast of the WTP
Test Information: Pre-maintenance pumping test

Flow Meter: Water Specialties Model ML20-D digital flow meter manufactured by McCrometer, Inc

Date/Time	Elapsed Time from Start of Pumping (minutes)	Elapsed Time from Start of Step (minutes)	Totalizer Reading (10000 gal)	Meter Rate (gpm)	Amount Pumped (gallons)	Average Pumping Rate (gpm)	Comments
12/6/11 8:50	0	0	16	3500	0		Start Step 1
12/6/11 8:52	2	2	17	3030	10000	5000	
12/6/11 8:55	5	5	18	3040	20000	4000	
12/6/11 9:00	10	10	19	2970	30000	3000	
12/6/11 9:05	15	15	21	2956	50000	3333	
12/6/11 9:10	20	20	22	2990	60000	3000	
12/6/11 9:15	25	25	24	2974	80000	3200	
12/6/11 9:20	30	30	25	2986	90000	3000	
12/6/11 9:25	35	35	27	2916	110000	3143	
12/6/11 9:30	40	40	28	2946	120000	3000	
12/6/11 9:35	45	45	30	2967	140000	3111	
12/6/11 9:40	50	50	31	2963	150000	3000	
12/6/11 9:45	55	55	33	2934	170000	3091	Ave. for step = 3000 gpm
12/6/11 9:50	60	60	34	2974	180000	3000	Start Step 2
12/6/11 9:55	65	5	36	4478	200000	4000	
12/6/11 10:00	70	10	39	4499	230000	5000	
12/6/11 10:05	75	15	41	4452	250000	4667	
12/6/11 10:10	80	20	43	4458	270000	4500	
12/6/11 10:15	85	25	45	4428	290000	4400	
12/6/11 10:20	90	30	48	4387	320000	4667	
12/6/11 10:25	95	35	50	4472	340000	4571	
12/6/11 10:30	100	40	52	4432	360000	4500	
12/6/11 10:35	105	45	54	4478	380000	4444	
12/6/11 10:40	110	50	56	4433	400000	4400	
12/6/11 10:45	115	55	59	4462	430000	4545	
12/6/11 10:50	120	60	61	4412	450000	4500	
12/6/11 10:55	125	65	63	4413	470000	4462	
12/6/11 11:00	130	70	65	4427	490000	4429	
12/6/11 11:05	135	75	68	4478	520000	4533	
12/6/11 11:10	140	80	70	4477	540000	4500	
12/6/11 11:15	145	85	72	4446	560000	4471	Ave. for step = 4470 gpm
12/6/11 11:20	150	90	74	5916	580000	4444	Start Step 3
12/6/11 11:25	155	5	77	5906	610000	6000	
12/6/11 11:30	160	10	80	5885	640000	6000	
12/6/11 11:35	165	15	83	5914	670000	6000	
12/6/11 11:40	170	20	86	5911	700000	6000	
12/6/11 11:45	175	25	89	5908	730000	6000	
12/6/11 11:50	180	30	92	5928	760000	6000	
12/6/11 11:55	185	35	95	5886	790000	6000	
12/6/11 12:00	190	40	98	5919	820000	6000	
12/6/11 12:05	195	45	101	5882	850000	6000	
12/6/11 12:10	200	50	104	5975	880000	6000	
12/6/11 12:15	205	55	107	5884	910000	6000	Ave. for step = 6000 gpm
12/6/11 12:20	210	60	110	5997	940000	6000	
12/6/11 12:22	212	2	111	7300	950000		

Well ID: Ranney Collector No. 3 **Job No. :** 14606
Client: Humboldt Bay Municipal Water Authority
Location: North side of Mad River approx. 3600 feet southeast of the WTP
Test Information: Pre-maintenance pumping test
Measuring Point: Top edge of hatch frame in intermediate floor, 0.5 feet above floor
Measuring Point Elevation: 53.50

Date/Time	Depth to Water (feet)	Elapsed Time from Start of Pumping (minutes)	Elapsed Time from Start of Step (minutes)	Observed Drawdown (feet)	Water Elevation (feet)	Comments
12/5/2011 15:21						
12/5/2011 15:42	28.13				25.37	
12/5/2011 15:52						
12/5/2011 15:57						
12/5/2011 16:00						
12/5/2011 16:01	33.00				20.50	
12/6/2011 7:46	27.37				26.13	
12/6/2011 7:54	27.44				26.06	
12/6/2011 8:47	27.59				25.91	
12/6/2011 8:50		0	0			Start Step 1
12/6/2011 8:51	30.50	1	1	2.91	23.00	
12/6/2011 8:52	31.35	2	2	3.76	22.15	
12/6/2011 9:12	37.69	22	22	10.10	15.81	
12/6/2011 9:23	38.34	33	33	10.75	15.16	
12/6/2011 9:47	38.31	57	57	10.72	15.19	
12/6/2011 9:50		60	0			Start Step 2
12/6/2011 9:54	42.25	64	4	14.66	11.25	
12/6/2011 9:58	43.77	68	8	16.18	9.73	
12/6/2011 10:24	45.79	94	34	18.20	7.71	
12/6/2011 11:02	46.33	132	72	18.74	7.17	
12/6/2011 11:20		150	0			Start Step 3
12/6/2011 11:23	49.95	153	3	22.36	3.55	
12/6/2011 11:43	54.32	173	23	26.73	-0.82	
12/6/2011 11:52	54.60	182	32	27.01	-1.10	
12/6/2011 12:11	54.22	201	51	26.63	-0.72	
12/6/2011 12:20		210	60			Increased Rate
12/6/2011 12:22		212				Start Recovery
12/6/2011 12:33	32.73	223		5.14	20.77	
12/6/2011 14:05	29.02	315		1.43	24.48	
12/6/2011 14:41	28.45	351		0.86	25.05	
12/6/2011 15:57	28.20	427		0.61	25.30	
12/7/2011 7:51	27.01	1381		-0.58	26.49	

Well ID: MW-1 **Job No. :** 14606
Client: Humboldt Bay Municipal Water Authority
Location: 186 feet east of outside wall of collector well caisson
Test Information: Pre-maintenance pumping test
Measuring Point: Top of protective casing
Measuring Point Elevation: 49.25 estimated

Date/Time	Depth to Water (feet)	Elapsed Time from Start of Pumping (minutes)	Elapsed Time from Start of Step (minutes)	Observed Drawdown (feet)	Water Elevation (feet)	Comments
12/5/2011 14:55	23.71				25.54	
12/5/2011 16:23	23.81				25.44	
12/6/2011 7:40	22.62				26.63	
12/6/2011 8:04	22.87				26.38	
12/6/2011 8:37	22.97				26.28	
12/6/2011 8:50		0				Start Step 1
12/6/2011 9:09	27.41	19		4.44	21.84	
12/6/2011 9:26	27.62	36		4.65	21.63	
12/6/2011 9:50		60				Start Step 2
12/6/2011 10:15	29.12	85		6.15	20.13	
12/6/2011 11:12	30.14	142		7.17	19.11	
12/6/2011 11:20		150				Start Step 3
12/6/2011 11:38	30.81	168		7.84	18.44	
12/6/2011 12:09	31.97	199		9.00	17.28	
12/6/2011 12:20		210				Increased Rate
12/6/2011 12:22		212				Pumps off
12/6/2011 14:00	24.26	310		1.29	24.99	
12/6/2011 14:19	24.03	329		1.06	25.22	
12/7/2011 8:44	22.72	1434		-0.25	26.53	
12/7/2011 11:09	23.40	1579		0.43	25.85	

Well ID: MW-7 **Job No. :** 14606
Client: Humboldt Bay Municipal Water Authority
Location: 221 feet west of outside wall of collector well caisson
Test Information: Pre-maintenance pumping test
Measuring Point: Top of steel casing
Measuring Point Elevation: 48.85 estimated

Date/Time	Depth to Water (feet)	Elapsed Time from Start of Pumping (minutes)	Elapsed Time from Start of Step (minutes)	Observed Drawdown (feet)	Water Elevation (feet)	Comments
12/5/2011 14:40	23.67				25.18	
12/5/2011 15:21	23.50				25.35	
12/6/2011 7:33	22.68				26.17	
12/6/2011 8:17	22.95				25.90	
12/6/2011 8:33	22.95				25.90	
12/6/2011 8:50		0				Start Step 1
12/6/2011 9:04	26.50	14		3.55	22.35	
12/6/2011 9:30	27.34	40		4.39	21.51	
12/6/2011 9:50		60				Start Step 2
12/6/2011 10:12	30.03	82		7.08	18.82	
12/6/2011 11:15	31.07	145		8.12	17.78	
12/6/2011 11:20		150				Start Step 3
12/6/2011 11:29	32.85	159		9.90	16.00	
12/6/2011 11:58	34.00	188		11.05	14.85	
12/6/2011 12:20		210				Increased Rate
12/6/2011 12:22		212				Pumps off
12/6/2011 13:56	24.99	306		2.04	23.86	
12/6/2011 14:25	24.68	335		1.73	24.17	
12/7/2011 7:38	22.57	1368		-0.38	26.28	
12/7/2011 10:54	23.41	1564		0.46	25.44	

Well ID: MW-2 **Job No. :** 14606
Client: Humboldt Bay Municipal Water Authority
Location: 29.5 feet west of outside wall of collector well caisson
Test Information: Pre-maintenance pumping test
Measuring Point: Top of steel casing
Measuring Point Elevation: 46.26 estimated

Date/Time	Depth to Water (feet)	Elapsed Time from Start of Pumping (minutes)	Elapsed Time from Start of Step (minutes)	Observed Drawdown (feet)	Water Elevation (feet)	Comments
12/6/2011 7:37	20.37				25.89	
12/6/2011 8:06	20.44				25.82	
12/6/2011 8:50		0				Start Step 1
12/6/2011 9:02	21.18	12		0.74	25.08	
12/6/2011 9:36	21.86	46		1.42	24.40	
12/6/2011 9:50		60				Start Step 2
12/6/2011 10:06	22.53	76		2.09	23.73	
12/6/2011 11:20		150				Start Step 3
12/6/2011 11:27	23.93	157		3.49	22.33	
12/6/2011 11:56	24.58	186		4.14	21.68	
12/6/2011 12:20		210				Increased Rate
12/6/2011 12:22		212				Pumps off
12/6/2011 13:54	22.41	304		1.97	23.85	
12/6/2011 14:22	22.11	332		1.67	24.15	
12/7/2011 8:32	20.24	1422		-0.20	26.02	
12/7/2011 10:38	20.51	1548		0.07	25.75	

Well ID: Ranney Collector No. 3 **Job No. :** 14606
Client: Humboldt Bay Municipal Water Authority
Location: North side of Mad River approx. 3600 feet southeast of the WTP
Test Information: Pre-maintenance pumping test
Sampling Point: Tap at turbidity meter

Date/Time	Thermometer Temperature (degrees F)	Meter Temperature (degrees F)	Specific Conductance (uS/cm)	pH (S.U.)	Comments
12/6/2011 8:50					Start of Pumping Test
12/6/2011 9:20	56.2	57.6	180	7.9	
12/6/2011 9:49	55.4	56.6	190	7.3	
12/6/2011 11:05	56.9	56.3	170	7.6	
12/6/2011 11:49	57.2	56.6	190	7.8	
12/6/2011 12:14	57.5	56.6	180	7.8	
12/6/2011 12:22					Pumps off

APPENDIX C
POST-MAINTENANCE TESTING DATA

	Ranney Collector No. 3		MW-1		MW-7		MW-2		SCADA
Date/Time	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	River Elevation (feet)
5/2/12 0:01									23.36
5/2/12 1:00									23.36
5/2/12 2:00									23.36
5/2/12 3:00									23.37
5/2/12 4:00									23.40
5/2/12 5:00									23.40
5/2/12 6:00									23.40
5/2/12 7:00									23.38
5/2/12 8:00									23.34
5/2/12 9:00									23.32
5/2/12 10:00									23.30
5/2/12 11:00									23.31
5/2/12 12:00									23.31
5/2/12 13:00									23.31
5/2/12 14:00									23.32
5/2/12 15:00									23.37
5/2/12 16:00	25.27	50.11							23.38
5/2/12 16:20	25.27	50.14			20.95	50.16			23.38
5/2/12 16:40	25.26	50.15	20.52	49.60	20.95	50.19			23.38
5/2/12 17:00	25.26	50.16	20.52	49.60	20.95	50.18			23.38
5/2/12 17:20	25.25	50.17	20.52	49.60	20.92	50.13	18.67	51.39	23.38
5/2/12 18:00	25.22	50.19	20.52	49.60	20.91	50.13	18.65	50.09	23.37
5/2/12 19:00	25.75	50.23	21.23	49.58	21.35	50.10	18.81	50.06	23.38
5/2/12 20:00	25.87	50.30	21.35	49.58	21.48	50.02	18.89	50.09	23.38
5/2/12 21:00	25.94	50.34	21.42	49.58	21.53	50.09	18.93	50.11	23.36
5/2/12 22:00	25.97	50.39	21.48	49.58	21.57	50.08	18.95	50.11	23.35
5/2/12 23:00	25.99	50.42	21.51	49.60	21.61	49.96	18.99	50.12	23.33
5/3/12 0:00	26.03	50.48	21.55	49.60	21.64	50.04	19.01	50.12	23.31
5/3/12 1:00	26.07	50.49	21.58	49.60	21.67	50.04	19.04	50.13	23.33
5/3/12 2:00	25.94	50.54	21.50	49.60	21.47	50.00	19.01	50.15	23.35
5/3/12 3:00	25.92	50.54	21.48	49.60	21.43	50.00	18.98	50.16	23.36
5/3/12 4:00	26.08	50.56	21.61	49.63	21.66	49.90	19.05	50.17	23.36
5/3/12 5:00	26.11	50.58	21.65	49.63	21.70	49.91	19.07	50.18	23.35
5/3/12 6:00	26.14	50.61	21.66	49.63	21.72	49.95	19.08	50.20	23.35
5/3/12 7:00	26.14	50.62	21.68	49.63	21.74	49.86	19.08	50.22	23.32
5/3/12 8:00	26.15	50.64	21.68	49.65	21.75	49.87	19.11	50.12	23.29
5/3/12 8:05	26.15	50.64	21.69	49.65	21.75	49.89	19.11	50.12	23.27
5/3/12 8:10	26.16	50.64	21.69	49.63	21.76	49.94	19.11	50.13	23.28
5/3/12 8:15	26.15	50.64	21.70	49.65	21.75	49.95	19.11	50.13	23.26
5/3/12 8:20	26.15	50.64	21.69	49.63	21.75	49.96	19.12	50.13	23.27
5/3/12 8:25	26.16	50.64	21.69	49.63	21.75	49.94	19.12	50.13	23.25
5/3/12 8:30	26.16	50.64	21.70	49.65	21.78	49.93	19.12	50.13	23.26
5/3/12 8:35	26.16	50.64	21.70	49.65	21.76	49.96	19.12	50.13	23.24
5/3/12 8:40	26.16	50.64	21.70	49.63	21.77	49.91	19.11	50.13	23.24
5/3/12 8:45	26.16	50.64	21.70	49.65	21.75	49.88	19.12	50.14	23.27
5/3/12 8:50	26.16	50.64	21.70	49.65	21.76	49.95	19.12	50.15	23.25
5/3/12 8:51	26.16	50.63	21.70	49.65	21.76	49.94	19.11	50.15	23.25
5/3/12 8:52	26.16	50.64	21.70	49.63	21.76	49.93	19.13	50.15	23.24
5/3/12 8:53	26.16	50.64	21.70	49.63	21.76	49.91	19.13	50.15	23.25
5/3/12 8:54	26.16	50.64	21.70	49.65	21.78	49.92	19.13	50.15	23.24
5/3/12 8:55	26.16	50.63	21.70	49.65	21.78	49.90	19.13	50.15	23.24
5/3/12 8:56	26.17	50.64	21.70	49.65	21.76	49.88	19.13	50.16	23.24
5/3/12 8:57	26.16	50.64	21.70	49.65	21.77	49.91	19.13	50.15	23.24
5/3/12 8:58	26.16	50.64	21.70	49.65	21.77	49.92	19.13	50.15	23.27
5/3/12 8:59	26.16	50.64	21.70	49.65	21.76	49.94	19.12	50.15	23.24
5/3/12 9:00		50.65	21.70	49.65	21.76	49.95	19.12	50.15	23.26
5/3/12 9:01	26.40	50.73	21.70	49.65	21.77	49.93	19.12	50.15	23.25
5/3/12 9:02	26.37	50.72	21.70	49.65	21.77	49.93	19.13	50.15	23.24
5/3/12 9:03	26.36	50.70	21.70	49.65	21.77	49.93	19.13	50.15	23.24
5/3/12 9:04	26.38	50.69	21.70	49.63	21.77	49.94	19.13	50.15	23.24
5/3/12 9:05	26.37	50.69	21.70	49.65	21.76	49.94	19.13	50.15	23.24
5/3/12 9:06	26.37	50.67	21.70	49.65	21.77	49.92	19.12	50.15	23.24

	Ranney Collector No. 3		MW-1		MW-7		MW-2		SCADA
Date/Time	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	River Elevation (feet)
5/3/12 9:07	26.76	50.68	21.78	49.65	21.80	49.93	19.11	50.16	23.23
5/3/12 9:08	31.95	50.67	24.53	49.65	23.78	49.94	19.44	50.14	23.24
5/3/12 9:09	32.55	50.65	25.80	49.67	24.82	49.89	19.65	50.12	23.24
5/3/12 9:10	32.23	50.63	25.61	49.69	24.76	49.85	19.69	50.17	23.26
5/3/12 9:11	32.55	50.61	25.77	49.72	24.90	49.83	19.74	50.19	23.24
5/3/12 9:12	32.73	50.57	25.98	49.72	25.03	49.81	19.78	50.20	23.24
5/3/12 9:13	32.99	50.55	26.27	49.72	25.14	49.79	19.82	50.22	23.25
5/3/12 9:14	33.07	50.50	26.43	49.72	25.23	49.77	19.86	50.23	23.24
5/3/12 9:15	33.17	50.49	26.55	49.74	25.32	49.76	19.90	50.24	23.24
5/3/12 9:16	33.26	50.45	26.60	49.74	25.39	49.77	19.93	50.24	23.25
5/3/12 9:17	33.38	50.45	26.67	49.76	25.44	49.76	19.96	50.26	23.24
5/3/12 9:18	33.44	50.42	26.72	49.79	25.49	49.75	20.00	50.27	23.24
5/3/12 9:19	33.48	50.40	26.77	49.79	25.53	49.75	20.02	50.25	23.23
5/3/12 9:20	33.58	50.37	26.81	49.79	25.57	49.74	20.06	50.26	23.24
5/3/12 9:21	33.62	50.35	26.84	49.76	25.60	49.75	20.09	50.27	23.25
5/3/12 9:22	33.55	50.34	26.87	49.72	25.63	49.74	20.10	50.26	23.24
5/3/12 9:23	33.62	50.33	26.90	49.67	25.67	49.73	20.10	50.26	23.24
5/3/12 9:24	33.63	50.35	26.92	49.60	25.69	49.73	20.14	50.26	23.23
5/3/12 9:25	33.73	50.31	26.95	49.58	25.71	49.72	20.16	50.25	23.23
5/3/12 9:26	33.70	50.27	26.97	49.58	25.73	49.72	20.19	50.25	23.24
5/3/12 9:27	33.78	50.28	26.99	49.58	25.75	49.74	20.21	50.25	23.24
5/3/12 9:28	33.78	50.26	27.00	49.60	25.75	49.74	20.24	50.25	23.21
5/3/12 9:29	33.76	50.21	27.02	49.63	25.78	49.74	20.25	50.26	23.23
5/3/12 9:30	33.80	50.21	27.03	49.65	25.79	49.74	20.27	50.26	23.24
5/3/12 9:31	33.80	50.16	27.05	49.65	25.82	49.75	20.29	50.25	23.24
5/3/12 9:32	33.84	50.08	27.06	49.67	25.82	49.75	20.31	50.27	23.24
5/3/12 9:33	33.84	50.04	27.08	49.67	25.85	49.76	20.32	50.26	23.22
5/3/12 9:34	33.85	50.02	27.09	49.67	25.86	49.76	20.34	50.26	23.23
5/3/12 9:35	33.87	49.98	27.10	49.67	25.87	49.79	20.35	50.27	23.23
5/3/12 9:36	33.92	49.98	27.11	49.67	25.87	49.79	20.38	50.27	23.22
5/3/12 9:37	33.92	49.98	27.12	49.67	25.90	49.79	20.41	50.28	23.22
5/3/12 9:38	33.99	49.95	27.13	49.67	25.92	49.78	20.42	50.29	23.23
5/3/12 9:39	33.86	49.89	27.15	49.67	25.91	49.79	20.45	50.30	23.24
5/3/12 9:40	33.91	49.92	27.15	49.67	25.92	49.81	20.45	50.31	23.24
5/3/12 9:41	33.90	49.91	27.17	49.67	25.93	49.81	20.47	50.32	23.22
5/3/12 9:42	33.97	49.89	27.17	49.69	25.94	49.81	20.47	50.32	23.23
5/3/12 9:43	33.99	49.87	27.17	49.69	25.97	49.81	20.49	50.32	23.23
5/3/12 9:44	33.92	49.89	27.19	49.69	25.97	49.81	20.50	50.33	23.23
5/3/12 9:45	33.98	49.87	27.21	49.69	25.98	49.80	20.51	50.34	23.23
5/3/12 9:46	34.00	49.87	27.21	49.69	25.99	49.80	20.56	50.36	23.24
5/3/12 9:47	34.01	49.85	27.21	49.69	26.01	49.78	20.55	50.36	23.24
5/3/12 9:48	34.00	49.86	27.22	49.69	26.01	49.76	20.57	50.39	23.24
5/3/12 9:49	34.03	49.85	27.22	49.69	26.02	49.76	20.59	50.41	23.23
5/3/12 9:50	34.00	49.85	27.24	49.69	26.03	49.75	20.59	50.42	23.22
5/3/12 9:51	34.02	49.78	27.24	49.69	26.05	49.75	20.61	50.43	23.24
5/3/12 9:52	34.04	49.73	27.25	49.69	26.04	49.76	20.61	50.43	23.24
5/3/12 9:53	34.07	49.73	27.26	49.67	26.06	49.76	20.62	50.44	23.21
5/3/12 9:54	34.07	49.73	27.26	49.67	26.06	49.77	20.64	50.45	23.22
5/3/12 9:55	34.05	49.72	27.27	49.67	26.06	49.78	20.65	50.45	23.23
5/3/12 9:56	34.04	49.67	27.28	49.69	26.08	49.77	20.66	50.45	23.24
5/3/12 9:57	34.13	49.65	27.28	49.69	26.09	49.77	20.68	50.43	23.23
5/3/12 9:58	34.04	49.67	27.29	49.67	26.10	49.78	20.69	50.41	23.24
5/3/12 9:59	34.13	49.66	27.29	49.69	26.11	49.79	20.70	50.37	23.23
5/3/12 10:00	34.12	49.62	27.30	49.67	26.11	49.79	20.71	50.33	23.23
5/3/12 10:01	34.04	49.60	27.31	49.67	26.12	49.79	20.72	50.30	23.23
5/3/12 10:02	34.08	49.57	27.31	49.65	26.13	49.79	20.73	50.25	23.24
5/3/12 10:03	34.15	49.57	27.32	49.67	26.14	49.78	20.75	50.21	23.23
5/3/12 10:04	34.10	49.60	27.33	49.67	26.15	49.78	20.76	50.20	23.24
5/3/12 10:05	34.16	49.62	27.34	49.67	26.15	49.78	20.77	50.20	23.24
5/3/12 10:06	34.10	49.63	27.35	49.69	26.15	49.77	20.78	50.18	23.21
5/3/12 10:07	34.16	49.67	27.35	49.67	26.17	49.75	20.80	50.17	23.23
5/3/12 10:08	34.62	49.67	27.51	49.65	26.26	49.75	20.80	50.18	23.22

Date/Time	Ranney Collector No. 3 Depth to Water (feet)	Ranney Collector No. 3 Water Temperature (degrees F)	MW-1 Depth to Water (feet)	MW-1 Water Temperature (degrees F)	MW-7 Depth to Water (feet)	MW-7 Water Temperature (degrees F)	MW-2 Depth to Water (feet)	MW-2 Water Temperature (degrees F)	SCADA River Elevation (feet)
5/3/12 10:09	35.53	49.70	28.09	49.65	26.66	49.74	20.87	50.22	23.22
5/3/12 10:10	36.20	49.73	28.57	49.60	26.99	49.73	20.94	50.30	23.24
5/3/12 10:11	36.68	49.76	28.93	49.67	27.24	49.73	21.00	50.39	23.23
5/3/12 10:12	37.06	49.74	29.22	49.74	27.45	49.73	21.05	50.47	23.23
5/3/12 10:13	37.36	49.71	29.44	49.76	27.62	49.72	21.08	50.49	23.21
5/3/12 10:14	37.60	49.68	29.63	49.72	27.76	49.72	21.13	50.45	23.22
5/3/12 10:15	37.80	49.62	29.77	49.67	27.87	49.72	21.17	50.39	23.23
5/3/12 10:16	37.96	49.56	29.89	49.63	27.95	49.72	21.23	50.34	23.22
5/3/12 10:17	38.07	49.51	29.99	49.58	28.05	49.73	21.24	50.30	23.24
5/3/12 10:18	38.35	49.49	30.11	49.56	28.14	49.73	21.28	50.27	23.21
5/3/12 10:19	38.93	49.47	30.39	49.51	28.31	49.74	21.32	50.25	23.22
5/3/12 10:20	40.52	49.46	31.24	49.54	28.83	49.73	21.40	50.22	23.23
5/3/12 10:21	41.69	49.49	32.12	49.60	29.44	49.73	21.39	50.20	23.21
5/3/12 10:22	40.85	49.54	32.02	49.63	29.48	49.73	21.39	50.19	23.22
5/3/12 10:23	40.36	49.50	31.66	49.60	29.26	49.73	21.40	50.17	23.22
5/3/12 10:24	39.95	49.42	31.37	49.54	29.10	49.73	21.39	50.16	23.23
5/3/12 10:25	39.66	49.38	31.19	49.47	28.96	49.74	21.39	50.15	23.21
5/3/12 10:26	39.55	49.36	31.07	49.42	28.89	49.74	21.40	50.15	23.22
5/3/12 10:27	39.44	49.35	30.99	49.38	28.85	49.74	21.40	50.14	23.21
5/3/12 10:28	39.33	49.33	30.94	49.38	28.81	49.73	21.41	50.13	23.23
5/3/12 10:29	39.27	49.32	30.89	49.36	28.79	49.73	21.39	50.13	23.22
5/3/12 10:30	39.24	49.31	30.85	49.33	28.78	49.73	21.40	50.12	23.21
5/3/12 10:31	39.20	49.30	30.83	49.29	28.77	49.73	21.39	50.12	23.23
5/3/12 10:32	39.17	49.26	30.82	49.29	28.77	49.73	21.39	50.11	23.23
5/3/12 10:33	39.16	49.25	30.81	49.26	28.76	49.72	21.40	50.11	23.23
5/3/12 10:34	39.14	49.24	30.81	49.26	28.76	49.73	21.39	50.11	23.22
5/3/12 10:35	39.16	49.24	30.80	49.26	28.76	49.73	21.40	50.11	23.21
5/3/12 10:36	39.09	49.25	30.79	49.24	28.76	49.74	21.39	50.11	23.22
5/3/12 10:37	39.06	49.22	30.78	49.22	28.76	49.73	21.40	50.11	23.23
5/3/12 10:38	39.11	49.21	30.77	49.22	28.78	49.72	21.39	50.12	23.22
5/3/12 10:39	39.08	49.19	30.77	49.24	28.77	49.72	21.39	50.11	23.22
5/3/12 10:40	39.05	49.19	30.77	49.22	28.76	49.73	21.39	50.11	23.21
5/3/12 10:41	39.11	49.21	30.78	49.22	28.77	49.72	21.38	50.11	23.21
5/3/12 10:42	39.05	49.21	30.79	49.24	28.79	49.72	21.40	50.11	23.21
5/3/12 10:43	39.11	49.21	30.79	49.22	28.79	49.72	21.39	50.10	23.21
5/3/12 10:44	39.10	49.20	30.80	49.24	28.81	49.73	21.38	50.10	23.21
5/3/12 10:45	39.11	49.20	30.80	49.26	28.82	49.72	21.39	50.10	23.21
5/3/12 10:46	39.15	49.20	30.81	49.26	28.82	49.72	21.40	50.10	23.21
5/3/12 10:47	39.11	49.20	30.81	49.24	28.83	49.72	21.38	50.09	23.21
5/3/12 10:48	39.15	49.19	30.82	49.26	28.84	49.72	21.39	50.10	23.21
5/3/12 10:49	39.17	49.18	30.83	49.24	28.86	49.72	21.39	50.09	23.21
5/3/12 10:50	39.20	49.19	30.84	49.24	28.86	49.72	21.39	50.09	23.21
5/3/12 10:51	39.14	49.18	30.85	49.22	28.88	49.71	21.40	50.09	23.22
5/3/12 10:52	39.16	49.18	30.86	49.22	28.89	49.71	21.39	50.08	23.21
5/3/12 10:53	39.17	49.18	30.87	49.22	28.91	49.71	21.39	50.08	23.22
5/3/12 10:54	39.20	49.17	30.87	49.24	28.91	49.70	21.38	50.08	23.21
5/3/12 10:55	39.21	49.15	30.88	49.24	28.92	49.71	21.39	50.08	23.21
5/3/12 10:56	39.20	49.13	30.89	49.24	28.92	49.70	21.40	50.08	23.21
5/3/12 10:57	39.24	49.13	30.90	49.24	28.93	49.70	21.40	50.07	23.21
5/3/12 10:58	39.28	49.14	30.90	49.26	28.91	49.70	21.39	50.07	23.22
5/3/12 10:59	39.22	49.16	30.91	49.31	28.90	49.70	21.39	50.07	23.21
5/3/12 11:00	39.22	49.14	30.91	49.31	28.88	49.69	21.40	50.07	23.21
5/3/12 11:01	39.26	49.13	30.91	49.31	28.88	49.69	21.41	50.07	23.20
5/3/12 11:02	39.24	49.11	30.90	49.31	28.88	49.70	21.41	50.06	23.19
5/3/12 11:03	39.23	49.12	30.91	49.31	28.88	49.70	21.39	50.07	23.21
5/3/12 11:04	39.20	49.12	30.90	49.31	28.87	49.69	21.40	50.06	23.21
5/3/12 11:05	39.17	49.12	30.91	49.29	28.86	49.69	21.39	50.06	23.21
5/3/12 11:06	39.23	49.11	30.90	49.29	28.88	49.69	21.40	50.07	23.21
5/3/12 11:07	39.22	49.11	30.91	49.29	28.86	49.68	21.40	50.07	23.21
5/3/12 11:08	39.35	49.11	30.95	49.29	28.90	49.68	21.39	50.06	23.21
5/3/12 11:09	40.21	49.10	31.35	49.29	29.11	49.68	21.39	50.06	23.20
5/3/12 11:10	41.01	49.11	31.89	49.49	29.47	49.67	21.40	50.07	23.20

Date/Time	Ranney Collector No. 3 Depth to Water (feet)	Ranney Collector No. 3 Water Temperature (degrees F)	MW-1 Depth to Water (feet)	MW-1 Water Temperature (degrees F)	MW-7 Depth to Water (feet)	MW-7 Water Temperature (degrees F)	MW-2 Depth to Water (feet)	MW-2 Water Temperature (degrees F)	SCADA River Elevation (feet)
5/3/12 11:11	41.61	49.11	32.32	49.67	29.78	49.68	21.39	50.06	23.19
5/3/12 11:12	42.10	49.11	32.67	49.74	30.01	49.68	21.40	50.06	23.19
5/3/12 11:13	42.47	49.10	32.95	49.76	30.21	49.68	21.39	50.06	23.20
5/3/12 11:14	42.78	49.09	33.18	49.79	30.38	49.68	21.39	50.06	23.18
5/3/12 11:15	43.03	49.08	33.36	49.79	30.50	49.68	21.38	50.06	23.21
5/3/12 11:16	43.26	49.09	33.50	49.81	30.63	49.69	21.39	50.06	23.19
5/3/12 11:17	43.41	49.09	33.62	49.81	30.71	49.68	21.38	50.05	23.19
5/3/12 11:18	43.52	49.08	33.73	49.81	30.79	49.69	21.40	50.06	23.21
5/3/12 11:19	43.63	49.08	33.81	49.83	30.85	49.69	21.38	50.06	23.20
5/3/12 11:20	43.75	49.08	33.89	49.83	30.91	49.68	21.41	50.05	23.20
5/3/12 11:21	43.84	49.09	33.95	49.83	30.96	49.68	21.38	50.05	23.21
5/3/12 11:22	43.90	49.10	34.00	49.83	31.01	49.68	21.39	50.06	23.21
5/3/12 11:23	43.95	49.10	34.07	49.85	31.05	49.69	21.38	50.05	23.18
5/3/12 11:24	44.01	49.09	34.10	49.85	31.08	49.68	21.40	50.05	23.21
5/3/12 11:25	44.04	49.09	34.14	49.85	31.12	49.68	21.39	50.05	23.20
5/3/12 11:26	44.07	49.08	34.18	49.85	31.14	49.67	21.38	50.04	23.19
5/3/12 11:27	44.10	49.08	34.21	49.88	31.18	49.67	21.39	50.05	23.19
5/3/12 11:28	44.14	49.08	34.24	49.88	31.20	49.67	21.38	50.04	23.22
5/3/12 11:29	44.19	49.07	34.27	49.88	31.21	49.66	21.39	50.05	23.21
5/3/12 11:30	44.22	49.08	34.28	49.90	31.24	49.66	21.38	50.05	23.21
5/3/12 11:31	44.22	49.08	34.30	49.90	31.26	49.65	21.39	50.04	23.19
5/3/12 11:32	44.23	49.08	34.32	49.90	31.29	49.64	21.39	50.05	23.18
5/3/12 11:33	44.27	49.09	34.34	49.90	31.30	49.64	21.39	50.06	23.19
5/3/12 11:34	44.31	49.09	34.34	49.92	31.33	49.63	21.38	50.07	23.19
5/3/12 11:35	44.34	49.08	34.36	49.92	31.34	49.62	21.39	50.07	23.21
5/3/12 11:36	44.32	49.09	34.37	49.92	31.35	49.62	21.39	50.07	23.19
5/3/12 11:37	44.34	49.07	34.39	49.92	31.38	49.61	21.39	50.07	23.21
5/3/12 11:38	44.36	49.07	34.40	49.94	31.38	49.60	21.39	50.07	23.18
5/3/12 11:39	44.38	49.06	34.42	49.94	31.40	49.60	21.39	50.07	23.19
5/3/12 11:40	44.38	49.06	34.43	49.94	31.42	49.59	21.39	50.07	23.19
5/3/12 11:41	44.41	49.05	34.45	49.97	31.44	49.59	21.38	50.07	23.19
5/3/12 11:42	44.44	49.05	34.46	49.97	31.45	49.59	21.39	50.06	23.18
5/3/12 11:43	44.46	49.07	34.47	49.97	31.46	49.58	21.39	50.06	23.19
5/3/12 11:44	44.45	49.04	34.47	49.99	31.47	49.58	21.38	50.06	23.18
5/3/12 11:45	44.46	49.04	34.49	49.99	31.49	49.57	21.38	50.06	23.18
5/3/12 11:46	44.47	49.05	34.50	49.99	31.50	49.57	21.39	50.06	23.19
5/3/12 11:47	44.50	49.06	34.51	49.99	31.51	49.57	21.39	50.06	23.18
5/3/12 11:48	44.51	49.06	34.52	50.01	31.53	49.56	21.39	50.06	23.18
5/3/12 11:49	44.53	49.05	34.52	50.01	31.54	49.56	21.38	50.06	23.19
5/3/12 11:50	44.54	49.05	34.54	50.01	31.55	49.55	21.39	50.05	23.19
5/3/12 11:51	44.56	49.06	34.53	50.03	31.56	49.55	21.38	50.05	23.21
5/3/12 11:52	44.55	49.07	34.55	50.03	31.57	49.55	21.37	50.05	23.20
5/3/12 11:53	44.57	49.07	34.57	50.03	31.59	49.55	21.39	50.05	23.18
5/3/12 11:54	44.58	49.07	34.57	50.03	31.59	49.55	21.38	50.05	23.21
5/3/12 11:55	44.58	49.08	34.57	50.06	31.61	49.55	21.38	50.05	23.19
5/3/12 11:56	44.61	49.10	34.58	50.06	31.62	49.55	21.38	50.05	23.19
5/3/12 11:57	44.61	49.11	34.60	50.06	31.63	49.55	21.38	50.05	23.18
5/3/12 11:58	44.62	49.11	34.60	50.06	31.65	49.54	21.38	50.04	23.19
5/3/12 11:59	44.64	49.11	34.62	50.08	31.65	49.53	21.39	50.04	23.21
5/3/12 12:00	44.63	49.10	34.62	50.08	31.67	49.53	21.39	50.04	23.18
5/3/12 12:01	44.65	49.09	34.60	50.08	31.68	49.53	21.39	50.04	23.19
5/3/12 12:02	44.65	49.07	34.55	50.10	31.68	49.53	21.39	50.05	23.20
5/3/12 12:03	44.64	49.06	34.48	50.10	31.69	49.53	21.39	50.04	23.20
5/3/12 12:04	44.64	49.08	34.44	50.10	31.68	49.53	21.38	50.04	23.19
5/3/12 12:05	44.61	49.08	34.38	50.12	31.68	49.53	21.39	50.04	23.22
5/3/12 12:06	44.58	49.07	34.35	50.12	31.68	49.52	21.38	50.03	23.19
5/3/12 12:07	44.58	49.06	34.30	50.12	31.68	49.52	21.38	50.04	23.20
5/3/12 12:08	45.01	49.05	34.43	50.15	31.75	49.52	21.39	50.04	23.18
5/3/12 12:09	45.91	49.05	34.91	50.15	32.06	49.52	21.37	50.03	23.20
5/3/12 12:10	46.61	49.03	35.35	50.15	32.37	49.51	21.39	50.03	23.20
5/3/12 12:11	47.15	49.02	35.73	50.15	32.64	49.51	21.38	50.02	23.21
5/3/12 12:12	47.58	49.02	36.02	50.17	32.84	49.51	21.39	50.03	23.19

Job No. : 14606

Date/Time	Ranney Collector No. 3 Depth to Water (feet)	Ranney Collector No. 3 Water Temperature (degrees F)	MW-1 Depth to Water (feet)	MW-1 Water Temperature (degrees F)	MW-7 Depth to Water (feet)	MW-7 Water Temperature (degrees F)	MW-2 Depth to Water (feet)	MW-2 Water Temperature (degrees F)	SCADA River Elevation (feet)
5/3/12 12:13	47.92	49.02	36.26	50.17	33.03	49.51	21.40	50.03	23.21
5/3/12 12:14	48.21	49.02	36.45	50.17	33.17	49.52	21.38	50.03	23.19
5/3/12 12:15	48.45	49.01	36.61	50.19	33.30	49.53	21.41	50.02	23.21
5/3/12 12:16	48.65	49.01	36.74	50.19	33.41	49.54	21.39	50.02	23.19
5/3/12 12:17	48.81	49.02	36.86	50.21	33.51	49.54	21.39	50.02	23.20
5/3/12 12:18	48.94	49.02	36.97	50.21	33.59	49.54	21.38	50.02	23.20
5/3/12 12:19	49.06	49.03	37.03	50.24	33.65	49.54	21.39	50.01	23.21
5/3/12 12:20	49.15	49.03	37.10	50.24	33.71	49.55	21.40	50.01	23.20
5/3/12 12:21	49.23	49.04	37.17	50.26	33.76	49.54	21.39	50.01	23.20
5/3/12 12:22	49.31	49.03	37.22	50.26	33.82	49.54	21.40	50.00	23.22
5/3/12 12:23	49.37	49.03	37.27	50.26	33.85	49.55	21.39	50.00	23.20
5/3/12 12:24	49.41	49.02	37.31	50.28	33.90	49.54	21.41	49.99	23.20
5/3/12 12:25	49.46	49.03	37.36	50.28	33.94	49.54	21.39	49.99	23.21
5/3/12 12:26	49.52	49.01	37.39	50.31	33.97	49.54	21.40	49.99	23.21
5/3/12 12:27	49.55	49.01	37.41	50.31	33.98	49.55	21.39	49.99	23.22
5/3/12 12:28	49.59	48.99	37.44	50.33	34.02	49.54	21.39	49.98	23.22
5/3/12 12:29	49.63	48.98	37.46	50.33	34.05	49.55	21.40	49.98	23.22
5/3/12 12:30	49.65	48.99	37.49	50.35	34.06	49.54	21.39	49.98	23.22
5/3/12 12:31	49.66	48.98	37.51	50.35	34.09	49.54	21.40	49.97	23.22
5/3/12 12:32	49.68	48.99	37.53	50.35	34.11	49.54	21.38	49.97	23.21
5/3/12 12:33	49.72	49.00	37.54	50.37	34.14	49.54	21.39	49.97	23.22
5/3/12 12:34	49.74	49.02	37.57	50.37	34.15	49.54	21.40	49.97	23.20
5/3/12 12:35	49.75	49.02	37.58	50.40	34.16	49.53	21.39	49.99	23.23
5/3/12 12:36	49.77	49.01	37.59	50.40	34.19	49.53	21.39	50.00	23.23
5/3/12 12:37	49.79	49.01	37.61	50.42	34.21	49.53	21.38	50.01	23.22
5/3/12 12:38	49.81	48.99	37.62	50.42	34.23	49.53	21.40	50.01	23.23
5/3/12 12:39	49.82	49.00	37.64	50.42	34.25	49.52	21.39	50.01	23.22
5/3/12 12:40	49.85	49.01	37.66	50.44	34.27	49.52	21.38	50.01	23.22
5/3/12 12:41	49.86	49.01	37.68	50.44	34.27	49.52	21.38	50.00	23.23
5/3/12 12:42	49.87	49.01	37.68	50.44	34.29	49.51	21.39	50.00	23.22
5/3/12 12:43	49.87	49.00	37.69	50.46	34.31	49.51	21.38	50.00	23.23
5/3/12 12:44	49.89	48.99	37.70	50.49	34.32	49.51	21.38	50.00	23.22
5/3/12 12:45	49.90	48.98	37.72	50.49	34.33	49.51	21.38	50.00	23.22
5/3/12 12:46	49.92	48.99	37.72	50.49	34.35	49.51	21.39	50.00	23.22
5/3/12 12:47	49.93	49.00	37.72	50.51	34.37	49.50	21.40	50.00	23.22
5/3/12 12:48	49.93	48.98	37.74	50.51	34.37	49.50	21.39	49.99	23.21
5/3/12 12:49	49.95	48.97	37.74	50.53	34.38	49.51	21.39	50.00	23.23
5/3/12 12:50	49.95	48.97	37.76	50.53	34.41	49.51	21.39	50.00	23.22
5/3/12 12:51	49.96	48.97	37.77	50.55	34.42	49.50	21.39	49.99	23.24
5/3/12 12:52	49.98	48.97	37.77	50.55	34.43	49.51	21.39	49.99	23.22
5/3/12 12:53	49.99	48.97	37.78	50.58	34.44	49.51	21.37	50.00	23.24
5/3/12 12:54	49.99	48.98	37.79	50.58	34.45	49.50	21.39	50.00	23.22
5/3/12 12:55	50.00	48.98	37.80	50.58	34.47	49.50	21.39	50.00	23.24
5/3/12 12:56	50.03	48.97	37.79	50.60	34.48	49.50	21.40	49.99	23.22
5/3/12 12:57	50.03	48.97	37.79	50.60	34.50	49.50	21.40	49.99	23.23
5/3/12 12:58	50.04	48.96	37.81	50.62	34.51	49.49	21.40	49.99	23.22
5/3/12 12:59	50.05	48.96	37.80	50.62	34.51	49.48	21.39	49.99	23.22
5/3/12 13:00	50.06	48.97	37.82	50.64	34.53	49.48	21.39	49.99	23.22
5/3/12 13:01	50.07	48.99	37.84	50.64	34.55	49.49	21.39	49.99	23.24
5/3/12 13:02	50.08	49.00	37.83	50.64	34.56	49.49	21.39	49.98	23.24
5/3/12 13:03	50.09	48.99	37.84	50.67	34.56	49.49	21.39	49.99	23.23
5/3/12 13:04	50.10	48.99	37.84	50.67	34.58	49.48	21.38	49.99	23.24
5/3/12 13:05	50.12	48.99	37.85	50.69	34.59	49.48	21.39	49.99	23.22
5/3/12 13:06	50.12	48.99	37.86	50.69	34.61	49.49	21.39	49.99	23.24
5/3/12 13:07	50.12	48.99	37.86	50.69	34.63	49.48	21.39	49.99	23.22
5/3/12 13:08	48.05	49.01	37.40	50.71	34.45	49.48	21.37	49.99	23.22
5/3/12 13:09	43.26	49.03	34.49	50.26	32.67	49.47	21.38	49.99	23.24
5/3/12 13:10	39.70	49.04	31.97	49.58	30.96	49.44	21.37	50.00	23.21
5/3/12 13:11	36.97	49.03	29.95	49.49	29.55	49.39	21.37	49.99	23.23
5/3/12 13:12	34.88	49.03	28.38	49.56	28.40	49.36	21.38	50.00	23.24
5/3/12 13:13	33.25	49.05	27.12	49.63	27.46	49.34	21.40	50.00	23.23
5/3/12 13:14	32.09	49.05	26.19	49.65	26.76	49.33	21.38	50.00	23.23

Date/Time	Ranney Collector No. 3 Depth to Water (feet)	Ranney Collector No. 3 Water Temperature (degrees F)	MW-1 Depth to Water (feet)	MW-1 Water Temperature (degrees F)	MW-7 Depth to Water (feet)	MW-7 Water Temperature (degrees F)	MW-2 Depth to Water (feet)	MW-2 Water Temperature (degrees F)	SCADA River Elevation (feet)
5/3/12 13:15	31.24	49.06	25.51	49.65	26.20	49.33	21.38	50.01	23.24
5/3/12 13:16	30.60	49.08	24.99	49.67	25.77	49.32	21.39	50.01	23.23
5/3/12 13:17	30.11	49.10	24.59	49.65	25.44	49.32	21.38	50.02	23.23
5/3/12 13:18	29.74	49.08	24.28	49.65	25.18	49.32	21.37	50.02	23.24
5/3/12 13:19	29.43	49.07	24.03	49.65	24.99	49.32	21.40	50.02	23.23
5/3/12 13:20	29.19	49.08	23.83	49.67	24.82	49.31	21.37	50.03	23.24
5/3/12 13:21	28.99	49.09	23.67	49.69	24.69	49.32	21.38	50.03	23.23
5/3/12 13:22	28.83	49.11	23.52	49.69	24.55	49.32	21.39	50.03	23.24
5/3/12 13:23	28.68	49.09	23.40	49.69	24.46	49.32	21.37	50.03	23.23
5/3/12 13:24	28.56	49.05	23.30	49.72	24.35	49.32	21.38	50.04	23.22
5/3/12 13:25	28.45	49.01	23.21	49.72	24.27	49.32	21.37	50.04	23.24
5/3/12 13:26	28.35	48.98	23.12	49.72	24.19	49.32	21.37	50.05	23.22
5/3/12 13:27	28.25	48.95	23.04	49.72	24.11	49.32	21.38	50.05	23.24
5/3/12 13:28	28.17	48.93	22.97	49.74	24.06	49.33	21.39	50.05	23.24
5/3/12 13:29	28.10	48.93	22.91	49.74	24.00	49.33	21.39	50.06	23.24
5/3/12 13:30	28.03	48.98	22.84	49.76	23.94	49.33	21.38	50.05	23.24
5/3/12 13:31	27.97	49.02	22.79	49.76	23.89	49.33	21.39	50.05	23.23
5/3/12 13:32	27.91	49.06	22.74	49.76	23.84	49.33	21.38	50.06	23.23
5/3/12 13:33	27.86	49.08	22.70	49.79	23.77	49.34	21.38	50.06	23.24
5/3/12 13:35	27.76	49.10	22.60	49.79	23.70	49.36	21.38	50.06	23.24
5/3/12 13:40	27.56	49.11	22.41	49.81	23.49	49.38	21.38	50.06	23.23
5/3/12 13:45	27.40	49.13	22.25	49.83	23.34	49.38	21.37	50.07	23.23
5/3/12 13:50	27.24	49.16	22.12	49.83	23.18	49.40	21.37	50.06	23.25
5/3/12 13:55	27.13	49.13	22.00	49.83	23.09	49.41	21.30	50.07	23.27
5/3/12 14:00	27.06	49.20	21.93	49.83	23.07	49.42	21.15	50.10	23.24
5/3/12 14:05	27.02	49.17	21.88	49.83	23.03	49.42	21.00	50.25	23.25
5/3/12 14:10	26.96	49.22	21.82	49.85	22.97	49.42	20.89	50.28	23.26
5/3/12 14:15	26.92	49.17	21.76	49.85	22.92	49.42	20.76	50.34	23.25
5/3/12 14:20	26.86	49.20	21.72	49.85	22.87	49.41	20.68	50.50	23.24
5/3/12 14:25	26.80	49.22	21.66	49.85	22.81	49.41	20.60	50.67	23.25
5/3/12 14:30	26.75	49.22	21.61	49.88	22.75	49.43	20.52	50.79	23.26
5/3/12 14:35	26.69	49.23	21.66	49.88	22.70	49.46	20.44	50.85	23.26
5/3/12 14:40	26.55	49.26	21.47	49.88	22.61	49.45	20.34	50.89	23.25
5/3/12 14:45	26.54	49.25	21.45	49.88	22.55	49.47	20.28	50.93	23.25
5/3/12 14:46	28.98	49.25	22.33	49.88	23.18	49.47	20.38	50.94	23.27
5/3/12 14:47	32.64	49.24	24.82	49.85	25.08	49.47	20.84	50.91	23.25
5/3/12 14:48	32.52	49.23	25.50	49.83	25.51	49.45	21.01	50.93	23.27
5/3/12 14:49	32.82	49.23	25.71	49.83	25.65	49.44	21.08	50.97	23.27
5/3/12 14:50	33.21	49.23	26.06	49.85	25.92	49.43	21.16	50.97	23.25
5/3/12 14:51	33.57	49.21	26.28	49.85	26.10	49.43	21.20	50.97	23.26
5/3/12 14:52	33.80	49.20	26.50	49.88	26.26	49.42	21.27	50.97	23.25
5/3/12 14:53	34.06	49.19	26.68	49.88	26.38	49.42	21.32	50.97	23.25
5/3/12 14:54	34.33	49.18	26.85	49.85	26.52	49.41	21.36	50.97	23.25
5/3/12 14:55	34.51	49.16	27.01	49.83	26.64	49.42	21.38	50.96	23.25
5/3/12 14:56	34.66	49.16	27.11	49.79	26.72	49.42	21.40	50.94	23.27
5/3/12 14:57	34.69	49.13	27.21	49.76	26.81	49.41	21.39	50.94	23.25
5/3/12 14:58	34.87	49.11	27.29	49.74	26.87	49.42	21.38	50.93	23.24
5/3/12 14:59	34.94	49.08	27.33	49.72	26.92	49.43	21.39	50.91	23.26
5/3/12 15:00	34.99	49.05	27.39	49.76	26.95	49.42	21.39	50.90	23.27
5/3/12 15:01	35.05	49.01	27.42	49.76	26.99	49.43	21.39	50.89	23.25
5/3/12 15:02	35.11	48.98	27.46	49.72	27.02	49.43	21.40	50.88	23.25
5/3/12 15:03	35.12	48.96	27.46	49.63	27.05	49.43	21.40	50.87	23.24
5/3/12 15:04	35.17	48.94	27.52	49.58	27.08	49.44	21.40	50.86	23.26
5/3/12 15:05	35.20	48.91	27.55	49.58	27.11	49.43	21.40	50.85	23.25
5/3/12 15:06	35.26	48.92	27.55	49.56	27.11	49.43	21.40	50.83	23.26
5/3/12 15:07	35.23	48.90	27.59	49.56	27.13	49.43	21.40	50.83	23.27
5/3/12 15:08	35.24	48.91	27.58	49.54	27.15	49.43	21.39	50.82	23.27
5/3/12 15:09	35.26	48.90	27.62	49.54	27.16	49.43	21.40	50.81	23.26
5/3/12 15:10	35.33	48.91	27.63	49.54	27.18	49.43	21.39	50.79	23.26
5/3/12 15:11	35.28	48.90	27.65	49.51	27.18	49.43	21.40	50.79	23.25
5/3/12 15:12	35.34	48.90	27.67	49.54	27.20	49.43	21.40	50.77	23.26
5/3/12 15:13	35.26	48.92	27.67	49.54	27.21	49.44	21.41	50.77	23.27

	Ranney Collector No. 3		MW-1		MW-7		MW-2		SCADA
Date/Time	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	River Elevation (feet)
5/3/12 15:14	35.34	48.92	27.66	49.54	27.23	49.43	21.40	50.76	23.27
5/3/12 15:15	35.39	48.94	27.67	49.51	27.24	49.44	21.41	50.75	23.27
5/3/12 15:16	35.39	48.95	27.67	49.54	27.25	49.44	21.41	50.74	23.26
5/3/12 15:17	35.38	48.97	27.69	49.54	27.26	49.44	21.40	50.74	23.26
5/3/12 15:18	35.36	48.99	27.67	49.54	27.27	49.43	21.39	50.72	23.26
5/3/12 15:19	35.35	48.99	27.70	49.51	27.28	49.44	21.39	50.71	23.27
5/3/12 15:20	35.36	49.00	27.70	49.49	27.29	49.44	21.41	50.70	23.26
5/3/12 15:21	35.40	49.00	27.72	49.49	27.31	49.44	21.40	50.70	23.27
5/3/12 15:22	35.42	48.99	27.73	49.54	27.31	49.44	21.41	50.68	23.27
5/3/12 15:23	35.45	48.96	27.70	49.51	27.30	49.44	21.40	50.68	23.26
5/3/12 15:24	35.50	48.92	27.70	49.51	27.32	49.43	21.40	50.67	23.27
5/3/12 15:25	35.50	48.91	27.68	49.49	27.33	49.43	21.40	50.65	23.28
5/3/12 15:26	35.45	48.90	27.72	49.51	27.34	49.42	21.40	50.65	23.27
5/3/12 15:27	35.49	48.93	27.72	49.54	27.34	49.43	21.39	50.64	23.27
5/3/12 15:28	35.45	48.93	27.73	49.54	27.35	49.42	21.39	50.63	23.27
5/3/12 15:29	35.47	48.91	27.74	49.54	27.36	49.42	21.39	50.62	23.28
5/3/12 15:30	35.47	48.91	27.74	49.51	27.36	49.42	21.39	50.61	23.27
5/3/12 15:31	35.50	48.92	27.75	49.51	27.36	49.42	21.41	50.61	23.27
5/3/12 15:32	35.44	48.91	27.74	49.51	27.37	49.42	21.39	50.59	23.28
5/3/12 15:33	35.48	48.93	27.75	49.49	27.38	49.41	21.40	50.59	23.25
5/3/12 15:34	35.48	48.92	27.75	49.51	27.39	49.41	21.39	50.59	23.27
5/3/12 15:35	35.48	48.94	27.76	49.54	27.40	49.42	21.40	50.57	23.26
5/3/12 15:36	35.53	48.92	27.77	49.54	27.40	49.40	21.40	50.56	23.28
5/3/12 15:37	35.47	48.92	27.77	49.49	27.41	49.41	21.42	50.56	23.28
5/3/12 15:38	35.53	48.92	27.77	49.49	27.42	49.41	21.39	50.55	23.26
5/3/12 15:39	35.48	48.93	27.78	49.51	27.42	49.41	21.40	50.54	23.29
5/3/12 15:40	35.51	48.92	27.77	49.49	27.43	49.41	21.41	50.53	23.26
5/3/12 15:41	35.51	48.91	27.77	49.51	27.43	49.41	21.40	50.53	23.27
5/3/12 15:42	35.54	48.90	27.79	49.49	27.44	49.40	21.41	50.52	23.25
5/3/12 15:43	35.53	48.88	27.79	49.47	27.44	49.41	21.40	50.52	23.27
5/3/12 15:44	35.52	48.87	27.79	49.49	27.44	49.40	21.40	50.50	23.28
5/3/12 15:45	35.54	48.88	27.78	49.47	27.45	49.39	21.41	50.50	23.25
5/3/12 15:46	35.54	48.89	27.79	49.49	27.45	49.40	21.40	50.50	23.27
5/3/12 15:47	35.56	48.89	27.77	49.49	27.47	49.40	21.39	50.49	23.28
5/3/12 15:48	35.55	48.90	27.79	49.51	27.46	49.39	21.40	50.48	23.27
5/3/12 15:49	35.55	48.91	27.80	49.51	27.47	49.39	21.40	50.48	23.26
5/3/12 15:50	35.58	48.91	27.79	49.51	27.47	49.39	21.39	50.47	23.28
5/3/12 15:51	35.60	48.93	27.78	49.49	27.49	49.39	21.40	50.47	23.27
5/3/12 15:52	35.61	48.92	27.79	49.49	27.49	49.39	21.40	50.46	23.28
5/3/12 15:53	35.62	48.91	27.80	49.51	27.50	49.39	21.40	50.46	23.26
5/3/12 15:54	35.59	48.92	27.79	49.49	27.52	49.39	21.39	50.45	23.28
5/3/12 15:55	35.56	48.92	27.81	49.49	27.50	49.39	21.39	50.45	23.29
5/3/12 15:56	35.59	48.91	27.79	49.49	27.50	49.38	21.40	50.44	23.28
5/3/12 15:57	35.63	48.92	27.80	49.45	27.52	49.38	21.40	50.44	23.26
5/3/12 15:58	35.60	48.92	27.81	49.51	27.52	49.38	21.40	50.44	23.26
5/3/12 15:59	35.60	48.91	27.81	49.51	27.51	49.38	21.40	50.43	23.27
5/3/12 16:00	35.58	48.90	27.77	49.51	27.52	49.38	21.40	50.42	23.28
5/3/12 16:01	35.65	48.92	27.77	49.54	27.53	49.38	21.39	50.42	23.27
5/3/12 16:02	35.62	48.94	27.79	49.54	27.53	49.37	21.38	50.42	23.27
5/3/12 16:03	35.61	48.95	27.80	49.54	27.54	49.37	21.39	50.41	23.26
5/3/12 16:04	35.61	48.94	27.80	49.56	27.56	49.37	21.40	50.41	23.27
5/3/12 16:05	35.62	48.94	27.80	49.54	27.55	49.38	21.38	50.40	23.29
5/3/12 16:06	35.58	48.94	27.81	49.51	27.56	49.37	21.39	50.40	23.27
5/3/12 16:07	35.63	48.93	27.80	49.51	27.58	49.37	21.40	50.40	23.28
5/3/12 16:08	35.61	48.91	27.81	49.54	27.57	49.37	21.38	50.40	23.28
5/3/12 16:09	35.63	48.89	27.83	49.56	27.58	49.36	21.39	50.39	23.27
5/3/12 16:10	35.64	48.89	27.82	49.54	27.56	49.37	21.39	50.39	23.27
5/3/12 16:11	35.65	48.90	27.83	49.54	27.57	49.37	21.38	50.39	23.29
5/3/12 16:12	35.60	48.89	27.83	49.54	27.58	49.36	21.40	50.38	23.27
5/3/12 16:13	35.60	48.89	27.81	49.51	27.59	49.37	21.40	50.38	23.27
5/3/12 16:14	35.60	48.88	27.83	49.51	27.58	49.37	21.41	50.37	23.28
5/3/12 16:15	35.64	48.89	27.83	49.54	27.59	49.37	21.39	50.37	23.27

	Ranney Collector No. 3		MW-1		MW-7		MW-2		SCADA
Date/Time	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	River Elevation (feet)
5/3/12 16:16	35.63	48.91	27.85	49.54	27.60	49.37	21.41	50.38	23.27
5/3/12 16:17	35.66	48.92	27.84	49.54	27.59	49.36	21.41	50.37	23.29
5/3/12 16:18	35.66	48.92	27.83	49.54	27.60	49.36	21.40	50.37	23.27
5/3/12 16:19	35.66	48.95	27.83	49.54	27.60	49.36	21.39	50.37	23.28
5/3/12 16:20	35.65	48.93	27.83	49.56	27.59	49.36	21.40	50.36	23.27
5/3/12 16:21	35.63	48.91	27.82	49.56	27.57	49.36	21.40	50.36	23.27
5/3/12 16:22	35.65	48.88	27.81	49.56	27.55	49.35	21.40	50.35	23.28
5/3/12 16:23	35.64	48.89	27.79	49.51	27.53	49.35	21.40	50.35	23.27
5/3/12 16:24	35.60	48.89	27.80	49.51	27.51	49.35	21.40	50.35	23.27
5/3/12 16:25	35.58	48.91	27.78	49.54	27.49	49.34	21.40	50.35	23.28
5/3/12 16:26	36.27	48.92	28.03	49.58	27.60	49.35	21.41	50.34	23.27
5/3/12 16:27	37.31	48.89	28.70	49.56	28.04	49.35	21.39	50.34	23.28
5/3/12 16:28	38.07	48.92	29.23	49.58	28.40	49.34	21.40	50.33	23.27
5/3/12 16:29	38.66	48.92	29.64	49.56	28.68	49.35	21.39	50.33	23.27
5/3/12 16:30	39.13	48.92	29.94	49.54	28.93	49.35	21.38	50.33	23.28
5/3/12 16:31	39.47	48.90	30.21	49.49	29.11	49.36	21.41	50.32	23.29
5/3/12 16:32	39.76	48.90	30.45	49.49	29.25	49.36	21.39	50.32	23.27
5/3/12 16:33	40.00	48.90	30.61	49.47	29.38	49.37	21.40	50.33	23.27
5/3/12 16:34	40.16	48.90	30.76	49.42	29.47	49.37	21.40	50.32	23.28
5/3/12 16:35	40.32	48.92	30.86	49.45	29.56	49.37	21.40	50.31	23.27
5/3/12 16:36	40.43	48.93	30.95	49.45	29.63	49.38	21.40	50.32	23.29
5/3/12 16:37	40.52	48.94	30.97	49.45	29.69	49.38	21.39	50.32	23.29
5/3/12 16:38	40.60	48.97	31.08	49.45	29.72	49.38	21.39	50.31	23.27
5/3/12 16:39	40.69	48.98	31.15	49.45	29.77	49.39	21.40	50.31	23.28
5/3/12 16:40	40.74	48.98	31.16	49.45	29.82	49.38	21.39	50.31	23.27
5/3/12 16:41	40.77	48.97	31.22	49.47	29.83	49.39	21.39	50.30	23.27
5/3/12 16:42	41.29	48.95	31.39	49.51	29.95	49.38	21.41	50.30	23.27
5/3/12 16:43	40.82	48.95	31.44	50.08	30.04	49.39	21.39	50.30	23.27
5/3/12 16:44	40.71	48.95	31.10	49.88	29.81	49.38	21.40	50.30	23.27
5/3/12 16:45	41.60	48.97	31.60	49.63	30.09	49.38	21.39	50.30	23.28
5/3/12 16:46	42.29	48.97	32.07	50.37	30.39	49.39	21.39	50.30	23.27
5/3/12 16:47	42.81	48.98	32.44	50.92	30.65	49.40	21.38	50.30	23.27
5/3/12 16:48	43.25	48.98	32.74	51.10	30.86	49.41	21.40	50.29	23.29
5/3/12 16:49	43.57	48.97	32.97	51.19	31.04	49.42	21.39	50.29	23.26
5/3/12 16:50	43.85	48.97	33.17	51.16	31.17	49.43	21.38	50.29	23.29
5/3/12 16:51	44.08	48.97	33.27	51.12	31.31	49.44	21.39	50.28	23.27
5/3/12 16:52	44.25	48.98	33.45	51.19	31.41	49.45	21.39	50.28	23.28
5/3/12 16:53	44.40	48.98	33.56	51.23	31.51	49.46	21.39	50.28	23.29
5/3/12 16:54	44.52	48.97	33.69	51.25	31.57	49.47	21.39	50.27	23.27
5/3/12 16:55	44.63	48.96	33.77	51.21	31.65	49.47	21.39	50.27	23.27
5/3/12 16:56	44.72	48.97	33.79	51.25	31.69	49.47	21.39	50.27	23.27
5/3/12 16:57	44.80	48.97	33.85	51.12	31.74	49.48	21.39	50.27	23.28
5/3/12 16:58	44.87	48.96	33.94	50.69	31.79	49.48	21.40	50.27	23.27
5/3/12 16:59	44.92	48.97	33.97	50.26	31.83	49.49	21.40	50.26	23.27
5/3/12 17:00	44.97	48.98	34.01	49.99	31.88	49.50	21.40	50.26	23.27
5/3/12 17:01	45.01	48.99	34.00	49.83	31.89	49.50	21.40	50.26	23.27
5/3/12 17:02	45.05	49.00	34.03	49.74	31.91	49.50	21.39	50.26	23.28
5/3/12 17:03	45.07	49.01	34.06	49.74	31.95	49.51	21.39	50.26	23.29
5/3/12 17:04	45.11	49.00	34.16	49.72	31.97	49.50	21.39	50.26	23.28
5/3/12 17:05	45.14	48.98	34.15	50.58	31.99	49.50	21.38	50.25	23.28
5/3/12 17:06	45.15	48.98	34.23	51.12	32.02	49.50	21.39	50.26	23.27
5/3/12 17:07	45.21	48.96	34.24	51.30	32.04	49.50	21.39	50.25	23.28
5/3/12 17:08	45.22	48.95	34.28	51.39	32.07	49.51	21.38	50.25	23.28
5/3/12 17:09	45.23	48.95	34.29	51.44	32.08	49.50	21.39	50.24	23.29
5/3/12 17:10	45.25	48.95	34.31	51.46	32.10	49.50	21.38	50.24	23.28
5/3/12 17:15	45.35	48.97	34.30	50.51	32.18	49.50	21.40	50.24	23.28
5/3/12 17:18	45.40	48.94	34.32	49.65	32.23	49.50	21.41	50.23	23.28
5/3/12 17:20	45.40	48.95	34.44	49.56	32.25	49.50	21.39	50.23	23.29
5/3/12 17:21	43.50	48.96	33.87	50.73	32.06	49.49	21.38	50.23	23.29
5/3/12 17:22	39.42	48.96	31.40	50.28	30.43	49.47	21.40	50.22	23.29
5/3/12 17:23	36.42	48.97	29.27	49.97	28.94	49.42	21.38	50.22	23.29
5/3/12 17:24	34.13	49.01	27.58	49.94	27.71	49.36	21.38	50.22	23.29

Date/Time	Ranney Collector No. 3 Depth to Water (feet)	Ranney Collector No. 3 Water Temperature (degrees F)	MW-1 Depth to Water (feet)	MW-1 Water Temperature (degrees F)	MW-7 Depth to Water (feet)	MW-7 Water Temperature (degrees F)	MW-2 Depth to Water (feet)	MW-2 Water Temperature (degrees F)	SCADA River Elevation (feet)
5/3/12 17:25	32.40	49.04	26.26	49.90	26.73	49.32	21.38	50.22	23.29
5/3/12 17:26	31.18	49.08	25.31	49.90	25.98	49.29	21.38	50.22	23.27
5/3/12 17:27	30.30	49.07	24.59	49.92	25.42	49.28	21.39	50.22	23.28
5/3/12 17:28	29.64	49.07	24.07	49.94	24.98	49.26	21.39	50.22	23.28
5/3/12 17:29	29.14	49.14	23.67	49.97	24.65	49.26	21.39	50.21	23.28
5/3/12 17:30	28.77	49.18	23.37	49.94	24.41	49.25	21.39	50.21	23.27
5/3/12 17:31	28.47	49.20	23.14	49.94	24.22	49.24	21.39	50.21	23.29
5/3/12 17:32	28.25	49.20	22.95	49.94	24.05	49.24	21.38	50.21	23.28
5/3/12 17:33	28.06	49.19	22.79	49.94	23.92	49.24	21.41	50.21	23.28
5/3/12 17:34	27.91	49.19	22.66	49.94	23.81	49.24	21.39	50.21	23.29
5/3/12 17:35	27.78	49.19	22.56	49.94	23.72	49.24	21.40	50.21	23.30
5/3/12 17:36	27.68	49.19	22.47	49.94	23.64	49.23	21.40	50.21	23.28
5/3/12 17:37	27.57	49.20	22.38	49.97	23.56	49.23	21.38	50.21	23.29
5/3/12 17:38	27.50	49.18	22.31	49.97	23.50	49.23	21.41	50.21	23.29
5/3/12 17:39	27.43	49.17	22.25	49.97	23.43	49.23	21.38	50.21	23.28
5/3/12 17:40	27.37	49.17	22.19	49.94	23.39	49.23	21.39	50.21	23.29
5/3/12 17:41	27.31	49.17	22.13	49.90	23.33	49.23	21.40	50.20	23.28
5/3/12 17:44	27.17	49.15	21.92	49.99	23.20	49.23	21.40	50.21	23.30
5/3/12 17:45	27.13	49.13	21.85	50.01	23.17	49.24	21.38	50.20	23.29
5/3/12 17:50	26.96	49.15	21.70	50.01	23.01	49.24	21.22	50.21	23.29
5/3/12 17:55	26.85	49.06	21.59	50.01	22.87	49.25	21.06	50.29	23.29
5/3/12 18:00	26.72	49.07	21.50	50.01	22.76	49.25	20.92	50.41	23.30
5/3/12 18:05	26.64	49.19	21.43	50.01	22.67	49.27	20.77	50.45	23.29
5/3/12 18:10	26.56	49.21	21.36	50.01	22.58	49.29	20.66	50.56	23.29
5/3/12 19:00	26.56	49.29	21.55	50.01	22.44	49.35	20.02	51.08	23.30
5/3/12 20:00	26.48	49.49	21.56	50.03	22.22	49.41	19.69	51.11	23.31
5/3/12 21:00	26.37	49.52	21.49	50.03	22.06	49.52	19.48	50.98	23.31
5/3/12 22:00	26.29	49.72	21.44	50.06	21.93	49.47	19.33	50.96	23.33
5/3/12 23:00	26.22	49.78	21.40	50.06	21.84	49.53	19.21	50.92	23.33
5/4/12 0:00	25.74	49.84	20.73	50.03	21.51	49.62	19.01	50.95	23.35
5/4/12 1:00	25.61	49.94	20.58	50.03	21.36	49.66	18.87	50.92	23.38
5/4/12 2:00	25.52	50.00	20.49	50.01	21.27	49.69	18.78	50.91	23.36
5/4/12 3:00	25.47	50.08	20.42	50.01	21.20	49.67	18.70	50.90	23.34
5/4/12 4:00	25.26	50.11	20.24	50.01	20.91	49.72	18.60	50.87	23.32
5/4/12 5:00	25.18	50.13	20.19	50.01	20.81	49.75	18.51	50.90	23.32
5/4/12 6:00	25.11	50.13	20.14	50.01	20.73	49.87	18.43	50.93	23.32
5/4/12 7:00	25.06	50.16	20.09	49.99	20.67	49.80	18.38	50.92	23.30
5/4/12 8:00	25.19	50.25	20.22	49.99	20.91	49.76	18.41	50.60	23.31
5/4/12 9:00	25.16	50.23	20.22	49.99	20.93	49.83	18.40	50.57	23.30
5/4/12 9:05	25.17	50.17	20.22	49.99	20.94	49.82	18.40	50.57	23.30
5/4/12 9:10	25.16	50.11	20.21	49.99	20.94	49.79	18.40	50.58	23.31
5/4/12 9:15	25.13	50.11	20.25	49.99	20.93	49.79	18.40	50.58	23.29
5/4/12 9:20	25.27	50.08	20.53	49.99	21.01	49.75	18.42	50.57	23.30
5/4/12 9:25	25.39	50.01	20.67	49.99	21.08	49.77	18.45	50.54	23.29
5/4/12 9:30	25.44	50.01	20.76	49.99	21.13	49.76	18.46	50.53	23.29
5/4/12 9:31	25.38	50.00	20.74	49.99	21.12	49.77	18.47	50.52	23.31
5/4/12 9:32	25.35	50.01	20.71	49.99	21.06	49.79	18.44	50.52	23.28
5/4/12 9:33	25.40	50.01	20.76	49.99	21.11	49.80	18.46	50.53	23.29
5/4/12 9:34	25.42	50.01	20.78	49.99	21.11	49.82	18.46	50.53	23.30
5/4/12 9:35	25.43	50.02	20.81	49.99	21.13	49.82	18.47	50.52	23.31
5/4/12 9:36	25.46	50.04	20.83	49.99	21.13	49.82	18.47	50.52	23.30
5/4/12 9:37	25.45	50.05	20.83	49.99	21.15	49.81	18.48	50.51	23.32
5/4/12 9:38	25.47	50.06	20.83	49.99	21.15	49.82	18.48	50.48	23.30
5/4/12 9:39	25.48	50.08	20.83	49.99	21.15	49.82	18.48	50.40	23.30
5/4/12 9:40	25.48	50.09	20.83	49.99	21.16	49.81	18.48	50.34	23.30
5/4/12 9:41	25.48	50.08	20.84	49.99	21.16	49.79	18.49	50.29	23.30
5/4/12 9:42	25.50	50.09	20.84	49.99	21.17	49.78	18.48	50.25	23.30
5/4/12 9:43	25.49	50.08	20.84	49.99	21.16	49.76	18.50	50.24	23.30
5/4/12 9:44	25.50	50.09	20.84	49.99	21.15	49.74	18.50	50.22	23.30
5/4/12 9:45	25.50	50.09	20.82	49.99	21.17	49.73	18.50	50.23	23.30
5/4/12 9:46	25.51	50.10	20.81	49.99	21.16	49.73	18.49	50.21	23.30
5/4/12 9:47	25.51	50.11	20.81	49.99	21.17	49.73	18.50	50.20	23.31

	Ranney Collector No. 3		MW-1		MW-7		MW-2		SCADA
Date/Time	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	River Elevation (feet)
5/4/12 9:48	25.51	50.11	20.81	49.99	21.17	49.73	18.49	50.20	23.30
5/4/12 9:49	25.54	50.12	20.81	49.99	21.18	49.73	18.51	50.20	23.29
5/4/12 9:50	27.35	50.12	21.73	49.99	21.87	49.72	18.64	50.19	23.30
5/4/12 9:51	29.27	50.12	22.97	49.99	22.85	49.73	18.89	50.17	23.31
5/4/12 9:52	30.43	50.11	23.76	49.99	23.51	49.74	19.07	50.15	23.30
5/4/12 9:53	31.28	50.11	24.34	49.99	23.99	49.72	19.21	50.15	23.29
5/4/12 9:54	31.88	50.12	25.00	49.99	24.36	49.72	19.31	50.14	23.30
5/4/12 9:55	32.29	50.11	25.31	49.99	24.63	49.71	19.41	50.16	23.30
5/4/12 9:56	32.65	50.09	25.54	49.99	24.84	49.69	19.50	50.20	23.29
5/4/12 9:57	32.92	50.06	25.72	49.99	25.01	49.69	19.55	50.24	23.31
5/4/12 9:58	33.15	50.03	25.84	49.99	25.14	49.69	19.60	50.27	23.30
5/4/12 9:59	33.23	50.01	25.96	49.99	25.24	49.68	19.65	50.26	23.29
5/4/12 10:00	33.37	49.96	26.04	49.99	25.33	49.68	19.68	50.26	23.30
5/4/12 10:01	33.45	49.89	26.12	49.99	25.38	49.67	19.72	50.24	23.29
5/4/12 10:02	33.51	49.79	26.16	49.99	25.43	49.68	19.76	50.24	23.31
5/4/12 10:03	33.52	49.73	26.20	49.99	25.47	49.67	19.78	50.24	23.30
5/4/12 10:04	33.59	49.68	26.24	49.99	25.52	49.66	19.80	50.24	23.30
5/4/12 10:05	33.60	49.64	26.26	49.99	25.55	49.66	19.83	50.26	23.30
5/4/12 10:06	33.66	49.58	26.28	49.99	25.57	49.65	19.85	50.26	23.29
5/4/12 10:07	33.69	49.51	26.30	49.99	25.59	49.65	19.87	50.28	23.29
5/4/12 10:08	33.73	49.49	26.30	49.99	25.60	49.66	19.90	50.29	23.30
5/4/12 10:09	33.76	49.49	26.31	49.99	25.63	49.65	19.92	50.30	23.29
5/4/12 10:10	33.73	49.47	26.31	49.99	25.67	49.65	19.93	50.29	23.30
5/4/12 10:11	33.77	49.45	26.33	49.99	25.66	49.65	19.95	50.27	23.30
5/4/12 10:12	33.82	49.39	26.35	49.97	25.69	49.66	19.97	50.28	23.29
5/4/12 10:13	33.85	49.35	26.36	49.97	25.71	49.66	19.99	50.29	23.30
5/4/12 10:14	33.81	49.33	26.35	49.97	25.71	49.66	20.01	50.29	23.30
5/4/12 10:15	33.81	49.32	26.38	49.97	25.72	49.65	20.03	50.28	23.32
5/4/12 10:16	33.83	49.31	26.37	49.97	25.74	49.66	20.05	50.29	23.28
5/4/12 10:17	33.83	49.31	26.38	49.97	25.76	49.66	20.07	50.29	23.29
5/4/12 10:18	33.87	49.32	26.38	49.97	25.76	49.66	20.08	50.30	23.30
5/4/12 10:19	33.90	49.31	26.40	49.94	25.78	49.67	20.10	50.30	23.32
5/4/12 10:20	33.87	49.30	26.42	49.94	25.79	49.68	20.11	50.30	23.30
5/4/12 10:21	33.87	49.29	26.43	49.94	25.80	49.67	20.13	50.30	23.29
5/4/12 10:22	33.92	49.26	26.45	49.94	25.82	49.67	20.15	50.29	23.29
5/4/12 10:23	33.94	49.25	26.45	49.94	25.84	49.67	20.18	50.27	23.29
5/4/12 10:24	33.91	49.25	26.49	49.94	25.86	49.67	20.20	50.26	23.29
5/4/12 10:25	33.91	49.24	26.50	49.94	25.87	49.67	20.20	50.26	23.29
5/4/12 10:26	33.93	49.23	26.51	49.97	25.86	49.66	20.22	50.25	23.31
5/4/12 10:27	33.94	49.23	26.54	49.97	25.88	49.65	20.22	50.26	23.30
5/4/12 10:28	33.96	49.23	26.56	49.99	25.89	49.66	20.24	50.27	23.30
5/4/12 10:29	33.94	49.19	26.54	49.99	25.91	49.65	20.25	50.28	23.31
5/4/12 10:30	34.01	49.19	26.56	49.99	25.90	49.65	20.28	50.29	23.30
5/4/12 10:31	33.98	49.18	26.56	49.99	25.91	49.66	20.27	50.29	23.30
5/4/12 10:32	33.97	49.14	26.54	49.99	25.93	49.66	20.29	50.30	23.29
5/4/12 10:33	34.01	49.13	26.55	49.97	25.93	49.65	20.30	50.28	23.30
5/4/12 10:34	33.97	49.13	26.55	49.97	25.93	49.65	20.32	50.28	23.30
5/4/12 10:35	34.00	49.12	26.54	49.97	25.95	49.65	20.33	50.28	23.30
5/4/12 10:36	33.97	49.10	26.54	49.97	25.95	49.67	20.34	50.27	23.29
5/4/12 10:37	33.98	49.10	26.53	49.94	25.97	49.67	20.36	50.26	23.30
5/4/12 10:38	34.03	49.09	26.52	49.92	25.97	49.68	20.38	50.26	23.30
5/4/12 10:39	34.03	49.09	26.55	49.92	25.98	49.68	20.41	50.25	23.30
5/4/12 10:40	34.03	49.09	26.55	49.92	25.99	49.68	20.39	50.25	23.29
5/4/12 10:41	34.05	49.10	26.54	49.92	26.00	49.68	20.41	50.26	23.30
5/4/12 10:42	34.06	49.08	26.56	49.94	26.02	49.68	20.45	50.28	23.31
5/4/12 10:43	34.07	49.08	26.57	49.94	26.01	49.68	20.44	50.29	23.30
5/4/12 10:44	34.07	49.07	26.57	49.92	26.02	49.69	20.47	50.30	23.29
5/4/12 10:45	34.08	49.08	26.57	49.92	26.03	49.68	20.47	50.32	23.30
5/4/12 10:46	34.09	49.08	26.59	49.92	26.03	49.67	20.48	50.34	23.31
5/4/12 10:47	34.07	49.09	26.60	49.92	26.04	49.67	20.49	50.35	23.30
5/4/12 10:48	34.05	49.10	26.61	49.90	26.06	49.67	20.50	50.38	23.30
5/4/12 10:49	34.11	49.11	26.61	49.92	26.06	49.66	20.52	50.41	23.29

	Ranney Collector No. 3		MW-1		MW-7		MW-2		SCADA
Date/Time	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	River Elevation (feet)
5/4/12 10:50	34.09	49.10	26.63	49.97	26.06	49.66	20.53	50.42	23.31
5/4/12 10:54	34.14	49.08	26.67	49.99	26.09	49.68	20.58	50.41	23.29
5/4/12 10:55	34.09	49.10	26.67	49.99	26.08	49.68	20.57	50.41	23.30
5/4/12 11:00	34.11	49.13	26.68	49.97	26.13	49.67	20.62	50.33	23.29
5/4/12 11:05	34.18	49.15	26.72	49.94	26.17	49.65	20.68	50.36	23.31
5/4/12 11:10	34.17	49.11	26.73	49.92	26.19	49.65	20.71	50.37	23.31
5/4/12 11:15	34.23	49.13	26.76	49.90	26.23	49.64	20.77	50.34	23.29
5/4/12 11:20	34.23	49.26	26.81	49.90	26.26	49.64	20.81	50.37	23.29
5/4/12 11:25	34.23	49.32	26.81	49.88	26.29	49.63	20.85	50.46	23.30
5/4/12 11:29	34.32	49.25	26.80	49.88	26.30	49.62	20.89	50.49	23.29
5/4/12 11:30	34.25	49.25	26.80	49.85	26.32	49.62	20.89	50.51	23.30
5/4/12 11:35	34.30	49.24	26.81	49.85	26.35	49.61	20.93	50.55	23.29
5/4/12 11:40	34.34	49.24	26.84	49.85	26.38	49.61	20.99	50.51	23.29
5/4/12 11:41	34.56	49.24	26.99	49.85	26.47	49.61	20.99	50.51	23.29
5/4/12 11:42	34.67	49.27	27.06	49.85	26.51	49.60	21.01	50.49	23.31
5/4/12 11:43	34.75	49.30	27.12	49.85	26.54	49.60	21.03	50.48	23.30
5/4/12 11:45	34.83	49.23	27.18	49.85	26.56	49.61	21.06	50.43	23.29
5/4/12 11:49	34.94	49.17	27.29	49.88	26.56	49.59	21.10	50.34	23.30
5/4/12 11:50	34.93	49.18	27.29	49.85	26.55	49.59	21.10	50.31	23.31
5/4/12 11:55	34.89	49.13	27.24	49.85	26.53	49.57	21.14	50.26	23.29
5/4/12 12:00	34.95	49.10	27.29	49.85	26.52	49.57	21.17	50.23	23.29
5/4/12 12:03	35.29	49.06	27.47	49.85	26.62	49.57	21.21	50.22	23.31
5/4/12 12:04	35.36	49.06	27.58	49.85	26.70	49.56	21.25	50.22	23.29
5/4/12 12:05	35.42	49.06	27.66	49.85	26.74	49.56	21.24	50.22	23.31
5/4/12 12:06	35.37	49.05	27.68	49.85	26.79	49.56	21.28	50.22	23.30
5/4/12 12:07	35.28	49.07	27.60	49.90	26.72	49.57	21.28	50.21	23.30
5/4/12 12:10	35.24	49.06	27.53	49.90	26.70	49.55	21.30	50.21	23.29
5/4/12 12:11	35.17	49.06	27.49	49.88	26.69	49.55	21.29	50.21	23.31
5/4/12 12:15	35.18	49.10	27.50	49.88	26.68	49.55	21.32	50.21	23.31
5/4/12 12:20	35.22	49.09	27.46	49.88	26.69	49.54	21.35	50.22	23.29
5/4/12 12:25	35.25	49.04	27.44	49.88	26.70	49.52	21.36	50.22	23.29
5/4/12 12:27	35.49	49.01	27.58	49.88	26.80	49.52	21.40	50.22	23.31
5/4/12 12:28	35.55	49.00	27.66	49.88	26.84	49.53	21.38	50.22	23.31
5/4/12 12:30	35.62	48.98	27.74	49.88	26.90	49.52	21.39	50.22	23.31
5/4/12 12:31	35.69	49.00	27.77	49.85	26.90	49.52	21.38	50.22	23.29
5/4/12 12:35	35.73	49.05	27.79	49.85	26.96	49.52	21.39	50.22	23.30
5/4/12 12:39	35.78	49.03	27.82	49.85	27.00	49.51	21.39	50.22	23.31
5/4/12 12:40	35.73	49.03	27.81	49.88	26.98	49.51	21.38	50.22	23.31
5/4/12 12:45	35.77	49.04	27.82	49.88	27.01	49.50	21.39	50.22	23.31
5/4/12 12:49	34.51	49.08	27.55	49.88	26.86	49.49	21.40	50.22	23.30
5/4/12 12:50	32.09	49.10	25.85	49.92	25.70	49.49	21.38	50.23	23.31
5/4/12 12:51	32.56	49.08	25.63	49.97	25.46	49.49	21.30	50.22	23.30
5/4/12 12:52	33.17	49.07	26.05	49.99	25.71	49.48	21.31	50.23	23.32
5/4/12 12:53	33.61	49.06	26.35	49.99	25.91	49.47	21.32	50.22	23.30
5/4/12 12:54	33.85	49.07	26.54	49.99	26.05	49.47	21.36	50.23	23.31
5/4/12 12:55	34.07	49.06	26.67	49.99	26.15	49.48	21.37	50.23	23.31
5/4/12 12:56	34.20	49.06	26.77	49.99	26.22	49.47	21.40	50.23	23.30
5/4/12 12:57	34.30	49.05	26.86	49.99	26.28	49.47	21.40	50.23	23.31
5/4/12 12:58	34.37	49.03	26.92	49.99	26.33	49.47	21.40	50.23	23.33
5/4/12 13:00	34.42	49.01	27.00	49.99	26.38	49.47	21.40	50.24	23.32
5/4/12 13:01	32.77	49.01	26.37	49.97	26.00	49.47	21.40	50.23	23.32
5/4/12 13:02	33.15	49.01	26.02	49.97	25.69	49.46	21.32	50.24	23.33
5/4/12 13:03	33.94	49.01	26.52	49.97	26.01	49.46	21.34	50.24	23.32
5/4/12 13:04	34.41	49.03	26.86	49.97	26.25	49.46	21.38	50.24	23.32
5/4/12 13:05	34.74	49.05	27.09	49.94	26.43	49.45	21.40	50.24	23.32
5/4/12 13:06	34.99	49.06	27.28	49.94	26.56	49.46	21.39	50.24	23.31
5/4/12 13:07	35.14	49.07	27.41	49.97	26.67	49.46	21.41	50.24	23.32
5/4/12 13:08	35.28	49.08	27.50	49.97	26.74	49.46	21.41	50.24	23.32
5/4/12 13:09	35.38	49.09	27.57	49.94	26.80	49.46	21.39	50.24	23.31
5/4/12 13:10	35.45	49.11	27.65	49.94	26.84	49.45	21.40	50.24	23.32
5/4/12 13:11	35.53	49.06	27.68	49.94	26.87	49.46	21.42	50.24	23.33
5/4/12 13:15	35.65	49.07	27.74	49.97	26.95	49.45	21.40	50.25	23.32

Date/Time	Ranney Collector No. 3 Depth to Water (feet)	Ranney Collector No. 3 Water Temperature (degrees F)	MW-1 Depth to Water (feet)	MW-1 Water Temperature (degrees F)	MW-7 Depth to Water (feet)	MW-7 Water Temperature (degrees F)	MW-2 Depth to Water (feet)	MW-2 Water Temperature (degrees F)	SCADA River Elevation (feet)
5/4/12 13:20	35.70	49.09	27.79	49.92	27.00	49.44	21.39	50.26	23.32
5/4/12 13:25	35.72	49.14	27.80	49.90	27.05	49.43	21.38	50.27	23.33
5/4/12 13:30	35.75	49.15	27.81	49.94	27.05	49.43	21.39	50.26	23.32
5/4/12 13:35	35.76	49.11	27.83	49.94	27.07	49.43	21.40	50.26	23.33
5/4/12 13:40	35.60	49.13	27.82	49.92	27.03	49.42	21.38	50.26	23.35
5/4/12 13:41	35.53	49.13	27.77	49.88	26.99	49.43	21.39	50.26	23.33
5/4/12 13:42	35.46	49.11	27.71	49.88	26.97	49.42	21.38	50.25	23.33
5/4/12 13:43	35.41	49.12	27.67	49.88	26.94	49.42	21.39	50.26	23.35
5/4/12 13:45	35.38	49.16	27.64	49.97	26.90	49.42	21.39	50.26	23.34
5/4/12 13:47	32.78	49.19	26.39	49.99	26.12	49.41	21.38	50.26	23.35
5/4/12 13:48	30.96	49.19	25.06	49.99	25.15	49.40	21.38	50.26	23.33
5/4/12 13:49	29.66	49.18	24.08	50.01	24.40	49.39	21.29	50.27	23.33
5/4/12 13:50	28.76	49.18	23.38	50.01	23.85	49.37	21.10	50.27	23.34
5/4/12 13:51	28.09	49.16	22.86	49.99	23.42	49.34	20.97	50.34	23.33
5/4/12 13:52	27.60	49.14	22.49	49.99	23.11	49.33	20.82	50.49	23.33
5/4/12 13:53	27.26	49.11	22.22	49.99	22.88	49.32	20.70	50.61	23.36
5/4/12 13:54	27.00	49.10	22.01	49.99	22.71	49.31	20.62	50.70	23.34
5/4/12 13:55	26.81	49.09	21.84	49.99	22.58	49.30	20.55	50.78	23.33
5/4/12 13:56	26.66	49.09	21.69	49.99	22.48	49.30	20.49	50.85	23.35
5/4/12 13:57	26.55	49.10	21.61	49.99	22.39	49.30	20.43	50.90	23.36
5/4/12 13:58	26.46	49.15	21.53	49.97	22.32	49.29	20.39	50.93	23.33
5/4/12 13:59	26.40	49.18	21.47	49.99	22.26	49.30	20.33	50.95	23.35
5/4/12 14:00	26.34	49.19	21.43	49.99	22.23	49.29	20.29	50.96	23.35
5/4/12 14:01	26.27	49.18	21.37	49.99	22.19	49.29	20.25	50.97	23.35
5/4/12 14:05	26.11	49.13	21.22	49.99	22.04	49.29	20.12	50.96	23.35
5/4/12 14:10	25.97	49.17	21.06	50.01	21.93	49.30	19.99	50.94	23.35
5/4/12 14:15	25.89	49.24	20.95	49.99	21.83	49.30	19.88	50.95	23.35
5/4/12 14:17	28.15	49.28	21.98	49.99	22.62	49.29	20.02	50.95	23.35
5/4/12 14:18	30.01	49.29	23.26	49.99	23.62	49.30	20.25	50.96	23.36
5/4/12 14:19	31.48	49.28	24.26	49.97	24.39	49.30	20.43	50.96	23.34
5/4/12 14:20	32.55	49.29	25.02	49.97	24.95	49.30	20.59	50.94	23.35
5/4/12 14:21	33.39	49.29	25.77	49.97	25.41	49.31	20.70	50.89	23.35
5/4/12 14:22	34.01	49.26	26.33	49.97	25.75	49.33	20.78	50.89	23.35
5/4/12 14:23	34.45	49.24	26.67	49.97	26.01	49.33	20.87	50.90	23.37
5/4/12 14:24	34.63	49.21	26.89	49.97	26.18	49.35	20.93	50.91	23.34
5/4/12 14:25	34.77	49.21	27.00	49.97	26.28	49.35	20.97	50.92	23.36
5/4/12 14:26	34.86	49.21	27.11	49.99	26.35	49.36	21.01	50.91	23.34
5/4/12 14:27	34.96	49.19	27.18	49.99	26.41	49.37	21.04	50.89	23.36
5/4/12 14:28	35.06	49.17	27.23	49.99	26.47	49.37	21.05	50.86	23.34
5/4/12 14:30	35.12	49.16	27.32	49.99	26.54	49.38	21.13	50.84	23.34
5/4/12 14:33	35.25	49.09	27.38	49.99	26.61	49.38	21.18	50.82	23.35
5/4/12 14:35	35.29	49.08	27.43	49.97	26.66	49.38	21.21	50.80	23.35
5/4/12 14:36	35.11	49.10	27.47	49.97	26.67	49.38	21.24	50.80	23.35
5/4/12 14:37	34.71	49.09	27.07	49.97	26.42	49.38	21.21	50.78	23.36
5/4/12 14:38	34.59	49.06	27.03	49.97	26.38	49.37	21.21	50.77	23.35
5/4/12 14:39	34.53	49.08	26.99	49.94	26.36	49.38	21.21	50.77	23.35
5/4/12 14:40	34.47	49.07	26.96	49.94	26.34	49.37	21.21	50.75	23.35
5/4/12 14:45	34.41	49.08	26.91	49.90	26.31	49.36	21.25	50.70	23.37
5/4/12 14:50	34.47	49.06	26.91	49.90	26.31	49.34	21.30	50.66	23.35
5/4/12 14:55	34.43	49.09	26.92	49.90	26.33	49.34	21.34	50.62	23.35
5/4/12 15:00	34.49	49.06	26.94	49.83	26.36	49.33	21.36	50.59	23.34
5/4/12 15:05	34.53	49.07	26.93	49.81	26.38	49.33	21.40	50.57	23.35
5/4/12 15:06	34.85	49.05	27.15	49.83	26.51	49.32	21.40	50.56	23.37
5/4/12 15:07	35.09	49.02	27.29	49.85	26.60	49.33	21.39	50.56	23.35
5/4/12 15:08	35.22	49.01	27.41	49.85	26.69	49.33	21.40	50.55	23.36
5/4/12 15:09	35.33	49.04	27.49	49.85	26.75	49.32	21.39	50.55	23.35
5/4/12 15:10	35.39	49.05	27.55	49.85	26.80	49.33	21.41	50.53	23.36
5/4/12 15:11	35.45	49.07	27.59	49.85	26.83	49.32	21.41	50.53	23.36
5/4/12 15:12	35.51	49.07	27.63	49.85	26.86	49.33	21.39	50.53	23.35
5/4/12 15:14	35.56	49.09	27.68	49.88	26.91	49.32	21.39	50.53	23.36
5/4/12 15:15	36.92	49.07	28.25	49.97	27.25	49.33	21.40	50.52	23.36
5/4/12 15:16	38.48	49.07	29.23	51.21	27.91	49.33	21.40	50.52	23.35

	Ranney Collector No. 3		MW-1		MW-7		MW-2		SCADA
Date/Time	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	River Elevation (feet)
5/4/12 15:17	39.56	49.06	30.00	51.75	28.45	49.34	21.39	50.51	23.35
5/4/12 15:18	40.35	49.07	30.61	51.96	28.87	49.36	21.39	50.51	23.35
5/4/12 15:19	41.00	49.08	31.08	52.05	29.20	49.37	21.40	50.51	23.35
5/4/12 15:20	41.44	49.07	31.43	52.09	29.46	49.39	21.39	50.51	23.35
5/4/12 15:21	41.79	49.08	31.66	52.14	29.67	49.40	21.40	50.50	23.36
5/4/12 15:22	42.03	49.08	31.92	52.16	29.83	49.42	21.40	50.50	23.36
5/4/12 15:23	42.31	49.08	32.08	52.18	29.97	49.43	21.40	50.49	23.35
5/4/12 15:24	42.48	49.08	32.24	52.20	30.06	49.44	21.39	50.49	23.35
5/4/12 15:25	42.64	49.09	32.28	52.23	30.16	49.44	21.39	50.49	23.35
5/4/12 15:27	42.78	49.11	32.52	52.25	30.31	49.46	21.39	50.48	23.36
5/4/12 15:28	42.91	49.09	32.55	52.27	30.36	49.46	21.38	50.48	23.35
5/4/12 15:30	43.05	49.07	32.67	52.29	30.43	49.48	21.40	50.48	23.37
5/4/12 15:32	43.13	49.09	32.68	52.32	30.51	49.49	21.40	50.46	23.35
5/4/12 15:34	43.19	49.07	32.79	52.34	30.55	49.49	21.39	50.46	23.37
5/4/12 15:35	43.23	49.07	32.76	52.34	30.58	49.50	21.40	50.46	23.36
5/4/12 15:40	43.32	49.09	32.91	52.41	30.68	49.49	21.40	50.45	23.36
5/4/12 15:41	43.26	49.08	32.90	52.43	30.71	49.49	21.39	50.44	23.36
5/4/12 15:43	43.36	49.09	32.93	52.43	30.75	49.48	21.41	50.44	23.35
5/4/12 15:45	43.40	49.07	32.92	52.45	30.78	49.48	21.39	50.44	23.38
5/4/12 15:49	43.46	49.10	32.96	52.50	30.83	49.48	21.40	50.43	23.36
5/4/12 15:50	43.50	49.10	32.96	52.52	30.85	49.47	21.38	50.43	23.37
5/4/12 15:51	43.43	49.11	33.03	52.52	30.85	49.48	21.39	50.42	23.35
5/4/12 15:55	43.49	49.12	33.03	52.57	30.92	49.46	21.39	50.42	23.37
5/4/12 16:00	43.53	49.08	33.10	52.61	30.97	49.46	21.38	50.41	23.39
5/4/12 16:03	43.59	49.08	33.14	52.63	31.00	49.45	21.39	50.40	23.37
5/4/12 16:05	43.55	49.08	33.15	52.66	31.02	49.45	21.39	50.40	23.38
5/4/12 16:09	43.58	49.09	33.20	52.68	31.07	49.45	21.40	50.39	23.37
5/4/12 16:10	43.60	49.09	33.20	52.70	31.07	49.44	21.38	50.39	23.37
5/4/12 16:15	43.65	49.07	33.26	52.75	31.15	49.43	21.38	50.39	23.38
5/4/12 16:20	43.74	49.06	33.28	52.79	31.17	49.43	21.41	50.38	23.38
5/4/12 16:25	43.75	49.08	33.31	52.81	31.23	49.42	21.39	50.37	23.37
5/4/12 16:30	43.76	49.09	33.30	52.86	31.26	49.42	21.39	50.36	23.38
5/4/12 16:35	43.83	49.06	33.36	52.90	31.32	49.41	21.40	50.38	23.39
5/4/12 16:40	43.85	49.07	33.35	52.95	31.37	49.41	21.41	50.36	23.37
5/4/12 16:45	43.87	49.08	33.38	52.97	31.40	49.40	21.40	50.35	23.38
5/4/12 16:50	43.87	49.10	33.45	53.02	31.43	49.39	21.40	50.34	23.40
5/4/12 16:55	43.92	49.10	33.48	53.04	31.47	49.39	21.40	50.33	23.39
5/4/12 17:00	43.95	49.08	33.47	53.09	31.52	49.39	21.40	50.32	23.39
5/4/12 17:05	43.96	49.08	33.54	53.11	31.55	49.38	21.40	50.30	23.40
5/4/12 17:10	44.01	49.08	33.52	53.15	31.58	49.38	21.40	50.30	23.39
5/4/12 17:14	43.80	49.10	33.50	53.18	31.62	49.38	21.40	50.29	23.40
5/4/12 17:15	43.57	49.08	33.33	53.18	31.48	49.38	21.39	50.29	23.38
5/4/12 17:16	43.42	49.09	33.21	53.20	31.43	49.38	21.39	50.29	23.38
5/4/12 17:17	43.34	49.10	33.13	53.20	31.40	49.38	21.39	50.29	23.39
5/4/12 17:18	43.24	49.10	33.06	53.22	31.38	49.37	21.41	50.29	23.39
5/4/12 17:19	43.18	49.10	33.04	53.22	31.37	49.37	21.39	50.29	23.39
5/4/12 17:20	43.12	49.10	33.01	53.22	31.37	49.37	21.40	50.29	23.40
5/4/12 17:21	43.07	49.09	32.99	53.22	31.37	49.36	21.40	50.28	23.40
5/4/12 17:25	43.06	49.09	33.01	53.27	31.40	49.36	21.40	50.28	23.38
5/4/12 17:26	43.12	49.11	33.01	53.27	31.42	49.35	21.40	50.28	23.39
5/4/12 17:30	43.12	49.12	33.03	53.29	31.46	49.36	21.40	50.28	23.39
5/4/12 17:35	43.16	49.08	33.05	53.31	31.52	49.36	21.39	50.28	23.40
5/4/12 17:40	43.15	49.05	33.07	53.33	31.56	49.35	21.40	50.28	23.38
5/4/12 17:45	43.20	49.09	33.09	53.38	31.60	49.35	21.40	50.28	23.39
5/4/12 17:46	41.78	49.10	32.50	53.38	31.28	49.35	21.40	50.27	23.39
5/4/12 17:47	40.50	49.08	31.64	52.38	30.70	49.35	21.40	50.27	23.38
5/4/12 17:48	39.59	49.07	30.97	50.96	30.24	49.34	21.39	50.27	23.38
5/4/12 17:49	38.91	49.07	30.44	50.35	29.88	49.34	21.41	50.28	23.40
5/4/12 17:50	38.36	49.08	30.05	50.10	29.60	49.33	21.39	50.27	23.40
5/4/12 17:51	37.98	49.09	29.75	50.01	29.38	49.32	21.40	50.28	23.39
5/4/12 17:52	37.68	49.09	29.52	49.97	29.21	49.33	21.41	50.28	23.41
5/4/12 17:53	37.42	49.09	29.34	49.97	29.09	49.32	21.41	50.28	23.40

	Ranney Collector No. 3		MW-1		MW-7		MW-2		SCADA
Date/Time	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	River Elevation (feet)
5/4/12 17:54	37.26	49.07	29.20	49.94	28.98	49.32	21.39	50.28	23.40
5/4/12 17:55	37.11	49.08	29.09	49.94	28.90	49.32	21.39	50.28	23.40
5/4/12 17:56	37.03	49.11	29.00	49.94	28.85	49.31	21.40	50.28	23.40
5/4/12 17:57	36.91	49.08	28.93	49.92	28.78	49.31	21.40	50.28	23.40
5/4/12 17:58	36.85	49.07	28.87	49.92	28.74	49.31	21.40	50.29	23.38
5/4/12 17:59	36.77	49.04	28.82	49.92	28.70	49.31	21.40	50.29	23.40
5/4/12 18:00	36.49	49.02	28.66	49.92	28.59	49.31	21.40	50.29	23.40
5/4/12 18:01	36.39	49.01	28.56	49.90	28.54	49.32	21.40	50.29	23.39
5/4/12 18:02	36.29	48.99	28.48	49.90	28.46	49.31	21.40	50.29	23.38
5/4/12 18:03	36.22	48.98	28.43	49.90	28.43	49.31	21.40	50.29	23.40
5/4/12 18:04	36.16	48.99	28.37	49.88	28.38	49.31	21.40	50.29	23.39
5/4/12 18:05	36.11	48.99	28.33	49.88	28.34	49.31	21.40	50.30	23.39
5/4/12 18:06	36.03	48.98	28.30	49.88	28.33	49.31	21.40	50.29	23.40
5/4/12 18:10	35.99	48.98	28.19	49.83	28.26	49.31	21.40	50.30	23.40
5/4/12 18:12	35.89	48.98	28.15	49.83	28.22	49.31	21.39	50.30	23.39
5/4/12 18:15	35.83	48.97	28.10	49.79	28.16	49.31	21.40	50.31	23.38
5/4/12 18:16	35.77	48.99	28.09	49.81	28.14	49.31	21.39	50.30	23.39
5/4/12 18:20	35.76	48.98	28.05	49.81	28.10	49.31	21.39	50.30	23.39
5/4/12 18:24	35.72	48.98	28.01	49.81	28.07	49.31	21.39	50.31	23.40
5/4/12 18:25	35.73	49.00	28.00	49.83	28.07	49.32	21.39	50.31	23.39
5/4/12 18:26	35.68	48.99	28.00	49.83	28.06	49.32	21.40	50.31	23.39
5/4/12 18:30	35.66	48.97	27.97	49.83	28.04	49.31	21.39	50.31	23.36
5/4/12 18:34	35.63	48.96	27.96	49.81	28.01	49.31	21.41	50.31	23.38
5/4/12 18:35	35.61	48.97	27.95	49.81	28.01	49.31	21.40	50.31	23.37
5/4/12 18:40	35.60	48.97	27.93	49.83	27.98	49.31	21.41	50.32	23.36
5/4/12 18:45	35.57	48.97	27.91	49.83	27.96	49.32	21.39	50.32	23.36
5/4/12 18:50	35.53	48.98	27.89	49.83	27.96	49.31	21.40	50.32	23.38
5/4/12 18:55	35.54	48.99	27.88	49.81	27.95	49.32	21.39	50.31	23.37
5/4/12 18:59	35.57	49.00	27.87	49.81	27.94	49.31	21.39	50.32	23.37
5/4/12 19:00	35.58	48.98	27.88	49.81	27.94	49.31	21.39	50.32	23.36
5/4/12 19:05	35.55	48.99	27.89	49.81	27.93	49.31	21.39	50.31	23.36
5/4/12 19:10	35.60	48.97	27.88	49.83	27.93	49.31	21.40	50.32	23.35
5/4/12 19:11	35.51	48.96	27.87	49.83	27.92	49.31	21.42	50.31	23.36
5/4/12 19:15	35.50	49.02	27.86	49.81	27.91	49.30	21.38	50.31	23.37
5/4/12 19:16	35.55	49.01	27.86	49.79	27.90	49.31	21.40	50.31	23.35
5/4/12 19:20	35.49	49.01	27.86	49.79	27.90	49.31	21.40	50.31	23.37
5/4/12 19:25	35.54	49.00	27.86	49.79	27.90	49.31	21.40	50.31	23.36
5/4/12 19:28	35.55	48.98	27.86	49.81	27.90	49.30	21.41	50.31	23.36
5/4/12 19:30	35.54	48.97	27.86	49.83	27.91	49.31	21.40	50.32	23.35
5/4/12 19:35	35.50	49.04	27.86	49.81	27.90	49.30	21.40	50.32	23.35
5/4/12 19:40	35.50	49.02	27.86	49.81	27.90	49.30	21.40	50.32	23.35
5/4/12 19:41	35.55	49.00	27.85	49.81	27.90	49.30	21.40	50.31	23.35
5/4/12 19:45	35.53	49.01	27.85	49.81	27.89	49.30	21.39	50.32	23.34
5/4/12 19:50	35.49	48.99	27.84	49.79	27.88	49.31	21.40	50.32	23.36
5/4/12 19:55	35.48	48.99	27.83	49.79	27.86	49.31	21.41	50.31	23.33
5/4/12 20:00	35.50	48.97	27.84	49.81	27.87	49.31	21.40	50.31	23.33
5/4/12 20:12	35.46	49.00	27.84	49.81	27.87	49.31	21.39	50.31	23.35
5/4/12 20:13	35.52	49.01	27.84	49.81	27.87	49.31	21.39	50.30	23.35
5/4/12 20:21	35.46	49.01	27.82	49.81	27.86	49.31	21.39	50.30	23.35
5/4/12 20:41	35.53	48.98	27.83	49.83	27.87	49.32	21.40	50.30	23.33
5/4/12 20:42	35.48	49.00	27.84	49.81	27.88	49.32	21.40	50.30	23.32
5/4/12 21:00	35.47	49.01	27.84	49.83	27.88	49.33	21.39	50.30	23.32
5/4/12 21:04	35.48	48.99	27.85	49.81	27.88	49.33	21.39	50.30	23.31
5/4/12 21:19	35.55	48.99	27.87	49.83	27.90	49.32	21.39	50.30	23.31
5/4/12 21:20	35.50	49.00	27.86	49.81	27.89	49.32	21.40	50.30	23.32
5/4/12 21:22	35.56	49.02	27.86	49.83	27.90	49.32	21.41	50.30	23.32
5/4/12 21:27	35.60	49.05	27.87	49.81	27.90	49.33	21.41	50.31	23.31
5/4/12 21:40	35.53	49.00	27.87	49.83	27.89	49.34	21.39	50.30	23.32
5/4/12 21:57	35.60	49.01	27.89	49.83	27.90	49.34	21.40	50.30	23.32
5/4/12 21:58	35.79	49.01	28.02	49.83	28.01	49.34	21.39	50.30	23.31
5/4/12 21:59	35.88	49.01	28.08	49.83	28.04	49.34	21.40	50.30	23.31
5/4/12 22:00	35.95	49.02	28.12	49.83	28.08	49.35	21.40	50.30	23.30

	Ranney Collector No. 3		MW-1		MW-7		MW-2		SCADA
Date/Time	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	River Elevation (feet)
5/4/12 22:42	36.22	49.02	28.32	49.83	28.28	49.37	21.38	50.31	23.32
5/4/12 23:00	36.16	49.02	28.33	49.88	28.26	49.37	21.40	50.31	23.31
5/4/12 23:04	36.14	49.02	28.32	49.88	28.26	49.37	21.39	50.31	23.32
5/4/12 23:07	36.21	49.02	28.32	49.85	28.28	49.37	21.40	50.30	23.32
5/4/12 23:45	36.17	49.02	28.34	49.88	28.30	49.39	21.41	50.31	23.34
5/5/12 0:00	36.21	49.05	28.34	49.88	28.32	49.40	21.39	50.30	23.34
5/5/12 1:00	36.26	49.05	28.39	49.88	28.38	49.42	21.40	50.32	23.36
5/5/12 1:05	36.30	49.03	28.40	49.83	28.38	49.42	21.40	50.31	23.36
5/5/12 1:09	36.59	49.01	28.55	49.92	28.47	49.42	21.40	50.31	23.35
5/5/12 1:12	36.69	49.02	28.65	49.92	28.51	49.42	21.40	50.31	23.36
5/5/12 2:00	36.59	49.08	28.56	49.92	28.27	49.43	21.38	50.32	23.36
5/5/12 3:00	36.58	49.07	28.52	49.90	28.21	49.45	21.40	50.32	23.39
5/5/12 3:01	36.51	49.08	28.53	49.92	28.21	49.45	21.40	50.33	23.37
5/5/12 4:00	36.49	49.09	28.50	49.94	28.15	49.47	21.39	50.32	23.41
5/5/12 4:50	36.50	49.14	28.48	49.94	28.12	49.49	21.39	50.34	23.38
5/5/12 5:00	36.54	49.14	28.53	49.92	28.13	49.50	21.38	50.33	23.39
5/5/12 5:01	36.48	49.14	28.52	49.92	28.14	49.50	21.39	50.34	23.40
5/5/12 6:00	36.50	49.12	28.52	49.97	28.12	49.52	21.42	50.34	23.40
5/5/12 6:02	36.38	49.16	28.49	49.97	28.10	49.53	21.39	50.34	23.40
5/5/12 6:03	36.02	49.17	28.28	49.97	27.94	49.52	21.39	50.34	23.39
5/5/12 6:04	35.88	49.16	28.22	49.94	27.88	49.53	21.38	50.34	23.40
5/5/12 6:05	35.79	49.17	28.19	49.94	27.81	49.53	21.40	50.34	23.40
5/5/12 6:06	35.69	49.19	28.19	49.94	27.78	49.53	21.39	50.34	23.41
5/5/12 6:11	35.63	49.21	28.26	49.94	27.73	49.54	21.39	50.34	23.38
5/5/12 6:12	35.69	49.21	28.27	49.97	27.73	49.54	21.38	50.34	23.40
5/5/12 7:00	35.77	49.26	28.46	49.97	27.75	49.52	21.40	50.35	23.39
5/5/12 7:23	35.75	49.29	28.48	49.97	27.75	49.56	21.39	50.35	23.39
5/5/12 7:38	35.82	49.27	28.52	49.99	27.74	49.54	21.40	50.31	23.38
5/5/12 8:00	35.78	49.31	28.52	49.99	27.74	49.55	21.38	50.34	23.38
5/5/12 8:11	35.80	49.33	28.53	50.01	27.73	49.58	21.41	50.34	23.38
5/5/12 8:29	35.81	49.27	28.55	50.01	27.74	49.57	21.37	50.36	23.39
5/5/12 9:00	35.79	49.33	28.58	50.01	27.74	49.58	21.38	50.35	23.38
5/5/12 9:14	35.82	49.30	28.59	50.01	27.72	49.59	21.38	50.36	23.37
5/5/12 9:19	35.76	49.32	28.60	50.01	27.73	49.60	21.39	50.35	23.38
5/5/12 9:20	35.81	49.32	28.59	50.01	27.74	49.60	21.39	50.36	23.39
5/5/12 9:26	35.85	49.31	28.60	50.01	27.74	49.60	21.38	50.36	23.39
5/5/12 9:32	35.48	49.34	28.40	50.01	27.63	49.60	21.38	50.36	23.39
5/5/12 9:33	35.33	49.32	28.32	50.01	27.57	49.61	21.39	50.37	23.39
5/5/12 9:34	35.23	49.29	28.24	50.01	27.52	49.61	21.39	50.36	23.40
5/5/12 9:35	35.16	49.28	28.19	50.03	27.53	49.61	21.39	50.36	23.40
5/5/12 9:36	35.10	49.30	28.15	50.03	27.50	49.62	21.39	50.36	23.39
5/5/12 10:00	35.10	49.26	28.16	50.03	27.60	49.61	21.39	50.37	23.40
5/5/12 10:05	35.10	49.34	28.16	49.99	27.60	49.62	21.39	50.38	23.39
5/5/12 10:10	35.10	49.32	28.18	50.01	27.63	49.61	21.41	50.37	23.39
5/5/12 10:12	35.10	49.34	28.18	50.06	27.62	49.60	21.39	50.37	23.39
5/5/12 10:15	35.09	49.33	28.18	50.03	27.63	49.62	21.38	50.37	23.40
5/5/12 10:19	35.07	49.31	28.18	50.01	27.65	49.62	21.39	50.39	23.39
5/5/12 10:20	35.10	49.30	28.18	49.99	27.63	49.62	21.39	50.39	23.39
5/5/12 10:21	35.12	49.30	28.19	50.01	27.63	49.62	21.39	50.39	23.40
5/5/12 10:22	35.12	49.30	28.18	50.01	27.64	49.61	21.38	50.39	23.40
5/5/12 10:23	35.12	49.31	28.18	50.03	27.65	49.62	21.39	50.39	23.40
5/5/12 10:24	35.09	49.31	28.19	50.03	27.64	49.62	21.40	50.39	23.40
5/5/12 10:25	35.13	49.28	28.18	50.01	27.64	49.62	21.39	50.39	23.39
5/5/12 10:26	35.13	49.28	28.19	49.97	27.64	49.62	21.39	50.39	23.38
5/5/12 10:27	35.12	49.27	28.19	49.94	27.64	49.62	21.39	50.39	23.40
5/5/12 10:28	33.05	49.30	27.19	49.94	27.01	49.63	21.38	50.39	23.39
5/5/12 10:29	31.60	49.30	26.10	49.90	26.19	49.62	21.39	50.38	23.39
5/5/12 10:30	30.57	49.29	25.31	49.99	25.61	49.62	21.39	50.39	23.40
5/5/12 10:31	29.87	49.26	24.75	50.08	25.16	49.63	21.39	50.38	23.39
5/5/12 10:32	29.36	49.25	24.34	50.12	24.84	49.63	21.40	50.39	23.39
5/5/12 10:33	28.98	49.29	24.04	50.15	24.60	49.64	21.40	50.39	23.40
5/5/12 10:34	28.71	49.33	23.81	50.12	24.42	49.64	21.40	50.39	23.40

	Ranney Collector No. 3		MW-1		MW-7		MW-2		SCADA
Date/Time	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	Depth to Water (feet)	Water Temperature (degrees F)	River Elevation (feet)
5/5/12 10:35	28.51	49.41	23.64	50.12	24.28	49.64	21.39	50.39	23.40
5/5/12 10:36	28.35	49.45	23.51	50.15	24.18	49.64	21.39	50.39	23.40
5/5/12 10:37	28.22	49.47	23.41	50.15	24.09	49.65	21.39	50.39	23.39
5/5/12 10:38	28.13	49.47	23.32	50.15	24.02	49.65	21.39	50.39	23.39
5/5/12 10:39	28.05	49.50	23.26	50.15	23.95	49.64	21.39	50.39	23.39
5/5/12 10:40	27.99	49.51	23.20	50.17	23.90	49.64	21.39	50.39	23.38
5/5/12 10:41	27.93	49.50	23.15	50.15	23.87	49.64	21.39	50.39	23.39
5/5/12 10:45	27.77	49.48	22.98	50.15	23.74	49.64	21.39	50.39	23.38
5/5/12 10:50	27.65	49.43	22.86	50.12	23.61	49.61	21.38	50.39	23.39
5/5/12 10:55	27.54	49.35	22.77	50.10	23.52	49.62	21.39	50.38	23.39
5/5/12 11:00	27.45	49.36	22.70	50.08	23.44	49.60	21.38	50.38	23.41
5/5/12 11:05	27.40	49.39	22.64	50.06	23.38	49.60	21.32	50.40	23.38
5/5/12 11:10	27.34	49.44	22.59	50.06	23.32	49.64	21.24	50.42	23.38
5/5/12 11:15	27.29	49.49	22.55	50.06	23.26	49.64	21.13	50.49	23.39
5/5/12 11:20	27.24	49.42	22.51	50.06	23.21	49.61	21.07	50.60	23.39
5/5/12 11:25	27.20	49.58	22.47	50.06	23.16	49.57	20.99	50.69	23.40
5/5/12 11:30	27.16	49.54	22.44	50.06	23.11	49.60	20.91	50.86	23.40
5/5/12 11:45	27.06	49.70	22.35	50.03	23.00	49.60	20.74	51.26	23.38
5/5/12 12:00	26.98	49.69	22.28	50.06	22.90	49.60	20.61	51.25	23.38
5/5/12 12:30	26.47	49.68	21.58	50.06	22.51	49.57	20.25	51.33	23.38
5/5/12 13:00	26.29	49.74	21.41	50.06	22.33	49.57	20.03	51.29	23.38
5/5/12 14:00	26.07	49.94	21.19	50.06	22.07	49.66	19.73	51.26	23.37
5/5/12 15:00	25.91	49.95	21.05	50.06	21.89	49.65	19.50	51.39	23.39
5/5/12 16:00	25.81	50.04	20.94	50.06	21.75	49.66	19.37	51.12	23.38
5/5/12 17:00	25.73	50.13	20.88	50.06	21.67	49.67	19.27	51.04	23.37
5/5/12 18:00	25.67	50.24	20.83	50.08	21.58	49.72	19.18	51.08	23.38
5/5/12 18:34	25.65	50.24	20.80	50.06	21.55	49.73	19.14	51.02	23.37
5/5/12 18:35			20.80	50.06	21.56	49.74	19.14	51.06	23.36
5/5/12 19:00			20.79	50.08	21.54	49.76	19.12	51.06	23.34
5/5/12 19:04			20.79	50.08	21.53	49.73	19.11	51.02	23.33
5/5/12 19:18					21.52	49.73	19.10	51.04	23.33
5/5/12 19:30							19.07	51.05	23.30
5/5/12 20:00									23.29
5/5/12 21:00									23.25
5/5/12 22:00									23.23
5/5/12 23:00									23.23
5/6/12 0:00									23.21

Well ID: Ranney Collector No. 3 **Job No. :** 14606
Client: Humboldt Bay Municipal Water Authority
Location: North side of Mad River approx. 3600 feet southeast of the WTP
Test Information: Post-maintenance pumping test

Flow Meter: Water Specialties Model ML20-D digital flow meter manufactured by McCrometer, Inc

Date/Time	Elapsed Time from Start of Pumping (minutes)	Elapsed Time from Start of Step (minutes)	Totalizer Reading (10000 gal)	Meter Rate (gpm)	Amount Pumped (gallons)	Average Pumping Rate (gpm)	Comments
5/3/12 9:07	0	0	117	8500			Start of Step 1
5/3/12 9:08	1	1		7300			
5/3/12 9:09	2	2		3000			
5/3/12 9:10	3	3	118	3000	10000	3333	
5/3/12 9:14	7	7	120		30000	4569	
5/3/12 9:15	8	8	120	3000	30000	3750	
5/3/12 9:20	13	13	122	3067	50000	3846	
5/3/12 9:25	18	18	123	3085	60000	3333	
5/3/12 9:27	20	20	124		70000	3556	
5/3/12 9:30	23	23	124	2998	70000	3043	
5/3/12 9:35	28	28	126	3018	90000	3214	
5/3/12 9:40	33	33	127	3074	100000	3030	
5/3/12 9:45	38	38	129	3058	120000	3158	
5/3/12 9:50	43	43	129	3016	120000	2791	
5/3/12 9:53	46	46	132		150000	3266	
5/3/12 9:55	48	48	132	3032	150000	3125	
5/3/12 10:00	53	53	132	3028	150000	2830	
5/3/12 10:05	58	58	135	3038	180000	3103	
5/3/12 10:06	59	59	136		190000	3217	Ave. for step = 3050 gpm
5/3/12 10:07	60	60					Start of Step 2
5/3/12 10:09	62	2	137		10000	5607	
5/3/12 10:10	63	3	137	4515	10000	3333	
5/3/12 10:15	68	8	139	4528	30000	3750	
5/3/12 10:20	73	13	142	4563	60000	4615	
5/3/12 10:25	78	18	144	4516	80000	4444	
5/3/12 10:30	83	23	147	4586	110000	4783	
5/3/12 10:34	87	27	149	4568	130000	4824	
5/3/12 10:35	88	28	149	4515	130000	4643	
5/3/12 10:40	93	33	151	4513	150000	4545	
5/3/12 10:45	98	38	153	4490	170000	4474	
5/3/12 10:49	102	42	156	4510	200000	4728	
5/3/12 10:50	103	43	156	4490	200000	4651	
5/3/12 11:00	113	53	161	4543	250000	4693	
5/3/12 11:05	118	58	163	4603	270000	4655	
5/3/12 11:07	120	60	164		280000	4678	Ave. for step = 4650 gpm
5/3/12 11:08	121	61					Start of Step 3
5/3/12 11:10	123	2	166	6058	20000		
5/3/12 11:15	128	7	168	5998	40000	5714	
5/3/12 11:20	133	12	171	6087	70000	5833	
5/3/12 11:25	138	17	174	6123	100000	5882	
5/3/12 11:30	143	22	178	6095	140000	6259	
5/3/12 11:35	148	27	180	6063	160000	5926	
5/3/12 11:40	153	32	184	6080	200000	6186	
5/3/12 11:45	158	37	186	6028	220000	5946	
5/3/12 11:50	163	42	189	6143	250000	5952	
5/3/12 11:55	168	47	192	6021	280000	5957	
5/3/12 11:57	170	49	194		300000	6131	
5/3/12 12:00	173	52	195	6030	310000	5962	
5/3/12 12:02	175	54	197		330000	6121	Ave. for step = 6020 gpm
5/3/12 12:05	178	57	198	6025	340000	5965	
5/3/12 12:08	181	60					Start of Step 4

Well ID: Ranney Collector No. 3 **Job No. :** 14606
Client: Humboldt Bay Municipal Water Authority
Location: North side of Mad River approx. 3600 feet southeast of the WTP
Test Information: Post-maintenance pumping test

Flow Meter: Water Specialties Model ML20-D digital flow meter manufactured by McCrometer, Inc

Date/Time	Elapsed Time from Start of Pumping (minutes)	Elapsed Time from Start of Step (minutes)	Totalizer Reading (10000 gal)	Meter Rate (gpm)	Amount Pumped (gallons)	Average Pumping Rate (gpm)	Comments
5/3/12 12:10	183	2	202	7540	40000		
5/3/12 12:15	188	7	205	7390	70000		
5/3/12 12:20	193	12	209	7483	110000	9167	
5/3/12 12:25	198	17	212	7481	140000	8235	
5/3/12 12:30	203	22	216	7404	180000	8182	
5/3/12 12:33	206	25	219		210000	8525	
5/3/12 12:35	208	27	221	7544	230000	8519	
5/3/12 12:40	213	32	224	7344	260000	8125	
5/3/12 12:45	218	37	228	7424	300000	8108	
5/3/12 12:47	220	39	230		320000	8108	
5/3/12 12:50	223	42	231	7518	330000	7857	
5/3/12 12:55	228	47	239	7514	410000	8723	
5/3/12 13:00	233	52	239	7381	410000	7946	
5/3/12 13:05	238	57	242	7302	440000	7719	
5/3/12 13:08	241	60	245		470000	7873	Ave. for step = 7420 gpm
5/3/12 14:45	0						Pump on to flush well
5/3/12 14:50	5		248	3400	30000	6000	
5/3/12 14:57	12		250		50000	4167	
5/3/12 15:22	37		259		140000	3784	
5/3/12 15:53	68		270		250000	3676	
5/3/12 16:10	85		276		310000	3647	
5/3/12 16:18	93		279		340000	3656	
5/3/12 16:25	100		281		360000	3600	
5/3/12 16:28	103		282	5300	370000	3592	
5/3/12 16:32	107		285		400000	3738	
5/3/12 16:41	116		290		450000	3879	
5/3/12 16:43	118			3700			
5/3/12 16:44	119			6500			
5/3/12 16:45	120		292		470000	3917	
5/3/12 16:53	128		297		520000	4063	
5/3/12 17:07	142		306		610000	4296	
5/3/12 17:21	156		315		700000	4487	

Well ID: Ranney Collector No. 3 **Job No. :** 14606
Client: Humboldt Bay Municipal Water Authority
Location: North side of Mad River approx. 3600 feet southeast of the WTP
Test Information: Post-maintenance pumping test
Measuring Point: Top edge of hatch frame in intermediate floor, 0.5 feet above floor
Measuring Point Elevation: 53.5

Date/Time	Depth to Water (feet)	Elapsed Time from Start of Pumping (minutes)	Elapsed Time from Start of Step (minutes)	Observed Drawdown (feet)	Water Elevation (feet)	Comments
5/2/12 15:13	25.30				28.20	
5/2/12 15:55	25.27				28.23	
5/3/12 7:55	26.19				27.31	
5/3/12 8:02	26.20				27.30	
5/3/12 8:48	26.21				27.29	
5/3/12 9:07		0				Start Step 1
5/3/12 9:18	33.32	11		7.11	20.18	
5/3/12 9:19	33.36	12		7.15	20.14	
5/3/12 9:20	33.42	13		7.21	20.08	
5/3/12 9:21	33.47	14		7.26	20.03	
5/3/12 9:22	33.49	15		7.28	20.01	
5/3/12 9:29	33.66	22		7.45	19.84	
5/3/12 9:39	33.79	32		7.58	19.71	
5/3/12 9:59	33.98	52		7.77	19.52	
5/3/12 10:04	34.01	57		7.80	19.49	
5/3/12 10:07		60				Start Step 2
5/3/12 10:11	36.54	64		10.33	16.96	
5/3/12 10:12	36.99	65		10.78	16.51	
5/3/12 10:14	37.52	67		11.31	15.98	
5/3/12 10:15	37.71	68		11.50	15.79	
5/3/12 10:17	37.95	70		11.74	15.55	
5/3/12 10:18	38.26	71		12.05	15.24	
5/3/12 10:20	40.38	73		14.17	13.12	
5/3/12 10:24	39.90	77		13.69	13.60	
5/3/12 10:30	39.15	83		12.94	14.35	
5/3/12 10:52	39.08	105		12.87	14.42	
5/3/12 10:56	39.12	109		12.91	14.38	
5/3/12 11:08		121				Start Step 3
5/3/12 11:12	42.16	125		15.95	11.34	
5/3/12 11:13	42.45	126		16.24	11.05	
5/3/12 11:14	42.75	127		16.54	10.75	
5/3/12 11:15	42.98	128		16.77	10.52	
5/3/12 11:19	43.52	132		17.31	9.98	
5/3/12 11:20	43.67	133		17.46	9.83	
5/3/12 11:21	43.75	134		17.54	9.75	
5/3/12 11:22	43.81	135		17.60	9.69	
5/3/12 11:23	43.87	136		17.66	9.63	
5/3/12 11:27	44.05	140		17.84	9.45	
5/3/12 11:47	44.43	160		18.22	9.07	
5/3/12 11:51	44.47	164		18.26	9.03	
5/3/12 11:54	44.51	167		18.30	8.99	
5/3/12 12:08		181				Start Step 4
5/3/12 12:12	47.50	185		21.29	6.00	
5/3/12 12:13	47.92	186		21.71	5.58	
5/3/12 12:14	48.20	187		21.99	5.30	
5/3/12 12:15	48.43	188		22.22	5.07	
5/3/12 12:16	48.60	189		22.39	4.90	
5/3/12 12:17	48.77	190		22.56	4.73	

Well ID: Ranney Collector No. 3 **Job No. :** 14606
Client: Humboldt Bay Municipal Water Authority
Location: North side of Mad River approx. 3600 feet southeast of the WTP
Test Information: Post-maintenance pumping test
Measuring Point: Top edge of hatch frame in intermediate floor, 0.5 feet above floor
Measuring Point Elevation: 53.5

Date/Time	Depth to Water (feet)	Elapsed Time from Start of Pumping (minutes)	Elapsed Time from Start of Step (minutes)	Observed Drawdown (feet)	Water Elevation (feet)	Comments
5/3/12 12:18	48.91	191		22.70	4.59	
5/3/12 12:19	49.01	192		22.80	4.49	
5/3/12 12:20	49.10	193		22.89	4.40	
5/3/12 12:21	49.20	194		22.99	4.30	
5/3/12 12:23	49.34	196		23.13	4.16	
5/3/12 12:28	49.54	201		23.33	3.96	
5/3/12 12:50	49.93	223		23.72	3.57	
5/3/12 12:55	49.98	228		23.77	3.52	
5/3/12 13:08		241				Pump off, Start Recovery
5/3/12 13:12	34.89	245		8.68	18.61	
5/3/12 13:44	27.32	277		1.11	26.18	
5/3/12 14:45						Pump on to flush well
5/3/12 15:04		357				Level meter 36.4
5/3/12 15:57		410				Level meter 36.0
5/3/12 16:12		425				Level meter 35.9
5/3/12 16:30		443				Level meter 33.0
5/3/12 17:04		477				Level meter 27.7
5/3/2012						
5/4/12 7:09	24.94				28.56	
5/4/12 9:46	25.51				27.99	
5/4/12 9:49		0		0		Start test
5/4/12 9:50	27.85	4		2.91	25.65	
5/4/12 9:51	29.14	5		4.20	24.36	
5/4/12 9:52	30.55	6		5.61	22.95	
5/4/12 9:53	31.21	7		6.27	22.29	
5/4/12 9:54	31.84	8		6.90	21.66	
5/4/12 9:55	32.29	9		7.35	21.21	
5/4/12 9:56	32.63	10		7.69	20.87	
5/4/12 9:57	32.91	11		7.97	20.59	
5/4/12 9:58	33.11	12		8.17	20.39	
5/4/12 9:59	33.25	13		8.31	20.25	
5/4/12 10:00	33.37	14		8.43	20.13	
5/4/12 10:01	33.45	15		8.51	20.05	
5/4/12 10:02	33.51	16		8.57	19.99	
5/4/12 10:03	33.57	17		8.63	19.93	
5/4/12 10:04	33.61	18		8.67	19.89	
5/4/12 10:09	33.74	23		8.80	19.76	
5/4/12 10:20	33.89	34		8.95	19.61	
5/4/12 10:28	33.96	42		9.02	19.54	
5/4/12 10:34	34.01	48		9.07	19.49	
5/4/12 10:39	34.03	53		9.09	19.47	
5/4/12 10:45	34.08	59		9.14	19.42	
5/4/12 10:49	34.10	63		9.16	19.40	
5/4/12 12:48	35.84	182		10.90	17.66	Pump 3.2 off
5/4/12 12:50		184				Pump 3.1 on
5/4/12 12:57	34.34	191		9.40	19.16	
5/4/12 13:00		194				Pump 3.1 off
5/4/12 13:01		195				Pump 3.2 on

Well ID: Ranney Collector No. 3 **Job No. :** 14606
Client: Humboldt Bay Municipal Water Authority
Location: North side of Mad River approx. 3600 feet southeast of the WTP
Test Information: Post-maintenance pumping test
Measuring Point: Top edge of hatch frame in intermediate floor, 0.5 feet above floor
Measuring Point Elevation: 53.5

Date/Time	Depth to Water (feet)	Elapsed Time from Start of Pumping (minutes)	Elapsed Time from Start of Step (minutes)	Observed Drawdown (feet)	Water Elevation (feet)	Comments
5/4/12 13:11	35.55	205		10.61	17.95	
5/4/12 13:46		240				Pump 3.2 off
5/4/12 14:16		270				Pump 3.2 on
5/4/12 14:34	35.31	288		10.37	18.19	
5/4/12 14:36		290				Pump 3.1 on, Pump 3.2 off
5/4/12 14:38	34.45	292		9.51	19.05	
5/4/12 14:43	34.50	297		9.56	19.00	
5/4/12 14:53	34.50	307		9.56	19.00	
5/4/12 15:04		318				Pump 3.2 on, Pump 3.1 off
5/4/12 15:11	35.51	325		10.57	17.99	
5/4/12 15:14		328				Pump 3.1 on, Pump 3.2 on
5/4/12 15:17	39.95	331		15.01	13.55	
5/4/12 15:21	41.85	335		16.91	11.65	
5/4/12 15:26	42.72	340		17.78	10.78	
5/4/12 15:30	43.10	344		18.16	10.40	
5/4/12 15:35	43.27	349		18.33	10.23	
5/4/12 15:42	43.40	356		18.46	10.10	
5/4/12 15:48	43.48	362		18.54	10.02	
5/4/12 16:05	43.66	379		18.72	9.84	
5/4/12 16:17	43.77	391		18.83	9.73	
5/4/12 16:39	43.92	413		18.98	9.58	
5/4/12 17:01	44.05	435		19.11	9.45	
5/4/12 17:14	44.11	448		19.17	9.39	
5/4/12 17:45		479				Pump 3.1 off
5/4/12 17:50	38.41	484		13.47	15.09	
5/4/12 18:13	35.93	507		10.99	17.57	
5/4/12 18:43	35.65	537		10.71	17.85	
5/4/12 19:10	35.62	564		10.68	17.88	
5/5/12 7:08	35.85	1282		10.91	17.65	
5/5/12 7:48	35.84	1322		10.90	17.66	
5/5/12 8:20	35.85	1354		10.91	17.65	
5/5/12 9:08	35.86	1402		10.92	17.64	
5/5/12 9:27	35.87	1421		10.93	17.63	
5/5/12 9:41	35.09	1435		10.15	18.41	
5/5/12 9:49	35.12	1443		10.18	18.38	
5/5/12 10:04	35.17	1458		10.23	18.33	
5/5/12 10:18	35.17	1472		10.23	18.33	
5/5/12 10:27		1481				Pump 3.2 off Start Recovery
5/5/12 10:28	32.82	1482		7.88	20.68	
5/5/12 10:29	31.80	1483		6.86	21.70	
5/5/12 10:30	30.43	1484		5.49	23.07	
5/5/12 10:31	30.01	1485		5.07	23.49	
5/5/12 10:32	29.46	1486		4.52	24.04	
5/5/12 10:33	29.07	1487		4.13	24.43	
5/5/12 10:34	28.79	1488		3.85	24.71	
5/5/12 10:35	28.58	1489		3.64	24.92	
5/5/12 10:36	28.41	1490		3.47	25.09	
5/5/12 10:37	28.28	1491		3.34	25.22	

Well ID: Ranney Collector No. 3 **Job No. :** 14606
Client: Humboldt Bay Municipal Water Authority
Location: North side of Mad River approx. 3600 feet southeast of the WTP
Test Information: Post-maintenance pumping test
Measuring Point: Top edge of hatch frame in intermediate floor, 0.5 feet above floor
Measuring Point Elevation: 53.5

Date/Time	Depth to Water (feet)	Elapsed Time from Start of Pumping (minutes)	Elapsed Time from Start of Step (minutes)	Observed Drawdown (feet)	Water Elevation (feet)	Comments
5/5/12 10:38	28.18	1492		3.24	25.32	
5/5/12 10:39	28.10	1493		3.16	25.40	
5/5/12 10:40	28.03	1494		3.09	25.47	
5/5/12 10:41	27.98	1495		3.04	25.52	
5/5/12 10:42	27.93	1496		2.99	25.57	
5/5/12 10:47	27.77	1501		2.83	25.73	
5/5/12 10:52	27.63	1506		2.69	25.87	
5/5/12 10:57	27.56	1511		2.62	25.94	
5/5/12 11:11	27.37	1525		2.43	26.13	
5/5/12 11:17	27.32	1531		2.38	26.18	
5/5/12 11:22	27.27	1536		2.33	26.23	
5/5/12 11:27	27.23	1541		2.29	26.27	
5/5/12 12:03	27.02	1577		2.08	26.48	
5/5/12 13:34	26.20	1668		1.26	27.30	
5/5/12 14:23	26.05	1717		1.11	27.45	
5/5/12 15:27	25.91	1781		0.97	27.59	
5/5/12 16:31	25.81	1845		0.87	27.69	
5/5/12 17:27	25.75	1901		0.81	27.75	
5/5/12 18:30	25.69	1964		0.75	27.81	

Well ID: MW-1 **Job No. :** 14606
Client: Humboldt Bay Municipal Water Authority
Location: 186 feet east of outside wall of collector well caisson
Test Information: Post-maintenance pumping test
Measuring Point: Top of protective casing
Measuring Point Elevation: 49.25 estimated

Date/Time	Difference	Elapsed Time from Start of Pumping (minutes)	Elapsed Time from Start of Step (minutes)	Observed Drawdown (feet)	Water Elevation (feet)	Comments
5/2/12 16:27					24.31	
5/2/12 16:49	0.00				28.73	
5/3/12 7:15	-0.15				27.72	
5/3/12 7:32	-0.15				27.72	
5/3/12 8:42	-0.15				27.70	
5/3/12 9:07		0				Start Step 1
5/3/12 9:44	-1.81	37		3.83	23.87	
5/3/12 10:07		60				Start Step 2
5/3/12 10:45	-3.12	98		6.13	21.57	
5/3/12 11:08		121				Start Step 3
5/3/12 11:38	-7.09	151		5.76	21.94	
5/3/12 12:08		181				Start Step 4
5/3/12 12:39	-9.41	212		6.68	21.02	
5/3/12 13:08		241				Pump off, Start Recovery
5/3/12 14:30	-0.41				28.05	
5/4/12 7:29	-0.35				29.45	
5/4/12 9:34	-0.52				28.99	
5/4/12 9:49		0				Start Test
5/4/12 13:16	-2.54	207		4.94	24.05	
5/4/12 15:14						Pump 3.1 on, Pump 3.2 on
5/4/12 16:34	-6.71	405		6.34	22.65	
5/4/12 17:45		476				Pump 3.1 off
5/4/12 18:30	-2.57	521		5.14	23.85	
5/4/12 19:26	-2.44	577		5.15	23.84	
5/5/12 7:31	-2.32	1302		5.92	23.07	
5/5/12 8:30	-2.45	1361		5.84	23.15	
5/5/12 9:31	-2.38	1422		5.94	23.05	
5/5/12 10:09	-1.97	1460		5.95	23.04	
5/5/12 10:27		1478				Pump off, Start Recovery
5/5/12 11:02	-0.16	1513		2.26	26.73	
5/5/12 11:32	-0.20	1543		1.97	27.02	
5/5/12 12:11	-0.12	1582		1.46	27.53	
5/5/12 13:23	-0.09	1654		0.96	28.03	
5/5/12 14:36	-0.08	1727		0.76	28.23	
5/5/12 15:33	-0.07	1784		0.66	28.33	
5/5/12 16:36	-0.06	1847		0.58	28.41	
5/5/12 16:52	-0.07	1863		0.56	28.43	
5/5/12 17:34	-0.05	1905		0.54	28.45	
5/5/12 19:02	-0.05	1993		0.48	28.51	

Well ID: MW-1 **Job No. :** 14606
Client: Humboldt Bay Municipal Water Authority
Location: 186 feet east of outside wall of collector well caisson
Test Information: Post-maintenance pumping test
Measuring Point: Top of protective casing
Measuring Point Elevation: 49.25 estimated

Date/Time	Depth to Water (feet)	Elapsed Time from Start of Pumping (minutes)	Elapsed Time from Start of Step (minutes)	Observed Drawdown (feet)	Water Elevation (feet)	Comments
5/2/12 16:27	24.94				24.31	
5/2/12 16:49	20.52				28.73	
5/3/12 7:15	21.53				27.72	
5/3/12 7:32	21.53				27.72	
5/3/12 8:42	21.55				27.70	
5/3/12 9:07		0				Start Step 1
5/3/12 9:44	25.38	37		3.83	23.87	
5/3/12 10:07		60				Start Step 2
5/3/12 10:45	27.68	98		6.13	21.57	
5/3/12 11:08		121				Start Step 3
5/3/12 11:38	27.31	151		5.76	21.94	
5/3/12 12:08		181				Start Step 4
5/3/12 12:39	28.23	212		6.68	21.02	
5/3/12 13:08		241				Pump off, Start Recovery
5/3/12 14:30	21.20				28.05	
5/4/12 7:29	19.80				29.45	
5/4/12 9:34	20.26				28.99	
5/4/12 9:49		0				Start Test
5/4/12 13:16	25.20	207		4.94	24.05	
5/4/12 15:14						Pump 3.1 on, Pump 3.2 on
5/4/12 16:34	26.60	405		6.34	22.65	
5/4/12 17:45		476				Pump 3.1 off
5/4/12 18:30	25.40	521		5.14	23.85	
5/4/12 19:26	25.41	577		5.15	23.84	
5/5/12 7:31	26.18	1302		5.92	23.07	
5/5/12 8:30	26.10	1361		5.84	23.15	
5/5/12 9:31	26.20	1422		5.94	23.05	
5/5/12 10:09	26.21	1460		5.95	23.04	
5/5/12 10:27		1478				Pump off, Start Recovery
5/5/12 11:02	22.52	1513		2.26	26.73	
5/5/12 11:32	22.23	1543		1.97	27.02	
5/5/12 12:11	21.72	1582		1.46	27.53	
5/5/12 13:23	21.22	1654		0.96	28.03	
5/5/12 14:36	21.02	1727		0.76	28.23	
5/5/12 15:33	20.92	1784		0.66	28.33	
5/5/12 16:36	20.84	1847		0.58	28.41	
5/5/12 16:52	20.82	1863		0.56	28.43	
5/5/12 17:34	20.80	1905		0.54	28.45	
5/5/12 19:02	20.74	1993		0.48	28.51	

Well ID: MW-7 **Job No. :** 14606
Client: Humboldt Bay Municipal Water Authority
Location: 221 feet west of outside wall of collector well caisson
Test Information: Post-maintenance pumping test
Measuring Point: Top of steel casing
Measuring Point Elevation: 48.85 estimated

Date/Time	Depth to Water (feet)	Elapsed Time from Start of Pumping (minutes)	Elapsed Time from Start of Step (minutes)	Observed Drawdown (feet)	Water Elevation (feet)	Comments
5/2/12 16:09	20.95				27.90	
5/2/12 17:15	20.92				27.93	
5/3/12 7:19	21.77				27.08	
5/3/12 7:37	21.77				27.08	
5/3/12 8:45	21.78				27.07	
5/3/12 9:07		0				Start Step 1
5/3/12 9:48	26.05	41		4.27	22.80	
5/3/12 10:07		60				Start Step 2
5/3/12 10:39	27.81	92		6.03	21.04	
5/3/12 11:08		121				Start Step 3
5/3/12 11:34	31.37	147		9.59	17.48	
5/3/12 12:08		181				Start Step 4
5/3/12 12:44	34.40	217		12.62	14.45	
5/3/12 13:08		241				Pump off, Start Recovery
5/3/12 14:07	23.05				25.80	
5/4/12 7:33	20.87				27.98	
5/4/12 9:41	21.19				27.66	
5/4/12 9:49		0		0.00		Start Test
5/4/12 10:14	25.77	25		4.58	23.08	
5/4/12 13:26	27.10	217		5.91	21.75	
5/4/12 15:14		325				Pump 3.1 on, Pump 3.2 on
5/4/12 16:22	31.28	393		10.09	17.57	
5/4/12 17:45		476				Pump 3.1 off
5/4/12 18:34	28.08	525		6.89	20.77	
5/4/12 19:32	27.97	583		6.78	20.88	
5/5/12 7:36	27.82	1307		6.63	21.03	
5/5/12 8:44	27.82	1375		6.63	21.03	
5/5/12 9:34	27.60	1425		6.41	21.25	
5/5/12 10:13	27.70	1464		6.51	21.15	
5/5/12 10:27		1478				Pump off, Start Recovery
5/5/12 11:07	23.41	1518		2.22	25.44	
5/5/12 11:37	23.12	1548		1.93	25.73	
5/5/12 12:16	22.70	1587		1.51	26.15	
5/5/12 13:27	22.26	1658		1.07	26.59	
5/5/12 14:33	22.03	1724		0.84	26.82	
5/5/12 15:39	21.86	1790		0.67	26.99	
5/5/12 16:42	21.75	1853		0.56	27.10	
5/5/12 17:39	21.67	1910		0.48	27.18	
5/5/12 19:17	21.58	2008		0.39	27.27	

Well ID: MW-2 **Job No. :** 14606
Client: Humboldt Bay Municipal Water Authority
Location: 29.5 feet west of outside wall of collector well caisson
Test Information: Post-maintenance pumping test
Measuring Point: Top of steel casing
Measuring Point Elevation: 46.26 estimated

Date/Time	Depth to Water (feet)	Elapsed Time from Start of Pumping (minutes)	Elapsed Time from Start of Step (minutes)	Observed Drawdown (feet)	Water Elevation (feet)	Comments
5/2/12 16:44	18.68				27.58	
5/2/12 17:01	18.67				27.59	
5/3/12 7:35	19.12				27.14	
5/3/12 8:43	19.13				27.13	
5/3/12 9:07		0				Start Step 1
5/3/12 9:46	20.55	39		1.42	25.71	
5/3/12 10:07		60				Start Step 2
5/3/12 10:35	21.79	88		2.66	24.47	
5/3/12 11:08		121				Start Step 3
5/3/12 11:32	23.05	145		3.92	23.21	
5/3/12 12:08		181				Start Step 4
5/3/12 12:34	24.50	207		5.37	21.76	
5/3/12 13:08		241				Pump off, Start Recovery
5/4/12 7:25	18.39				27.87	
5/4/12 9:37	18.50				27.76	
5/4/12 9:49		0				Start Test
5/4/12 13:18	21.67	209		3.17	24.59	
5/4/12 15:14		325				Pump 3.1 on, Pump 3.2 on
5/4/12 16:31	23.88	402		5.38	22.38	
5/4/12 17:45		476				Pump 3.1 off
5/4/12 18:37	23.29	528		4.79	22.97	
5/4/12 19:29	23.07	580		4.57	23.19	
5/5/12 7:34	23.33	1305		4.83	22.93	
5/5/12 8:40	23.32	1371		4.82	22.94	
5/5/12 9:37	23.25	1428		4.75	23.01	
5/5/12 10:16	23.19	1467		4.69	23.07	
5/5/12 10:27		1478				Pump off, Start Recovery
5/5/12 11:05	21.38	1516		2.88	24.88	
5/5/12 11:42	20.81	1553		2.31	25.45	
5/5/12 12:14	20.47	1585		1.97	25.79	
5/5/12 13:25	19.91	1656		1.41	26.35	
5/5/12 14:31	19.63	1722		1.13	26.63	
5/5/12 15:36	19.44	1787		0.94	26.82	
5/5/12 16:40	19.31	1851		0.81	26.95	
5/5/12 17:37	19.23	1908		0.73	27.03	

Well ID: Ranney Collector No. 3 **Job No. :** 14606
Client: Humboldt Bay Municipal Water Authority
Location: North side of Mad River approx. 3600 feet southeast of the WTP
Test Information: Post-maintenance pumping test
Sampling Point: Tap at turbidity meter

Date/Time	Thermometer Temperature (degrees F)	Thermometer Temperature (degrees C)	Specific Conductance (uS/cm)	Turbidity [(1)] (NTU)	Comments
5/3/12 9:07					Start Step 1
5/3/12 9:34	51.8	11	139		
5/3/12 10:02	51.4	10.8	127		
5/3/12 10:07					Start Step 2
5/3/12 10:28	50.9	10.5	123		
5/3/12 10:54	50.4	10.2	122		
5/3/12 11:08					Start Step 3
5/3/12 11:26	49.8	9.9	123		
5/3/12 11:50	49.6	9.8	123		
5/3/12 12:08					Start Step 4
5/3/12 12:26	49.5	9.7	126		
5/3/12 12:53	49.3	9.6	125		
5/3/12 13:08					Pump off, Start Recovery
5/3/12 15:05	49.6	9.8	121	11.8	
5/3/12 14:45					Pump on to flush well
5/3/12 15:56				3.9	
5/3/12 16:12				3.4	
5/3/12 16:30				2.8	
5/3/12 17:04				4.0	
5/4/12 9:49					Start Test
5/4/12 13:06	49.5	9.7	124	1.8	
5/4/12 14:36				1.3	
5/4/12 14:58	49.6	9.8	125	1.3	
5/4/12 15:14					Pump 3.1 on, Pump 3.2 on
5/4/12 15:33	49.6	9.8	127	1.9	
5/4/12 16:08	49.5	9.7	128	1.8	
5/4/12 16:42	49.3	9.6	129	1.5	
5/4/12 17:03	49.6	9.8	128	1.4	
5/4/12 17:45					Pump 3.1 off
5/4/12 17:53	49.6	9.8	126	1.4	
5/4/12 18:17	49.6	9.8	127	1.2	
5/4/12 18:46	49.5	9.7	129	1.1	
5/4/12 19:14	49.5	9.7	127	1.1	
5/5/12 7:14	49.6	9.8	130	0.9	
5/5/12 7:51	49.6	9.8	128	1.0	
5/5/12 8:22	49.6	9.8	129	1.0	
5/5/12 9:15	49.6	9.8	130	1.0	
5/5/12 9:43	49.8	9.9	130	1.0	
5/5/12 10:21	49.6	9.8	129	1.0	
5/5/12 10:27					Pump off, Start Recovery

Humboldt Bay Municipal Water District

Collector 3 Capstone Report

New Lateral Installation with Pump and Electrical System Upgrades

November 2015

HBMWD

Collector 3 Capstone Report

November 2015

Project #: 8411920

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1. Introduction

The Humboldt Bay Municipal Water District (HBMWD or District) is implementing a systematic approach to the assessment and planning for the refurbishing of the Ranney Collector Wells that provide the source groundwater to the District from the Mad River. The long-term use, condition and maintenance of the existing Ranney Collectors is of significant importance to the District as the collectors represent the foundation of the District's domestic water supply. The Ranney Collectors have been well maintained by the District and have performed very well over their lifetime; however, they were constructed in the 1960s and are over fifty years old. An extensive effort has been put forth to understand the physical condition of the Ranney Collectors and to plan for their refurbishment so they can last the next fifty years and beyond. This report serves to document the results of this effort as it relates to the assessment and installation of new laterals, pumps and electrical upgrades in Collector 3. The intent is to detail the work that was performed to serve as a guide for the following Collector upgrades and for future District personnel.

The work recently completed included the installation of six new laterals in Collector 3, as well as the installation of one completely new 250hp pump and motor, replacement of one of the other pumps with a new 400hp pump and motor (a second 400hp pump and motor was also purchased and will be installed at a later time), the replacement of the existing transformer with a new transformer and upgrades to the electrical system for the Collector. However, extensive work had been performed prior to the recent upgrades. This previous work included focused physical assessments of collectors, the development of a groundwater model, and several reports to provide an understanding of the condition of the Collector wells system. This previous work is summarized in the following documents:

1. 2005 – *Performance and Vibration Evaluation*, Flowserve
2. 2006 – *Pump Station 2 Evaluation Final Report*, Winzler & Kelly
3. 2006 – *Humboldt Bay Municipal Water District Groundwater Study*, Winzler & Kelly
4. 2007 – *Inspection Report Collector Wells 1, 1A, 3, 4,* Collector Wells International, Inc.
5. 2007 – *Report on Cleaning of Wells 1, 1A, 3 & 4,* MM Diving Inc.
6. 2008 – *Ranney Collector Final Evaluation Report*, Winzler & Kelly

Section 2 of this report summarizes the results and findings of the assessment, data collection, analysis, and modeling results contained in the reports listed above as well as the initial construction documents. Section 3 then details the installation of the new laterals at Collectors 3 in 2012. Sections 4 and 5 detail the upgrades to the pumps and electrical system, respectively. Section 6 then compares the pre- and post-upgrade performance of the Collector. Section 7 summarizes the costs for each portion of the upgrade, and Section 8 is the conclusion and recommendations section, highlighting the lessons learned during the Collector 3 upgrade process. All Figures referenced in this Report are contained in the Figures Appendix, and many of the supporting reports, including those listed above, can be found in the appendices.

2. Background Data

2.1 Background and Construction Data

The District has four operating collector wells (1/1A, 2, 3, and 4) located along the Mad River (see Figure 1). The District designates Collector Wells 1 through 4 as pumping stations (PS) and Collector 3 is also known as Pump Station 3 (PS3).

Collector 3 is located on the north bank of the Mad River near Arcata, CA. Collector 3 was constructed by the Ranney Method Western Corporation in 1961. Figure 2 shows the original Collector 3 Construction Details contained in the May 31, 1962 *Report on Performance Tests Ranney Collector System for Bechtel Corporation* (see Appendix 1 for a copy of the report). Figures 3 through 11 include original drawings issued for bid in the *Construction of Pumping Stations, Buildings and Related Facilities for Mad River Project,* Bechtel, December 1961, and original drawings issued for bid in the *Construction of Pump Stations, Pipe Lines, Reservoir and Controls,* Winzler & Kelly and Kennedy Engineers, February 1966.

The collector is constructed of a 13-foot inside by 16-foot outside diameter reinforced concrete caisson that is sunk to a depth of 83.4 feet below the ground surface. The caisson extends five feet above ground and is completed with a pump house. Before the recent pump replacement, Collector 3 had two 350 hp Worthington vertical turbine pumps (Model 24H-590, 3-stage) that were installed in the central caisson. Collector 3 was originally constructed with a series of five lateral well screens that are projected horizontally from the caisson in two tiers. The B-tier laterals and A-tier laterals are positioned at elevations of 72.9 and 73.9 feet below the ground surface, respectively. The original laterals vary in length from 64 to 110 feet and have a total length of 430 feet. The original laterals were constructed of 12-inch outside diameter punch-slotted mild steel well screen. The slots are rectangular in shape and the slot size is 3/8-inch by 1-1/16-inch. The well screens had a calculated open area of 18.6% (Ranney Method Western Corporation, 1962) at the time of installation.

2.2 Collector 3 2005 Flowserve Performance & Vibration Evaluation Report

In April of 2005, Flowserve conducted an evaluation of all of the collector pumps as well as the pumps in Pump Station 6, the Industrial Water Direction Diversion Facility. A copy of this report is contained in Appendix 2. A Flowserve Pump Improvement Engineering Team performed testing on the District's pumps to compare the pumps' present condition to its original built performance. The collectors' flow meters were used for determination of flow. All pumps were tested in single pump operation. Pressure gauges were calibrated and mounted on pump discharge piping to obtain pressure, and recalibrated between pumps. Electrical readings were measured and recorded by District personnel. Vibration analysis was taken with CSI 2120 two channel vibration analyzers.

At the time of testing, Pump 3.1 and Pump 3.2 were both 350 hp Worthington 24H-590 pumps. Pump 3.2 was out of service, and the report recommended rebuilding this pump to restore it to factory specifications. No original factory pump performance records could be found for either pump, so there was nothing with which to compare the performance of Pump 3.1. The actual measured flow was 2,869 gpm. The vibration in this pump was deemed to be acceptable. The report recommended an overhaul on Pump 3.1 at a later date that would include consideration for minimizing leakage across wear parts by use of nonmetallic material. These pumps were recently replaced as part of the collector rehabilitation, and more detail on the new pumps is provided in Section 4.

2.3 Pump Station 2 Evaluation Final Report

The Pump Station 2 Evaluation Final Report is contained in Appendix 3. The evaluation of Pump Station 2 began in 2002 and initially began as a Feasibility Study to:

1. Identify and contact agencies which have performed rehabilitation of existing laterals, or have installed new laterals on Ranney Collectors to determine what their experience was and how the collector performed before and after restoration work was completed.
2. Based on the findings in Reynolds, Inc. report "Inspection and Pump Test of Ranney Well No. 2 (PS2), February 2003" and the information obtained from talking to other agencies that have performed similar work, evaluate and provide a summary of long-term supply alternatives (e.g., rehabilitate or replace Ranney laterals vs. other supply alternatives).
3. Provide a brief summary of the permit and other regulatory requirements for the various options.

During the course of the performance of the Feasibility Study, discussions with two of the companies that did this type of work offered vastly different recommendations. Reynolds Inc. offered the following recommendation:

"…With the age and condition of these laterals there is significant risk that the stress of these operations may cause failure of laterals… and may render the well inoperable."

Collector Wells International offered the following recommendation:

"The well appears to be in good condition, both structurally and operationally. The condition of the well screen appears to be good and cleaning of the well screens would help in better showing the condition of the well screens."

Following completion of the Feasibility Study and with the information developed as a part of the study, it was ultimately determined and approved by the HBMWD Board of Directors to undertake a project to clean the laterals in Pump Station 2 (PS2). The purpose of cleaning the laterals was to gain a true understanding of the condition of the laterals, to determine if cleaning the laterals is a worthwhile investment to maintain the laterals in their present condition and potentially increase production and efficiency of the collectors. The project was bid and completed by Collector Wells International in the summer of 2005.

The rehabilitation completed in the summer of 2005 by Collector Wells International provided valuable information on the condition of PS2 and helped the District make a decision on the next steps to take in planning for the future of the District's Ranney Collectors. The following is a summary and conclusion of issues established based on the work regarding PS2:

1. Cleaning of the laterals provided valuable information regarding the condition of the laterals in PS2. The cleaning increased the specific capacity of the well by 13% with a decrease in drawdown of approximately 1.8 feet. The economic result of the decrease in drawdown as calculated and was estimated to provide a savings to the District of less than $1000/yr based on the then current average power rates. Based on economics, Winzler & Kelly did not recommend cleaning of the Ranney Collectors laterals to rehabilitate the remaining pump stations.
2. Production increases due to cleaning appear to be minimal in PS2. As discussed in the Maintenance Report of PS2 by Collector Wells International, Inc. if the District needs to increase production from PS2 or other Ranney Collectors, new laterals should be installed. New laterals

will increase the total screen open area and reduce entrance velocity that translates to less potential for turbidity in the well.

Ultimately the cost of the rehabilitation project ($270,000) coupled with the lack of economic savings resulting from the rehabilitation and that fact that the cleaning of the laterals did nothing to increase their longevity, resulted in the decision by the District to move forward on installing new laterals in the existing collectors.

2.4 Collector 3 2007 Collector Wells International Inspection Report

In October of 2006, Collector Wells International (CWI) conducted inspections of Collectors 1, 1A, 3 and 4. A copy of the full report is included in Appendix 4, and the text in this section largely summarizes the findings of the report. Inspections were conducted by a professional diver and support crew experienced in collector well inspections including a CWI hydrogeologist. Diving services were provided by MM Diving of Crescent City, California. The inspections were conducted from October 17 through October 20, 2006 and included the following tasks:

a. Placement of temporary screens over each of the operating pumps in each well and the siphon line in Collector 1A during the inspection for protection of the diver and equipment.

b. Video inspection of each caisson to determine an accurate count and condition of the control valves and laterals screens in each collector well.

c. Video inspection of each accessible lateral to observe the condition of the lateral well screen, presence and location of sand lines, degree of mineral precipitation on the screens, and accumulation of sand, silt and sediment in each lateral.

d. Measurement of the flow and temperature for each lateral under pumping conditions.

e. Video inspection of the siphon line between Collectors 1 and 1A.

f. Preparation of a report detailing procedures, findings and recommendations.

During the inspections, the hydrogeologist measured water levels in the collector well caissons and accessible adjacent monitoring wells using an electric water level meter. Water levels were obtained in the wells with the pumps turned on to reflect the normal operating conditions for the wells, and static water levels were obtained before the pumps were turned on when possible.

For the period during which the well inspections were conducted, the District provided CWI with caisson water level records for Collector Wells 1, 2, 3 and 4; river level records; and total production values from their Supervisory Control and Data Acquisition (SCADA) system. River level data were also obtained from the US Geological Survey (USGS) Mad River gage station number 11481000 that is located approximately 2000 feet downstream of Essex.

The hydrogeologist also inspected above-water conditions in the caisson and in the pump house where the pumps and motors are installed. The diver inspected the underwater portion of the well including such features as: the lateral control valves, caisson walls, the bottom of the caisson and the pump column and intake area. The diver also inspected the inside of the lateral screens in the section nearest the caisson in order to observe the amount and type of encrustation present, and to estimate the structural condition of the screens.

The diver assisted with measurements of the relative rate of flow and water temperature from each accessible lateral utilizing a specially-designed hand-held flow meter/temperature sensor. These measurements were used to determine the relative productivity of the individual laterals. During the flow measurements, the District operated only the collector being inspected. This allowed determination of the total pumping rate from the collector well at the time of the flow measurements.

A color video camera was inserted into each accessible lateral to visually inspect the lateral screen to its full accessible length. The camera used was a static camera system that was projected into the laterals using a length of flexible high-density polyethylene (HDPE) pipe. MM Diving provided the camera system. DVD format copies of the videos taken during the inspections were provided with the report.

Water samples were collected from Collector Wells 1A, 3 and 4 and from the river, and these samples were submitted to a laboratory for chemical screening analysis of inorganic constituents, metals and volatile organic chemicals.

2.4.1 Collector 3 Inspection Results

The inspection of Collector Well 3 was conducted on October 19, 2006. The text from the report is as follows:

A diagram showing the construction details for Collector Well 3 is presented in Appendix A [of the full Report, contained in Figure 2 of this Report]. The number and orientation of the laterals observed during the inspection do appear to correspond to this diagram. There are two tiers of laterals in the well, with the centerline of the lower tier about 3 feet above the caisson floor, and the centerline of the upper tier about 4 feet above the caisson floor. There are a total of five (5) laterals in the well with four (4) laterals in the lower tier and one (1) lateral in the upper tier.

A summary of the inspection observations in Collector Well 3 is presented in Table 6 [of the full Report, contained in Appendix 4 of this Report]. A summary of the diver's observations during the inspections is presented in Appendix C [of the full Report]. Photographs and still images from the video inspection of Collector Well 3 are presented in Appendix F [of the full Report].

Visual inspection showed no apparent problems with the caisson, pump house, pumps and pump columns. The housekeeping in the pump house is generally very good. The floor of the caisson is relatively free of debris. There is a t-shaped I-beam assembly in Collector Well 3 about 20 feet below the static water level (approximate elevation 15 feet) that is attached to the wall at two points and suspended by a cable on the free end. Also in this well, there is a valve port in the side of the caisson that might be for a surface water intake. The top of this port is at an elevation of approximately 20 feet, and the valve is capped off. The lateral valves in Collector Well 3 have long-stemmed actuator assemblies, and all but the valve on lateral A3 have a cable attached to the actuator that leads up to the intermediate floor. Also, there are pipes leading to the bottom of the caisson that are attached to what appears to be some type of venturi lift system.

Video inspection of the laterals in Collector Well 3 showed that the interiors of the lateral screens are generally coated with gray and reddish-colored bacterial and/or mineral deposits. These deposits generally appear to be less than ½-inch thick. The screen slot openings are generally visible in most of the laterals, but the deposits coating the inside of the laterals prevented observation of the well screen material. The diver was able to advance the camera to the end of all of the laterals except A3 and A5. There is a 90-degree elbow on the end of lateral A3 that points downward. The valve on this lateral is opened only about 1 to 1-½ inches so no video inspection of the interior of lateral A3 could be conducted. The diver observed that there is flow from the lateral. Lateral A3 is the only lateral in Collector Well 3 that does not have a cable attached to the valve actuator. Lateral A5 was partially blocked by what appeared to be sand and gravel at about 58 feet and 62 feet from the caisson wall. The camera could not be advanced beyond 62 feet. The reported length of lateral A5 is 68 feet. No sharp deviations or deflections from horizontal in the lateral orientations were observed, although there could be gradual deviations. There are no sand lines remaining in the Collector Well 3 laterals that were videoed, which is further indication that there are no significant deviations from horizontal in the lateral orientations.

During the inspection, water levels were obtained using an electric water level meter in an 8-inch diameter vertical well located 39 feet west of the west side of the Collector Well 3 caisson. These water levels and water levels provided by the District for the river intake and Collector Well 3 and also for the USGS river gage are depicted in the hydrographs in Figure 5 [of the full Report, see Appendix 4 of this Report]. Because of pump lubricating oil floating on the surface of the water in the Collector Well 3 caisson, water level measurements could not be accurately made in the caisson with the electric water level meter during the inspection. There is also a monitoring well located about 200 feet to the east of Collector Well 3, but water levels were not monitored in this well during the inspection. A summary of water level data and pumping rates during the inspection are presented in Table 2 [of the full Report]. As indicated in Table 2 [of the full Report], the average pumping rate from Collector Well 3 during the inspection was 4.8 MGD or about 3330 gpm with pump 3-1 running. After 2 hours of pumping during the inspection, there was an observed drawdown in Collector Well 3 of 13.4 feet. This gives an apparent specific capacity of 250 gpm/ft. The 1962 performance testing results indicate an apparent specific capacity of about 250 gpm/ft after 2 hours of pumping, but the reported pumping rate for the performance test was 10.2 to 10.4 MGD (Ranney, 1962). Given that the valve on lateral A3 is not fully opened on the lateral that is reported to be the longest, the performance of the well is quite good considering its age.

Lateral flow and temperature measurements conducted in Collector Well 3 are summarized in Table 7 [of the full Report]. The results indicate that the flow from the individual laterals ranges from a minimum of about 18% of the total flow in lateral B2 to a maximum of about 36% of the total flow in lateral A2. This assumes that all of the flow is from laterals A2, A4, A5 and B2. With the valve on lateral A3 partially open, there is some flow from this lateral. However, because the flow estimates are based on water velocity measurements, it is difficult to quantify the amount of flow from the lateral with the valve partially opened. The water temperature from the individual laterals ranged from about 61° to about 63° F.

2.4.2 Collector Wells Inspection Report Summary for Collectors 3

The Collector Wells Report summary for Collector 3 is as follows:

In general, the above ground condition of the collector wells was found to be good, and the housekeeping practices in the pump houses to be very good.

Visual inspection of Collector Well 3 showed no apparent problems with the caisson, pump house, pumps and pump columns. The floor of the caisson is relatively free of debris. There is a t-shaped I-beam assembly about 20 feet below the static water level that is attached to the wall at two points and suspended by a cable on the free end. The interiors of the lateral screens in Collector Well 3 are generally coated with gray and reddish-colored bacterial and/or mineral deposits. The diver was able to advance the camera to the end of three of the five laterals. There is a 90° elbow on the end of lateral A3, and the valve is opened only about 1 to 1-½ inches. Lateral A5 is partially blocked by what appeared to be sand and gravel at about 58 feet and 62 feet from the caisson wall, and the camera could not be advanced beyond 62 feet, whereas the reported length of this lateral is 68 feet. The apparent specific capacity of this well during the inspection was 250 gpm/ft.

2.4.3 Collector Wells Inspection Report Recommendations for Collector 3

The Collector Wells recommendation in the Report for Collector 3 is as follows:

A slight improvement of the performance of Collector Well 3 might be made by fully opening the valve on lateral A3. A more substantial increase in yield could be made by the installation of new laterals in the interval from depths of 60 to 70 feet below ground surface. A more detailed pumping test using the collector well and the adjacent observation wells may be necessary to more fully evaluate the potential yield of additional laterals. It is understood that Winzler & Kelly has developed a computer-based ground water flow model for the District's well field. This model could also be used to help estimate the maximum potential yield of Collector Well 3, and the affect that additional pumping from Collector Well 3 could have on the performance of the other collector wells. If new laterals were installed in Collector Well 3, the existing laterals could be cleaned and redeveloped at the same time. Any maintenance work on Collector Well 3 would require the removal of the I-beam assembly that is suspended in the caisson [Note: this I-beam assembly was subsequently removed]. If this I-beam assembly was intended to secure the pump columns, such as to prevent damage during a seismic event, it might be prudent to replace this assembly. It is also recommended that the pump lubricating oil observed floating on the water inside Collector Well 3 be removed [Note: this vegetable-based lubricating oil was subsequently removed].

2.5 2006 & 2008 Winzler & Kelly Ranney Collector Final Evaluation Reports

In 2004, the District obtained a grant from the State Department of Water Resources, Local Groundwater Assistance Grant program to develop a groundwater model of the Essex reach of the Mad River to help the District in the management of the groundwater basin and to assist in the development of recommendations on where to install additional laterals in the existing collectors to allow for their rehabilitation.

The 2006 Report focused on the groundwater system in the region of the four active Ranney Collectors (Collectors 1 through 4) but focused, due to available data, on Collectors 1, 1A, and 2. The activities of the 2006 study consisted of: collecting existing data (from construction plans, well logs, operational data, and previous studies), collecting new data (from the installation of four new monitoring wells and seismic refraction study), compiling the collected data into a site conceptual model, construction of a three dimensional computational model, numeric and parameter model calibration, and model application. As part of the 2006 Report effort, a number of geological borings and seismic refraction studies were completed in the vicinity of Collectors 1 and 1A. Figure 2 in the 2006 Report shows the locations of the borings, monitoring wells, and seismic refraction studies that were conducted. The site conceptual model resulted in a three dimensional representation of the model domain depicting the confining layer and soil properties of the overlying hydro geologic units. The site conceptual model was used to construct the computational model. The computational model estimated the groundwater flow and head by solving the groundwater flow equations using MODFLOW-SURFACT, a MODFLOW based finite difference model. The model was then applied to seven operational pumping regimes, as listed in Table 4 of the 2006 Report, with the results shown in Appendix A of the full Report. The model results closely matched observed drawdown from pumping tests at the four new monitoring wells between Collectors 1/1A and Collector 2. Observed drawdown at the Ranney collectors was generally less than what was predicted by the model.

The 2008 Groundwater Study: 1) updated and refined the previously developed groundwater model with additional data near Collectors 3 and 4 not included in the original groundwater modeling efforts; 2) completed a final evaluation to determine the potential yields from Collectors 3 and 4; and 3) provided a recommendation to the District regarding at which collector the District should start the lateral replacement program under the broader Ranney Rehabilitation program being developed in the CIP. A copy of the 2008, *Humboldt Bay Municipal Water District, Ranney Collector Final Evaluation Report* is included in Appendix 6, and this report includes a copy of the May 2006 Report as an appendix.

The conclusions and recommendations from the 2008 Report identified Collector 3 as a suitable collector to investigate for lateral replacement due to the fact that:

1. The boring installed adjacent to Collector 3 indicated a favorable zone to install laterals approximately 10 feet above the existing laterals.
2. Technical data developed indicate the potential for additional flow from Collector 3 to meet additional demand.
3. The construction and installation of new laterals will require taking a collector out of service until completion of the construction. Collector 3 is land based and accessible all year long so construction can occur during winter months that do not coincide with summer peak demands. The District relies operationally on all four collectors to provide peak flows during the summer peak demand period.

Recommendations from the Report included:

1. Begin planning efforts for lateral installation. From the results of the modeling efforts we have determined that Pump Station 3 has a potential yield of 10 MGD at a drawdown of 30 feet based on installation of 200 feet of additional lateral length as described in Section 6.1. Based on the results of the modeling efforts, boring data collected and physical location we recommend that planning for the installation of new laterals be completed during the 08/09 fiscal year for Pump Station 3. Planning efforts will include development of costs for installation of laterals, completion of CEQA and permitting requirements and development of specifications for installation. In addition, as a part of the cost analysis it would be prudent to analyze costs associated with full lateral replacement versus installation of only additional laterals with replacement laterals installed at a later date. Regardless of the ultimate capacity realized, the District will be installing laterals that have to be installed as replacement infrastructure so there will not be any wasted dollars spent. Subsequent to installation of new laterals in Pump Station 3, new data will be able to be collected and developed that will provide further information on the capability of the system and sustained yield that will help direct the next phase of lateral replacement.
2. Continue to develop additional information for lateral replacement. The installation of new laterals is a complex issue that will include additional analysis of the District's infrastructure such as pump capacity, electrical capacity at individual collectors, pipeline condition and capacity and overall collector condition.
3. Continue to investigate the system capacity at a broad level. We recommend to investigate the potential for increased yield in the system due to installation of new laterals with the developed groundwater model. As the District proceeds with lateral replacement new information will be developed that will help planning efforts and data will be developed indicating the true capacity of the collectors. Meeting future demands is a complex issue that could include investigation of alternate methods to meet increased demands such as storage and surface water treatment in addition to lateral replacement and installation of additional laterals.

The 2006 Report ran various pumping scenarios and modeled the flows and presented the output in color flooded plan view maps. The model can report the hydraulic head at each of the computational nodes in the model. While the head at any specified location may be evaluated, it is easiest to view these results in a color flooded plan view map. The groundwater heads are shown in color flood and with contour lines of light blue. The warmer orange color flood indicates higher heads and the cooler greens indicate lower heads. Results like this can be viewed for each of the seven layers of the model. The interactions between the Ranney Wells may also be viewed by plotting the flood plots with vectors indicating the speed and direction of groundwater flow. The velocity vectors clearly depict the regions that are impacted by the pumping at the various pump stations. Figures 12-15 reproduce modeled plan views originally presented in the 2006 report. Figure 12 depicts the model results for layers 5 and 6 (just above the existing laterals) for the scenario where Collectors 1 and 1A are pumping at 6 MGD. Figure 13 depicts layers 5 and 6 in the modeled scenario where Collectors 1, 1A, 2, and 4 are all pumping at 4.8 MGD. Figure 14 depicts the model results for layers 5 and 6 in the modeled scenario where Collectors 1, 1A, 3, and 4 are all pumping at 5.2 MGD, and Figure 15 depicts layers 5 and 6 in the modeled scenario where Collectors 1, 1A, 2, 3, and 4 are all pumping at 5 MGD. This information was used to determine the optimal lateral layout so as to tap into aquifer regions that will provide for maximum capacity and cause minimal drawdown.

3. Lateral Installation

Design and permitting for the Collector 3 New Lateral Installation Project began in 2008. The original design for the project included the installation of four new laterals, each with 5-foot blanks and 160 feet of screen, for a total of 660 feet of new lateral. The intent was to install two new laterals at the same elevation as the existing laterals (-30.9' NGVD 29), and two new laterals at a higher level (-14.5 ft NGVD 29). A temporary percolation pond was also designed for the disposal of water that would flow into the caisson during projection of the new laterals. See Appendix 7 for the design plans and specifications.

A CEQA Categorical Exemption was filed for the project, and it was determined that the only permit required for the project was a grading permit from Humboldt County for the construction of the temporary percolation pond. The grading permit was obtained, and the contract documents for the Collector 3 New Lateral Installation Project were let for bid in June 2011. Only one bid was received in the amount of $967,700 from the Layne Christensen Company (Columbus, OH). Prior to the work, conversations were also conducted with Brechtel Radial Collector Wells, LLC (Sparta, OH); however, after the project was let for bid, it was discovered they were unable to obtain a California Contractor's license in time and they were unable to bid on the project.

The Layne Christensen Company (d/b/a Ranney Collector Wells), was contracted by the Humboldt Bay Municipal Water District (District) to install the new laterals on the District's Ranney Collector No. 3. The activities, as completed, included installation of new ports in the caisson wall, installation of six (6) new laterals, and pre- and post-maintenance performance testing of the well. The rehabilitation of the collector well was accomplished during the period from December 2011 through May 2012. Procedures and results for the maintenance activities and testing are included in the Ranney report (Appendix 8) along with recommendations regarding future collector well operations, which are detailed in the following sections.

3.1 Initial performance tests

The pre-maintenance pumping test was conducted utilizing one of the existing well pumps. Because the discharged water was directed to the temporary percolation pond, the amount and duration of the pumping was limited by the capacity of the pond. Because of this, the pre-maintenance performance testing was limited to a multiple-rate step pumping test conducted with three steps with lengths of 1 hour, 1.5 hours and 1 hour, respectively. The average pumping rates for the steps were 3,000, 4,470, and 6,000 gpm, respectively. During the second step a diver entered the well to conduct lateral flow analyses and measure the water temperature from each of the existing laterals. The second step was extended to allow time for the lateral flow and temperature measurements. At the end of the third step the percolation pond was filled nearly to its maximum capacity and pumping was ended.

During the testing, water levels were monitored in the collector well caisson, and in the adjacent observation wells MW-1, MW-2 and MW-7. MW-1 is located approximately 190 feet east of Ranney Collector No. 3 and is reportedly screened from 8 to 108 feet below ground surface. MW-7 is located approximately 220 feet west of Ranney Collector No. 3 and is reportedly screened from 55 to 75 feet below ground surface. MW-2 is located approximately 21 feet west of Ranney Collector Well No. 3 and is reportedly screened from 10 to 30 feet below ground surface. Water levels were monitored using pressure transducers equipped with digital data loggers. Also manual water level measurements were made to calibrate the transducers and confirm that they were functioning properly. All measurements of water level and drawdown were made within 0.01 foot. Pumping rates were measured using an in-line Water Specialties Model ML20-D digital flow meter manufactured by McCrometer, Inc. Mad River level data during the testing period were provided by the District from their telemetry system for their gage at the intake at the water treatment plant (Pumping Station 6).

Hydrographs for the pre-maintenance test depicting the water levels in Ranney Collector No. 3, adjacent monitoring wells and the Mad River area presented in Figure 3 of the full Report, see Appendix 8. Plots of the observed drawdown with respect to elapsed pumping time for the pre-maintenance test for the collector well and adjacent observation wells are depicted in Figure 4 of the full Report. Table 3 of the full Report presents a summary of the pre-maintenance test water level changes, and Table 4 of the full Report presents the results of the lateral flow and temperature measurements during the pre-maintenance test. The water level data collected by the data loggers and pumping rate data during the test are included in Appendix B of the full Report, contained in Appendix 8.

After 1-hour of pumping at rates of 3,000, 4,470, and 6,000 gpm the observed drawdown in Ranney Collector No. 3 for each step in the pre-maintenance test was 10.7, 18.5 and 27.7 feet, respectively. This gives observed pre-maintenance specific capacity values of 280, 241 and 217 gallons per minute per foot of drawdown (gpm/ft). The observed drawdown at the end of step 3 in observation well MW-1 was 15.4 feet, and the observed drawdown in MW-7 was 11.4 feet. The drawdown differential values (i.e. the difference between the water elevation in adjacent observation wells and the water elevation in the collector divided by the pumping rate) at the end of step 3 were 2.1 feet per 1000 gallons per minute (ft/1000 gpm) for MW-1 and 2.7 ft/1000 gpm for MW-7. The Mad River level at PS6 was at an elevation of approximately 21.7 feet during the pre-maintenance testing period.

Lateral flow analyses were conducted on the five original laterals during step 2 of the pre-maintenance test. The flow velocity and water temperature at the caisson end of the laterals were measured by the diver using handheld meters, which were remotely read by the hydrogeologist.

The individual flows from the original laterals varied from 11% to 33% of the total with the highest flow observed in Lateral A-2 and the lowest observed in Lateral B-2. The temperature of the water produced from the existing laterals during the flow analyses ranged from 55.5 °F in Lateral A-4 to 57.5 °F in Lateral B-2. The pre-maintenance test lateral flow distribution was similar to that observed during the 2006 inspection of Ranney Collector No. 3, i.e. with Lateral A-2 having the highest flow and Lateral B-2 having the lowest. However, during the 2006 inspection, the valve for Lateral A-3 was only partially opened (CWI, 2006).

3.2 New lateral installation

The procedures for the lateral installations were as follows:

Following set up, portal assemblies were installed in circular openings cut in the caisson wall at the selected locations and bonded to the caisson by grouting (see Appendix 12 for the wall port submittal). Then projection equipment, pipe and tools were lowered into the well and set up. After installation of the portal assemblies, the laterals were constructed by initially projecting 16-inch diameter pipe to the desired length and sampling the aquifer materials as the pipe was projected. Prior to installation of the well screens, the vertical orientation of the projection pipe was determined. The vertical orientation of the projection pipe was determined using a Reflex EZ-DIP Electronic Inclinometer. In addition to the inclinometer measurements, a “Dutch level”, consisting of sufficient small diameter plastic pipe to reach the end of the projection pipe and a manometer tube, was utilized to determine if the far end of the projection pipe was above the centerline at the caisson end. Following selection of the screen slot size distribution based upon sampling (see Appendix 12 for the well screen submittal), the 12-inch ID diameter stainless steel (type 304) screen assemblage was installed within the projection pipe and the 16- inch pipe hydraulically extracted from the aquifer, exposing the screened lateral to the aquifer. The screen slot sizes were varied depending on the coarseness of the material encountered, which was based upon the samples collected during the projection of the drive pipe. Sieve analyses of samples collected during the drive pipe projection are included in Appendix A [of the full Report].

Lateral screen slot sizes were approved by the District prior to installation. The screens were installed using 10-foot long sections, with each section having 9.5 feet of its length screened. In addition to the screen, each lateral was installed with a 5-foot long section of blank pipe extending from the caisson wall. Each lateral is completed with a 12-inch stainless steel gate valve in the caisson (see Appendix 12 for the gate valve and gasket submittals).

Following installation of all laterals, each lateral was fully developed using the BoreBlast II® system (see Appendix 12 for the lateral development submittal). This system provides a high energy pulse to screens and was selected to ensure that development energy penetrated the formation. The BoreBlast II® system uses pressure-pulse technology, delivered by gaseous nitrogen driven Air Impulse Generator (AIG), to agitate and break up bridging in order to develop coarse grained zones around the lateral screens. The high pressure AIG creates a high intensity pressure pulse and associated high frequency acoustic waves that break up and remove fines within the well screen. The system is piston-actuated and discharges automatically delivering pressure pulses of up to 450 psi. The ports on the AIG were angled at 90º to provide pulses to effectively surge out through the screen and allow for strong liquid return, pulling debris from the aquifer into the well.

The AIG was hydraulically advanced through each lateral at a controlled rate. The AIG with angled ports was attached to a “centralizing” sled fabricated to center the AIG in the lateral screen. The sled was advanced using the four-inch diameter sand line, which was also used to flush water and entrained sediments from the well screen. As the development proceeded, water samples were caught from the sand line and measured in an Imhoff Cone to evaluate the quantity of entrained sediment and sand.

When no further improvement could be made, the tool was advanced. Sediment removed during the lateral installation and development process was conveyed to the percolation pond for disposal. To determine the adequacy of development, centrifugal sand-separating device manufactured by the Roscoe Moss Company was used to measure sand production. The standard for sand production from the completed collector was specified to be less than 2 parts per million (ppm). Sand content testing was conducted on flow from the individual laterals.

After the development of the new laterals was completed, all sediment remaining on the floor of the caisson was removed. Also, the valve actuator lines on the original laterals were cut off and removed from the caisson. The caisson walls were cleaned and washed with a chlorine solution. Once the walls were cleaned, the caisson was re-watered and additional calcium hypochlorite was added and the resulting chlorine solution was allowed to remain in the caisson. Prior to the post maintenance performance testing, the temporary construction pump and discharge line in the caisson were removed. Divers entered the well to open the valves on the new laterals, remove the blind flanges and reinstall the valves on the old laterals. The District reinstalled its well pumps, and the discharge line from the well pumps was directed to the temporary percolation ponds.

Plan and section views for the rehabilitated collector well are depicted in Figure 16, and construction details are summarized Table 1. The initial plan called for the installation of four (4) new laterals each having 5-foot blanks and 160 feet of screen for a total of 660 feet of new lateral. The plans showed the proposed layout of the new laterals, but the locations were revised based on the constraints of the lateral installation equipment. In the revised layout, Laterals 1 and 3 were planned to be installed 5.75 feet above the existing A-tier laterals (as a new C-tier) and Laterals 2 and 4 were planned to be installed 16.75 feet above the A-tier laterals (as a new D-tier). Laterals 1 and 3 were installed first. Lateral 1 was projected to refusal at 115 feet and Lateral 3 was projected to refusal at 75 feet from the inside caisson wall.

Table 1: Ranney Collector 3 As-Built Design Summary

CAISSON AND LATERAL DESIGN

CAISSON INSIDE DIAMETER	13 feet
CAISSON OUTSIDE DIAMETER	16 feet
TOP OF TOP SLAB ELEVATION	53.0 feet, msl.
TOP OF CAISSON ELEVATION	51.0 feet, msl.
GRADE ELEVATION	47.1 feet, msl.
TOP OF PLUG (caisson floor) ELEVATION	-30.9 feet, msl.
CAISSON DEPTH (top of caisson to top of plug)	81.9 feet
CENTER LINE OF LATERAL ELEVATION A-tier (original installation))	-27.9 feet, msl.
CENTER LINE OF LATERAL ELEVATION B-tier (original installation)	-26.9 feet, msl.
CENTER LINE OF LATERAL ELEVATION C-tier (Installed 2012)	-22.2 feet, msl.
CENTER LINE OF LATERAL ELEVATION D-tier (Installed 2012)	-11.2 feet, msl.
MINIMUM RECOMMENDED PUMPING ELEVATION	-1.0 feet, msl.
LATERAL DIAMETER	12.0 inches

LATERAL LENGTH AND OPEN AREA

LATERAL NUMBER	TIER		BLANK LENGTH (feet)	LATERAL SCREEN LENGTH (feet)	TOTAL LATERAL LENGTH (feet)	Screen Slot Open Area (square feet)
A-2	A	Original	0	104	104	57.7
A-3	A	Original	0	110	110	61.1
A-4	A	Original	0	84	84	46.6
A-5	A	Original	0	68	68	37.7
B-2	B	Original	0	64	64	35.5
1	C	Installed 2012	5	110	115	179.5
2	D	Installed 2012	5	100	105	164.0
3	C	Installed 2012	5	70	75	112.0
4	D	Installed 2012	5	80	85	125.7
5	C	Installed 2012	5	150	155	240.5
6	C	Installed 2012	5	150	155	242.3
TOTAL ORIGINAL LATERALS			0	430	430	238.7
TOTAL NEW LATERALS			30	660	690	1063.9
TOTAL ALL LATERALS			30	1,090	1,120	1,302.6

Because neither lateral reached the target length, it was decided to install two additional C-tier laterals designated as Laterals 5 and 6. Both of these laterals were successfully projected to lengths of 155 feet. Once Laterals 5 and 6 were completed, the temporary work platform was raised to install the D-tier laterals. Lateral 2 was projected to a length of 105 feet, and Lateral 4 was projected to a length of 85 feet so that the total installed length of the new laterals would be 690 feet or 30 feet more than the original specification of 660 feet.

Information on the screen slot sizes used in the new laterals is presented in Table 2 [of the full Report]. As listed in the table, screen slot openings varied between 0.100 inches and 0.150 inches. The slot size openings were selected based upon sieve analyses (Appendix A [of the full Report]) of samples collected during lateral projection. The total open area of the new screen installed in the collector well, adjusting for couplings and blank sections, is 1,063.9 square feet, which has a mechanical capacity of 7,960 gpm (11.5 MGD) at an entrance velocity of 1 foot per minute (ft/min) assuming no blockage of the screen slots. This is an approximate increase of 813.9 square feet, or 426% more open area than the original laterals. The original laterals have an open area of 18.6% (Ranney Method Western of California, 1962) so the total open area of the original laterals is approximately 250 square feet assuming no blockage of these laterals.

The specifications called for each new lateral to be installed horizontally in a straight line throughout its full length with the maximum allowable deviation from horizontal being two lateral projection pipe diameters over the entire projected length of the lateral. As the diameter of the projection pipe was 16 inches, the allowable deviation from horizontal is 32 inches. The vertical orientation of the new laterals was determined using a Reflex EZ-DIP Electronic Inclinometer. The inclinometer measurements were conducted in the projection pipe prior to installation of the lateral screens. In addition to the inclinometer measurements, a "Dutch level" was utilized to determine if the far end of the projection pipe was above the centerline of the projection pipe at the caisson end. The inclinometer measurements indicated that all of the laterals were within the tolerance for vertical alignment except for Laterals 4 and 5. The inclinometer readings for Lateral 5 indicated that it deviated upward by 36.5 inches, 2.5 inches out of tolerance. The Dutch level measurements indicated an upward deviation in Lateral 5 of only 32 inches. In Lateral 4, the inclinometer measurements indicated an upward deviation of 46 inches, 14 inches out of tolerance. However, the Dutch level measurements in Lateral 4 indicated an upward deviation of only 16 inches, well within tolerance. On the other laterals the Dutch level and the inclinometer measurements agreed more closely. In Lateral 4, one was able to see the back of the digging head from the caisson and the sand line unscrewed from the head without difficulty. Both of these are indications that the projection pipe had not deflected significantly. It is suspected that there was operator or equipment error that led to the discrepancy in readings in Lateral 4.

3.3 Post lateral installation performance tests

Ranney conducted post-maintenance testing to evaluate collector performance following the installation of the new laterals. The post-maintenance performance testing consisted of a multiple-rate step test and a 24-hour pumping test. The post-maintenance performance testing was conducted from May 3rd to May 5th, 2012. The testing procedures generally followed those utilized for the pre-maintenance testing. During post-maintenance testing, water levels were monitored in the collector well caisson, and in the adjacent observation wells MW-1, MW-2 and MW-7. Mad River level data during the testing period were provided by the District from their telemetry system for their gage at the intake at the water treatment plant (Pumping Station 6).

3.3.1 Multiple-rate step test

The post-maintenance multiple-rate step pumping test was conducted on May 3rd, 2012. The discharge water was conveyed to the percolation pond and the pumping rate was determined using an in-line flow meter on the temporary discharge line. The multiple-rate step pumping test was conducted with four steps with durations of 1 hour each. The average pumping rates for the steps were 3,050; 4,650; 6,020 and 7,420 gpm, respectively.

After the end of each 1-hour step at pumping at rates of 3,050; 4,650; 6,020 and 7,420 gpm the observed drawdown values in Ranney Collector No. 3 for the post-maintenance step test were 7.8, 12.9, 18.3 and 23.8 feet, respectively. This gives observed post-maintenance specific capacity values of 392, 362, 329 and 312 gpm/ft. These values are 40% to 50% greater than the specific capacity values observed during the pre-maintenance step test at similar pumping rates. The observed drawdown at the end of step 3 in observation well MW-1 was 12.9 feet, and the observed drawdown in MW-7 was 9.9 feet. The drawdown differential values at the end of step 3 were 1.0 ft/1000 gpm for MW-1 and 1.4 ft/1000 gpm for MW-7. These values represent decreases of about 50% from the pre-maintenance drawdown differential values at similar pumping rates. The Mad River level at PS6 was at an elevation of approximately 23.2 feet during the post-maintenance step test, which is approximately 1.6 feet higher than it was during the pre-maintenance step test.

Hydrographs for the post-maintenance multiple-rate step test depicting the water levels in Ranney Collector No. 3, adjacent monitoring wells and the Mad River area presented in Figure 5 [of the full Report]. Plots of the observed drawdown with respect to elapsed pumping time for the post-maintenance step test for the collector well and adjacent observation wells are depicted in Figure 6 [of the full Report]. Table 5 [of the full Report] presents a summary of the post-maintenance multiple-rate step test water level changes.

3.3.2 24-hour pumping test

For the 24-hour pumping test (May 4th, 2012), the discharge was conveyed to the water system and the pumping rate was controlled by the pumps in operation and the system line pressures. Following the multiple-rate step test, the collector well was allowed to recover overnight. Prior to the start of the 24-hour pumping test, a diver entered the well to put screen baskets over the pump intakes. The 24-hour pumping test was started with an initial pumping rate of approximately 3,700 gpm. After the well had been pumping for approximately one hour, a diver entered the well to conduct lateral flow analyses and measure the water temperature from each of the laterals. The diver also obtained water samples from the laterals. The well pumps were off for approximately one half hour for the divers to remove the screen baskets from the pump intakes. For a period of about two and one half hours both well pumps were operated for a combined pumping rate of about 5,600 gpm. For the remainder of the pumping period, the well was pumped with one pump at a rate of about 3,500 gpm.

At 9:49 AM on 5/4/12, the 24-hour pumping test was started with an initial pumping rate of approximately 3,700 gpm with pump number 3-2 in operation. After the well had been pumping for approximately one hour, a diver entered the well to conduct lateral flow analyses and measure the water temperature from each of the laterals. The diver also obtained water samples from the laterals. The diver had previously noted that the column pipe for pump 3-1 was very close to the Lateral 4 valve, and apparently the valve wheel on Lateral 4 had been broken during the reinstallation of pump 3-1. At about 12:50 PM, with the diver observing the pump 3-1 column, pump 3-2 was turned off and pump 3-1 was turned on briefly. This allowed the diver to observe that there was very little movement of the pump 3-1 column during start-up and operation so that it did not come into contact with the valve on Lateral 4. After the diver completed the necessary testing and observations, the pump 3-2 was turned off at 1:46 PM for the diver to remove the screen baskets from the pump intakes. At 2:16 PM pump 3-2 was turned back on. At 2:36 PM an attempt was made to run pump 3-1 in addition to pump 3-2, but a fault in the control system prevented both pumps from operating at the same time, and pump 3-2 turned off. At 3:04 PM pump 3-2 was turned on but this caused pump 3-1 to turn off. At 3:14 pump 3-1 was turned on and pump 3-2 remained in operation. For a period of about two and one half hours both well pumps were operated for a combined pumping rate of about 5,600 gpm. At 5:45 PM, pump 3-1 was turned off, and for the remainder of the pumping period, the well was pumped with only 3-2 in operation. The pumping period ended at 10:27 AM on 5/5/12 when pump 3-2 was turned off.

During the 24-hour pumping test, with pump 3-2 in operation, the pumping rate was about 3,500 gpm. However, the pumping rate from Ranney Collector No. 3 varied as the system line pressure changed when the other collector wells were turned on and off. Water levels in the Ranney Collector No. 3 were also affected by pumping interference with the other collector wells. The pumping rate changes in Ranney Collector No. 3 due to system line pressure change tended to have more influence on the water levels in Ranney Collector No. 3 than did pumping interference from the other collector wells. Prior to the start of the 24-hour pumping test, Ranney Collector No. 2 was turned on at 7:18 AM on 5/4/12. Following this, the water level in Ranney Collector No. 3 decreased by about 0.1 to 0.2 foot, apparently due to drawdown from Ranney Collector No. 2. Ranney Collector No. 4 was turned on at 9:14 on 5/4/12, and following this, the water level in Ranney Collector No. 3 decreased by about 0.4 foot, apparently due to drawdown from Ranney Collector No. 4. During the 24-hour pumping test, Ranney Collector No. 1 was turned off at 9:56 PM on 5/4/12. After Ranney Collector No. 1 was turned off, the water level in Ranney Collector No. 3 decreased by about 0.7 foot, apparently due to an increase in the Ranney Collector No. 3 pumping rate due to a decrease in the system line pressure.

Similarly, when Ranney Collector No. 2 was turned off at 2:08 AM on 5/5/12, the water level in Ranney Collector No. 3 decreased by about 0.3 foot. When Ranney Collector No. 4 was turned on at 6:02 AM on 5/5/12, the water level in Ranney Collector Well No. 3 increased by about 0.7 foot. This was apparently due to a decrease in the Ranney Collector Well No. 3 pumping rate due to an increase in the system line pressure. Similarly, when Ranney Collector No. 2 was turned on at 9:30 AM on 5/5/12, the water level in Ranney Collector Well No. 3 again increased by about 0.7 foot. During the period from about 1:10 AM to 6:00 AM on 5/5/12, Ranney Collector No. 3 was the only collector well in operation. The average pumping rate during this period was approximately 3,490 gpm (5.02 MGD), and the pumping level in the Ranney Collector No. 3 was relatively stable at an elevation of about 17.0 feet, which is about 28 feet above the upper tier (D-tier) of the new laterals.

During the 24-hour pumping test, lateral flow analyses and water temperature measurements were conducted on the laterals. Because the pump 3-1 column is very close to the end of Lateral 4, the flow and temperature from this lateral could not be measured. For the lateral flow analysis, it was assumed that flow in Lateral 4 is proportional to the flow in Lateral 2 relative to the lengths of the two laterals. It was assumed that the flow in Lateral 4 would be similar to the flow in Lateral 2 because these are the two laterals installed on the upper tier (D-tier). With this assumption, the flow analysis indicated the flow from Lateral 2 was 9% of the total and the estimated flow from Lateral 4 is 7% of the total. The individual flows from all of the laterals varied from 2% to 24% of the total with the highest flow observed in the new Lateral 6 and the lowest observed in the original Lateral B-2. The new laterals account for 73% of the total flow. The distribution of the flow among the original laterals after the installation of the new laterals is similar to the pre-maintenance distribution with A-2 having the highest proportion and B-2 having the lowest proportion of the flow from the original laterals. However, Lateral A-5, which previously had the second highest proportion of the flow, had the second lowest proportion of the flow from the original laterals. Lateral A-5 is the western most of the original laterals and previously had less interference from the other laterals. With the installation of the new laterals, Lateral A-5 is between Laterals 1 and 3 and nearly parallel and below Lateral 2, and consequently has substantially more interference from the adjacent laterals. The temperature of the water produced from the laterals during the flow analyses varied from 48.6 °F in Lateral 6 to 50.4 °F in Lateral 2.

Hydrographs for the post-maintenance 24-hour pumping test are presented in Figure 7 [of the full Report]. Table 6 [of the full Report] presents the results of the post-maintenance lateral flow and temperature measurements. The water level data collected by the data loggers and pumping rate data during the post-maintenance testing are included in Appendix C [of the full Report].

3.4 Sand content testing

Following development of the new laterals, sand content testing was conducted on the individual laterals while the caisson was dewatered. The sand production was measured using a centrifugal sand-separating device manufactured by the Roscoe Moss Company. For each test a reducer was attached to the valve on the lateral being tested, and an 8-inch diameter pipe with an in-line flow meter was attached to the reducer. The sand tester was attached to a port in the side of the 8-inch pipe. The lateral valve was opened and adjusted so that there was a discharge of 1,200 gpm from the lateral. The tests were conducted for durations of 15 to 25 minutes. The results of the sand testing are summarized in Table 7 [of the full Report]. None of the sand test results from the post-maintenance test exceeded 1.1 ppm, and consequently all were well within the sand specification of 2 ppm.

3.5 Collector 3 yield projections

As called for in the specifications for the installation of the new laterals, estimated yields for Ranney Collector No. 3 were calculated for both the conditions prior to the installation of the new laterals and following the installation of the new laterals. The long-term yield of a collector well is dependent upon length of pumping, efficiency, available drawdown and aquifer hydraulics. Aquifer hydraulics are related to saturated thickness, hydraulic conductivity and recharge. It is possible to project the yield of a collector well for varying aquifer water levels and water temperature using the following equation:

$$Q_2 = \frac{Q_1 m_2 s_2 V_1}{m_1 s_1 V_2}$$

Where:

Q = Yield (gpm) of collector well under test (Q_1) and design (Q_2) conditions;

s = Drawdown (ft) in collector well under test (s_1) and design (s_2) conditions;

m = Aquifer thickness (ft) corrected for dewatering under test (m_1) and design (m_2) conditions; and

V = Viscosity coefficient under test (V_1) and design (V_2) temperature conditions.

Using the post-maintenance performance testing results (test conditions) and the above equation it is possible to estimate the maximum yield of the collector well under the test conditions. For the estimation, the following values were assumed:

Top of Aquifer Elevation	10.0 Feet msl
Base of Aquifer Elevation	-40.0 Feet msl
Static Water Level	
Pre Maintenance Performance Test	27.1 Feet msl
Post Maintenance Performance Test	28.1 Feet msl
Assumed High River Conditions	29.4 Feet msl
Assumed Low River Conditions	23.0 Feet msl
Pumping Levels	
Pre Maintenance Performance Test (Projected for 3,000 gpm)	12.0 Feet msl
Post Maintenance Performance Test (3,490 gpm)	17.0 Feet msl
Pre Maintenance Minimum Recommended Pumping Level (10 feet above B-tier lateral)	-16.9 Feet msl
Post Maintenance Minimum Recommended Pumping Level (10 feet above new D-tier laterals)	-1.0 Feet msl
Water Temperature / Viscosity Coefficient	
Pre Maintenance Performance Test	56^{o} F / 1.06
Post Maintenance Performance Test	49^{o} F / 1.18
Assumed High River Conditions	55^{o} F / 1.08
Assumed Low River Conditions	45^{o} F / 1.26

To estimate the minimum and maximum recharge conditions, the daily mean stream flow values were obtained for the USGS stream gage station number 11481000 for the period from September 1, 1990 through June 20, 2012 (USGS, 2012). For this record period the minimum flow that was recorded was 4.5 cubic feet per second (cfs). The minimum flow value on the current rating table is 6.8 cfs, and this is associated with a stage of 3.9 feet and an elevation of 16.7 feet. For the purposes of estimating collector well yield, an elevation of 16.0 feet at the stream gage is assumed for the low river condition. The flow for the record period that was exceeded for only 10% of the records was 3,660 cfs. Based on the current rating table and gage datum, this flow corresponds to a river elevation at the gage station of 22.4 feet. The data from the pre and post maintenance tests indicates that the static water level at Ranney Collector No. 3 is about 7 feet above the river elevation at the USGS gage. Based on these values, the static water level at Ranney Collector No. 3 under low river conditions is assumed to be at an elevation of 23.0 feet, and the static water level under high river conditions is assumed to be at an elevation of 29.4 feet.

During the post-maintenance 24-hour pumping test, the water level in Ranney Collector No. 3 was relatively stable at an elevation of 17.0 feet when the pumping rate was 3,490 gpm for several hours. Because of the short duration of the pre-maintenance pumping test, stabilized pumping levels were not observed. Based on the results of the post-maintenance testing, it appears that pumping levels stabilize within 24 hours. Projecting the trend of the observed drawdown from the first step of the pre-maintenance test to 24 hours gives an estimate of 12 feet of drawdown for a stabilized pumping level at an elevation of 13.9 feet for the pumping rate of 3000 gpm.

Based upon the available data, the discharge temperature for the collector well is likely to range from about 45^{o} to 65^{o} F. For the low river conditions it was assumed that the water temperature would be 45^{o}

as this would give the least favorable recharge conditions. For the high river conditions the water temperature was assumed to be 55^o to simulate high river conditions during late spring, which would probably represent the most favorable recharge conditions.

Prior to installation of the new laterals, the centerline elevation of the highest tier of laterals was -26.9 feet. To maintain ten (10) feet of water over the top of the upper tier of laterals the minimum recommended pumping level prior to installation of the new laterals would have been at an elevation of -16.9 feet. Given that the centerline of the upper tier of the new laterals is at an elevation of -11.2 feet, the minimum pumping level should be an elevation of -1.0 feet, to maintain a minimum of ten feet of water over the top of the new upper tier laterals.

Using the above equation and assumptions, the estimated yields for Ranney Collector No. 3 were calculated for the pre-maintenance and post-maintenance conditions. The results of the pre-maintenance estimates are presented in Figure 8 [of the full Report], and the results of the post-maintenance estimates are presented in Figure 9 [of the full Report]. The maximum yields under the assumed conditions are summarized in Table 2:

Table 2: Maximum Collector 3 yields under assumed conditions

Conditions for Yield Estimates	Pre-Maintenance Minimum Pumping Level at -16.9 feet (MGD)	Pre-Maintenance Minimum Pumping Level at -1.0 feet (MGD)	Post-Maintenance Minimum Pumping Level at -1.0 feet (MGD)
Test	10.8	8.3	11
Low River	8.5	6.2	8.5
High River	11.5	9.2	12.5

For comparability, the maximum pre-maintenance yields were calculated with minimum pumping levels at both -16.9 feet and -1.0 feet. As indicated, the maximum yields after the installation of the new laterals are the same for the low river conditions and 1.0 MGD higher for the high river conditions than the pre-maintenance estimates with the pumping level at -16.9 feet. The maximum yields after the installation of the new laterals are 2.3 MGD and 3.3 MGD higher, for the low river conditions and high river conditions, respectively than the pre-maintenance estimates with the pumping level at -1.0 feet. Although there has been a decrease in the available drawdown, the improvement in the specific capacity since the installation of the new laterals gives Ranney Collector No. 3 additional capacity under most conditions.

The estimated yields for Ranney Collector No. 3 are dependent on how well the assumed conditions match the actual conditions. The actual day to day yield of this well will vary under differing conditions and pumping durations. The yield estimates assume that there is sufficient flow in the river to provide sufficient recharge to the collector wells and also do not consider pumping interference from the other collector wells.

3.6 Lessons Learned on Lateral Installation

In general, the Collector 3 Lateral Installation Project went very well, however, there is always room for improvement and these are some of the items that we feel could been improved upon in preparation for or in performance of the next Collector project.

3.6.1 General Comments

1. Project Datum. The locations and elevations of the laterals, the pumps, the surrounding monitoring well, etc. at Collector 3 were never surveyed in and confirmed that they were on the same datum prior to the performance of the work. This should be done at the start on any of the next projects.
2. Percolation Pond. The original percolation rate and pond was thought to be of sufficient size to handle construction and development water. It was not. Another disposal option needs to be established, along with a back-up plan (whether this is a percolation pond on the river bar or filtered discharge into the river).
3. The exact locations of existing laterals, pump bottoms, and caisson construction joints needs to be well established prior to locating new proposed laterals.
4. Discussions with the Contractor need to be undertaken on where their jacks land on the opposite wall of where they are pushing and whether any other “new foot” or some other means of straddling an existing or new lateral can be developed.
5. A set of required hours for the Contractor PM/Engineer to be on site was not established in the contract documents. The documents mention having a Project Foreman on site, and Ranney did that. This was not an issue early on in construction, but there was a lack of Contractor PM involvement at the end of the project. Considerations should be made for altering the specifications to ensure PM involvement throughout the entirety of the project.
6. Require a firm schedule from the Contractor upfront including showing when the crews are going to be taking breaks.
7. Site safety. The site control for PS-3 was already existing, as the entire area is fenced. We did not have a spec for minimum security fencing. Future collectors will have much greater exposure to the public. We need to consider fencing for the pond and construction areas. We should also require that all fueled equipment be stored in a locked area out of the river area.
8. Need to include plenty of time for Engineer oversight in the construction inspection budget. The required inspection time was significantly underestimated, and we need to make sure we budget appropriately for the next one, which should include a full-time inspector.
9. A means for sampling individual laterals should be installed during future lateral installations to allow turbidity testing without the use of divers.

3.6.2 Bid Schedule Comments

10. Need to finalize if an “Alternate Lateral Cost per unit foot” should be established in the original bid documents, or whether the District should negotiate that after the Contractor is on-site, as was done in this case. We got a good rate for additional lengths of lateral, but we may want to know that rate up front if we have two or more bidders on the next project.
11. Include “Port Installation Cost” as a separate line item on the bid.
12. Should consider adding the removal of extra items in the caisson to the bid schedule if we know that there are things we want taken out of a specific caisson that we are working on. When the caisson is dewatered is the ideal time to remove obsolete items.

13. In caissons that have more than two pumps, we should consider that we may need to completely remove some of the pumps to make room for the construction equipment.
14. Ranney bid the job and intended to do the lower laterals from the floor of the caisson. All of our caissons have rough finished floors. In future jobs we should include a floor installation as a separate bid item or make it clear that it will have to be included in the base bid.

3.6.3 Specification Comments

15. Construction hours are listed as 7:00 a.m. - 8:00 p.m. daily, except for the Constant Rate Tests, but we told them to keep it to 8:00 am - 5:00 pm because of concern for neighbors. We should consider adjusting these hours in the specifications to 8:00 am - 5:00 pm in the future.
16. The specs call for the prevention of surface erosion, but we did not specify what to do about stormwater running on to the site. This may not be an issue at other locations, but we did have quite a bit of turbid water running on to the site that we then had to control.
17. Specs are loose on how we would like the site to be cleaned up or what standards are required; it just says as required and approved by the Engineer. The Contractors did a good job and there was not a problem, but they didn't know what we expected as "proper" and they commented that it was quite ambiguous and open to interpretation. If we had a different Contractor, things could have been different.
18. Need submittal table in the submittal section. There were several times that the Contractor asked why we wanted a submittal on a certain item. It is the responsibility of the Contractor to read and know the specs, but a table of required submittals would have made it easier.
19. Need a grout spec in the specifications.
20. Need a better spec on how to handle the sand tests. There was confusion on how the Contractor was going to do this and on reporting requirements.
21. Consider requiring a confined space entry plan in the specs. (It has subsequently been decided that the District should not be requesting/reviewing health and safety plans, but should simply require the Contractor to conform to all health and safety requirements).
22. Need to be more specific about what we expect for well head protection with regards to fueling and any other chemicals. The Contractors work in many different areas and they don't all have the same level of concern that the District and regulatory agencies in California have for working in the river channel or well head areas. The specification did require an Environmental Protection Plan with water pollution plan but we need to be more explicit in what we are asking for. We should add a requirement for secondary containment for any equipment operating in the river/wellhead area. Secondary containment should be at a minimum of 1.5 times the volume of any liquid, fuel, or contaminant on site.
23. Need to edit the disinfection spec on how exactly we want the Contractor to disinfect. Need to specify what happens with the highly chlorinated water, how they dechlorinate, what they can use to disinfect, etc.
24. Need to establish in the specs that if they chose to measure deflection at the end of the installation and then move on with construction prior to data being processed and approved, they

need to cover the cost of the lateral that is out of spec. (We got bad inclinometer data on one lateral and the screen was installed prior to processing and the District approving that data).

25. Need to add what to do with the anchor bolts upon completion (leave in, burn off, seal holes with grout).
26. Need to establish a better specification on what “level” the bore blast or development tool is used adjacent to existing laterals to minimize the risk of collapsing or damaging the existing laterals.
27. Need to establish whether we want to have existing laterals re-developed or videoed before and after the new lateral installation. We may want to require that a sand line be inserted into old laterals to clean them out prior to opening the closed laterals. The performance test requires high pumping rates that could mobilize sediments, temporally increasing turbidity. By cleaning the old laterals prior to the test we will minimize these impacts.
28. We should possibly require Contractor to add time to the schedule for the District to conduct Microscopic Particulate Analysis testing after the lateral installation.
29. Need to have baskets for the pumps prior to diving.
30. Have Contractor provide tags for all the new valves.
31. The specs may need to be cleaned up about the Contractor’s responsibility for site security and locking gates. It was a problem with this crew, but it was clear in the specs that they were supposed to do that. Not sure if it needs to be address or how.
32. Clean up specs about what to do with gravel and sand spoils from the lateral installation. It is good gravel, and perhaps we should make it clear that the District will utilize the available gravel.
33. Add to the specs the District running pump tests and capturing SCADA data prior to and after installation.
34. Add to the specs that the Contractor shall attend weekly progress meetings with Owner and Engineer.
35. Add grounding plan requirement for dewatering pump or any electrical equipment in the caisson.

4. Pump Upgrades

Collector 3 originally had two 350hp, Worthington model 24H-590, 3-stage pumps. The motors had been rewound, and the pumps were well-maintained. However, both pumps had been in use for about 50 years, and three new pumps and motors were purchased in 2014. After the 2012 installation of new laterals in Collector 3, the performance and hydraulics of the collector were assessed, and new pumps and motors were sized that would perform as efficiently as possible under the new hydraulic conditions.

The new pumps included two 400hp, 6-stage, Flowserve model 18ENH pumps and a 250hp, 8-stage, Flowserve model 16ENL pump (see Appendix 9 for manufacturer specifications and performance curves). The new 400hp pumps served to replace the two existing 350hp pumps. To date, one 350hp pump has been replaced with a new 400hp pump, but the second 400hp pump has yet to be installed. The new 250hp Flowserve pump was installed to provide greater operational flexibility and redundancy. Its purpose is to provide reduced flow to keep storage tanks full during periods of lower usage, or to be used in conjunction with the other pumps in the case that higher flows are required. An existing column piece and starter was reused for the newly installed 400hp pump, while a new starter and new column members were required for the new 250hp pump. An existing column piece will also be reused for the second 400hp pump, while a new starter will likely be required.

The design flow for the 400hp model 18ENH pumps is 4,300 gallons per minute (gpm) at 275 feet total dynamic head (TDH). The design flow for the 250hp model 16ENL pump is 2,500 gpm at 254 feet TDH. Both pump models are designed to be over 80% efficient at their respective operating points. Initial performance tests were performed for each new pump that was installed, and the performance of each closely followed the design performance specifications.

5. Transformer and Electrical Upgrades

Collector 3 still had the original transformer and electrical equipment that was installed in 1966, and it was planned to replace this equipment upon installation of the new pumps. Upon specification of the new pumps, the new associated electrical upgrades that were required were able to be specified. Replacement of the existing transformer and other electrical equipment occurred in 2014.

There was an existing 1500KVA transformer that had been in use since the original construction of Collector 3. While this transformer was well-maintained, it was over 50 years old and needed to be replaced. The old transformer was replaced with a new Cutler Hammer 1500KVA, pad-mounted transformer (see Appendix 10 for the new transformer specifications). A new transformer pad was also designed and constructed at the same time (see Appendix 10 for the transformer pad drawings).

The collector electrical system was previously serviced by a single main breaker, which was to be replaced. When doing research on replacing this breaker, it was brought to the District's attention that the new electrical code requires three additional sub-breakers for each of the proposed pumps. New bus work was also required between the transformer to the new main and sub-breakers. Also included in the electrical upgrades was a high resistance grounding junction box, as well as soft starter controls for the new 250hp pump. The single line drawings and specification for the electrical equipment are contained in Appendix 11.

6. Post Upgrade Performance Assessment

HBMWD collects data on their collectors including the river level, water level inside the caisson (well level), and the turbidity of the water coming out of the caisson when it is pumping. The Collector 3 new lateral installation work occurred from December 2011 through May 2012, and relevant data was compiled from time periods before and after this work to assess the performance of the new laterals in Collector 3. Figures 17 through 20 illustrate how the lateral installation in Collector 3 influenced drawdown and turbidity in the collector.

Figures 17 & 18 show turbidity and river level data from the following time periods:

- December 2010 and March 2011 (before the installation of new laterals)
- March 2014 and December 2014 (after the installation of new laterals)

Figure 17 shows data from the 9th through the 31st of each month to allow a more detailed look at the data, while Figure 18 shows data from the entirety of each month.

As shown in Figures 17 & 18, and as always has been the case, the turbidity in the collectors increases as the river level increases and the bed of the river becomes mobilized. The spikes in turbidity shown on the figures correspond to when the pumps in the collectors are turned on and off. The District generally starts to see turbidity in the collectors at a river level above 24 feet, as measured at Collector 1 near the Essex Control Center. Turbidity levels increase as the river levels increase. It is also common to see a larger turbidity spike when the pumps in the collectors are first turned on, and then the turbidity frequently drops off very quickly. This general pattern holds true both before and after the lateral installations. The highest river level in this data set was on December 29th, 2010, prior to the lateral installation, when the river level exceeded 32 feet. The corresponding turbidity from the collector was sustained above 7 Nephelometric Turbidity Units (NTU) with a peak of 7.7-NTU. In this data set, the only other time turbidity exceeded 7-NTU was a brief spike above 8-NTU on March 30, 2014 (after the lateral installation) when the river level was at 26 feet. This spike dropped down to 3.6-NTU very quickly and stabilized there, but the collector was only run for a short time on that day. The river level exceeded 30 feet on December 21, 2014 (after the lateral installation) and the turbidity briefly peaked at 5.5 NTU, but the pumps in the collector were turned off shortly thereafter. If one compares all of the turbidity levels for when the river level was dropping below 25 feet from about the 10th through the 14th of December 2014, the turbidity levels pre-and post-lateral installation are generally in the 0.5 to 2 NTU range.

Based on the review of the data, it doesn't appear that there is a major change in turbidity levels in Collector 3 after the installation of the laterals. That being said, the District Operators have felt like the turbidity in Collector 3 has increased during high river flows. If future data support this, it may be worthwhile collecting individual turbidity samples from each lateral during high river flows to see the turbidity can be traced to a specific lateral(s) such as the two laterals installed at the higher elevation. It is recommended that means of sampling individual laterals be installed during future lateral installations to allow such testing without the use of divers.

Figures 18 and19 show well level (i.e. drawdown) and river level data from the following time periods:

- October 2011 (before the installation of new laterals), and
- October 2012 and October 2013 (after the installation of new laterals but prior to the installation of the new pumps and motors)

Figure 19 shows data from the 25th through the 31st of each month, while Figure 20 shows data from the entirety of each month. As seen in both figures, the river elevation for this time period in October 2011 was consistently higher than the river elevation for this same time period in October in both 2012 and 2013. Generally, a higher river elevation allows the aquifer to recharge quicker and reduces the drawdown in the collector. However, even with a higher river elevation, the drawdown in 2011 caused by pumps turning on was generally significantly greater than the drawdown in 2012 or 2013. This can be attributed to the effectiveness of the new laterals, allowing more water to be drawn into the caisson at a faster rate, thus reducing drawdown within the caisson. This re-confirms the findings of the post lateral installation testing detailed in Chapter 3. This reduced drawdown leads to less energy use and lower overall pumping costs.

7. Project Financial Summary

The finances associated with the Collector 3 Rehabilitation Project included costs for design, permitting, installation of new laterals, construction inspection and management, and electrical upgrades. These costs are summarized in Table 3:

Table 3: Total costs for the Collector 3 Rehabilitation Project

Item	Cost
Engineering	$ 23,826
Permitting	$ 6,401
Construction Management	$ 82,784
New Laterals Installation Construction	$ 1,066,400
New 250hp Pump & Motor	$ 175,000
(2) Replacement 400 hp Pumps & Motors	$ 379,000
New Transformer & Electrical Upgrades	$ 93,000
Total Project Cost	**$ 1,826,411**

8. Conclusions and Recommendations

8.1 Summary of the Ranney Collector Wells lateral installation

Ranney Collector Wells recently completed the rehabilitation of the Humboldt Bay Municipal Water District Ranney Collector No. 3. The work included the installation of six new 12- inch diameter laterals, two new 400-hp pumps and a new 250-hp pump, a new transformer, and new electrical system upgrades. The total project cost, including engineering, permitting, construction management, and construction, was $1,826,411. The new laterals were installed in two tiers with centerline elevations of -22.2 feet and -11.2 feet. The lengths of the new laterals vary from 75 feet to 155 feet, and the total length of the newly installed laterals is 690 feet. Each lateral is constructed from stainless steel, wire-wrapped well screen with 5 feet of blank pipe at the caisson end. The total open area of the new lateral well screens is 1,063.9 square feet. The capacity of the collector with the new laterals is approximated at 10 MGD.

The pre-maintenance multiple-rate step test indicated that the collector well had observed specific capacity values of 280, 241 and 217 gpm/ft when pumped at rates of 3,000, 4,470, and 6,000 gpm, respectively. The post-maintenance multiple-rate step test indicated that the collector well had observed specific capacity values of 392, 362, 329 and 312 gpm/ft when pumped at rates of 3,050, 4,650, 6,020 and 7,420 gpm, respectively. The observed post-maintenance specific capacity values are approximately 50% higher than those observed during the pre-maintenance test at similar pumping rates. The pre-maintenance lateral flow analysis indicated that Lateral A-2 had the highest flow rate and Lateral B-2 had the lowest flow rate. The post-maintenance lateral flow analysis indicated that Lateral 6 had the highest flow rate and Lateral B-2 had the lowest. The new laterals were producing 73% of the total flow. Analysis of the testing results indicates that the new laterals are efficiently providing the water that is available.

The lateral installation process was generally very successful. However, several of the laterals met refusal and projection had to be terminated. This resulted in the installation of two additional laterals at a shallower depth than originally anticipated to achieve the total desired new lateral length. It is recommended that prior to lateral installations at other collectors, geophysical tests be performed to assess the location of bedrock outcroppings and that alternative lateral installation locations be identified prior to the start of construction. There were also several other areas where the plans, specifications or contract documents could have been improved upon and these suggestions are noted in Chapter 3 of the Report. These suggestions should be thoroughly reviewed prior to the next lateral installation project.

Several years of operational data have also been reviewed since the lateral completion in May of 2012, allowing for the comparison of turbidity data and collector drawdown data since the lateral installation. The data shows that drawdown in the collector continues to be less after the installation of the new laterals than it was before the new laterals were installed. This reduced drawdown leads to less energy use and lower overall pumping costs. The data shows that the turbidity in the collector appears to be similar to what existed prior to the lateral installation; however, the District Operators feel like the turbidity may have gotten higher. It would likely be worthwhile to review turbidity data again after additional high water events in the Mad River, and if turbidity appears to be a problem, it may be worthwhile installing sampling tubing to allow the District to collect turbidity data from individual laterals. This would allow the District to see if high turbidity can be traced to individual laterals, such as the two shallower laterals that were installed.

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