Central Coast Regional Water Quality Control Board

July 11, 2024

Sent Via Electronic Mail

Damaris Hanson, Utilities Division Manager
City of Morro Bay Public Works
595 Harbor Street
Morro Bay, CA 93442
Email: dhanson@morrobayca.gov

Dear Damaris Hanson:

<u>REVISED</u> NOTICE OF APPLICABILITY, RE-ENROLLMENT OF CITY OF MORRO BAY IN WATER QUALITY ORDER 2012-0010, *GENERAL WASTE DISCHARGE REQUIREMENTS FOR AQUIFER STORAGE AND RECOVERY PROJECTS THAT INJECT DRINKING WATER INTO GROUNDWATER*, AND TRANSMITTAL OF REVISED MONITORING AND REPORTING PROGRAM NO. R3-2021-0067

Central Coast Regional Water Quality Control Board (Central Coast Water Board) staff reviewed GSI Water Solution Inc.'s April 14, 2021 *Draft Technical Report: Notice of Intent to Enroll in ASR General Order (2012-0010) For Injection Well Testing* and GSI's August 26, 2021 *Draft Injection Testing Work Plan for Groundwater Replenishment and Reuse Project,* submitted on behalf of the City of Morro Bay. According to the information provided, the proposed pilot aquifer storage and recovery (ASR) project meets the conditions of Water Quality Order 2012-0010, *General Waste Discharge Requirements for Aquifer Storage and Recovery Projects that Inject Drinking Water into Groundwater* (General Permit).

The Central Coast Water Board enrolled the City of Morro Bay's (City) pilot ASR project in the General Permit on September 24, 2021. The City began pilot testing on October 14th, 2022 with an injection step test. A long-term injection test was initiated on December 6th, 2022, and lasted approximately 4 weeks, ending on January 4th, 2023. In accordance with the requirements of the General Permit, a pilot injection test shall not exceed a length of time of two years. The City's enrollment in the General Permit was paused on January 5th, 2023, allowing the City time to reevaluate their pilot program goals. On June 18, 2024, GSI Water Solutions (GSI) issued an Interim Tracer Test Draft Work Plan on behalf of the City (Attachment 6). This second phase of pilot testing is expected to run for approximately two months and is the final phase of pilot testing anticipated for the project.

This letter also includes site-specific requirements and facility information (Attachment 1), the revised monitoring and reporting program requirements (Attachment 2), a copy of the notice of intent with figures (Attachment 3), an updated Form 200 (Attachment 4), a copy of the initial injection testing work plan (Attachment 5), and a copy of the interim tracer test draft work plan (Attachment 6).

The City of Morro Bay must comply with the following:

1. **General Permit** – The City of Morro Bay must comply with all conditions and requirements of the General Permit. As described in the General Permit, ongoing operation, maintenance, monitoring, and reporting are required. A copy of the General Permit is available electronically at the following link:

   https://www.waterboards.ca.gov/board_decisions/adopted_orders/water_quality/2012/wqo2012_0010_with%20signed%20mrp.pdf

2. **Monitoring and Reporting Program** – The City of Morro Bay must comply with the requirements of Revised Monitoring and Reporting Program No. R3-2021-0067 (Attachment 2).

   Per the Revised Monitoring and Reporting Program, you are required to submit quarterly reports for the first four quarters of operation. These quarterly reports will be due by the **first day of the third month after the quarter.** Your next quarterly report for the July-September quarter is due on **December 1, 2024**.

   In addition to the quarterly reports, annual reports are required by March 1. Your next annual report is due on **March 1, 2025,** and every year afterwards for the duration of this project.

   The City is required to submit reports in a searchable PDF format and laboratory data in EDF format electronically via GeoTracker (see Attachment 2 for instructions). Each monitoring report must include the transmittal sheet found at the link below as the cover page:

   https://www.waterboards.ca.gov/centralcoast/water_issues/programs/wastewater_permitting/docs/transmittal_sheet.pdf

3. **Fees** –The City of Morro Bay must also pay an annual fee to maintain coverage in the General Permit. Annual fees are determined by the State Water Resources Control Board's fee program and cover the state fiscal year of July 1 through June 30. Your current annual fee is $3,746. A copy of the current state fee schedule is available electronically at the following link:

https://www.waterboards.ca.gov/resources/fees/water_quality/

Your facility currently is assigned a threat and complexity rating of 3C.

4. **Future Discharge Modification** – Pursuant to California Water Code section 13260, you must inform the Central Coast Water Board at least 120 days prior to modifying your discharge. Prior to any modification of your discharge, you must submit a revised notice of intent to the Central Coast Water Board for review and approval that documents proposed changes to the potable water and injection system at the facility. If there are any significant changes in either treatment or disposal methodologies, or the volume or character of the treated wastewater, you must notify the Central Coast Water Board immediately of such changes.

5. **Regulatory Coverage Duration** – According to information provided by the City of Morro Bay, the Central Coast Water Board understands that the City began pilot testing on October 14th, 2022 with an injection step test. A long-term injection test occurred from December 6th, 2022 through January 4th, 2023. The City’s enrollment in the General Permit was paused on January 5th, 2023. Due to the ambiguity observed with intrinsic tracers in the first injection test, the City plan to proceed with an extended interim injection test using an added tracer compound to generate an estimate of travel time and groundwater velocity under project operating conditions. The remaining testing is scheduled to begin again as early as July 11, 2024. The City plans to conduct interim testing when there is no surficial flow of water in Morro Creek. Based on the substantial amount of rainfall in the 2023-2024 water year, it is anticipated that no-flow conditions may exist in late summer 2024. In this case, the injection period would likely extend through September 2024. The City has 21 months to conduct additional injection testing at the existing injection well (Well No. 1) using the same source water (State Water Project water) as previous testing. Enrollment in the General Permit will terminate on April 9, 2026, unless the City of Morro Bay requests an earlier termination date. The Central Coast Water Board will not be pausing the General Permit a second time.

6. **Responsible Party** – The City of Morro Bay is responsible for the management and disposal of the wastewater in compliance with the conditions of the General Permit. Any noncompliance with this General Permit constitutes a violation of the California Water Code and subjects the City of Morro Bay to enforcement action and/or termination of enrollment under this General Permit.

7. **Change in Ownership** – In the event of any change in control or ownership of the property, the City of Morro Bay must notify the succeeding owner or operator of the existence of this General Permit by letter. A copy of the letter must immediately be forwarded to the Central Coast Water Board so that the new owner or operator can be enrolled in the General Permit and your enrollment in the General Permit can be terminated.

If you have any questions, please contact **Rachel Hohn** at **805-542-4789** or **by email at** or Jennifer Epp at (805) 594-6181 or by email at Jennifer.Epp@waterboards.ca.gov.

Sincerely,

Jennifer Epp Digitally signed by Jennifer Epp Date: 2024.07.10 17:58:37 -07'00'

for Ryan Lodge
Executive Officer

Attachments:
1. Site-specific Requirements and Facility Information
2. Revised Monitoring and Reporting Program No. R3-2021-0067
3. Draft Technical Report: Notice of Intent to Enroll in ASR General Order (2012-0010)
4. Updated Form 200
5. Injection Testing Work Plan for Groundwater Replenishment and Reuse Project
6. Interim Tracer Test Draft Work Plan.

cc:
Tim Thompson, GSI Water Solutions, tthompson@gsiws.com
David O'Rourke, GSI Water Solutions, dorourke@gsiws.com
Daniel Heimel, Confluence Engineering Solutions, danheimel@confluencees.com
Lydia Holmes, Carollo, lholmes@carollo.com
Mary Kate Forkan, Carollo, mforkan@carollo.com
Rachel Hohn, Rachel.Hohn@Waterboards.ca.gov
James Bishop, James.Bishop@waterboards.ca.gov
Jennifer Epp, Jennifer.Epp@Waterboards.ca.gov
Jesse Woodard, Jesse.Woodard@waterboards.ca.gov
WDR Program, *GeoTracker* RB3-WDR@Waterboards.ca.gov

ECM/CIWQS Place = 868768
GeoTracker No. = WDR100053984
Rev 4/30/20
ECM Subject Name = INJECTION WELL TESTING – ENROLLMENT IN GENERAL WDR FOR AQUIFER STORAGE AND RECOVERY PROJECTS

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ATTACHMENT 1

SITE-SPECIFIC LIMITS, REQUIREMENTS, AND FACILITY INFORMATION

1. PROJECT DESCRIPTION AND FACILITY INFORMATION

The intent of this project is to assess the feasibility of a permanent groundwater recharge project that would inject advanced purified recycled water. The injectate source water of the ASR pilot will be the City's State Water Project supply, which is treated to drinking water standards at the Polonio Pass Water Treatment Plant, pursuant to the requirements in the district's State Water Resources Control Board Division of Drinking Water permit. Facility and ownership information are shown in Table 1.

On May 11, 2021, the City submitted a draft technical report describing the proposed well installation, development and pump-testing, injectate water quality, native groundwater quality, plans for injection, and plans for water quality and sediment sample collection (Attachment 3). On August 26, 2021, the City submitted its *Draft Injection Testing Work Plan for Groundwater Replenishment and Reuse Project* (Attachment 5). On June 18, 2024, GSI Water Solutions (GSI) issued an Interim Tracer Test Draft Work Plan on behalf of the City (Attachment 6).

The City of Morro Bay conducted an injection step test in Injection Well No. 1 (IW-1, in the Lower Morro Valley groundwater basin) on October 14th, 2022. Changes in water quality and water table elevations were measured in monitoring well 21P-01. A long-term injection test of pilot injection well was initiated on December 6th, 2022, and lasted approximately 4 weeks, ending on January 4th, 2023. Prior to the initiation of the long-term injection test, a brief backflush of the injection well was performed along with a flush of the injection line. Transducer data indicated an appearance of the injected source water in the monitoring well on December 19th, 2022, which provided an indication of groundwater travel time between the two wells. Water quality samples were collected the following day from the monitoring well. On January 3rd, 2023, results from water quality samples confirmed source water was present in the monitoring well. This supported the decision to terminate the long-term injection test, which occurred the following day on January 4th, 2023.

The City plans to proceed with an extended interim injection test using an added tracer compound (Fluorescein dye) to generate an estimate of travel time and groundwater velocity under project operating conditions. The test will be used to determine the migration rate of injected water between IW-1 and two downgradient piezometers (20P-01 and 21P-01) and well MB-15 under conditions when the City's wellfield (located to the north) is actively pumping. However, this interim test is not intended to substitute for the full operational test required after startup under the terms of the Groundwater Replenishment Reuse Project regulations.

1.1. ASR Pilot Schedule: IW-1 and Monitoring Well 21P-01 were installed and developed according to the original injection testing workplan (Attachment 5). Pressure transducers were installed in both the monitoring and the injection wells to monitor pressure, conductivity, and temperature throughout the initial aquifer testing and pilot injection testing.

The City plans to conduct an interim tracer test with potable water injected into IW-1 (Attachment 6). Testing will be as early as July 11, 2024, and is estimated to continue for 2 months.

Table 1. Facility and Ownership Information for the City of Morro Bay Aquifer Storage and Recovery Pilot Project

Facility Name	City of Morro Bay Aquifer Storage and Recovery Project Pilot
Owner and Permittee	City of Morro Bay
Facility Physical Address	955 Shasta Ave, Morro Bay, CA 93442
Owner of Facility	City of Morro Bay
Operator of Facility	City of Morro Bay
Legally Responsible Official of Owner	Damaris Hanson
Owner Mailing Address	955 Shasta Ave, Morro Bay, CA 93422
Employee Contact for Owner	Damaris Hanson, Utilities Division Manager
Employee Contact Phone	805-772-6265
Employee Contact Email	dhanson@morrobayca.gov
For Internal Use	
Threat to Water Quality	3
Complexity	C
Fee Code	58
Primary Place Type	Utility Structure
Facility Type	All other facilities
Facility Waste Type	Potable Water
Program	WDRMUNIENROTH
Regulatory measure Type	Enrollee - WDR
Reclamation Included	No
EPA Approved Pretreatment Program	No

1.2. ASR Sampling Schedule: An initial round of sampling will be conducted at IW-1, 20-P01, 21-P01, and MB-15 (the nearest extraction well to the injection well) before injection testing begins again to document baseline water quality. Samples collected from the wells will be analyzed for general chemistry and fluorescein.

IW-1, 21P-01, 20P-01, and MB-15 will each be fitted with continuous data logging transducers for the purpose of consistent monitoring of water level, temperature, and specific conductivity for the duration of the injection testing. The transducer in IW-1 will be placed above the screen to accurately reflect influent water quality before it exits the well through the screen. The transducers in the piezometers will be placed near the bottom of the screened interval in each piezometer.

There will be two sampling methods to detect fluorescein dye concentrations at the two downgradient piezometers 20-P01 and 21-P01: charcoal sampling packets and collection of water samples. Charcoal samplers will serve as screening tools as they represent a time-integrated sample of water flowing through the piezometer over the time period between samples and may detect lower dye concentrations compared to grab groundwater samples. The charcoal packet samples will be analyzed before the water samples to confirm dye presence. If the charcoal packet does not yield a detectable concentration of fluorescein dye, the associated groundwater grab samples will not be analyzed. If dye is detected in the charcoal samples, the groundwater samples will undergo confirmation analysis. Groundwater samples, if analyzed, will also be analyzed for fluorescein and general chemistry constituents (cations/anions, pH, conductivity).

The well head assembly at City Well MB-15 cannot easily be modified to accommodate the placement of charcoal packets. Instead, groundwater samples collected from MB-15 will be analyzed for the selected parameters without the intermediate step of installing and sampling the charcoal packets. Additional continuously recorded data will include water level, conductivity, and temperature via the pressure transducers installed in the well and piezometers.

After the first week of the injection test, samples will be collected from the downgradient piezometers and MB-15. The charcoal packet will be removed from 21P-01 and 20P-01, then the piezometers will be purged for 3 casing volumes using a submersible pump. After the wells stabilize to low-flow parameters, a 30 mL water sample will be collected and stored in the cooler with the charcoal packet samples.

Following the interim tracer test, a draft technical memorandum will be prepared by the consultant. After City review and appropriate incorporation of comments, the technical memo will be submitted to the Central Coast Water Board and the State Water Resources Control Board

Division of Drinking Water on behalf of the City to provide documentation of the testing results and to support future project permitting.

Sampling frequency and constituents are detailed in the Revised Monitoring and Reporting Program (Attachment 2) and must be consistent with the Interim Tracer Test Draft Work Plan (Attachment 6).

2. SITE-SPECIFIC REQUIREMENTS AND LIMITS

2.1. Injection Rate Limits: Maximum injection rate at IW-1 must not exceed 350 GPM.

2.2. Groundwater Limitations: The City of Morro Bay must manage the operation to comply with the *Water Quality Control Plan for the Central Coastal Basin*[1] (Basin Plan). Specifically, the city must comply with section 3.3.4, Objectives for Groundwater, which currently includes:

i. General objectives for tastes and odors and radioactivity for all groundwaters.

ii. Objectives for municipal/domestic supply including organic chemicals, inorganic chemicals, and radio nucleotides, which are established at the drinking water Maximum Contaminant Levels (MCLs) as defined in California Code of Regulations, title 22, division 4, chapter 15[2].

3. GROUNDWATER BASIN AND AQUIFER TARGET INJECTION ZONE

3.1. Groundwater Basin: Injection will occur into the Lower Morro Valley Groundwater Basin, basin number 3-41 per the numbering convention of the Department of Water Resources. The Basin Plan refers to this groundwater basin as the Morro Valley groundwater subbasin.

3.2. Aquifer Target Injection Zone: Treated surface water will be injected into the Lower Morro Valley Groundwater Basin (LMVGB). The LMVGB consists of two hydrostratigraphic units; both consist of unconsolidated sands and gravels. The target aquifer zone is the older, deeper alluvial aquifer, called the Lower Basin, at 60 to 80 feet below ground surface (bgs). The lower target aquifer is overlain by finer-grained deposits,

[1] The 2019 edition of the Water Quality Control Plan for the Central Coastal Basin can be accessed on the Internet via the following webpage: https://www.waterboards.ca.gov/centralcoast/publications_forms/publications/basin_plan/docs/2019_basin_plan_r3_complete_webaccess.pdf

[2] Current MCLs are available at: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/MCLsandPHGs.html

creating confined conditions. Previous aquifer test results have shown the Lower Basin to have higher permeability than the shallower younger alluvial deposit. GSI's groundwater monitoring data have shown that the basin's major source of recharge is from Morro Creek streambed percolation. Water levels are also influenced by City extraction wells located north of Morro Creek (Attachment 3). IW-1 was completed to a total depth of 88 feet bgs and screened in the deep aquifer zone, approximately 60 to 80 feet bgs. Construction information for IW-1 is shown in Table 2. Non-pumping groundwater flow direction is believed to be from northeast to southwest.

Table 2. City of Morro Bay Injection Well Location, Well Depth, Screened Intervals, And Injection Rate

Well name	Latitude	Longitude	Well depth (ft bgs)	Screened interval depths (ft)	Injection Rate (GPM)
Injection Well No. 1 (IW-1)	35.375999	-120.85584	88	60-80	350

4. INJECTATE WATER QUALITY AND SOURCE

4.1. Water Treatment: The City's primary water source is surface water from the State Water Project, which is sometimes blended with local groundwater. The City obtains State Water Project water from the Central Coast Water Authority's treatment plant located at 10923 Antelope Road, Shandon, San Luis Obispo County. Treatment of injectate water to drinking water standards is the responsibility of the Central Coast Water Authority. Groundwater extracted from the Lower Morro Valley Groundwater Basin will not be used in this pilot study. State Water Project water quality data is shown in Table 3.

4.2. Injectate Water Quality: According to the information provided, all of the treated water quality constituents of concern (as shown in Table 3) meet primary state and federal drinking water standards. The Basin Plan does not designate Basin-specific water quality objectives for the Lower Morro Valley Groundwater Basin.

5. AMBIENT GROUNDWATER QUALITY

Ambient groundwater quality reported for the City's well field complies with drinking water standards for all constituents except for nitrate and total dissolved solids. These constituents exceed the recommended concentrations for drinking water. The Basin Plan does not specify basin-specific water quality objectives for the Lower Morro Valley Groundwater Basin. Native groundwater quality for select constituents is shown in Table 3.

6. GROUNDWATER QUALITY MONITORING WELLS

6.1. To verify that injection water is not impairing groundwater quality, the City of Morro Bay will monitor groundwater quality in monitoring well 21P-01, 20P-01, and MB-15. The injection well and monitoring wells will be monitored for temperature, pressure, and conductivity with dedicated transducers throughout the pilot project. Groundwater will be sampled at each location during the interim test, prior to any injection activities, and weekly for four weeks after injection testing.

Table 3. Groundwater Limitations, Anticipated Injectate Water Quality, and Native Groundwater Quality

Constituent	Units	Groundwater Limitations	Injectate Concentration[a]	Native Groundwater[b]
Arsenic	µg/L	10[c]	ND	3
Boron	mg/L	0.75[d]	ND	125
Chloride	mg/L	106[e]	73	238
Specific Conductance	µmhos /cm	900[f]	503	1,749
Iron	µg/L	300[g]	No data	No data
Manganese	µg/L	50[g]	No data	No data
Nitrate as N	mg/L	10[c]	ND	15
Sodium	mg/L	69[e]	56	94
Sulfate	mg/L	250[g]	63	127
Total Dissolved Solids	mg/L	500[g]	280	1,175
Haloacetic acids[h]	µg/L	60[c]	13	14.6
Trihalomethanes[i]	µg/L	80[c]	40	35

µg/L = micrograms per liter
mg/L = milligrams per liter
µmhos/cm = micromhos/centimeter
ND = non-detect
NA = not applicable

a. Injectate water data are reported for 2020 in the City of Morro Bay Annual Consumer Confidence Report.
b. Native groundwater data are raw water results taken from all City of Morro Bay groundwater wells as reported in the 2020 City of Morro Bay Annual

Consumer Confidence Report. Note that nitrate and dissolved arsenic samples were for 2018.

c. US EPA and California Primary Maximum Contaminant Levels.
d. Central Coast Basin Plan Table 3-2 Water Quality Objectives for Agricultural Use
e. Central Coast Basin Plan Table 3-1. Guidelines for Interpretation of Quality of Water for Irrigation, Specific ion toxicity from foliar absorption.
f. California Code of Regulations, Title 22, Div 4, Chapter 15, Article 16 Recommended consumer acceptance contaminant levels
g. California Code of Regulations, Title 22, Div 4, Chapter 15, Article 16 Secondary Drinking Water Standards
h. Haloacetic acids include bromoacetic acid, chloroacetic acid, dibromoacetic acid, dichloroacetic acid, and trichloroacetic acid.
i. Trihalomethanes include bromodichloromethane, bromoform, chloroform, and dibromochloromethane.

Table 4. Aquifer Monitoring Wells for Groundwater Quality

Well Name	Latitude	Longitude	Distance from Injection Well No. 1 (IW-1) (ft)	Well Depth (ft)	Screened Interval (ft bgs)
21P-01	35.37614	-120.85596	53 feet north of IW-1	74	45-70
20P-01	35.37733	-120.85556	460 feet north of IW-1	66	41-66
MB-15	35.37868	-120.85573	980 feet north of IW-1	70	40-70

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL COAST REGION
895 Aerovista Place, Suite 101
San Luis Obispo, California 93401

MONITORING AND REPORTING PROGRAM NO. R3-2021-0067
REVISED JULY 11, 2024
for
THE CITY OF MORRO BAY'S
AQUIFER STORAGE AND RECOVERY PILOT PROJECT
SAN LUIS OBISPO COUNTY

This Revised Monitoring and Reporting Program (MRP) describes requirements for monitoring an aquifer storage and recovery pilot project operated by the City of Morro Bay. This MRP is issued pursuant to Water Code section 13267. The City of Morro Bay must not implement any changes to this MRP unless and until a revised MRP is issued by the Central Coast Water Quality Control Board (Central Coast Water Board) Executive Officer.

The City of Morro Bay receives State Water Project water from the Polonio Pass Water Treatment Plant (PPWTP), which is owned and operated by the Central Coast Water Authority. The City of Morro Bay is subject to the Central Coast Water Board's notice of applicability, dated September 24, 2021 and re-issued on July 11, 2024, for Water Quality Order 2012-0010-DWQ*, General Waste Discharge Requirements for Aquifer Storage and Recovery Projects that Inject Drinking Water Into Groundwater* (General Permit).

1. SUPPLEMENTAL MONITORING AND REPORTING FOR ASR PILOT PROJECT

On August 26, 2021, GSI Water Solutions, Inc. (GSI) submitted the updated *Draft Injection Testing Work Plan for Groundwater Replenishment and Reuse Project, Morro Bay, California*, on behalf of the City of Morro Bay. This work plan described a water quality monitoring and reporting program for initial ASR pilot testing. On June 18, 2024, GSI issued an Interim Tracer Test Draft Work Plan, which describes updated monitoring for the final phase of ASR pilot testing. This second phase of pilot testing is expected to run for approximately two months. The Central Coast Water Board has reviewed the Interim Tracer Test Draft Work Plan (Notice of Applicability Attachment 6) and has no comments at this time. Monitoring must be consistent with the Interim Tracer Test Draft Work Plan (Notice of Applicability Attachment 6).

2. SAMPLING AND ANALYSIS

Within 90 days after issuance of the re-issued notice of applicability, the City of Morro Bay must submit an updated Sampling and Analysis Plan (SAP) to the Central Coast Water Board for approval. All samples must be representative of the volume and nature of the injected potable water or matrix of materials sampled. The name of the sampler, sample type (grab or composite), time, date, location, bottle type, and any preservative used for each sample must be recorded on the sample chain of custody form. The chain of custody form must also contain all custody information including date, time, and to whom the samples were relinquished. If composite samples are collected, the basis for sampling (time or flow weighted) must be approved by the Central Coast Water Board. Unless otherwise specified, sampling must be performed as specified in Table 1.

Table 1. Sampling Schedule

Monitoring Period	Sample Collection Month
Monthly	Each Calendar Month
Quarterly	February, May, August, November

Field instruments (such as those used to test pH, dissolved oxygen, and electrical conductivity) may be used provided that they are operated by a State Water Board California Environmental Laboratory Accreditation Program (ELAP) certified laboratory, or each of the following requirements are met:

1. The operator is trained in the proper use of the instrument;
2. The instruments are field calibrated prior to each use;
3. Instruments are serviced and/or calibrated by the manufacturer at the recommended frequency; and
4. Field calibration reports are submitted as described in the “Reporting” section of this MRP.

3. INJECTION WELL MONITORING

Injection wells must be monitored when water is being injected into the aquifer. Monitoring of the injection wells must include the constituents and parameters shown in Table 2. Injection wells to be monitored are shown in Table 3.

Table 2. Injection Well Monitoring

Parameter	Units	Type of Sample	Sampling Frequency
Well Operational Status	N/A	Recorded	Daily
Daily Average Injection Rate	gpd	Meter	Continuous
Injected Water, cumulative total for year to date	ac•ft/yr	Meter	Continuous
Extracted Water, cumulative total for year to date	ac•ft/yr	Meter	Continuous

Parameters must be reported for each well associated with the ASR project.
Injection activity must be recorded daily.
N/A = not applicable
gpd = gallons per day

ac•ft/yr = acre-feet per year

Table 3. Injection Well to be Monitored

Well name	Latitude	Longitude	Well depth (feet bgs)	Screened interval depth (feet)
Injection Well No. 1 (IW-1)	35.375999	-120.855744	88	60-80

4. INJECTED WATER MONITORING

Injected water quality must be monitored at the wellhead inflow line when water is being injected into the aquifer. Monitoring of the injection well must include the constituents and frequencies shown in Table 4. Sampling events will be timed according to injection activities as described in Interim Tracer Test Draft Work Plan (Notice of Applicability Attachment 6). The sampling schedule includes weekly sampling events at the injection well and the monitoring wells.

Table 4. Injection Water Monitoring

Constituent/Parameter	Units	Type of Sample	Sampling Frequency[a]
Dissolved Oxygen	mg/L	Meter	Quarterly
ORP	mV	Meter	Quarterly
pH	pH units	Meter	Quarterly
Specific Conductance	µmhos/cm	Meter	Quarterly
Arsenic (dissolved)	µg/L	Grab	Quarterly
Iron (dissolved)	µg/L	Grab	Quarterly
Manganese (dissolved)	µg/L	Grab	Quarterly
Nitrate (as Nitrogen)	mg/L	Grab	Quarterly
Total Dissolved Solids	mg/L	Grab	Quarterly
Haloacetic acids	µg/L	Grab	Quarterly
Trihalomethanes	µg/L	Grab	Quarterly

[a] Injected water sampling is not required for any monitoring period during which injection did not occur.
mg/ L = milligrams per liter
ORP = oxidation-reduction potential
mV = millivolts
µg/L = micrograms per liter

5. EXTRACTION WELL MONITORING

An extraction well must be monitored if either of the following conditions apply:

1. An extraction well was used for injection the previous calendar year
2. An extraction well that is pumping a substantial amount of previously injected water

After four sampling events consistent with the frequencies described in this Revised MRP, the City of Morro Bay may request annual extraction well monitoring. Monitoring of each extraction well must include the constituents and parameters shown in Table 5.

Table 5. Extraction Well Monitoring

Constituent/Parameter	Units	Type of Sample	Sampling Frequency[c]
Well Activity[a]	N/A	Recorded	Daily
Daily Average Pumping Rate	gpd	Meter	Continuous
Extracted Water/Year[b]	ac•ft/yr	Meter	Continuous
Specific Conductance	µmhos/cm	Meter	Quarterly
Arsenic (dissolved)	µg/L	Grab	Quarterly
Iron (dissolved)	µg/L	Grab	Quarterly
Manganese (dissolved)	µg/L	Grab	Quarterly
Nitrate (as Nitrogen)	mg/L	Grab	Quarterly
Total Dissolved Solids	mg/L	Grab	Quarterly
Haloacetic acids	µg/L	Grab	Quarterly
Trihalomethanes	µg/L	Grab	Quarterly

[a] - Well Activity must be reported for all wells associated with the ASR project. Injection/extraction activity must be recorded on a daily basis.
[b] - Extracted Water/Year represents the total amount of water extracted from a well for the calendar year.
[c] - Extracted water sampling is not required for any quarter during which extraction did not occur.
µmhos/cm = micromhos per centimeter

6. AQUIFER MONITORING FOR GROUNDWATER QUALITY

To verify that injection water is not impairing groundwater quality, the City will monitor groundwater quality at the monitoring wells before, during, and after this ASR pilot project. The injection well and monitoring wells have been installed and developed prior to this final phase of pilot testing. The monitoring wells are shown in Table 6.

Table 6. Aquifer Monitoring Wells for Water Quality

Monitoring Well Name	Latitude	Longitude	Distance from Injection Well (ft)	Well Depth (ft)	Screened Intervals (ft bgs)
21P-01	35.37621	-120.855932	80.4	74	60-80
20P-01	35.37733	-120.85556	460 feet north of IW-1	66	41-66
MB-15	35.37868	-120.85573	980 feet north of IW-1	70	40-70

All aquifer monitoring samples must be collected using approved EPA methods. Groundwater elevations must be measured to determine injection-related drawup and radius of hydraulic influence for each injection well as well as regional groundwater gradient and direction of flow.

Prior to sampling, the groundwater elevations must be measured as described in Table 7 below, and the wells must be purged of at least three well casing volumes until temperature, pH, and electrical conductivity have stabilized. Use of low flow or passive sampling methods that do not require well purging are acceptable if described in the approved SAP. Samples must be filtered using a 0.45-micron filter for dissolved constituents such as metals. Groundwater monitoring must include the constituents and frequencies described in Table 7. Groundwater quality monitoring must be conducted in accordance with Table 7 for each quarter that injection testing has occurred.

Table 7. Aquifer Monitoring Parameters and Constituents for Groundwater Quality

Constituent/Parameter	Units	Type of Sample	Sampling Frequency
Groundwater Depth	Feet	Measuring Tape	Quarterly

Constituent/Parameter	Units	Type of Sample	Sampling Frequency
Groundwater Elevation	Feet NAVD88	Recorded	Quarterly
Specific Conductance	µmhos/cm	Meter	Quarterly
Dissolved Oxygen	mg/L	Meter	Quarterly
ORP	mV	Meter	Quarterly
pH	pH units	Meter	Quarterly
Arsenic (dissolved)	µg/L	Grab	Quarterly
Iron (dissolved)	µg/L	Grab	Quarterly
Manganese (dissolved)	µg/L	Grab	Quarterly
Nitrate (as Nitrogen)	mg/L	Grab	Quarterly
Total Dissolved Solids	mg/L	Grab	Quarterly
Haloacetic acids	µg/L	Grab	Quarterly
Trihalomethanes	µg/L	Grab	Quarterly

7. REPORTING

In reporting monitoring data, the City of Morro Bay must arrange the data in tabular form so that the date, sample type (e.g., source water, injection well, extraction well, etc.), and reported analytical result for each sample are readily discernible. The data must be summarized in such a manner to clearly illustrate compliance with the General Permit, notice of applicability, and Basin Plan. The results of any monitoring done more frequently than required at the locations specified in this MRP must be reported in the next scheduled monitoring report.

As required by the California Business and Professions Code sections 6735, 7835, and 7835.1, all groundwater monitoring reports must be prepared under the supervision of a registered professional engineer or geologist and signed by the registered professional.

A letter transmitting monitoring reports must accompany each report. The letter must summarize the numbers and severity of violations found during the reporting period, and actions taken or planned to correct the violations and prevent future violations. The transmittal letter must contain the following penalty of perjury statement and must be signed by the Administrator or the Administrator's authorized agent:

> "I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of the those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including

the possibility of fine and imprisonment."

The transmittal letter can be accessed via the following website:
https://www.waterboards.ca.gov/centralcoast/water_issues/programs/wastewater_permitting/docs/transmittal_sheet.pdf

7.1. QUARTERLY MONITORING REPORT

The City of Morro Bay must **submit quarterly monitoring reports** for the first year of operation and annually thereafter. The monitoring period and corresponding report due date are described in Table 8. Quarterly monitoring reports must be submitted to the Central Coast Water Board by the **1st day of the third month after the quarter.** Quarterly reporting must occur in accordance with Table 8.

Table 8. Quarterly Reporting Schedule

Report	Monitoring Period	Report Due Date
First Quarter	January 1 to March 31	June 1
Second Quarter	April 1 to June 30	September 1
Third Quarter	July 1 to September 31	December 1
Fourth Quarter	October 1 to December 31	March 1

The quarterly monitoring report must include the following:

1. A discussion of compliance with the General Permit and a description of any violations.

2. A discussion of the status (dates of injection, extraction, storage, and idle time) for all extraction/injection wells associated with the ASR project.

3. A narrative description of all preparatory, monitoring, sampling, and analytical testing activities for the injection, extraction, and groundwater monitoring. The narrative must be sufficiently detailed to verify compliance with the General Permit, the Notice of Applicability, this MRP, and the Standard Provisions and Reporting Requirements. The narrative must be supported by field logs for each monitoring well documenting depth to groundwater; parameters measured before, during, and after purging; method of purging; calculation of casing volume; and total volume of water purged.

4. Calculation of groundwater elevations, an assessment of groundwater flow direction and gradient on the date of measurement, comparison of previous flow direction and gradient data, and discussion of seasonal trends, if any.

5. Calculation of maximum groundwater drawup and maximum hydraulic radius of influence for each injection well.

6. Results of groundwater monitoring (analytical results tabulated with reporting limits for nondetectable results).

7. A narrative discussion of the analytical results for all groundwater locations monitored including spatial and temporal trends, with reference to summary data tables, graphs, and appended analytical reports (as applicable).

8. A comparison of monitoring data to the groundwater limitations presented in the Notice of Applicability and an explanation of any violation of those requirements. Any other violation of the General Permit with explanation and corrective action to prevent future violations.

9. Summary data tables of historical and current groundwater elevations and analytical results.

10. A scaled map showing relevant structures and features of the facility, the locations of monitoring wells and any other sampling stations, and groundwater elevation contours referenced to mean sea level datum.

11. Copies of laboratory analytical report(s) for groundwater monitoring.

12. The Central Coast Water Board executive officer may modify the reporting requirements by issuing a Revised MRP at any time.

7.2. ANNUAL MONITORING REPORT

The annual monitoring report must be submitted to the Central Coast Water Board by **March 1** each year, in accordance with Table 9.

Table 9. Annual Reporting Schedule

Report	Monitoring Period	Report Due Date
Annual Report	January 1 to December 31	March 1

The first year's annual monitoring report must summarize the first four quarters of reporting. Each annual monitoring report after the first year must include all the components that are required of quarterly monitoring reports. In addition, all annual reports must include the following:

1. **Water Quality and Public Health Goal Report**
   The annual water quality report and public health goal report published during the calendar year (if required by the Division of Drinking Water).

2. **Data Tables and Graphs**
   Tabular and graphical summaries of all monitoring data collected during the year.

3. **ASR Project Activity**
   Projected ASR project activity for the next calendar year.

4. **Compliance and Performance Discussion**
   - A discussion of compliance and corrective actions taken, as well as any planned or proposed actions needed to bring the discharge into full compliance with the General Permit and/or the notice of applicability.
   - An evaluation of water treatment facilities' performance, including concentration of the main pollutants (boron, chloride, sulfate, etc.) over time, nuisance conditions, system problems, etc.
   - An evaluation of treatment.
   - Note any changes or upgrades that were made over the past year (or need to be made) to the treatment plant to improve performance.
   - Groundwater elevation maps, flow direction, and concentration contours.

8. ELECTRONIC SUBMITTAL

The City of Morro Bay must submit all reports/documents and laboratory data (using the transmittal sheet linked below as the cover page) to the State Water Resources Control Board's GeoTracker[3] database for the City of Morro Bay's aquifer storage and recovery project in San Luis Obispo County, GeoTracker No. WDR100053984. This information must be submitted via the internet at:

http://www.waterboards.ca.gov/ust/electronic_submittal/index.shtml

Transmittal sheet:
https://www.waterboards.ca.gov/centralcoast/water_issues/programs/wastewater_permitting/docs/transmittal_sheet.pdf

Table 10 below summarizes all the electronic reporting requirements. Staff may request submittal of some documents on paper, particularly drawings or maps that require a large size to be readable, or in other electronic formats where evaluation of data is required.

[3] Information for first-time GeoTracker users is available here:
https://www.waterboards.ca.gov/ust/electronic_submittal/docs/beginnerguide2.pdf

Table 10. GeoTracker Electronic Submittal Information (ESI) Data Requirements

Electronic Submittal	Description of Action	Action	Frequency
Reports and Documents	Complete copy of all documents including monitoring reports (in searchable PDF format) and any other associated documents related to the facility.	Upload directly to GeoTracker all monitoring reports (in searchable PDF format) and any other associated documents.	On or before the due dates required by this General Permit and for other documents when requested by Central Coast Water Board staff.
Laboratory Data	All analytical data (including geochemical data) in electronic deliverable format (EDF). This includes all water samples collected when monitoring.	Direct your State Certified Laboratory staff to upload all laboratory data directly to GeoTracker.	On or before the due date of the required monitoring report.
Location Data (Geo XY)	Survey and mark all permanent sampling locations (i.e., monitoring wells, drinking water wells, and permanent injection source water sampling locations). These data points are required prior to laboratory data uploads.	Upload the survey data to the GeoTracker Geo_XY file.	Every time a permanent monitoring point is established.
Depth to groundwater	Monitoring wells must have the depth-to-water information reported.	Upload depth-two-water information to the GeoTracker GEO_WELL file.	On or before the due date of the required monitoring report.
Elevation data (Geo Z)	Survey and mark the elevation at the top of the groundwater well casing for all permanent groundwater wells. These points are required prior to depth-two-water data uploads.	Upload the survey data to the GeoTracker GEO_Z file.	One-time, for all groundwater monitoring wells.
Geo Map	Site layout, map of facilities, potable water treatment system, and disposal area(s).	Upload the Site layout PDF to the GeoTracker site plan file.	Year one and every five years thereafter and when the facilities are modified.

9. LEGAL REQUIREMENTS

Water Code section 13267 states, in part:

> "In conducting an investigation specified in subdivision (a), the regional board may require that any person who has discharged, discharges, or is suspected of having discharged or discharging, or who proposes to discharge waste within its region, or any citizen or domiciliary, or political agency or entity of this state who has discharged, discharges, or is suspected of having discharged or discharging, or who proposes to discharge, waste outside of its region that could affect the quality of waters within its region shall furnish, under penalty of perjury, technical or monitoring program reports which the regional board requires. The burden, including costs, of these reports shall bear a reasonable relationship to the need for the report and the benefits to be obtained from the reports. In requiring those reports, the regional board shall provide the person with a written explanation with regard to the need for the reports, and shall identify the evidence that supports requiring that person to provide the reports."

Water Code section 13268 states, in part:

> "(a) Any person failing or refusing to furnish technical or monitoring program reports as required by subdivision (b) of section 13267, or failing or refusing to furnish a statement of compliance as required by subdivision (b) of section 13399.2, or falsifying any information provided therein, is guilty of a misdemeanor and may be liable civilly in accordance with subdivision (b).
>
> (b)(1) Civil liability may be administratively imposed by a regional board in accordance with article 2.5 (commencing with section 13323) of chapter 5 for a violation of subdivision (a) in an amount which shall not exceed one thousand dollars ($1,000) for each day in which the violation occurs."

The burden and cost of preparing the reports is reasonable and consistent with the intent of the state in maintaining water quality. These reports are necessary to ensure that the City of Morro Bay complies with the Notice of Applicability and General Permit. Pursuant to Water Code section 13267, the City of Morro Bay must implement this MRP and must submit the monitoring reports described herein.

The City of Morro Bay must implement the above monitoring program as of July 11, 2024.

Ordered by:

Jennifer Epp Digitally signed by Jennifer Epp Date: 2024.07.10 17:59:11 -07'00'

for Ryan Lodge
Executive Officer

ECM/CIWQS Place = 868768
GeoTracker No. = GT-WDR100053984
ECM Subject Name = City of Morro Bay NOA Order WQ 2012-0010 pilot

\\ca.epa.local\RB\RB3\Shared\WDR\WDR Facilities\San Luis Obispo Co\City of Morro Bay IPR and ASR\City of Morro Bay ASR pilot\1- Permit\Updated NOA for ASR GO - Pilot Test\Morro_Bay_NOA_ASR_Pilot_update_July11_2024_Final.docx

ATTACHMENT 3

DRAFT TECHNICAL REPORT

City of Morro Bay

Notice of Intent to Enroll in ASR General Order (2012-0010) for Injection Well Testing

City of Morro Bay Groundwater Replenishment and Reuse Project

April 14, 2021

Prepared by:
GSI Water Solutions, Inc.
418 Chapala Street, Suite H, Santa Barbara, CA 93101

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Abbreviations and Acronyms

µg/L	microgram per liter
AFY	acre-feet per year
Basin	Morro Valley Groundwater Basin
bgs	below ground surface
BWRO	Brackish Water Reverse Osmosis
CCRWQCB	Central Coast Regional Water Quality Control Board
CEQA	California Environmental Quality Act
COC	chemical of concern
DDW	California Department of Drinking Water
DTSC	California Department of Toxic Substances Control
EIR	environmental impact report
ft	feet
GRRP	Groundwater Replenishment Reuse Project
GSI	GSI Water Solutions, Inc.
in	inches
IPR	indirect potable use
LUC	land use covenant
LUST	leaking underground storage tank
MBMWC	Morro Bay Mutual Water Company
MBTE	methyl tertiary butyl ether
MCL	maximum contaminant level
mg/L	milligram per liter
NAVD88	North American Vertical Datum of 1988
PCA	potentially contaminating activity
PG&E	Pacific Gas and Electric
PHG	public health goal
ROWD	Report of Waste Discharge
RWQCB	California Regional Water Quality Control Board
SMP	soil management plan
SWRCB	California State Water Resources Board
TDS	total dissolved solids
THM	trihalomethanes
TPH	petroleum hydrocarbon
UST	underground storage tank
WQ	water quality
WRF	water recycling facility

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SECTION 1: **Project Overview**

1.1 Background

The City of Morro Bay (City) is seeking permitting compliance from the California Regional Water Quality Control Board (RWQCB) for injection testing at a new injection well proposed to be installed on City-owned property within the Lower Morro Groundwater Basin in the vicinity of the City's existing production wells. GSI Groundwater Solutions, Inc. (GSI), is supporting the City with permitting and installation of the planned indirect potable use (IPR) project. The installation and operation of a series of injection wells is planned and will comply with the Groundwater Replenishment Reuse Project (GRRP) regulations for subsurface application.

Results of injection testing will provide diagnostic information of injection rates at the first injection well currently planned for this project. The installation of a nearby monitoring well (21P-01) will also be conducted as part of this effort. Injection testing will be conducted at the proposed Injection Well No. 1 site, located on vacant property along the west side of Highway 1, as shown on Figure 1.

To date, GSI has conducted hydrogeologic evaluations and modeling in support of the City's goal of establishing an IPR project. After consideration of cost-effective alternative uses of the highly treated recycled water to enhance the City's water supply from the new water recycling facility (WRF) currently under construction, two areas were evaluated for the planned IPR project. These areas are referred to as the Narrows Project Area (east of Highway 1, along Morro Creek), and the Western Project Area (west of Highway 1, also along Morro Creek). Both are located within the lower Morro Valley Groundwater Basin. The Western Project Area was selected as the preferred location.

Subsequent hydrogeologic assessments, including field characterization and groundwater modeling, support the selection of the Western Project Area (Figure 1). The water supply for the IPR project will be highly treated recycled water from the WRF, which will include the advanced treatment steps of microfiltration, reverse osmosis, and ultraviolet light advanced oxidation to produce purified effluent that meets the California State Water Resources Board's (SWRCB's) GRRP regulations. The water from the WRF will be conveyed to the several planned injection wells for subsurface application. Preliminary modeling has indicated that the requirement for adequate retention time, in compliance with the GRRP requirements, can be met prior to extraction at the City's production wells. Geochemical mixing analysis will also be conducted to assess the potential for any adverse reactions associated with the proposed injection.

The proposed WRF will be completed in 2023. The source water for injection testing at Injection Well No. 1 will be supplied from the City of Morro Bay's treated drinking water supply system, using the City's State Water supply (rather than groundwater pumped from the City's groundwater wells. Using the City's State Water Project water will more closely represent the conditions expected under full-scale IPR operations.

1.2 Statement of Intent

As part of this project, this technical report provides the data and information necessary to complete the Notice of Intent to comply with the terms and conditions of the SWRCB Water Quality (WQ) Order 2012-0010 (General Waste Discharge Requirements for Aquifer Storage and Recovery Projects that Inject Drinking Water into Groundwater). The purpose of this report is to demonstrate the compliance by the City of Morro Bay with the General Waste Discharge Requirements in WQ Order 2012-0010 to test a single injection well (Injection Well No. 1) in the lower portion of the Morro Valley Groundwater

Basin in the vicinity of the City's existing production wells. This report also provides additional information needed to describe and characterize the IPR project and anticipated effects on groundwater quality (Attachment C of the Order).

1.3 Public Outreach and Coordination

As part of the permitting required for a GRRP, there will be a Report of Waste Discharge (ROWD) prepared for submittal to RWQCB.

As part of the ROWD and GRRP approval process, there are public outreach and notification requirements to be followed. In compliance with the anticipated ROWD, the City will (1) provide notification via U.S. Postal Service mail to the owners of record for properties adjacent to injection well site and area, (2) include notification of the project via the City monthly newsletter to its customers, and (3) give two presentations at City Council meetings. The City will use the newsletters and meetings to provide project updates and notify interested parties of changes in operation. Newsletters are also available online and via free subscription. The City's community outreach activities include updates to its website to provide information on water quality, water supply, and relevant topics that may affect customers.

SECTION 2: **Hydrogeologic Setting**

2.1 Morro Valley Groundwater Basin

The Morro Valley Groundwater Basin (Basin) (DWR Bulletin 118 basin 3-41) is a shallow alluvial basin that encompasses approximately 1.9 square miles and is bounded on the west by the Pacific Ocean and surrounded and underlain on all other sides by consolidated and impermeable rocks of the Franciscan Complex (Jurassic to Cretaceous age). The Basin is further divided into lower and upper parts by a restriction in the valley commonly referred to as the Narrows, located approximately 1,000 feet (ft) east of Highway 1, where the alluvium underlying Morro Creek is constrained by the bedrock to a narrow corridor about 300 ft wide. The principal water-bearing units in the Lower Basin are younger alluvium, dunes sand, and Holocene- and Pleistocene-aged terrace deposits that extend approximately 60 to 80 ft beneath the valley floor. Two aquifer zones (shallow and deep) have been identified within the Lower Basin sediments (Brown and Caldwell, 1981; Cleath, 1993).

Groundwater monitoring conducted by GSI for the proposed project refined the inflow and outflow of the existing water conditions in the groundwater basin (GSI, 2017). The primary source of recharge to the Lower Basin is mostly from Morro Creek streambed percolation. Morro Creek is predominantly a losing stream (i.e., water in the creek is usually percolating down into and recharging the underlying aquifer). However, during wet periods, portions of Morro Creek can become a gaining stream (i.e., water from the underlying aquifer rises up enough to discharge into the stream and support its flow). The volume of Morro Creek percolation is believed to be partly affected by City pumping from its existing wells. The higher the rate of pumping, the more water Morro Creek loses to the aquifer, because groundwater levels decrease and do not support the creek flow.

Aquifer testing on existing wells conducted during GSI modeling studies for the GRRP revealed that the aquifer has a large contrast in permeability between the upper (shallow) and lower (deep) aquifers, with the lower aquifer being more permeable than the upper aquifer.

2.2 Target Aquifer Zones

Recent alluvial deposits are the primary water-bearing unit in the Lower Morro Valley Basin and are composed primarily of unconsolidated sand, silt, and clay. The hydrostratigraphy of the Lower Basin has been divided into hydrostratigraphic zones based on data from geologic and geophysical logs. The zones that produce meaningful amounts of groundwater include a younger shallow alluvial aquifer and an older deep alluvial aquifer, both of which consist of well-graded sand and gravels. The deep alluvial aquifer is typically overlain by finer sediments ranging from clayey silt to silty clay, creating confining conditions in the Lower Basin area (B&C, 1981). The target aquifer zone (approximately 60 to 80 ft below ground surface [bgs]) for the injection testing of Injection Well No. 1 (and for future injection wells will be the deep alluvial aquifer. As discussed above, modeling of these two sub-aquifer units favors the deep alluvial aquifer for injection purposes (because of its higher permeability and higher hydraulic conductivity values).

2.3 Area of Hydrologic Influence

Planned injection wells for the proposed IPR project will be distributed along the southern boundary of the Western Project Area. Predictive numerical modeling scenarios performed by GSI suggest the area of hydrologic influence during full-scale injection operations will predominantly cover the areas between the planned injection wells and the City's existing wells to the north. Figures 2a and 2b were adapted from GSI's January 2021 technical memorandum, *Characterization and Selection of Project Area for Injection Testing*, and show the modeled heads and particle tracking results for the pumping scenario of baseline pumping (pumping 581 AFY from the City's 7 existing production wells) plus 75 percent of total injection volume (1,200 acre-feet per year [AFY]) from planned injection wells during dry and wet conditions. The extent of hydrologic influence will depend on the duration, volume, and frequency of future injection. For injection testing, the area of hydrologic influence is anticipated to be much smaller than the full-scale project, and will likely not extend outside those areas of influence at full-scale injection operations, as shown on Figures 2a and 2b.

2.4 Land Use

Current land use in the Western Project Area (area of planned injection for the initial injection well and testing) of the Lower Basin is undeveloped and covers an area of approximately 17 acres. The Western Project Area is essentially flat and centrally located relative to the City's infrastructure. The Western Project Area is adjacent to the currently planned alignment of the forthcoming recycled water pipeline. The Western Project Area is also adjacent to (north of) the former Morro Bay Power Plant (Power Plant) site (shown by a light blue triangle on Figure 4). Portions of the adjacent former Power Plant site are going through land use covenant (LUC) procedures associated with its closure by the California Department of Toxic Substances Control (DTSC). This proposed LUC procedure would restrict some areas of the former Power Plant site outside of the project area to future commercial/industrial uses. The Western Project Area is not located within these areas and therefore is not subject to the forthcoming LUC. This is discussed in more detail in Section 3.3.

The existing land use designations for the proposed injection well area (i.e., the Western Project Area) and surrounding areas are depicted in Figure 3.

SECTION 3: **Regional Groundwater Conditions**

3.1 Groundwater Elevations

Groundwater elevation data for three of the City's existing production wells (Well MB-4, Well MB-14, and Well MB-15) located near the proposed injection area reveal that static (non-pumping) water elevations for these three wells have fluctuated between a high of about 20 ft above mean sea level to a low of about 15 ft below mean sea level (GSI, 2017) during the period of observed data between 1994 and 2016. Water levels tend to be at their highest each year during the wet winter months when rainfall recharge is higher, and deepest during the dry summer months when rainfall recharge is limited. Water levels generally appear to recover each year; no significant declines in water level were apparent.

Groundwater movement in the Lower Basin is largely controlled by the City wells. Pumping from the City wells develops a water level depression that slopes radially towards the City wells, and can include seawater during drought (Cleath, 2007). The regional groundwater gradient is generally from northeast to southwest. During non-pumping periods, groundwater flows below the Narrows toward the coast at a nominal hydraulic gradient of 0.005 ft/ft (Aqui-Ver, 2005). This gradient reflects the migration of water from the recharge areas mostly in the areas above the Narrows toward the areas where significant pumping occurs in the Lower Basin.

In December 2018, GSI installed 11 pressure transducers in existing City production and desalination wells for the purpose of long-term groundwater elevation monitoring. This work was completed in support of the IPR project proposed for the City. The transducers are programmed to measure water pressure (convertible to water level), temperature, and specific conductivity (convertible to chloride concentration) every 4 hours to document aquifer water levels and quality. The data will also provide warning of any potential seawater intrusion.

3.2 Groundwater Quality Trends and Constituents of Concern

General water quality data collected from City water supply production wells between 2011 and 2015 are summarized in Table 1, along with California Department of Drinking Water (DDW) maximum contaminant levels (MCLs), including primary and secondary drinking water standards; and public health goals (PHGs) (MKN, 2017)[10]. More recent water quality results for the City's existing wells (i.e., the average and range of detections) as presented in the City's *Annual Water Quality Report 2019* (City of Morro Bay, 2020) are also shown on Table 1. The data indicate nitrates and seawater intrusion are the predominant concerns for water quality (MKN, 2017; MNS, 2016).

Nitrate levels are elevated due to agricultural application of nitrogen fertilizers in the watershed, which is restricting the City's ability to use groundwater as a potable water supply. In the past 20 to 30 years, pumpage has been significantly reduced from its permitted amount due in part to elevated nitrate concentrations observed in groundwater pumped from City wells. Historically, Basin wells have experienced elevated nitrate concentrations as high as 110 milligrams per liter (mg/L) as nitrate (MKN, 2017). The current primary MCL for nitrate (as nitrogen) is 10 mg/L for potable domestic use; nitrate also has a PHG of 10 mg/L. Periodically, high iron (which has a secondary MCL of 300 micrograms per liter [μg/L]) and manganese (with a secondary MCL of 50 μg/L) levels have

[10] Table 1 has been adapted from the *Morro Bay Water Reclamation Facility Draft Environmental Impact Report* (ESA, 2018) and from the *Annual Water Quality Report 2019* (City of Morro Bay, 2020).

also been detected. To meet MCLs, the City operates a brackish water reverse osmosis facility that treats water pumped for potable use from the City's Well Field.

In general, under natural conditions, the seaward movement of freshwater prevents seawater from encroaching on coastal aquifers (USGS, 2018). An interface between freshwater and seawater is maintained with denser seawater underlying freshwater. When groundwater is pumped from a coastal aquifer, lowered water levels can cause seawater to be drawn toward the freshwater zones of the aquifer. The intruding seawater decreases the freshwater storage in the aquifers. In the mid-1980s, total dissolved solids (TDS) concentrations in groundwater downstream of the Narrows near Highway 1 began to exceed 1,000 mg/L seasonally due to seawater intrusion and tidal influences (MNS, 2016).

In 2007, TDS concentrations in the Basin were typically between 400 and 800 mg/L and increasing toward the coast, except for an area beneath agricultural fields in the lower valley where TDS concentrations reached 1,000 mg/L, and nitrate concentrations reached 220 mg/L as nitrate (MNS, 2016). Groundwater wells in the Basin have experienced elevated levels of salinity during dry periods, with TDS levels as high as 4,000 mg/L, exceeding the secondary MCL of 1,000 mg/L by factor of four.

Historical data and groundwater modeling indicate that the City's wells are at risk of seawater intrusion if the full permitted pumpage is produced with no corresponding injection. Predictive modeling scenarios indicate that an injection well layout in the Western Project Area would mitigate against seawater intrusion during pumping of City wells. Predictive nitrate modeling scenarios indicate that, during combined IPR injection and City pumping, all City wells will have improved water quality over time with significantly lower nitrate concentrations.

3.3 Contamination

A preliminary inventory of past and current potentially contaminating activities (PCAs) was compiled using readily available data for the proposed injection well field. An initial assessment was performed using the RWQCB GeoTracker website, which provides a compilation of environmentally impacted sites, and is also linked to the DTSC EnviroStor website that shows sites for cleanup, land disposal, waste permits, permitting underground storage tanks (USTs), and leaking underground storage tanks (LUSTs).

Figure 4, Potentially Contaminating Activity Sites, shows the locations of PCAs in the general area of the proposed injection area. The GeoTracker and EnviroStor websites show there are four closed LUST sites with a half-mile radius of the Western Project Area. The sites listed gasoline and/or diesel as the "potential contaminant of concern" and generally listed groundwater as the "potential media of concern." At these four closed LUST sites, cleanup actions have been completed and the case has been closed by that lead agency. All four sites, delineated by red squares with an "X" through them, are located east of Highway 1, as shown on Figure 4.

In 1999, methyl tertiary butyl ether (MTBE) was discovered in groundwater in the Basin, and in 2000, SWRCB issued an order prohibiting the use of the City's five Lower Basin wells. The source of the MTBE was found to be the Shell gasoline service station on Main Street at Highway 41; this site is more than 1,500 ft northeast of the proposed injection area, as well as northeast of the City's wells that will recover the injected water. The Central Coast Regional Water Quality Control Board (CCRWQCB) required the Shell service station owner to install monitoring wells and to conduct groundwater and soil sampling. Subsequent investigations confirmed the MTBE contamination originated from this Shell service station. The USTs and gasoline-impacted soils beneath the USTs were removed from the location in January 2002. The owner implemented extensive remedial actions after the discovery of the contamination, which included the excavation of contaminated soil, addition of an oxygen-releasing compound to the UST excavation backfill, soil vapor extraction, and onsite and offsite groundwater extraction and treatment. Extensive monitoring conclusively demonstrated that the City's Well Field was never impacted, even prior to MTBE plume stabilization. On September 26, 2008, RWQCB sent a case closure letter to Shell Oil Company and the City's municipal water supply wells were reinstated for use as a safe water supply for Morro Bay residents.

The Morro Bay Power Plant, located on property south and adjacent to the proposed injection area (Figure 4) was a power generation facility that started producing power in the 1950s under the ownership of Pacific Gas and Electric (PG&E), and was subsequently acquired by Duke Energy in 1998, LS Power in 2006, and Dynegy in 2007. In 2014, operations at the Power Plant ceased, and the plant was shut down. The site was sold in 2018 to Vistra Energy, which currently owns the approximately 90-acre property.

Various environmental investigations have been conducted at the Power Plant since the 1990s. Human health and ecological risk assessments initially identified the chemicals of concern (COCs) in soil and shallow groundwater as petroleum hydrocarbons (TPH) and arsenic, concentrations of which were above commercial screening levels. Subsequent groundwater monitoring evaluations were performed on the Power Plant via sampling from several monitoring wells. The DTSC-approved human health and ecological risk assessment concluded that constituents in groundwater at the site do not pose unacceptable risks to ecological or human health receptors and further evaluation was not warranted (Jacobs, 2018). A request for termination of the groundwater monitoring program on the Vistra site was approved by DTSC in January 2019.

The corrective action objectives and proposed final remedy for the Vistra site recommends that LUC be recorded to address total petroleum hydrocarbons and arsenic at the site in soil and groundwater. The LUC would restrict land use and groundwater uses on the Vistra site and would require a soil management plan (SMP) to verify soil at the site will be managed in the manner protective of human health and the environment. In addition, annual inspections would occur to verify the protectiveness of the remedy over time (DTSC, 2020).

Groundwater flow is generally from northeast to southwest across the site, and thus away from the proposed injection area for the City towards the Pacific Ocean.

3.4 Basin Plan Management Goals and Objectives

The RWQCB regulates GRRPs under numerous state laws and regulations, including the *Water Quality Control Plan for the Central Coast Basin* (Basin Plan) (Central Coast RWQCB, 2019) and SWRCB policies. The Basin Plan includes water quality objectives for municipal and domestic supply groundwater supplies, including the following:

- **Taste and odors:** shall not adversely affect beneficial uses
- **Bacteria:** <2.2/100 milliliter median concentration over any 7-day period
- **Organic chemicals:** shall not exceed MCLs
- **Inorganic chemicals (trace metals):** shall not exceed MCLs
- **Radioactivity:** shall not exceed MCLs

There are no additional water quality objectives for the Basin.

The Basin Plan also applies the SWRCB Antidegradation Policy,[11] which has been further interpreted pursuant to the 2019 SWRCB Water Quality Control Policy for Recycled Water (SWRCB, 2019). Per the Anti-degradation Policy, if the existing water quality of a water body is better than the objectives defined in the Basin Plan, the existing quality shall be maintained. Pertaining to this particular project for the City, the modeling results and the simple basics of reverse osmosis-based purification allow the team to conclude that improvements in groundwater quality will occur due to the very low levels of TDS and nitrogen (including nitrate) in the purified water (compared to the Basin groundwater). An assessment of anti-degradation aspects is provided in Table 2.

Drinking water from the City's existing water supply system will be the source water for injection testing; therefore, it is not anticipated that injection water will be of lesser quality than the existing quality of the Basin groundwater.

[11] Available at https://www.waterboards.ca.gov/plans_policies/antidegradation.html. (Accessed April 13, 2021.)

SECTION 4: **Injection Well Initial Testing**

4.1 Background

Injection testing will be performed to support the assessment of the potential viability of the proposed IPR project that would use highly treated recycled water from the City's planned WRF for groundwater supply augmentation. Injection testing will provide diagnostic information of injection rates and capacity of the first full-scale injection well as part of this project. Initial injection testing will consist of constructing an initial injection well, performing baseline monitoring, and long-term injection tests. The proposed location of the initial injection well is shown on Figure 1. Additionally, the installation of a dedicated monitoring well (21P-01) will also be conducted as part of this effort to support DDW permit requirements.

4.2 Injection Well Construction and Initial Testing

One complete and fully operational, injection well will be installed for this early phase of the overall project. The installation effort will include drilling, construction, development, testing, and completion of the injection well. This work is proposed to begin in May 2021. The new injection well will be located on a vacant property owned by Vistra along the west side of Highway 1 as shown on Figure 1. The location of the site, including the temporary construction areas and temporary discharge hose alignment, are also presented on Figure 1.

The injection well will be drilled by mud-rotary drilling methods to an estimated depth of 90 to100 ft bgs. Following pilot hole drilling, geophysical logging of the well will be conducted, consisting of a spontaneous potential, resistivity, and caliper surveys in the pilot hole. The pilot hole will then be enlarged to 18-inch diameter, followed by installation of 12-inch diameter Type 316 stainless steel casing and wire-wrapped screen. The annulus within the screened interval will be filled with gravel pack gradation consisting of 1.7-to-2.5-millimeter SiLibeads. A concrete sanitary seal will be installed in compliance with state and local standards. The design of the proposed injection well is presented on Figure 5.

Following well construction, the injection well will be developed to remove accumulated drilling fluids. A test pump, drop pipe for conveyance of injection water, and sounding tube for water level measurements will be installed. The pump will be capable of discharging up to 350 gallons per minute. A pair of pumping tests will be conducted, including an 8-hour step drawdown test, and a 24-hour constant rate test to assess pumping performance characteristics of the wells.

4.3 Injection Testing Program

Following completion of the initial pumping tests, a series of injection tests will be conducted by injecting treated potable drinking water from the City's existing municipal supply system into the well for a series of short- and long-term periods for a total duration of up to 4 weeks. During the injection tests, the injection rates will be varied to assess the acceptance rates and variability of the specific capacity during injection. All testing and monitoring will be conducted in compliance with permitting requirements. Details regarding the planned injection testing is included in the *Injection Testing Work Plan for Groundwater Management Replenishment and Reuse Project, Morro Bay, California* (*Injection Testing Work Plan*) (Appendix A of this report).

Results from these analyses will be used to identify potential injection rates, which will be used to estimate the anticipated yield of the full-scale injection wellfield and the ultimate the number of wells needed for the full-scale project. Recommendations will be provided for anticipated operational scheduling and for an approach to minimize adverse consequences while maximizing the benefits of the proposed injection program.

4.4 Geochemical Modeling

The geochemical analysis will use the mineralogical analysis results from a specialized analytical laboratory and the water quality data from the native groundwater and predicted IPR water to assess any potential deleterious conditions associated with the project activities. To obtain these data, the following will be conducted:

1. The chemistry of the in-situ groundwater will be characterized using existing water quality data from the City's production wells, and chemical analysis of water samples collected from the newly installed injection and monitoring wells.
2. The expected chemistry of the water to be injected will be based on water quality estimates from the WRF design engineer/program manager.
3. To characterize the aquifer materials, mineralogical analyses will be conducted on sediment samples collected during drilling of the monitoring well.
4. The data will be used in a geochemical mixing model analyses to assess whether potential deleterious effects may occur.

The results of this analysis will allow GSI to assess potential problems associated with mixing of the injected water and the aquifer materials, including dissolution or precipitation of minerals through geochemical reactions, which can cause clogging in the both the well screen and the pore space of the aquifer. Recommendations will be provided for water quality treatment or operational approaches, if needed, to minimize any potential adverse consequences of the proposed injection program. Additional details of this effort are included in the attached *Geochemical Work Plan for Groundwater Management Replenishment and Reuse Project, Morro Bay, California* (*Geochemical Work Plan*) (Appendix B).

4.5 Injection Testing and Reporting Schedule

The injection testing will be conducted following the completion of the well installation and pumping tests. It is anticipated that injection will begin late May 2021 and require approximately 6 weeks to complete. The results will be provided in a technical memorandum, anticipated to be completed approximately 1 month after completion of the field work (by the end of July), if the proposed drilling and injection testing schedules are met.

The results of this injection testing plan will be incorporated into the Title 22 Engineering Report being prepared by the City. Additionally, the results of the pilot injection testing will be provided in an addendum to this report to complete the information needs of the Notice of Intent.

SECTION 5: **Injection Water and Groundwater Quality**

Source water for planned injection purposes will ultimately come from the proposed WRF, which is under construction until 2023. For the purposes of injection testing at the initial injection well, treated potable drinking water from the City's municipal supply system will be used as the injection water source.

The City's primary source of municipal supply water is surface water from the State Water Project, which is administered locally by the Central Coast Water Authority. The water is treated at the Polonio Pass Water Treatment Plant near Highways 41 and 46 and then conveyed via the Chorro Valley pipeline for use by the City. The State Water Project supply can be augmented by and blended with water pumped from existing City production wells in the Basin.

Some of the well water has nitrate contaminant levels that require treatment through blending or filtration. The City uses its Brackish Water Reverse Osmosis (BWRO) plant to remove nitrates from groundwater and all well water has a disinfectant added prior to distribution. During 2019, State Water Project water made up 90 percent of the City's drinking water and the wells provided the remaining 10 percent with all of this well water being treated by the Brackish Water Reverse Osmosis (BWRO) plant (Morro Bay, 2019).

In accordance with State of California Division of Drinking Water (DDW) requirements, the City regularly collects water samples to determine the presence of radioactive, biological, inorganic (trace metals), volatile organic compound (VOC), or synthetic volatile organic compound (SVOC) contaminants. The range of contamination in the raw well water, at times, has exceeded the drinking water standards, but drinking water served to the public had contaminant levels reduced through either blending or treatment. Detections of constituents from the most recent drinking water samples collected by the City are presented in the *Annual Water Quality Report 2019* (City of Morro Bay, 2019); Table 1 has been adapted from this report and shows a comparison of water quality data results from both City groundwater wells and State Water Project supply for 2019. The presence of these constituents in the water does not necessarily pose a health risk, as DDW allows the City to monitor for certain contaminants less frequently than once per year because the concentration of these contaminants do not change frequently. As shown on this table, municipal supply water for the City meets or exceeds all DDW drinking water MCLs and PHGs.

SECTION 6: **Groundwater Degradation Assessment**

6.1 Constituents of Concern

As discussed in Section 3.2 of this technical report, the primary chemical constituents of concern for the proposed injection testing are nitrate and TDS. Recent and historical measured concentrations of these chemical constituents from existing City wells in the Basin were compiled and used to establish the baseline conditions. Table 1 shows the applicable water quality objectives and the median and range of concentrations for both City well water and State Water Project water sources. None of the listed constituents for State Water Project water are shown to exceed Basin water quality objectives. As discussed in Section 5 above, State Water Project water is a primary water source for the City and will be the source water for initial injection testing purposes for Injection Well No. 1. Thus, injection testing is not anticipated to have any potential impact on the basin groundwater quality and is expected to meet all Basin water quality objectives.

6.2 Impact on Assimilative Capacity

The expected quality of the City water used for injection is discussed in Section 5 and summarized in Table 1. Injection water will meet or exceed all primary and secondary MCLs, state Notification Levels (NLs), and Basin Plan Objectives (BPOs). Using these water quality data, groundwater quality impacts relative to assimilative capacity are not expected to occur as a result of injection of City product water at Injection Well No. 1 during initial injection testing. The results of geochemical modeling analysis from samples collected during injection testing (described in Section 4.4) will allow an assessment of the potential for problems associated with mixing of the injected IPR water, native groundwater, and the aquifer sediments, including dissolution or precipitation of minerals through geochemical reactions, which can cause clogging in the both the well screen and the pore spaces immediately adjacent to the well.

6.3 Impact on Seawater Intrusion and Nitrates

The City's existing wells are approximately one-half mile from the Pacific Ocean. As such, they are at risk of seawater intrusion in times of severe drought, or if the groundwater flow gradient reverses from its natural direction for a significant period of time. Water quality sampling documented in the *Seawater Intake Evaluation Report* (GSI, 2017b) indicates that the nearby seawater intake wells along the Embarcadero boundary show TDS concentrations that range from about 5,000 mg/L to 17,000 mg/L. Evaluation of sampling records from wells on the adjacent Vistra site indicate that that wells have a concentration of about 1,000 mg/L on the northern edge of the site. Baseline TDS concentrations in the City's Highway 1 wells are in the 600 to 800 mg/L range. Groundwater modeling indicates that, under full permitted pumping scenarios, the City wells are susceptible to degradation of water quality due to seawater intrusion. Injection scenarios input into the groundwater model resulted in reducing all the instances of elevated TDS concentrations that had been evident in baseline modeling concentrations (i.e., in scenarios with no injection). Injection conducted at wells located in the Western Project Area would provide benefits to preventing seawater intrusion for the nearby City wells.

Nitrate concentrations have also increased in City wells due in part to the decades-long use of land upstream for agriculture and the growth in that land use. A few years after the establishment of upgradient vegetable fields, significant concentrations of nitrates began to be detected in the City's wellfield. Groundwater modeling scenarios performed by GSI using injection wells in the Western Project Area results in significant reductions in nitrate concentrations at the Highway 1 well field.

6.4 Impact on Existing Contaminant Plumes

As discussed in Section 3.3, groundwater quality in some parts of the Basin has been affected by PCAs in some areas, including the at Vistra property to the southwest of the injection site. In discussions with the City, DTSC determined that it was unlikely that contamination from the Vistra property would affect the planned injection by the City (DTSC, 2020).

As stated in the DTSC (2020) letter, based on groundwater sampling performed at the Vistra property over 9 years and documented in investigative reports, no significant plume of contaminants in groundwater has been found (DTSC, 2020). While there were a few Vistra property wells that when sampled, groundwater contaminants were found above unrestricted use screening levels, these wells were not near proposed Injection Well No. 1 or other planned injection sites on the Vistra property, and nearby wells surrounding these historically sampled wells were free from contaminants.

Vistra is proposing to evaluate groundwater at the site. Vistra submitted an evaluation to DTSC on September 24, 2020, but DTSC has not yet provided a response or comment as of the writing of this report. Continued review of relevant groundwater monitoring investigative reports for the Vistra property will be conducted as they are published by DTSC and/or others.

6.5 Disinfection

In compliance with the DDW, State Water Project water is treated at the Polonio Pass Water Treatment Plant before it conveyed to the City. During groundwater pumping, disinfectant (chlorination) is added to pumped water at the City's BWRO plant prior to distribution to the City's public system. Total residual chlorine has a DDW MCL and PHG of 4 mg/L. Total residual chlorine and total coliform bacteria are measured at the plant before distribution to the City's public system.

6.6 Disinfection By-Products

The City's potable water meets all primary state and federal drinking water standards, including standards for disinfection by-products such as haloacetic acids and trihalomethanes that form when chlorine reacts with naturally occurring organic matter in the surface water supply and/or with organic carbon compounds that may be naturally present in the aquifer. These disinfection by-products continue to remain well below state and federal drinking water standards (see Table 1). These constituents will be monitored during and after the injection testing, as stated in the *Injection Testing Work Plan* (Appendix A).

6.7 Metals Mobilization

In an effort to assess the potential of metals mobilization in response to the IPR project, geochemical analyses as stated in the *Geochemical Work Plan* will be conducted (see Appendix B). A key element of this will be the retrieval of injected water over a period of 4 weeks following the injection test to assess the geochemical changes that have occurred to the injected water. The procedure and suggested analytes for this sampling are provided in the *Injection Testing Work Plan* (Appendix A).

SECTION 7: **Proposed Changes to Monitoring and Reporting Program**

Injection operations at full-scale of the proposed IPR project will adhere to the Monitoring and Reporting Program outlined in Order WQ 2012-0010. For initial pilot injection testing, a work plan that includes monitoring and reporting protocols for the initial injection testing is attached to this report as Appendix A.

SECTION 8: **State and Federal Requirements for Groundwater Replenishment Projects**

8.1 California Environmental Quality Act

Per the California Environmental Quality Act (CEQA), a Draft Environmental Impact Report (EIR) was prepared and issued for comment in March 2018 for the proposed Morro Bay WRF. The Draft EIR found the following:

> "operation of the proposed project would implement the beneficial reuse of a renewable resource – recycled water. This renewable resource would provide a benefit to the City of Morro Bay in the form of a new water supply, improving reliability of the City's water supply portfolio through the use of local resource and decreasing the degree of dependency on imported water through the State Water Project."

The draft EIR was available for public and agency comment and received 35 comment letters that don't significantly change the findings. The Final EIR was published in June 2018 and was certified and adopted by the Morro Bay City Council in August 2018. Injection well construction and operation are included in the proposed IPR project discussed above, and therefore, this injection well construction and testing meet CEQA requirements.

Based on initial studies and modeling scenarios performed by GSI, this initial injection testing would cause no significant impacts to hydrology or water quality in the project area; therefore, mitigation measures are not required.

8.2 Division of Drinking Water Permits

The City currently holds a DDW permit for the City water system and its wells. The City's Public Water Supply ID is CA4010011. The California Division of Drinking Water Permit is provided in Appendix C.

8.3 Underground Injection Well Registration (EPA Region 9)

The City has submitted a registration with the U.S. Environmental Protection Agency Region 9 for the initial injection well as a Class V well. The Class V Injection Well Notification Documentation is attached to this report as Appendix D.

SECTION 9: **Conclusions**

The City of Morro Bay's planned IPR project has been carefully evaluated and modeled. The next key step in the development process is to install and test the first injection well. Approval for this effort through this permitting process will support moving forward with the project.

Careful monitoring during the injection testing will track water level and water quality responses to the injection. Results from the monitoring will be used to plan for the installation of the additional wells needed for the overall project. Information developed as part of the geochemical analyses will be used to refine the project operations, if necessary.

SECTION 10: **References**

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USGS. 2018. Groundwater Resources Program, Saltwater Intrusion. Available at: https://water.usgs.gov/ogw/gwrp/saltwater/salt.html. Accessed: March 30, 2018.

Tables

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Table 1
City Groundwater and Surface Water Quality (2019)

CONSTITUENT	Units	MCL	PHG	YEAR SAMPLED	STATE WATER		GROUNDWATER		
					AVERAGE AMOUNT[1]	RANGE LOW-HIGH[1]	AVERAGE AMOUNT[1,2]	RANGE LOW-HIGH[1,2]	MAXIMUM ANNUAL DETECTED RANGE (All Wells)[3] 2011 to 2015
Primary Drinking Water Standards									
Aluminum	mg/L	1	0.6	2019	0.056	ND - 0.094	ND	ND	ND-0.01
Arsenic	µg/L	10	0.004	2018	ND	ND	3	ND-4	--
Barium	mg/L	1	2	2018	ND	ND	0.135	0.107-0.198	0.0128-100
Total Chromium	µg/L	50	100	2018	ND	ND	15	13-18	--
Fluoride	mg/L	2	1	2018	ND	ND	0.2	0.2	0.2-0.3
Nickel	µg/L	100	12	2018	--	--	--	--	ND-10
Nitrate (as Nitrogen)	mg/L	10	10	2018	ND	ND	15	2-22.8	20.34-37.41
Selenium	µg/L	50	30	2016	ND	ND	20	ND-27	ND-19
Secondary Drinking Water Standards									
Chloride	mg/L	500		2019	59	13-146	238	71-729	64-1480
Color	color units	300		--	--	--	--	--	ND-20
Corrosivity	Aggressivity Index	NA		2019	12	12	12.3	11.6-12.4	--
Manganese	µg/L	50		--	--	--	--	--	ND-30
Specific Conductance	µmhos/cm	1600		2019	403	138-762	1749	1030-3370	715-5050
Sulfate	mg/L	500		2019	46	46	127	63.6-163	36-149
Total Dissolved Solids	mg/L	1000		2019	260	260	--	--	423-2870
Turbidity	NTU	5		2019	0.05	ND-0.12	1.2	0.2-6.8	0.11-11.7
Unregulated and Other Constituents									
2-Methylisborneol	ng/L			2019	0.2	ND-1	--	--	--
Alkalinity	mg/L			2019	56	30-80	393	370-430	--
Boron	µg/L			2019	ND	ND	125	100-200	--
Calcium	mg/L			2019	19	19	107	172	--
Geosmin	mg/L			2019	2.8	ND-6	--	--	--
Hardness (as CaCO3)	mg/L			2019	82	26-144	706	464-1090	533-1800
Heterorophic Plate Count (HPC)	cfu/ml			2019	0	0-2	3.9	1-65	--
Potassium	mg/L			2019	3.1	3.1	0	ND-1	--
pH	Units			2019	8.4	7.7-8.7	7.3	6.7-7.7	--
Sodium	mg/L			2019	58	58	94	53-239	42-317
Total Organic Carbon	mg/L			2019	1.9	1.5-3	NA	NA	--
Vanadium	µg/L			2019	ND	ND	8	6-19	--
Disinfection By-Products and Residual Disinfectants									
Haloacetic Acids	µg/L	60	NA	2019	15 (highest LRAA 15.5)	7.4-25	14	4-21	--
Total Trihalomethanes (TTHMs)	µg/L	80	NA	2019	45 (highest LRAA 47.8)	27-75	30	18-52	--
Total Residual Chlorine	mg/L	4	4	2019	2.47	0.33-3.5	2	0.03-3.95	--
Total Coliform Bacteria	# of positive samples	0	0	2019	0	0	0	0	--

Notes:

1. From City of Morro Bay. 2019. Annual Water Quality Report 2019. Prepared by the City of Morro Bay, PWS ID# CA4010011
2. Sampling from well water is for raw water results. Samples are taken prior to either treatment or blending. Sample dates are from 2018.
3. Adapted from Table 3.9-1 General Groundwater Quality from Morro Bay Reclamation Facility Draft Environmental Impact Report, 2018, and MKN, 2017.

mg/l - milligrams per liter
µg/L - micrograms per liter
ng/L - nanograms per liter
cfu/ml - colony forming units per ml
µmhos/cm - micromhos per cm
NTU - nepheloid turbidity units
MCL - maximum contaminant level
PHG - public health goal
AL - action level
ND - Not Detected

Table 2
Anti-Degradation Assessment

SWRCB Resolution No. 68-16 Component	Anti-Degradation Assessment Result
Water quality changes associated with proposed project are consistent with the maximum benefit of the people of the State.	Water quality changes associated with proposed project in the Lower Morro Basin are consistent with the maximum benefit of the people of the State.
The water quality changes associated with proposed project will not unreasonably affect present and anticipated beneficial uses.	The water quality changes associated with injection will not unreasonably affect present and anticipated beneficial uses.
The water quality changes will not result in water quality less than prescribed in the Basin Plan.	The water quality changes associated with injection will not result in water quality less than prescribed in the Basin Plan. Per the Basin Plan's Anti-degradation Policy, if existing water quality of a water is better than the objectives defined in the Basin Plan, the existing quality shall be maintained. For this project, drinking water from the City's existing water supply system will be the source water for injection testing, so it is not anticipated that injection water will be of lesser quality than existing groundwater quality of the Basin.
The projects are consistent with the use of best practicable treatment or control to avoid pollution or nuisance and maintain the highest water quality consistent with the maximum benefit to the people of the State.	The City project is consistent with the use of the best practicable treatment or control to avoid pollution or nuisance and maintain the highest water quality consistent with the maximum benefit to the people of the State.
The proposed project is necessary to accommodate important economic or social development.	The City project is necessary to accommodate important economic and social development. Given the reliability uncertainties and increasing costs of imported water, increasing use of groundwater storage ensures a diversified and more reliable water supply. The City project provides a sustainable and reliable water source to replenish the groundwater basin, maintains high-quality groundwater, complies with pertinent regulatory requirements by employing an institutionally feasible approach, minimizes costs to customers using groundwater, and engages stakeholders in the decision-making process.
Implementation measures are being or will be implemented to help achieve Basin Plan Objectives in the future.	Injection water will meet drinking water quality standards, thus ensuring Basin Plan Objectives are being met during injection testing.

Figures

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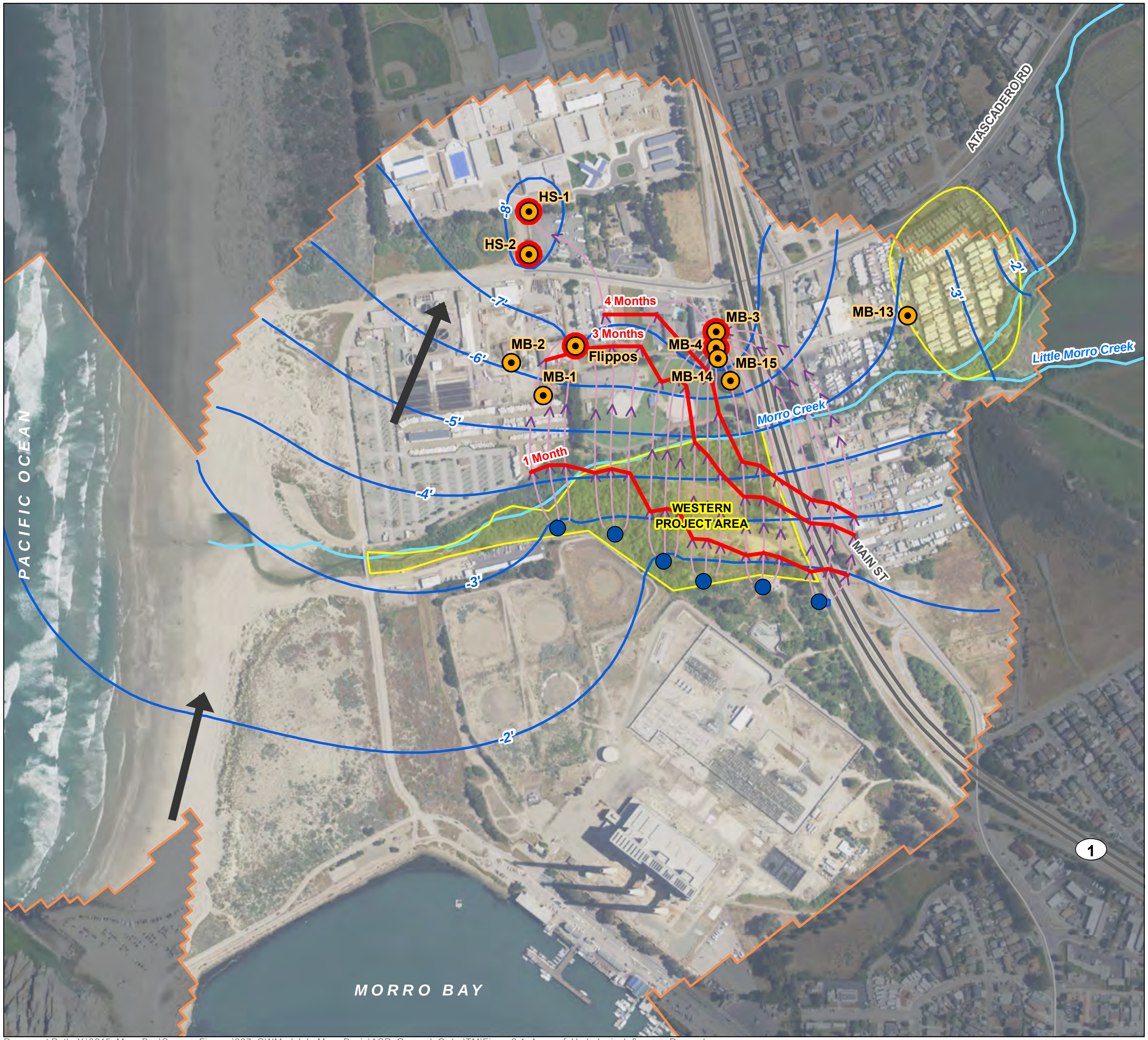

FIGURE 2a

Area of Hydrologic Influence - Dry Conditions

Morro Bay
Indirect Potable Reuse
Program Injection Testing

LEGEND

- City of Morro Bay Well
- Pumping Well
- Simulated Injection Well Location
- Particle Track Arrow (1 month)
- Particle Track
- Month Indicator
- Groundwater Elevation Contour (ft)
- Modeled Groundwater Flow Direction
- Active Area
- Potential Project Area
- Major Road
- Watercourse

NOTES

AFY: acre feet per year
Each travel time arrow along particle track represents 1 month.

Figure is adapted from Figure 14 of GSI "Characterization of Selection of Project Area for Injection Testing, City of Morro Bay" (GSI. 2021).

N

0 350 700
Feet

Date: March 23, 2021
Data Sources: NAIP Imagery, ESRI

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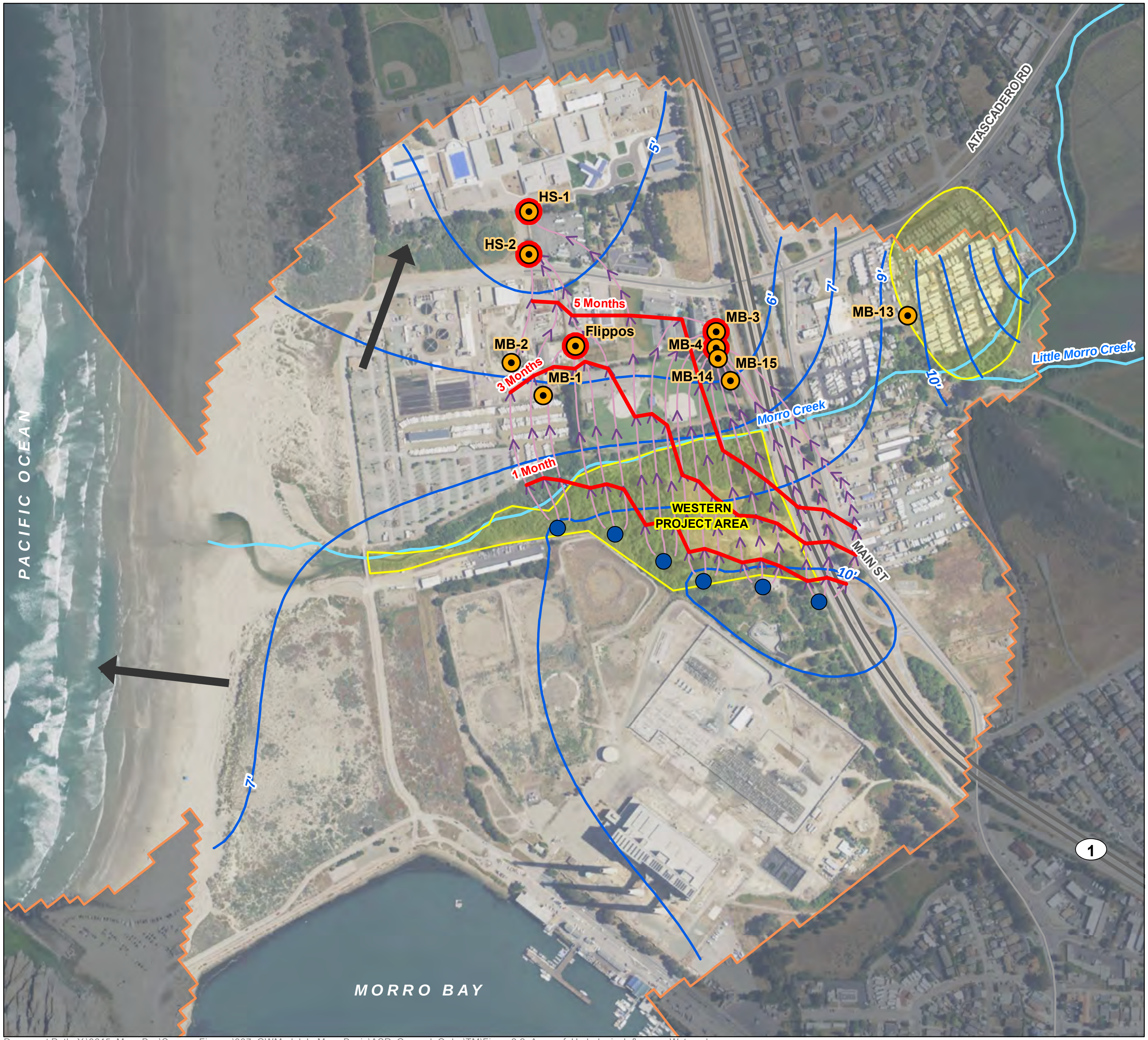

FIGURE 2b

Area of Hydrologic Influence - Wet Conditions

Morro Bay
Indirect Potable Reuse
Program Injection Testing

LEGEND

- City of Morro Bay Well
- Pumping Well
- Simulated Injection Well Location
- Particle Track Arrow (1 month)
- Particle Track
- Month Indicator
- Groundwater Elevation Contour (ft)
- Modeled Groundwater Flow Direction
- Active Area
- Potential Project Area
- Major Road
- Watercourse

NOTES

AFY: acre feet per year
Each travel time arrow along particle track represents 1 month.

Figure is adapted from Figure 15 of GSI "Characterization of Selection of Project Area for Injection Testing, City of Morro Bay" (GSI, 2021).

N

0 350 700
Feet

Date: March 23, 2021
Data Sources: NAIP Imagery, ESRI

GSI Water Solutions, Inc.

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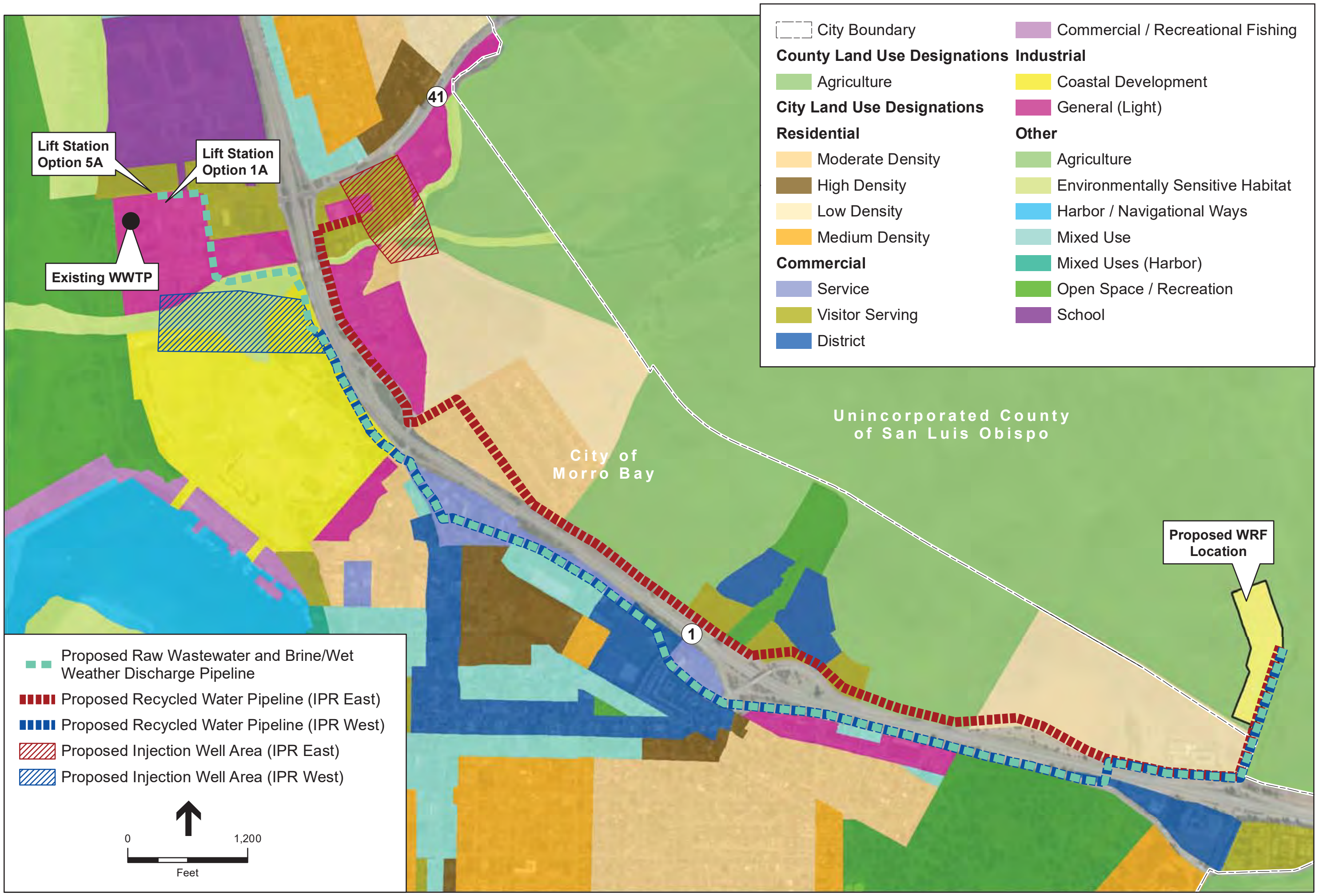

FIGURE 3

City and County Land Use Designation

Morro Bay
Indirect Potable Reuse
Program Injection Testing

NOTES
WRF: Water Reclamation Facility
WWTP: Waste Water Treatment Plant

Adapted from Figure 3.10-1 of "Morro Bay WRF Draft Environmental Impact Report" (ESA 2018)

Data Sources: City of Morro Bay, San Luis Obispo County, ESRI 2016

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FIGURE 4

Potentially Contaminating Activity Sites

Morro Bay
Indirect Potable Reuse Program
Injection Testing

LEGEND

- Injection Well No. 1
- DTSC Cleanup Site
- Closed LUST Cleanup Site
- Western Project Area
- Major Road
- Watercourse

NOTES

DTSC: Department of Toxic Substances Control
LUST: Leaking Underground Storage Tank

N

0 350 700
Feet

Date: April 1, 2021
Data Sources: NAIP Imagery, ESRI, GeoTracker

GSI Water Solutions, Inc.

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\ASR_General_Order\TM\Figure4_Potentially_Contaminating_Activity_Sites.mxd

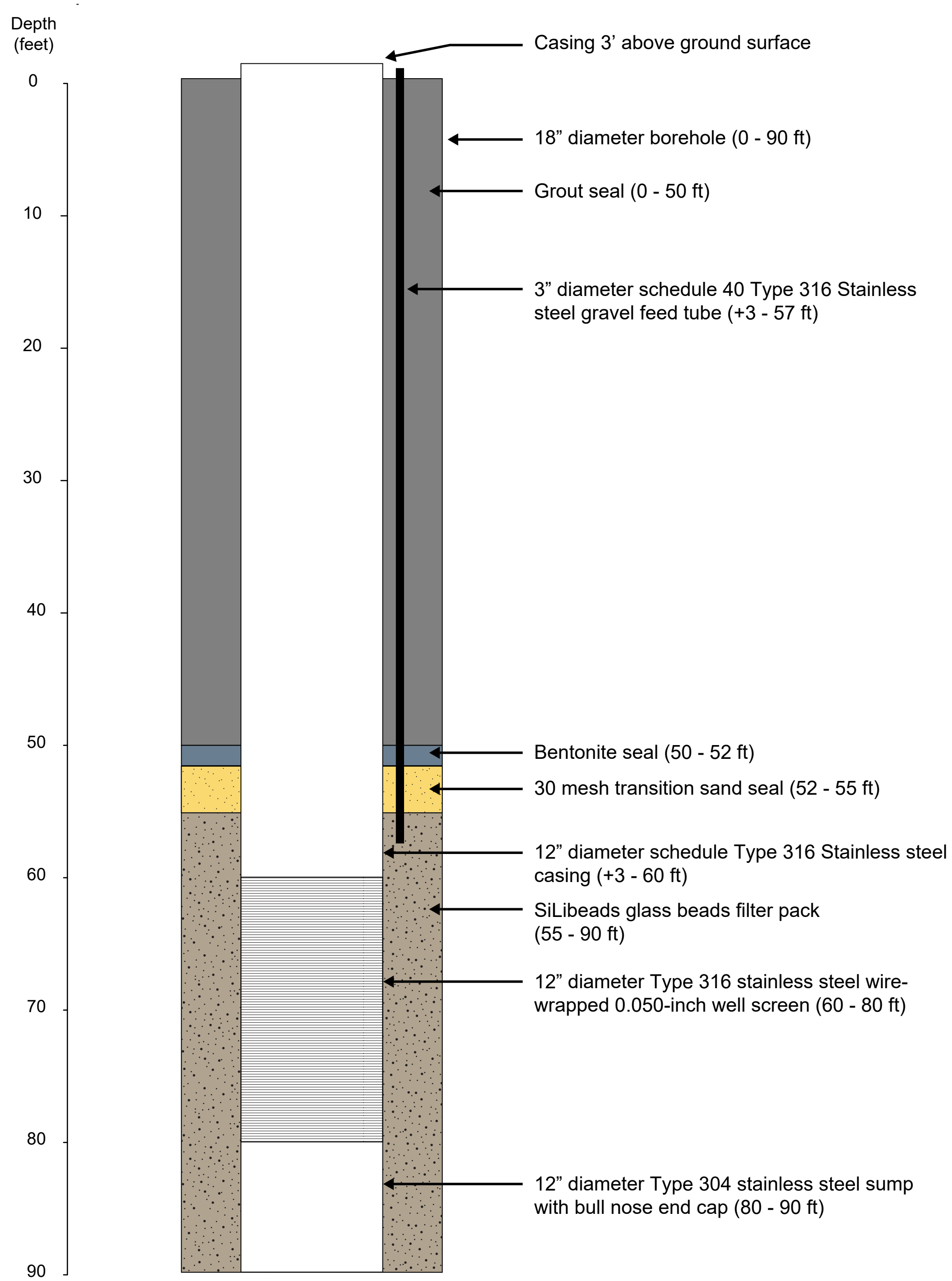

FIGURE 5

Proposed Injection Well Design

Indirect Potable Reuse Program Injection Testing
Morro Bay, CA

GSI Water Solutions, Inc.

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Appendices

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APPENDIX A

Injection Testing Work Plan for Groundwater Management Replenishment and Reuse Project, Morro Bay, California

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GSI Water Solutions, Inc.

DRAFT TECHNICAL MEMORANDUM

DRAFT Injection Testing Work Plan for Groundwater Replenishment and Reuse Project, Morro Bay, California

To: Lydia Holmes and Anthony Cemo, Carollo Engineers

From: Tim Thompson and Tim Nicely, GSI Water Solutions

CC: Brynne Weeks and Andrew Salveson, Carollo Engineers

Attachments: Figure
Water Quality Sampling Constituents Table

Date: April 9, 2021

Introduction and Purpose

GSI Water Solutions (GSI) is supporting the City of Morro Bay with the implementation of a planned indirect potable reuse (IPR) project, which will use highly treated recycled water from the City's forthcoming Water Reclamation Facility (WRF). The installation and operation of a Groundwater Replenishment Reuse Project (GRRP) using injection wells is a key part of the overall project. This memorandum presents the work plan for testing at a new injection well proposed to be installed in Spring 2021.

The injection testing presented in this work plan is a portion of work being performed by GSI for the City of Morro Bay in the lower portion of the Morro Valley Groundwater Basin, which also includes injection well design and installation, groundwater monitoring, permitting support, and groundwater flow modeling.

Injection Work Plan

The injection testing presented in this work plan provides diagnostic information regarding injection rates, aquifer response, and water quality at anticipated injection rates for a single well. Injection testing will be conducted at a newly constructed injection well located as shown on Figure 1.

Injection Testing

A series of injection tests will be conducted by conveying water from the City's municipal water supply distribution system into the new injection well. The injection tests will consist of an 8-hour injection step test and a 7-day injection constant rate test, operated by the Contractor. The wellhead will be sealed and capable of maintaining injection pressures up to 20 psi with anticipated injection pressures of up to 10 psi during testing in order to observe and maintain a range of injection rates. The injected water will consist of chlorinated water provided by the City from their State Water Project source.

City staff will install an outlet fitting and backflow prevention device onto the nearby City distribution pipeline located east of the nearby bike path for the purposes of this project. City staff will also construct a trench across the bike path and install a short section of piping that daylights west of the bike path and, for security purposes, west of the fence within the Dynegy/Vistra property. The drilling Contractor will connect to this fitting, the location of which is shown approximately on Figure 1 and run a temporary pipeline that will convey

the water to the injection well for the testing. The pipeline conveying the injection water to the well will be equipped by the Contractor with a flow control valve, flow meter, sampling port, pressure gauge, and a bypass filter. The bypass filter allows for monitoring of the turbidity of the injected water and will verify if turbid water is being injected (which is undesirable because of clogging potential) -- GSI will provide guidance to the Contractor for the materials and setup of this filter. A pressure transducer will be installed by the Contractor in the well to collect continuous water level data, and manual water level (and wellhead pressure) measurements will also be collected. All conveyance piping, measurement devices, and downhole equipment will be installed, maintained, and operated by the Contractor. GSI staff will be onsite to oversee the installation of the equipment. The Contractor will be required to provide temporary fencing around the immediate wellhead, which is assumed to require a 12- by 20-foot fenced area.

The following sections provide details for each phase of the injection testing program. The injection testing activities will be conducted following the drilling, construction, and pump testing of the injection well. The pump testing component will consist of both a step test and a constant rate test using a temporary pump installed and operated by the drilling contractor. The step test will involve pumping the well at 4 successively higher flow rates for 1 to 2 hours each while carefully monitoring water level drawdowns in the injection well and at the nearby monitoring well. The drawdown results of the step test will be used to establish the pumping rate used in the 24-hour constant rate pumping test.

Injection Step Test

The data collected during the pumping tests will be used by GSI to select the injection rates for the injection step test. This initial injection test will consist of four steps conducted at a series of discrete flow rates that will each last approximately 2 hours. The steps for the injection rates will be selected based on the drawdown results of the constant rate aquifer pumping test performed as part of the injection well installation. They will likely vary from approximately 10 to 80 gpm, but final rates will be determined after installation and testing of the injection well. The injection rate will be increased incrementally for each of the steps while simultaneously monitoring the water level in the well. Water level measurements will be recorded both at the injection well and at the nearby monitoring well with transducer and manual measurements. The results of the injection step test will be analyzed to determine appropriate injection rate for the constant rate injection test.

Injection Constant Rate Test

After the well has fully recovered from the injection step test, the constant rate injection test will be run at a continuous injection rate for various durations and ultimately for a continuous period of up to 7 days. During the tests, measurements of the flow rate, and corresponding water level shall be made at both the injection well and the nearby monitoring well. During the injection tests, a pressure transducer will record continuous water level data throughout the test. Manual measurement of water levels will also be collected at the following times relative to the start of the test:

- Every 5 minutes until 30 minutes have elapsed.
- Every 10 minutes until one hour has elapsed.
- Every 20 minutes until two hours have elapsed.
- Every hour until 24 hours have elapsed.
- Every two hours until 48 hours have elapsed.
- Every 4 to 6 hours until the end of the 7-day test.

Immediately after termination of the test, the rate of recovery of the water level shall be monitored for a period of 48 hours at both the injection and monitoring wells. The water levels will be recorded at the same time intervals (logarithmic) as the start of the constant rate injection test.

Analysis of Injection Testing Results

Following the completion of injection testing, data will be analyzed to estimate aquifer properties and provide a range of operational injection rates for the well. This information will also be used to update the groundwater model to evaluate project build out options.

Following updates to groundwater model, a series of scenarios will be developed in coordination with the City and Carollo Engineers to assess the ultimate number and location of wells required for the full project. Additional information from the modeling scenarios will include assessment of retention time within the aquifer, water level changes during and following injection periods and identification of any potential adverse conditions.

Recommendations will be provided for anticipated operational scheduling and approaches to minimize any potential adverse consequences and maximize the benefits of the proposed injection program.

Water Quality Sampling and Geochemical Evaluation

In addition to the collection of aquifer data collected during the tests, water quality samples will be collected at both the Injection well and/or the nearby monitoring well at the following times and analyzed for the list of constituents identified in the attached table:

- Collect samples at both the Injection and monitoring well just prior to the end of the constant rate pumping test (to establish the baseline aquifer water quality)
- Collect a sample at the Injection well during the early phase of injection to document water quality of source water (at the end of the first day of the constant rate injection test)
- Collect a sample at the Injection well during the late phase injection source water (during the final day of the constant rate injection test)
- Samples will be collected from the monitoring well during the constant rate injection test during day 3, day 5, and day 7 (three sampling events). Results from these analyses will be used to assess if water quality changes indicate if injected water has reached the monitor well during the duration of the test.
- After completion of the constant rate injection test, groundwater samples will be collected once a week at the Injection well for four consecutive weeks. For each sampling episode, the well will be pumped to waste until parameters stabilize prior to sampling.

Water quality results for key constituents will be evaluated to identify mixing relationships and/or the presence of geochemical reactions. These field results will be used to verify the findings of the geochemical modeling described in the Geochemical Work Plan for Groundwater Replenishment and Reuse Project (GSI, 2021).

Injection Testing Schedule and Reporting

The injection testing will be conducted following the completion of the well installation and constant rate aquifer test. It is anticipated that the injection testing will begin by late May 2021 and require approximately 6 to 7 weeks to complete, including the 4 weeks of post-testing water quality sampling. Following the completion of the injection testing program, the Contractor will be responsible for removing all equipment and conveyance pipelines. The Contractor will not be provided final payment until the site condition is deemed satisfactory by the City and the terms of the project Technical Specifications are met.

The testing results will be provided in a technical memorandum (TM). This TM is anticipated to be completed by the end of July, approximately one month following the completion of the field work if the proposed drilling and injection testing schedules are met.

Figure

FIGURE 1

Site and Well Location Map

Morro Bay
Indirect Potable Reuse Program
Injection Testing

LEGEND

InjWell

- Injection Well No. 1
- Well Construction Site
- Cuttings and Drilling Fluids Disposal
- Bike Path
- Piezometer
- Temporary Hose
- MBMWC Well
- Yeh Piezometer
- PG&E Property Boundary
- Western Project Area, 17 Acres
- Watercourse

NOTE

MBMWC: Morro Bay Mutual Water Company

N

0 150 300
Feet

Date: March 19, 2021
Data Sources: NAIP Imagery, ESRI

GSI Water Solutions, Inc.

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\Pilot_Inject_Well\Figure1_Western_Project_Site_Injection_Well_2021.mxd

Water Quality Sampling Constituents

Parameter Type	Parameter	Method
Field	Dissolved oxygen	YSI 556 or similar
	pH	EPA 150.1
	Oxidation-Reduction Potential	SM2580B
	Specific Conductance	EPA 120.1
	Temperature	YSI 556 or similar
	Turbidity	EPA 180.1
Inorganics	Alkalinity	SM2320B
	Ammonia	SM4500NH3G
	Bicarbonate	SM2320B
	Carbonate	SM2320B
	Chloride	EPA 300.0
	Cyanide (HCN)	EPA 335.4
	Fluoride	EPA 300.0
	Hardness	EPA 200.8
	Nitrate+Nitrite (total N)	EPA 300.0
	Nitrate (as N)	EPA 300.0
	Nitrite-N	EPA 300.0
	Orthophosphate as P	EPA 300.0
	Total Silica (as SiO2)	EPA 200.7
	Dissolved Silica (as SiO2)	EPA 200.7
	Sulfate	EPA 300.0
	Sulfide	SM4500S2F
Metals (Dissolved)	Aluminum	EPA 200.7
	Antimony	EPA 200.8
	Arsenic	EPA 200.8
	Barium	EPA 200.8
	Beryllium	EPA 200.8
	Cadmium	EPA 200.8
	Calcium	EPA 200.7
	Chromium	EPA 200.8
	Cobalt	EPA 200.8
	Copper	EPA 200.8
	Iron	EPA 200.7
	Lead	EPA 200.8
	Lithium	EPA 200.8
	Magnesium	EPA 200.7
	Manganese	EPA 200.8
	Mercury	EPA 245.7
	Molybdenum	EPA 200.8
	Nickel	EPA 200.8
	Potassium	EPA 200.7
	Selenium	EPA 200.8
	Silver	EPA 200.8
	Sodium	EPA 200.7
	Strontium	EPA 200.8
	Thallium	EPA 200.8

	Uranium	EPA 200.8
	Vanadium	EPA 200.8
	Zinc	EPA 200.8
Miscellaneous	Chemical Oxygen Demand	EPA 410.4
	Color	SM 2120B
	Corrosivity	Langelier Index
	Dissolved Organic Carbon	SM 5310C
	Foaming Agents (MBAs)	SM5540C
	Methane	RSK175
	Odor	2150B
	Oxidation-Reduction Potential	SM2580B
	pH	EPA 150.1
	Specific Conductance	EPA 120.1
	Total Dissolved Solids	SM 2540C
	Total Organic Carbon	SM5310C
	Total Suspended Solids	SM 2540D
	Turbidity	EPA 180.1
	Asbestos	Microscope: Hitachi 7000FA
DBPs	Residual Chlorine	SM 4500CL-G
	Dibromoacetic Acid (HAA)	SM6251B
	Dichloroacetic Acid (HAA)	SM6251B
	Monobromoacetic Acid (Bromoacetic acid) (HAA)	SM6251B
	Monochloroacetic Acid (HAA)	SM6251B
	Trichloroacetic Acid (HAA)	SM6251B
	Total Haloacetic Acids (Total HAA's)	SM6251B
	Bromodichloromethane (THM)	EPA 524.3
	Bromoform (THM)	EPA 524.3
	Chloroform (THM)	EPA 524.3
	Dibromochloromethane (THM)	EPA 524.3
	Total Trihalomethane (TTHM)	EPA 524.3
	Chlorite	EPA 300
Other	Bromate	EPA 317
	Hexavalent Chromium	EPA 218.7

APPENDIX B

Geochemical Work Plan for Groundwater Management Replenishment and Reuse Project, Morro Bay, California

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DRAFT TECHNICAL MEMORANDUM

DRAFT Geochemical Work Plan for Groundwater Replenishment and Reuse Project, Morro Bay, California

To: Lydia Holmes and Anthony Cemo; Carollo Engineers

From: Tim Thompson and Tim Nicely; GSI Water Solutions

CC: Brynne Weeks and Andrew Salveson; Carollo Engineers

Date: April 7, 2021

Introduction and Purpose

GSI Water Solutions (GSI) is supporting the City of Morro Bay with permitting and installation of a planned indirect potable reuse (IPR) project, which will use highly treated recycled water from the City's forthcoming Water Reclamation Facility (WRF). The installation and operation of a Groundwater Replenishment Reuse Project (GRRP) using IPR (subsurface application) is central to the overall project. As a part of this project, this memo presents our work plan to characterize significant subsurface geochemical parameters that may impact the project.

Background

As part of the installation of the monitoring well that will be installed along with the initial injection well, undisturbed physical samples of the aquifer sediments from the primary injection zone will be collected. These samples will be submitted for geochemical analysis by a specialized analytical laboratory (Minerology, Inc). Results of this analysis will be used along with native groundwater water quality and anticipated injection water quality to model the potential for geochemical reactions in the aquifer soil matrix that may occur during project operations.

Two important objectives of this work will be to assess (a) the potential for the injection well screens and filter pack to become clogged due to reactions between injected water, native groundwater, and the aquifer matrix in the vicinity of the injection wells, and (b) the potential for geochemical reactions to occur which could generate adverse groundwater quality in the recovered groundwater. These analyses will assess the potential geochemical reactions that may occur both through reactions associated with the mixing of two different waters (native groundwater and the advanced treated recycled water), and through the chemical reactions of the injected water with the sediments comprising the aquifer.

Additionally, as described in the Injection Testing Work Plan, a series of water quality samples will be collected and analyzed during the injection well testing to assess any changes in water quality following the injection. A series of sampling events will be conducted to ascertain changes in the injected water quality following residence within the aquifer for up to several weeks. The results of this analysis will be used in tandem with the analyses described below to better understand the potential for adverse geochemical reactions to occur.

Laboratory Analyses

The soil samples collected during installation of the new monitoring well to be located near the proposed injection well will be sent to a specialty laboratory (Mineralogy, Inc) for analysis by the following methods:

- X-Ray Diffraction (XRD): This method analyzes soil mineralogy, which is used to evaluate potential mineral-water reactions.
- X-Ray Fluorescence (XRF): This method analyzes soil chemical composition, which provides the abundances of elements not identified by XRD.
- SEM & Thin Section Petrography: Microscopy is used to identify mineral occurrences present below XRD detection limits; it also informs on mineral sizes, reactive coatings, and morphology.
- Particle Size Distribution: This method analyzes the clay content of soil.
- Cation Exchange Capacity: This method quantifies the abundance of reactive cation exchange sites on clay.

We will also send samples to a standard analytical laboratory for analysis of the following constituents:

- Hexavalent Chromium, Total Arsenic, Total Organic Carbon (TOC), Total Selenium, Total Sulfides, and Total Solids

Results from these analyses will be used in combination with the anticipated water quality of the recycled water to be injected to identify potential geochemical reactions that may occur.

Geochemical Modeling

To assess the potential for chemical reactions that could be problematic for injection well operations, GSI's subcontractor SS Papadopoulos & Associates, Inc. will employ the USGS geochemical modeling package PHREEQC to evaluate potential aqueous geochemical calculations. PHREEQC is a widely accepted geochemical modeling tool and is based on an ion-association aqueous model and has capabilities for speciation and saturation-index calculations, reaction-path and advective-transport calculations, mixing of solutions, mineral and gas equilibria, and other geochemical calculations. If the chemistry of the injected advanced treated water and the in-situ groundwater are known, and the minerology of the aquifer is characterized, the modelling package allows a detailed chemical analysis of the expected reaction products between the mixed waters and with the minerals comprising the aquifer sediments.

The chemistry of the in-situ groundwater will be characterized using existing water quality data from the City's production wells, and chemical analysis of the newly installed test and monitoring wells. The expected chemistry of the water to be injected will be based on water quality estimates from the WRF design engineer. To characterize the aquifer materials, mineralogical analyses will be conducted on core samples collected during drilling of the monitoring wells. The results of this analysis will allow GSI to assess the potential for potential problems associated with mixing of the injected water and the aquifer materials including dissolution or precipitation of minerals through geochemical reactions, which can cause clogging in both the well screen and the pore space of the aquifer skeleton itself.

Results

Utilizing the (a) mineralogical analysis results from Minerology Inc., (b) the water quality information of the native groundwater and predicted IPR water, and (c) the water quality results collected during the Injection Well Testing, the geochemical analysis will be conducted and used to develop the assessment of any potentially deleterious conditions associated with the project activities. Recommendations will be provided for water quality treatment or operational approaches to minimize any potential adverse consequences of the proposed injection program.

Schedule

The aquifer sediment sample will be collected during monitoring well installation in late April. . Samples will be sent to Minerology, Inc. for analysis, a process that takes 2-3 weeks. Results will be received and used along with water quality data in the geochemical modeling which will occur over the following 4 weeks. A technical memorandum (TM) will be prepared documenting the work. This TM is anticipated to be complete by the end of May, if the proposed drilling and laboratory analysis schedules are met.

APPENDIX C

California Division of Drinking Water Permit

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CA Drinking Water Watch

Links

- PS Code Transition
- Water System Details
- Water System Facilities
- Monitoring Schedules
  - Old Format
  - New Format
- Monitoring Results
- Monitoring Results By Analyte
- Lead And Copper Sampling
  - Summaries
  - Next Sampling Due Dates
  - All Lead Sampling Results
  - All Copper Sampling Results
- Violations/Enforcement Actions
- Site Visits
- Consumer Confidence Reports
  - 2019
  - 2018
  - 2017
  - 2016
- Lead Service Line Documents
  - Certified Form

Water System Details

Water System No. :	CA4010011	**Federal Type :**	C
Water System Name :	MORRO BAY PW DEPT - WATER DIVISION	**State Type :**	C
Principal County Served :	SAN LUIS OBISPO	**Primary Source :**	SWP
Status :	A	**Activity Date :**	03-22-1979
Distribution System Classification :	D3	**Max Treatment Plant Classification :**	T2

Water System Contacts

Type	Address	Phone	Email - Web Address
Physical Location Contact	CA4010011-MORRO BAY PW DEPT - WATER DIV 955 SHASTA AVENUE MORRO BAY,CA 93442	805-772-6261	www.morrobayca.gov There is no web address
Administrative Contact	955 Shasta Avenue MORRO BAY,CA 93442		

Division of Drinking Water District / County Health Dept. Info

Name	Phone	Email	Address
DISTRICT 06 - SANTA BARBARA	805-566-1326	dwpdist06@waterboards.ca.gov	1180 EUGENIA PLACE SUITE 200 CARPENTERIA CA 93013

Annual Operating Periods & Population Served

Start Month	Start Day	End Month	End Day	Population Type	Population Served
1	1	12	31	R	10234

Service Connections

Type	Count	Meter Type	Meter Size Measure
CB	5532	ME	0

Sources of Water

Service Areas

Return Links

Water System Search

County Map

Glossary

Contact Info

Name	Type Code	Status
CALIFORNIA MENS COLONY	CC	A
CCWA - TREATED	CC	A
FLIPPOS WELL	WL	A
HIGH SCHOOL WELL 01	WL	A
HIGH SCHOOL WELL 02	WL	A
WELL 03	WL	A
WELL 04	WL	A
WELL 11A	WL	A
WELL 14	WL	A
WELL 15	WL	A
DESAL RAW - SEAWATER - STANDBY-INACTIVE	IN	I
GOLF COURSE WELL - INACTIVE	WL	I
PG&E WELL 02 - INACTIVE	WL	I
WELL 01 - INACTIVE	WL	I
WELL 02 - INACTIVE	WL	I
WELL 05 - ABANDONED	WL	I
WELL 06 - ABANDONED	WL	I
WELL 07 - ABANDONED	WL	I
WELL 08 - ABANDONED	WL	I
WELL 09 - INACTIVE	WL	I
WELL 09A - INACTIVE	WL	I
WELL 10 - INACTIVE	WL	I
WELL 10A - INACTIVE	WL	I
WELL 11 - DESTROYED	WL	I
WELL 12 -	WL	I

Code	Name
R	RESIDENTIAL AREA

ABANDONED		
WELL 13 - INACTIVE	WL	I
WELL 16 - INACTIVE	WL	I

Water Purchases

Seller Water System No.	Water System Name	Seller Facility Type	Seller State Asgn ID No.	Buyer Facility Type	Buyer State Asgn ID No.
CA4010830	CALIFORNIA MENS COLONY	IN	001	CC	033
CA4210030	CENTRAL COAST WATER AUTHORITY			CC	024

APPENDIX D

Class V Injection Well Notification Documentation

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Underground Injection Well Registration for the Pacific Southwest (Region 9)

Resources

- **Underground Injection Control in Region 9**
- **General Inquiries** or send email to R9iWells@epa.gov
  (Be sure to include your e-mail address if you'd like a response)

Register any class of injection well using the inventory form below.

On this page:

How to Register Injection Wells

If you own, operate or plan to construct one or more injection wells, you are required to register those features, also known as injection wells, with the Underground Injection Control program. This requirement applies to deep and shallow subsurface disposal systems as defined in 40 CFR part 144. Compliance with the federal Underground Injection Control (UIC) regulations includes fulfilling two basic requirements: (1) - register injection well(s) and (2) - do not use injection wells in a manner that will contaminate underground sources of drinking water.

These instructions and e-Form were developed to assist injection well owners in Arizona, California, Hawaii, and Indian Tribes of the desert southwest comply with the federal UIC regulations. Other state and local regulations may apply. See the regulations at 40 CFR part 144 for more information, at the U.S. Government Printing Office.

Frequently Asked Questions

My runoff discharges to a swale, pond or ditch. Is this injection?

If there is no subsurface (buried) discharge component to the system, then it is not subject to UIC requirements, however it may be subject to Clean Water Act requirements or other water protection regulations.

The injection well serves a single family home. Do I have to register the well?

Injection wells serving single family homes do not have to submit inventory information unless they are used by a home-based business, such as car repair, pet boarding, medical services or other businesses that generate a liquid waste stream that is to be disposed underground.

I have a septic system with multiple leachfield lines. Does each leachfield pipe count as a different injection well?

No, if all of the leachfields receive effluent from the same septic tank or other treatment device, they count as components of one injection well or subsurface fluid distribution system.

Is registering the injection well my only obligation?

Some injection activities are subject to state and local requirements and/or permits. Single-family onsite sewage systems are generally regulated by county environmental health agencies. Large capacity sanitary waste disposal and industrial discharges may be regulated by local or state water quality agencies. If your injection well(s) are subject to a discharge permit from the state, please list that permit number in the comments box to help reduce duplicative requirements.

Depending on multiple factors, such as your location in relation to drinking water supply wells or the type of injectate, your injection well(s) may be subject to additional federal requirements. These requirements may include sampling, characterization, permitting or closure of injection wells. Shallow injection of hazardous waste, untreated sewage and motor vehicle repair fluids is **prohibited** except in ongoing remedial actions overseen by regulatory agencies. See the regulations for more information. **IMPORTANT:** You must notify EPA if the ownership, well operating status or injectate changes.

How does EPA use the information?

EPA will use this information to notify you of applicable regulatory requirements or best management practices to prevent contamination. EPA shares the data with other water quality agencies, public water supply agencies, and in response to Freedom of Information Act requests for the data.

For more information, contact your EPA or state UIC program or email R9iWells@epa.gov.

Injection Well Inventory Form

After submitting this form, a confirmation email with the submitted form data will be sent to the Email address provided.

Transaction Type (choose one): [x] First time entry [ ] Change

---------- Facility Information ----------

Facility Name: (Required)

City of Morro Bay

This is a private residence [ ] true [x] false

Street:

955 Shasta Ave

Street 2:

City: (Required)

Morro Bay

State: (Required) CA

Zip: (Required) 93442

Facility Phone: 805-772-6261

---------- Facility Location ----------

County CA-San Luis Obispo

Land ID:

RCRA ID, APN, or TMK or leave blank

066-331-046

Indicate the land ownership of the property: (Required)

- [ ] Private
- [x] Government-local, state
- [ ] Government-federal
- [ ] Government-tribal
- [ ] Non-Profit

If Tribal select Tribe name: - None -

NAICS Code

Numbers only, please. For industry/business, find NAICS code at www.census.gov

Latitude

Latitudes in American Samoa should be entered as *negative* numbers. Free lat/long finder is latlong.net

35.376036 °N

Longitude

Enter positive numbers for degrees longitude east or negative numbers for longitude west, in this field.

120.856095

Longitude (W or E)
Specify "W" for longitudes in the U.S., or "E" for longitudes in Guam & the Northern Mariana Islands.

W

---- Legal Contact Information: Owner or Other Responsible Party ----

Owner Contact Name:

Joe Mueller

Email: (Required)

jmueller@morrobayca.gov

Organization: (Required)

City of Morro Bay

Street:

955 Shasta Ave

Street 2:

City: (Required)

Morro Bay

State: CA

Zip: (Required) 93442

---------- Well Details ----------

Total number of injection wells at this site: (Required)
If you would like to report other types of wells at this site, please submit this form, then use the back button to modify this entry or start over.

1

Number of identical wells reported below (Required)

Well Operating Status of your well(s):

- [x] Planned/under construction
- [ ] Active
- [ ] Inactive/not plugged
- [ ] Plugged and approved by regulator
- [ ] Plugged and abandoned without approval

Plugged & Abandoned?

Plugged & Abandoned:

If well(s) have been plugged and abandoned enter the *numerical* year only.

Injection Well Depth
(# of feet below ground surface)

- [ ] < 50
- [x] 50 - 500
- [ ] > 500

Injection Purpose

- [ ] Disposal
- [ ] Energy production
- [ ] Hydraulic barrier
- [ ] Oil or mineral recovery
- [ ] Remediation
- [ ] Recharge
- [x] Water supply storage and withdrawal

Injectate
Select the primary constituent of injected fluids.

- [ ] Storm drainage
- [ ] Irrigation runoff
- [ ] Non-contact cooling water
- [ ] Brine
- [ ] Combined industrial/sanitary
- [ ] Disinfected Tertiary Effluent (CA Title 22)
- [ ] Geothermal fluids
- [ ] Industrial Non-hazardous (describe in comments)
- [ ] Mine lixiviant
- [x] Potable water
- [ ] Remedial fluids/air
- [ ] Septic tank effluent
- [ ] Untreated sewage

Dispersal Direction
Select the predominant plumbing orientation of the injection well(s): horizontal such as a leachfield; vertical such as a drywell or seepage pit

- [ ] horizontal
- [x] vertical

Injectate Sources
Please select one.

- [x] From this site only
- [ ] This site and others

Comments
Please list any local or state permits that authorize, monitor, or otherwise affect the reported injection well(s). If this site is subject to any relevant local or state permits, or if you have any operational considerations for the injection well(s) that you would like to note, please list them here.

Your Name
If you are NOT the owner listed above, please enter your name here.

Chris Wick

Your Email (Required)

cwick@gsiws.com

Your Organization
Your organization if other than the contact above.

GSI Water Solutions, Inc.

Submit Registration

LAST UPDATED ON AUGUST 21, 2020

ATTACHMENT 4

State of California
Regional Water Quality Control Board

APPLICATION/REPORT OF WASTE DISCHARGE GENERAL INFORMATION FORM FOR WASTE DISCHARGE REQUIREMENTS OR NPDES PERMIT

I. FACILITY INFORMATION

A. FACILITY:

Name City of Morro Bay

Address 955 Shasta Ave

City/County/State/Zip Code Morro Bay/San Luis Obispo/California/93442

Contact Person Damaris Hanson

Telephone Number 805-772-6265 Email dhanson@morrobayca.gov

B. FACILITY OWNER:

Name City of Morro Bay

Address 955 Shasta Ave

City/State/Zip Code Morro Bay/San Luis Obispo/California/93442

Contact Person Damaris Hanson

Telephone Number 805-772-6265 Email dhanson@morrobayca.gov

Federal Tax ID 95-2308629

Owner Type (*Mark one*):

☐ Individual ☐ Corporation ☑ Governmental Agency ☐ Partnership

☐ Other: ______

C. FACILITY OPERATOR (The agency or business, not the person):

Name City of Morro Bay

Address 955 Shasta Ave

City/State/Zip Code Morro Bay/San Luis Obispo/California/93442

Contact Person Damaris Hanson

Telephone Number 805-772-6265 Email dhanson@morrobayca.gov

Operator Type (*Mark one*):

☐ Individual ☐ Corporation ☑ Governmental Agency ☐ Partnership

☐ Other: ______

D. OWNER OF THE LAND

Name City of Morro Bay

Address 955 Shasta Ave

City/State/Zip Code Morro Bay/San Luis Obispo/California/93442

Contact Person Damaris Hanson

Telephone Number 805-772-6265 Email dhanson@morrobayca.gov

Owner Type (*Mark one*):

☐ Individual ☐ Corporation ☑ Governmental Agency ☐ Partnership

☐ Other: ____

E. ADDRESS WHERE LEGAL NOTICE MAY BE SERVED

Address 955 Shasta Ave

City/State/Zip Code Morro Bay/San Luis Obispo/California/93442

Contact Person Damaris Hanson

Telephone Number 805-772-6265 Email dhanson@morrobayca.gov

F. BILLING ADDRESS

Address 955 Shasta Ave

City/State/Zip Code Morro Bay/San Luis Obispo/California/93442

Contact Person Damaris Hanson

Telephone Number 805-772-6265 Email dhanson@morrobayca.gov

II. TYPE OF DISCHARGE

Check Type of Discharge(s) Described in this Application:

☑ **Waste Discharge to Land** ☐ **Waste Discharge to Surface Water**

Check all that apply:

☐ Animal or Aquacultural Wastewater	☐ Land Treatment Unit
☐ Animal Waste Solids	☐ Landfill (*see instructions*)
☐ Biosolids/Residual	☐ Mining
☐ Cooling Water	☐ Storm Water
☑ Domestic/ Municipal Wastewater Treatment and Disposal	☐ Surface Impoundment
☐ Dredge Material Disposal	☐ Waste Pile
☐ Hazardous Waste (*see instructions*)	☐ Wastewater Reclamation
☐ Industrial Process Wastewater	☐ Other, *please describe* ____

III. LOCATION OF THE FACILITY

Describe the physical location of the facility:

1. Assessor's Parcel Number(s)
   - Facility: 066-331-046
   - Discharge Point: 066-331-046
2. Latitude
   - Facility: 35.376036°N
   - Discharge Point: 120.856095°W
3. Longitude
   - Facility: 35.376036°N
   - Discharge Point: 120.856095°W

IV. REASON FOR FILING

Check all that apply:

- [x] New Discharge or Facility
- [ ] Change in Design or Operation
- [ ] Change in Quantity/Type of Discharge
- [ ] Changes in Ownership/Operator (see instructions)
- [ ] Waste Discharge Requirements Update or NPDES Permit Reissuance
- [ ] Other: ______________________

V. CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA)

Name of Lead Agency City of Morro Bay

Has a public agency determined that the proposed project is exempt from CEQA?

☐ Yes ☑ No

If yes, state the basis for the exemption and the name of the agency supplying the exemption on the line below:

____

____

Has a "Notice of Determination" been filed under CEQA?

☑ Yes ☐ No

If Yes, enclose a copy of the CEQA document, Environmental Impact Report (EIR), or Negative Declaration. If No, identify the expected type of CEQA document and expected date of completion.

Expected CEQA Documents: ☑ EIR ☐ Negative Declaration

Expected CEQA Completion Date: June 2018

VI. OTHER REQUIRED INFORMATION

Please provide a COMPLETE characterization of your discharge. A complete characterization includes, but is not limited to, design and actual flows, a list of constituents and the discharge concentration of each constituent, a list of other appropriate waste discharge characteristics, a description and schematic drawing of all treatment processes, a description of any Best Management Practices (BMPs) used, and a description of disposal methods.

Also include a site map showing the location of the facility and, if you are submitting this application for an NPDES permit, identify the surface water to which you propose to discharge. Please try to limit your maps to a scale of 1:24,000 (7.5' USGS Quadrangle) or a street map, if more appropriate.

VII. OTHER

Attach additional sheets to explain any responses which need clarification. List attachments with titles and dates below:

Complete list of attachments with titles and dates included in Technical Memorandum

You will be notified by a representative of the RWQCB within 30 days of receipt of your application. The notice will state if your application is complete or if there is additional information you must submit to complete your Application/Report of Waste Discharge, pursuant to Division 7, Section 13260 of the California Water Code.

VIII. CERTIFICATION

"I certify under penalty of law that this document, including all attachments and supplemental information, were prepared under my direction and supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment."

Print Name Damaris Hanson Title Utility Division Manager

Signature Damaris Hanson Digitally signed by Damaris Hanson Date: 2023.07.17 16:28:54 -07'00' Date 7/17/23

FOR OFFICE USE ONLY

Date Form 200 Received:	Letter to Discharger:	Fee Amount Received:	Check #:

California Environmental Protection Agency
Bill of Rights for Environmental Permit Applicants

California Environmental Protection Agency (Cal/EPA) recognizes that many complex issues must be addressed when pursuing reforms of environmental permits and that significant challenges remain. We have initiated reforms and intend to continue the effort to make environmental permitting more efficient, less costly, and to ensure that those seeking permits receive timely responses from the boards and departments of the Cal/EPA. To further this goal, Cal/EPA endorses the following precepts that form the basis of a permit applicant's "Bill of Rights."

1. Permit applicants have the right to assistance in understanding regulatory and permit requirements. All Cal/EPA programs maintain an Ombudsman to work directly with applicants. Permit Assistance Centers located throughout California have permit specialists from all the State, regional, and local agencies to identify permit requirements and assist in permit processing.
2. Permit applicants have the right to know the projected fees for review of applications, how any costs will be determined and billed, and procedures for resolving any disputes over fee billings.
3. Permit applicants have the right of access to complete and clearly written guidance documents that explain the regulatory requirements. Agencies must publish a list of all information required in a permit application and of criteria used to determine whether the submitted information is adequate.
4. Permit applicants have the right of timely completeness determinations for their applications. In general, agencies notify the applicant within 30 days of any deficiencies or determine that the application is complete. California Environmental Quality Act (CEQA) and public hearing requests may require additional information.
5. Permit applicants have the right to know exactly how their applications are deficient and what further information is needed to make their applications complete. Pursuant to California Government code Section 65944, after an application is accepted as complete, an agency may not request any new or additional information that was not specified in the original application.
6. Permit applicants have the right of a timely decision on their permit application. The agencies are required to establish time limits for permit reviews.
7. Permit applicants have the right to appeal permit review time limits by statute or administratively that have been violated without good cause. For state environmental agencies, appeals are made directly to the Cal/EPA Secretary or to a specific board. For local environmental agencies, appeals are generally made to the local governing board or, under certain circumstances, to Cal/EPA. Through this appeal, applicants may obtain a set date for a decision on their permit and, in some cases, a refund of all application fees (ask boards and departments for details).
8. Permit applicants have the right to work with a single lead agency where multiple environmental approvals are needed. For multiple permits, all agency actions can be consolidated under a lead agency. For site remediation, all applicable laws can be administered through a single agency.
9. Permit applicants have the right to know who will be reviewing their application and the time required to complete the full review process.

ATTACHMENT 5

GSI Water Solutions, Inc.

DRAFT TECHNICAL MEMORANDUM

DRAFT Injection Testing Work Plan for Groundwater Replenishment and Reuse Project, Morro Bay, California

To: Lydia Holmes and Anthony Cemo, Carollo Engineers

From: Tim Thompson and Tim Nicely, GSI Water Solutions

CC: Brynne Weeks and Andrew Salveson, Carollo Engineers

Attachments: Figure
Water Quality Sampling Constituents Table

Date: August 26, 2021

Introduction and Purpose

GSI Water Solutions (GSI) is supporting the City of Morro Bay with the implementation of a planned indirect potable reuse (IPR) project, which will use highly treated recycled water from the City's forthcoming Water Reclamation Facility (WRF). The installation and operation of a Groundwater Replenishment Reuse Project (GRRP) using injection wells is a key part of the overall project. This memorandum presents the work plan for testing at a new injection well proposed to be installed in Spring 2021.

The injection testing presented in this work plan is a portion of work being performed by GSI for the City of Morro Bay in the lower portion of the Morro Valley Groundwater Basin, which also includes injection well design and installation, groundwater monitoring, permitting support, and groundwater flow modeling.

Injection Work Plan

The injection testing presented in this work plan provides diagnostic information regarding injection rates, aquifer response, and water quality at anticipated injection rates for a single well. Injection testing will be conducted at a newly constructed injection well located as shown on Figure 1.

Injection Testing

A series of injection tests will be conducted by conveying water from the City's municipal water supply distribution system into the new injection well. The injection tests will consist of an 8-hour injection step test and a 7-day injection constant rate test, operated by the Contractor. The wellhead will be sealed and capable of maintaining injection pressures up to 20 psi with anticipated injection pressures of up to 10 psi during testing in order to observe and maintain a range of injection rates. The injected water will consist of chlorinated water provided by the City from their State Water Project source.

City staff will install an outlet fitting and backflow prevention device onto the nearby City distribution pipeline located east of the nearby bike path for the purposes of this project. City staff will also construct a trench across the bike path and install a short section of piping that daylights west of the bike path and, for security purposes, west of the fence within the Dynegy/Vistra property. The drilling Contractor will connect to this fitting, the location of which is shown approximately on Figure 1 and run a temporary pipeline that will convey

the water to the injection well for the testing. The pipeline conveying the injection water to the well will be equipped by the Contractor with a flow control valve, flow meter, sampling port, pressure gauge, and a bypass filter. The bypass filter allows for monitoring of the turbidity of the injected water and will verify if turbid water is being injected (which is undesirable because of clogging potential) -- GSI will provide guidance to the Contractor for the materials and setup of this filter. A pressure transducer will be installed by the Contractor in the well to collect continuous water level data, and manual water level (and wellhead pressure) measurements will also be collected. All conveyance piping, measurement devices, and downhole equipment will be installed, maintained, and operated by the Contractor. GSI staff will be onsite to oversee the installation of the equipment. The Contractor will be required to provide temporary fencing around the immediate wellhead, which is assumed to require a 12- by 20-foot fenced area.

The following sections provide details for each phase of the injection testing program. The injection testing activities will be conducted following the drilling, construction, and pump testing of the injection well. The pump testing component will consist of both a step test and a constant rate test using a temporary pump installed and operated by the drilling contractor. The step test will involve pumping the well at 4 successively higher flow rates for 1 to 2 hours each while carefully monitoring water level drawdowns in the injection well and at the nearby monitoring well. The drawdown results of the step test will be used to establish the pumping rate used in the 24-hour constant rate pumping test.

Injection Step Test

The data collected during the pumping tests will be used by GSI to select the injection rates for the injection step test. This initial injection test will consist of four steps conducted at a series of discrete flow rates that will each last approximately 2 hours. The steps for the injection rates will be selected based on the drawdown results of the constant rate aquifer pumping test performed as part of the injection well installation. They will likely vary from approximately 10 to 80 gpm, but final rates will be determined after installation and testing of the injection well. The injection rate will be increased incrementally for each of the steps while simultaneously monitoring the water level in the well. Water level measurements will be recorded both at the injection well and at the nearby monitoring well with transducer and manual measurements. The results of the injection step test will be analyzed to determine appropriate injection rate for the constant rate injection test.

Injection Constant Rate Test

After the well has fully recovered from the injection step test, the constant rate injection test will be run at a continuous injection rate for various durations and ultimately for a continuous period of up to 7 days. During the tests, measurements of the flow rate, and corresponding water level shall be made at both the injection well and the nearby monitoring well. During the injection tests, a pressure transducer will record continuous water level data throughout the test. Manual measurement of water levels will also be collected at the following times relative to the start of the test:

- Every 5 minutes until 30 minutes have elapsed.
- Every 10 minutes until one hour has elapsed.
- Every 20 minutes until two hours have elapsed.
- Every hour until 24 hours have elapsed.
- Every two hours until 48 hours have elapsed.
- Every 4 to 6 hours until the end of the 7-day test.

Immediately after termination of the test, the rate of recovery of the water level shall be monitored for a period of 48 hours at both the injection and monitoring wells. The water levels will be recorded at the same time intervals (logarithmic) as the start of the constant rate injection test.

Analysis of Injection Testing Results

Following the completion of injection testing, data will be analyzed to estimate aquifer properties and provide a range of operational injection rates for the well. This information will also be used to update the groundwater model to evaluate project build out options.

Following updates to groundwater model, a series of scenarios will be developed in coordination with the City and Carollo Engineers to assess the ultimate number and location of wells required for the full project. Additional information from the modeling scenarios will include assessment of retention time within the aquifer, water level changes during and following injection periods and identification of any potential adverse conditions.

Recommendations will be provided for anticipated operational scheduling and approaches to minimize any potential adverse consequences and maximize the benefits of the proposed injection program.

Water Quality Sampling and Geochemical Evaluation

In addition to the collection of aquifer data collected during the tests, water quality samples will be collected at both the Injection well and/or the nearby monitoring well at the following times and analyzed for the list of constituents identified in the attached table:

- Collect samples at both the Injection and monitoring well on the last day of the constant rate pumping test (to establish the baseline aquifer water quality)
- Collect a sample at the Injection well at the end of the first and last day of contestant rate injection to document water quality of source water
- Samples will be collected from the monitoring well during the constant rate injection test during day 3, day 5, and day 7 (three sampling events). If groundwater quality changes occur based on field parameters (indicating that the injected water has reached the monitor well), the samples will be analyzed for a reduced suite of parameters.
- After completion of the constant rate injection test, groundwater samples will be collected once a week at the Injection well and monitoring well for four consecutive weeks. For each sampling episode, the well will be pumped to waste until parameters stabilize prior to sampling.

Water quality results for key constituents will be evaluated to identify mixing relationships and/or the presence of geochemical reactions. These field results will be used to verify the findings of the geochemical modeling described in the Geochemical Work Plan for Groundwater Replenishment and Reuse Project (GSI, 2021).

Table 1. Sampling Schedule

Stage	Purpose	Injection Well	Monitoring Well 21P-01
		Constituents	**Constituents**
Pumping constant rate (end)	Baseline groundwater quality	Complete suite	Complete suite
Injection Day 1 (end of day)	Source water quality	Complete suite	Field parameters [2]
Injection Day 3	Source water quality changes	--	Field parameters [2]
Injection Day 5	Source water quality changes	--	Field parameters [2]
Injection Day 7	Residence time	Complete suite	Complete suite
Post-Injection Weeks 1, 2, 3 and 4	Geochemical reactions	Complete suite [1]	Reduced / Complete suite [3]

Notes:
Complete and reduced suite defined in Water Quality Testing Constituents attached.
[1] If any trends are evident, a further complete sample will be collected at 6 weeks.
[2] Water quality samples will be collected for reduced suite if field-measured groundwater quality parameters changes.
[2] The monitoring well will be analyzed for the reduced suite (except DPBs) unless the field parameters indicate a change, which would trigger complete suite,

Injection Testing Schedule and Reporting

The injection testing will be conducted following the completion of the well installation and constant rate aquifer test. It is anticipated that the injection testing will begin by late May 2021 and require approximately 6 to 7 weeks to complete, including the 4 weeks of post-testing water quality sampling. Following the completion of the injection testing program, the Contractor will be responsible for removing all equipment and conveyance pipelines. The Contractor will not be provided final payment until the site condition is deemed satisfactory by the City and the terms of the project Technical Specifications are met.

The testing results will be provided in a technical memorandum (TM). This TM is anticipated to be completed by the end of July, approximately one month following the completion of the field work if the proposed drilling and injection testing schedules are met.

Figure

FIGURE 1

Site and Well Location Map

Morro Bay
Indirect Potable Reuse Program
Injection Testing

LEGEND

- Injection Well No. 1
- Well Construction Site
- Cuttings and Drilling Fluids Disposal
- Bike Path
- Piezometer
- Temporary Hose
- MBMWC Well
- Yeh Piezometer
- PG&E Property Boundary
- Western Project Area, 17 Acres
- Watercourse

NOTE
MBMWC: Morro Bay Mutual Water Company

N
0 150 300
Feet

Date: August 26, 2021
Data Sources: NAIP Imagery, ESRI

GSI Water Solutions, Inc.

Water Quality Sampling Constituents

Parameter Type	Parameter	Method
Field	Dissolved oxygen	YSI 556 or similar
	pH	EPA 150.1
	Oxidation-Reduction Potential	SM2580B
	Specific Conductance	EPA 120.1
	Temperature	YSI 556 or similar
	Turbidity	EPA 180.1
Inorganics	Alkalinity	SM2320B
	Ammonia	SM4500NH3G
	Bicarbonate	SM2320B
	Carbonate	SM2320B
	Chloride	EPA 300.0
	Cyanide (HCN)	EPA 335.4
	Fluoride	EPA 300.0
	Hardness	EPA 200.8
	Nitrate+Nitrite (total N)	EPA 300.0
	Nitrate (as N)	EPA 300.0
	Nitrite-N	EPA 300.0
	Orthophosphate as P	EPA 300.0
	Total Silica (as SiO2)	EPA 200.7
	Dissolved Silica (as SiO2)	EPA 200.7
	Sulfate	EPA 300.0
	Sulfide	SM4500S2F
Metals (Dissolved)	Aluminum	EPA 200.7
	Antimony	EPA 200.8
	Arsenic	EPA 200.8
	Barium	EPA 200.8
	Beryllium	EPA 200.8
	Cadmium	EPA 200.8
	Calcium	EPA 200.7
	Chromium	EPA 200.8
	Cobalt	EPA 200.8
	Copper	EPA 200.8
	Iron	EPA 200.7
	Lead	EPA 200.8
	Magnesium	EPA 200.7
	Manganese	EPA 200.8
	Mercury	EPA 245.7
	Molybdenum	EPA 200.8
	Nickel	EPA 200.8
	Potassium	EPA 200.7
	Selenium	EPA 200.8
	Silver	EPA 200.8

	Sodium	EPA 200.7
	Strontium	EPA 200.8
	Thallium	EPA 200.8
	Uranium	EPA 200.8
	Vanadium	EPA 200.8
	Zinc	EPA 200.8
Miscellaneous	Chemical Oxygen Demand	EPA 410.4
	Color	SM 2120B
	Corrosivity	Langelier Index
	Dissolved Organic Carbon	SM 5310C
	Foaming Agents (MBAs)	SM5540C
	Methane	RSK175
	Odor	2150B
	Oxidation-Reduction Potential	SM2580B
	pH	EPA 150.1
	Specific Conductance	EPA 120.1
	Total Dissolved Solids	SM 2540C
	Total Organic Carbon	SM5310C
	Total Suspended Solids	SM 2540D
	Turbidity	EPA 180.1
	Asbestos	Microscope: Hitachi 7000FA
DBPs	Residual Chlorine	SM 4500CL-G
	Dibromoacetic Acid (HAA)	SM6251B
	Dichloroacetic Acid (HAA)	SM6251B
	Monobromoacetic Acid (Bromoacetic acid) (HAA)	SM6251B
	Monochloroacetic Acid (HAA)	SM6251B
	Trichloroacetic Acid (HAA)	SM6251B
	Total Haloacetic Acids (Total HAA's)	SM6251B
	Bromodichloromethane (THM)	EPA 524.3
	Bromoform (THM)	EPA 524.3
	Chloroform (THM)	EPA 524.3
	Dibromochloromethane (THM)	EPA 524.3
	Total Trihalomethane (TTHM)	EPA 524.3
Other	Bromate	EPA 317
	Hexavalent Chromium	EPA 218.7

Parameter Type	Parameter	Method
Field	Dissolved oxygen	YSI 556 or similar
	pH	EPA 150.1
	Oxidation-Reduction Potential	SM2580B
	Specific Conductance	EPA 120.1
	Temperature	YSI 556 or similar
	Turbidity	EPA 180.1
Inorganics	Chloride	EPA 300.0
Metals (Dissolved)	Arsenic	EPA 200.8

Miscellaneous	Odor	2150B
	Oxidation-Reduction Potential	SM2580B
	pH	EPA 150.1
	Specific Conductance	EPA 120.1
	Total Dissolved Solids	SM 2540C
	Total Organic Carbon	SM5310C
	Total Suspended Solids	SM 2540D
	Turbidity	EPA 180.1
DBPs	Residual Chlorine	SM 4500CL-G
	Dibromoacetic Acid (HAA)	SM6251B
	Dichloroacetic Acid (HAA)	SM6251B
	Monobromoacetic Acid (Bromoacetic acid) (HAA)	SM6251B
	Monochloroacetic Acid (HAA)	SM6251B
	Trichloroacetic Acid (HAA)	SM6251B
	Total Haloacetic Acids (Total HAA's)	SM6251B
	Bromodichloromethane (THM)	EPA 524.3
	Bromoform (THM)	EPA 524.3
	Chloroform (THM)	EPA 524.3
	Dibromochloromethane (THM)	EPA 524.3
	Total Trihalomethane (TTHM)	EPA 524.3
Other	Hexavalent Chromium	EPA 218.7

ATTACHMENT 6

DRAFT TECHNICAL MEMORANDUM

Interim Tracer Test Draft Work Plan for proposed Indirect Potable Reuse Program, Morro Bay, California

To: Rachel Hohn, Central Coast Regional Water Quality Control Board

From: Tim Thompson and David O'Rourke, GSI Water Solutions

Copy: Damaris Hanson, City of Morro Bay

Dan Heimel, Confluence ES

Attachments:
Figure 1: Site Plan Detail
Figure 2: Cross Section X-X'
Figure 3: July 2021 Groundwater Elevation Contour Map
Figure 4: May 2024 Groundwater Elevation Contour Map
Appendix A: Final Well Design for IW-1
Appendix B: Boring Logs and well diagrams for 20P-01, 21P-01
Appendix C: Notice Of Applicability, Enrollment of City of Morro Bay in Water Quality Order 2012-0010
Appendix D: Safety data sheets for fluorescein
Appendix E: Fluorescein dye preparation procedures (OUL)

Date: June 18, 2024

Introduction and Purpose

GSI Water Solutions (GSI) is supporting the City of Morro Bay (City) with the development of Indirect Potable Reuse (IPR) recycled water facilities as part of the City's overall Water Reclamation Facility (WRF) Program. The IPR component of the WRF Program (Project) will include the injection of advanced purified recycled water produced at the City's Water Resources Center treatment facility into a series of injection wells located in the lower Morro Valley Groundwater Basin (Basin), west of Highway 1. This memorandum presents the work plan for an interim tracer test that will be conducted using Injection Well 1 (IW-1) to inject potable water into the Basin. The test will be used to determine the migration rate of injected water between IW-1 and two downgradient piezometers (20-P01 and 21-P01) and wells (MB-15) under conditions when the City's wellfield (located to the north) is actively pumping (Figure 1). At a minimum, two months of travel time (subsurface retention time) is required between the injection wells and extraction wells to be assessed via conducting a tracer test.

The interim tracer testing presented in this work plan is a portion of the work being conducted by GSI for the City in the lower portion of the Morro Valley Groundwater Basin that is compliant with the California State Water Resources Control Board's (State Board) Groundwater Replenishment Reuse Project (GRRP) regulations for subsurface application (GSI, 2021). This interim test is intended to confirm the aquifer travel times under conditions approximating project operation conditions and to demonstrate the continued viability of the project. However, this interim test is not intended to substitute for the full operational test required after startup under the terms of the GRRP regulations. It is expected that this interim tracer test will be run for approximately two months.

Hydrogeologic Setting and Wells

The Morro Valley Groundwater Basin (DWR Bulletin 118 basin 3-41) is a shallow alluvial basin that encompasses approximately 1.9 square miles. It is bounded on the west by the Pacific Ocean and is surrounded and underlain on all other sides by consolidated and impermeable rocks of the Franciscan Formation (Jurassic to Cretaceous age). The Basin is further divided into Lower and Upper parts by a restriction in the valley commonly referred to as the Narrows, located approximately 1,000 feet east of Highway 1, where the alluvium underlying Morro Creek is constrained by bedrock to a narrow corridor about 300 feet wide. The principal water-bearing units in the Lower Basin are younger alluvium, dune sand, and Holocene- and Pleistocene-aged terrace deposits that extend approximately 60 to 80 feet beneath the valley floor. Alluvial deposits are the primary water-bearing unit in the Basin and are composed primarily of unconsolidated gravel, sand, silt, and clay. The stratigraphy of the Lower Basin has been conceptually divided into an upper zone dominated by finer-grained sediments, and a lower zone dominated by productive sands and gravels (GSI, 2021). Pumping and injection wells target the deep aquifer because of its higher transmissivity and productivity. There are no piezometers screened exclusively in the shallow zone, but based on understanding of alluvial depositional environments, it is likely that the water levels in the deep and shallow zones are similar. Figure 2 presents a cross section of the subsurface between IW-1 and the City well field, displaying our understanding of the expected subsurface pathway between the injection and extraction wells.

IW-1 is located on the Vistra property, approximately 450 feet west of Highway 1, and about 700 feet south of Morro Creek (Figure 1). It was completed to a total depth of 88 feet below ground surface (bgs) and screened in the deep aquifer zone (approximately 60 to 80 feet bgs in September of 2022. A completed well design diagram for IW-1 is presented in Appendix A.

Piezometer 21P-01 was constructed in 2022 approximately 53 feet north of IW-1 and was completed to a total depth of 74 feet bgs with a screened interval from 45 to 70 feet bgs. Piezometer 20P-01 was constructed in 2022 approximately 460 feet north of IW-1 and was completed to a total depth of 66 feet bgs with a screened interval from 41 to 66 feet bgs (Figure 1). Piezometers 21P-01 and 20P-01 were both completed in the deeper aquifer zone, to monitor conditions in the deeper productive zone into which IW-1will be injecting. Boring logs and well diagrams for piezometers 20-P01 and 21P-01 are presented in Appendix B.

Figure 3 displays groundwater elevation contours in Summer 2021 in the Morro Valley Groundwater Basin. This is representative of groundwater elevations during dry periods when there is no surface flow in Morro Creek. The regional groundwater gradient under non-pumping conditions is generally westward, towards the coast, with a hydraulic gradient of approximately 0.005 ft/ft. Local groundwater gradients in the Project Area change in response to pumping at the City production wells, and during periods of recharge from percolation of streamflow when Morro Creek is actively flowing.

During periods when Morro Creek is flowing, the aquifer is recharged by percolation of streamflow through the creek channel. Figure 4 presents a groundwater elevation map from May 2024, when Morro Creek was still flowing. This figure indicates higher groundwater elevations near the creek (at piezometers 18P-02 and 19P-04) than at IW-1. For this reason, it is recommended that this interim tracer test not be conducted when Morro Creek is flowing; the elevated groundwater elevations observed during stream flow conditions could present a potential barrier to the flow path between the injection wells and the extraction wells.

When the City is pumping its wells, as it does during regularly scheduled SWP shutdowns (typically occurring in November) and as it will be doing during the interim tracer test, the pumping causes a water level depression that slopes radially towards the City wells.

The City's production wells (shown on Figure 3) are the only wells that extract groundwater from the Lower Basin. Wells MB-3, MB-4, MB-14, and MB-15 (referred to as the Highway 1 wells) are used for potable supply. The High School wells (HS-1 and HS-2) are used primarily for landscape irrigation at Morro Bay High School. No other groundwater production occurs in the Lower Basin, nor is any anticipated during the duration of the proposed IPR project. The nearest groundwater production is from private agricultural wells located in the upper Basin, upgradient of the Narrows, approximately 3/4 of a mile east of Highway 1, and substantially upgradient of the Project. Pumping upgradient of the Narrows is not expected to have any impact on the Project, nor is the Project anticipated to have any impact on the agricultural operations in the Upper Basin.

IW-1 and piezometers 21P-01 and 20P-01 will each be fitted with continuous data logging transducers for the purpose of consistent monitoring of each piezometer's water level, temperature, and specific conductivity for the duration of the injection testing. The transducer in IW-1 will be placed above the screen to accurately reflect influent water quality before it exits the well through the screen. The transducers in the piezometers will be placed near the bottom of the screened interval in each piezometer.

Summary of Previous Injection Testing

Following installation of injection well IW-1 and traditional pumping tests in late 2022, two injection tests were conducted by injecting treated potable drinking water from the City's water distribution system into IW-1. All testing and monitoring were conducted in compliance with the Regional Board ASR permit requirements ("Notice Of Applicability, Enrollment of City of Morro Bay in Water Quality Order 2012-0010, General Waste Discharge Requirements for Aquifer Storage and Recovery Projects that Inject Drinking Water into Groundwater, and Transmittal of Monitoring and Reporting Program No. R3-2021-0067"), which are attached to this report as Appendix C.

Initially, on October 14, 2022, an injection step-test was conducted to evaluate the well's response to injection at a series of increasing rates (20, 40 70 and 90 gallons per minute [gpm]). The injection was conducted continuously with each rate held constant for 90 minutes. Analysis of these testing results indicated that a rate of at least 90 gpm would be sustainable for the duration of the subsequent long-term injection test.

The initial workplan called for a constant rate injection test of 7 days for the purpose of determining the ability of the injection well to operate over multiple days. After consultation with the project team, the City decided to expand the scope of the injection test to try to determine an estimate of travel time in the aquifer during injection based on observed changes in water quality parameters, using the intrinsic tracer of specific conductivity. It was observed that specific conductivity of the ambient groundwater was typically in the range of 1,500 to 2,000 uS/cm, while the conductivity of State Water (which was the only water supply present in the City's distribution system at that time) was typically approximately 700 uS/cm. With transducers installed in IW-1 and 21-P01, it was thought that conductivity could be monitored continuously to observe changes in conductivity at the monitoring well that would represent breakthrough of injected water. The long-term injection test started on December 6, 2022, and continued through January 4, 2023. The injection rate was maintained between 96 and 102 gpm, with an overall average injection rate of 99 gpm. Ultimately, there was ambiguity introduced into the results observed in 21-P01, likely due to the occurrence of vertical flow from the shallow zone. Regardless, a physically-based groundwater velocity estimate of about 4 feet/day was calculated based on the results of this injection test.

Due to the ambiguity observed with intrinsic tracers in the first injection test, the City desires to proceed with an extended interim injection test using an added tracer compound to generate an estimate of travel time and groundwater velocity under project operating conditions (i.e., with City wells producing groundwater simultaneously with the injection of potable water at the injection wells).

Selection of Added Tracer

Fluorescein dye is commonly used as a conservative groundwater tracer to track the migration of water and is certified by the ANSI NSF 60 Drinking Water Standard (Attachment D). In addition to these qualifications, Fluorescein was selected as the tracer compound for the proposed interim tracer test because it poses minimal environmental risk, is relatively low-cost, and can be detected at low concentrations. Preparation, injection and sampling are relatively straightforward and require minimal quantities as a benefit of the dye's high sensitivity.

Fluorescein is a non-reactive dye that is covered by the Central Coast Regional Board's low-threat waiver. A non-reactive dye is a tracer compound that highly contrasts and is non-reactive with the formation, water within the formation, waste constituents, and/or injected materials (Order R3-2019-0089, Attachment A, Section B, Item 1g).

Added Tracer Properties

Fluorescein dye has been extensively employed as a tracer of groundwater movement from as early as 1875 (Fleury et al., 2003), as it is inexpensive, non-toxic, easily detectable, and stable over time. Previous investigations into the human and environmental health risks associated with fluorescent dyes have consistently demonstrated the safety of fluorescein at concentrations that exceed several parts per billion (ppb) concentration. The anticipated recovery concentration of dye will be between 1-10 micrograms per liter (ug/L). As discussed previously, there are not any privately-owned third-party wells in the Lower Basin that would represent unintended receptors of the dye.

Numerous manufacturers of fluorescein dye have obtained certification for their products, which are marketed under various trade names, under the ANSI/NSF Standard 60 for use as tracer compounds in potable water systems for infrequent and short-term use (Todd Groundwater, 2021). Kingscote Chemicals in Miamisburg, Ohio is a manufacturer that produces fluorescein dye in powder form and will be the source of the tracer dye used for the Project. The fluorescein dye is sold (and listed in the NSF certified compounds database) under the trade name "Fluorescent FLT Yellow/Green Powder". The Safety Data Sheets for fluorescein dye are provided in Appendix E.

Fluorescein dye is anionic, rendering it less susceptible to adsorption onto inorganic substances such as clays and similar materials when compared to cationic dyes. Fluorescein was also chosen as the most adequate tracer by accounting for the local groundwater's pH and salinity levels. Highly saline groundwater that may increase adsorption of fluorescein onto minerals and sediment is not anticipated. Chloride levels previously measured at IW-1 report chloride at 140mg/L and total dissolved solids at 860 mg/L (GSI, 2023) which is considered by the US Geological Survey as fresh water. Due to non-saline conditions, dye behavior is not expected to be impacted by interactions of fluorescein with injection water or native groundwater.

Groundwater in the Lower Basin is generally neutral with pH levels between 6.9-7.8 (GSI, 2023) decreasing the likelihood of adsorption. This estimate demonstrates that fluorescein dye will be optimal as a highly conservative tracer amidst the current salinity and pH conditions (Todd Groundwater, 2021).

Operational Conditions During Test

It is anticipated that the interim tracer test will be conducted for a duration of two months to determine if the tracer arrives at the City well MB-15 within the two-month regulatory criteria under pumping conditions.. During the initial injection test, a groundwater velocity of 4 feet per day was calculated between IW-1 and piezometer 21P-01 during the specific conditions and gradients of that test (City production wells were not operating during that test.) IW-1 is anticipated to inject City potable water at approximately 95 to 100 gallons per minute (gpm) continuously throughout the duration of the interim tracer test.

Production pumping from the City's wellfield will occur during the interim tracer test. It is anticipated that the City will pump wells MB-4, MB-14 and MB-15 at a combined pumping rate of approximately 225 to 350 gpm; the City will be blending the pumped groundwater with State Water to achieve nitrate concentrations required by the Regional Water Quality Control Board (RWQCB) prior to delivery to the distribution system (City of Morro Bay, 2024). Coordination with City operations staff will be required during the injection test. The City's production wells (both the Highway 1 wellfield and the two High School wells) are the only wells that extract groundwater from the Lower Basin. The City will attempt to minimize pumping from the High School wells during the test, but nominal pumping of those wells is not expected to affect the operation of the interim tracer test. No other pumping wells exist in the Lower Basin nor are any anticipated to be installed.

City production wells will be operated for 1-2 days prior to the onset of dye injection in order to document the change in water level conditions from static (non-pumping) to pumping conditions prior to injection.

IW-1, 21P-01, 20P-01, and MB-15 (the nearest extraction well to the injection well) will be outfitted with transducers to collect data on water levels, temperature, and conductivity continuously through the testing period.

Dye Preparation and Injection

Fluorescent FLT Yellow/Green Powder (fluorescein dye) will be purchased from Ozark Underground Laboratories (OUL) in Protem, Missouri, a Fluorescent Tracer Dye specialist company. The fluorescein dye is purchased as a powder, delivered in sealed packets within a 5-gallon carboy which is ready for mixing in the field in the delivered carboy. Mixing with de-ionized water will occur on-site prior to injection by trained field staff in the appropriate PPE. Prior to mixing, a spill-containment pallet will be placed underneath the carboy to catch potential spills. Deionized water[1] will be added directly into the carboy via funnel to dissolve and dilute the solid dye to the predetermined injection concentration. De-ionized water is a preferred solvent as it does not contain residual chlorine. After vigorous manual mixing, the solution will be left to settle overnight to reduce foaming. Additional details regarding the dye preparation procedure can be found in Appendix F.

The injected concentration of the dye is designed to surpass minimum detection limits while remaining non-toxic to the environment. Safety Data Sheets for fluorescein (Appendix E) identify the hazards and safety protocols associated with fluorescein handling. In significant quantities, residual chlorine has been documented (Deaner, 1973) to have quenching effects on fluorescein dye emissions which underestimate dye concentration. However, we have spoken with staff at OUL and that is not anticipated to be an issue during this test. Also, according to OUL staff the presence of chloramines in the injection water will not present any issues.

Additional precautions will also be taken to avoid photo-degradation of UV-sensitive fluorescein dye (Todd Groundwater, 2021). These precautions will include limiting sunlight exposure by using closed opaque mixing containers during mixing, using opaque tubing and/or metal pipe in the above ground injection set-up, and operating in the shade when possible.

All valves and wellhead equipment that were used in previous injection activities will be utilized for the interim tracer test. The contents of the carboys will then be pumped into the well via the influent plumbing assembly at the IW-1 wellhead over the duration of a few minutes.

Downgradient Monitoring

An initial round of sampling will be conducted at IW-1, 20-P01, ,21-P01, and City well MB-15 prior to the startup of the injection test to document baseline water quality at these wells. Samples collected from the wells will be analyzed for general chemistry and fluorescein. (It is rare, but not unheard of, for fluorescein to be present in groundwater from non-specific sources; this possibility must be disproven prior to the injection test.)

There will be two sampling methods to detect fluorescein dye concentrations at the two downgradient piezometers 20-P01 and 21-P01: charcoal sampling packets and collection of water samples. Charcoal samplers will serve as screening tools as they represent a time-integrated sample of water flowing through the piezometer over the time period between samples and may detect lower dye concentrations compared to grab groundwater samples. The charcoal packet samples will be analyzed before water samples to confirm dye presence. If the charcoal packet does not yield a detectable concentration of fluorescein dye, the associated groundwater grab samples will not be analyzed. If dye is detected in the charcoal samples, the groundwater samples will undergo confirmation analysis. Groundwater samples, if analyzed, will also be analyzed for fluorescein and general chemistry constituents (cations/anions, pH, conductivity).

Because the well head assembly for City Well MB-15 cannot easily be modified to accommodate the placement of the charcoal packets, that method of sampling will not be implemented at MB-15. Rather, each of the groundwater samples collected from MB-15 will be analyzed for the selected parameters without the intermediate step of installing and sampling the charcoal packets.

On the first week of injection, 2 x 4 inch active coconut charcoal packets will also be lowered to the middle of the screened intervals at both piezometers. Charcoal packets will be anchored with a weight to prevent floatation. The weight will be attached with a colorless cord to prevent contamination of cords dyed with fluorescent dyes. Additional continuously recorded data will include water level, conductivity, and temperature via the pressure transducers installed in the well and piezometers.

After the first week of the injection test, samples will be collected from the downgradient piezometers and City Well MB-15 (the closest well to the injection well). Each charcoal packet will be removed from 21P-01 and 20P-01, then the piezometers will be purged for 3 casing volumes using a submersible pump. Following collection, charcoal packets will be lightly shaken to remove excess water, then stored in resealable bags in a dark refrigerated cooler. After the wells stabilize to low-flow parameters, a 30 mL water sample will be collected and stored in the cooler with the charcoal packet samples. Each week's samples will be shipped overnight under refrigeration to Ozark Underground Laboratory (OUL), the laboratory performing the analysis, located in Protem, Missouri. All procedures will adhere to OUL standard operating protocols outlined in Appendix E.

Testing Schedule and Reporting

It is recommended to commence the interim tracer test when there is no surficial flow of water in Morro Creek. Based on the substantial amount of rainfall so far in 2024, it is anticipated that no-flow conditions may exist in late summer 2024. In this case, the injection period would likely extend through September 2024. Downgradient monitoring wells that will be monitored and sampled are piezometers 21P-01 and 20P01.

Following the interim tracer test, a draft technical memorandum will be prepared for the City. After City review and appropriate incorporation of comments, the technical memo will be submitted to the Regional Board and DDW on behalf of the City to provide documentation of the testing results and to support future project permitting.

Table 2. Estimated Sampling Frequency and Travel Times to Downgradient Monitoring Wells

Monitoring Well	Estimated Travel Time (days)	Planned Sample Dates
21P-01	14	Days 7, 10, 12, 15, 17, 21, 28, 35…
20P-01	30 to 60	Weeks 2-9
MB-14	>60	Weeks 3-9

Dye Recovery

The purpose of the Interim Injection Test is to determine the subsurface retention time between IW-1 and the downgradient piezometers. A spectrofluorophotometer (Shimadzu Model RF-5301) will be used at the OUL laboratory to measure fluorescein concentration in the water samples. An ammonia-alcohol solution is used to elute the fluorescein dye in the charcoal sampling packets which allows for a minimum detection limit of 0.02 µg/L. This high sensitivity allows for easier detection of fluorescein dye even after several magnitudes of dye concentration have been lost due to radial dispersion following injection.

Four criteria are outlined by OUL Procedures (Appendix E) for determining fluorescein dye recovery from charcoal samplers, as follows:

1. Criterion 1 is that at least one fluorescein peak must be observed in the range between 514.5 to 519.6 nm in the sample.
2. Criterion 2 is that the dye concentration that is associated with the fluorescein peak must be 0.075 ppb which is at least 3 times the detection limit of an elutant sample at 0.025 ppb.
3. Criterion 3 is that the dye concentration must be at least 10 times greater than any other concentration reflective of background at the sampling station in question.
4. Criterion 4 is that the shape of the fluorescein peak must not be low, broad, and asymmetrical and rather should exhibit typical fluorescein peak shapes such as a narrow and symmetrical shape.

According to the GRRP regulations, underground retention time is based on the "difference from when the water with the tracer is applied at the injection well to when either (a) two percent (2%) of the initially introduced tracer concentration has reached the downgradient monitoring point, or (b) ten percent (10%) of the peak tracer unit value observed at the downgradient monitoring point reached the monitoring point" (Title 22, Div. 4, sec. 60320.208). Time-concentration graphs will be prepared for each downgradient piezometer to determine when the concentration reaches 10% of the maximum concentration observed at the location. Travel time (t_{10}) will be the elapsed time at which concentration reaches 10% of the maximum concentration and travel time (t_{50}) will be the elapsed time to reach maximum concentration. However, the first positive detection of fluorescein in either piezometer will be recorded.

Following initial fluorescein dye injection at IW-1, breakthrough curves will be produced for each piezometer to identify subsurface travel time between IW-1 and piezometers 21P-01 and 20P-01. Injection will continue until the fluorescent dye has been detected at both downgradient piezometers.

In 21-P01, because it is closer to IW-1 and a previous groundwater velocity estimate has been developed, sampling will begin 10 days after injection and occur twice a week until it is determined that adequate data is collected.

In 20-P01, sampling will begin two weeks after the start of the test and continue weekly until fluorescein is detected. At this point sampling will occur twice a week until it is determined that adequate data has been collected.

The collection frequency of samples from the piezometers may be adjusted based on data collected during the test. Initial estimates of sampling frequency are presented in Table 1.

The introduction of fluorescein during this interim tracer test could conceivably complicate the use of fluorescein as a tracer in future tests if baseline sampling for those tests indicates that legacy fluorescein is still detected in the groundwater samples in the future. In that event, it may be necessary to select a different tracer compound.

References

Aley, T. (2002). Groundwater tracing handbook. Ozark Underground Labs.

Deaner, D. G. (1973). Effect of Chlorine on Fluorescent Dyes. Journal (Water Pollution Control Federation), 45(3), 507–514. http://www.jstor.org/stable/25037774

Fleury, Markus, and Nu Nu Wai. 2003. Dyes as Tracers for Vadose Zone Hydrology. Review of Geophysics 41.1.

GSI Water Solutions, Inc. 2021. "2021 Annual Monitoring Report for City of Morro Bay Aquifer Storage and Recovery Pilot Project (R3-2021-0067)". Prepared for the City of Morro Bay.

GSI Water Solutions, Inc. September 2023. "Basis of Design Report for Groundwater Injection, Monitoring, and Extraction". Technical Report. Prepared for the City of Morro Bay.

Minerology Inc. (2021, December 22). Morro Bay IPR Geochemistry Analysis.

Todd Groundwater. September 28, 2021. "Pure Water Monterey Groundwater Replenishment Reuse Project, Added Tracer Work Plan". Submitted to Aide Ortiz, Jonathan Weininger, Querube Moltrup, State Water Resources Control Board, Division of Drinking Water and James Bishop, Central Coast Regional Water Quality Control Board.

City of Morro Bay, May 3 2024, Nitrate Blending Operations, Maintenance, and Monitoring Plan.

Figures

FIGURE 1

Injection Well Site Detail

Morro Bay Interim Tracer Test

LEGEND

- Morro Bay City Well
- Injection Well (IW-1)
- Piezometer
- Hydrant
- Project Area
- Permanent Easement
- Cross Section Line
- Bike Path
- Water Supply Line
- Gas Line
- Watercourse

NOTES

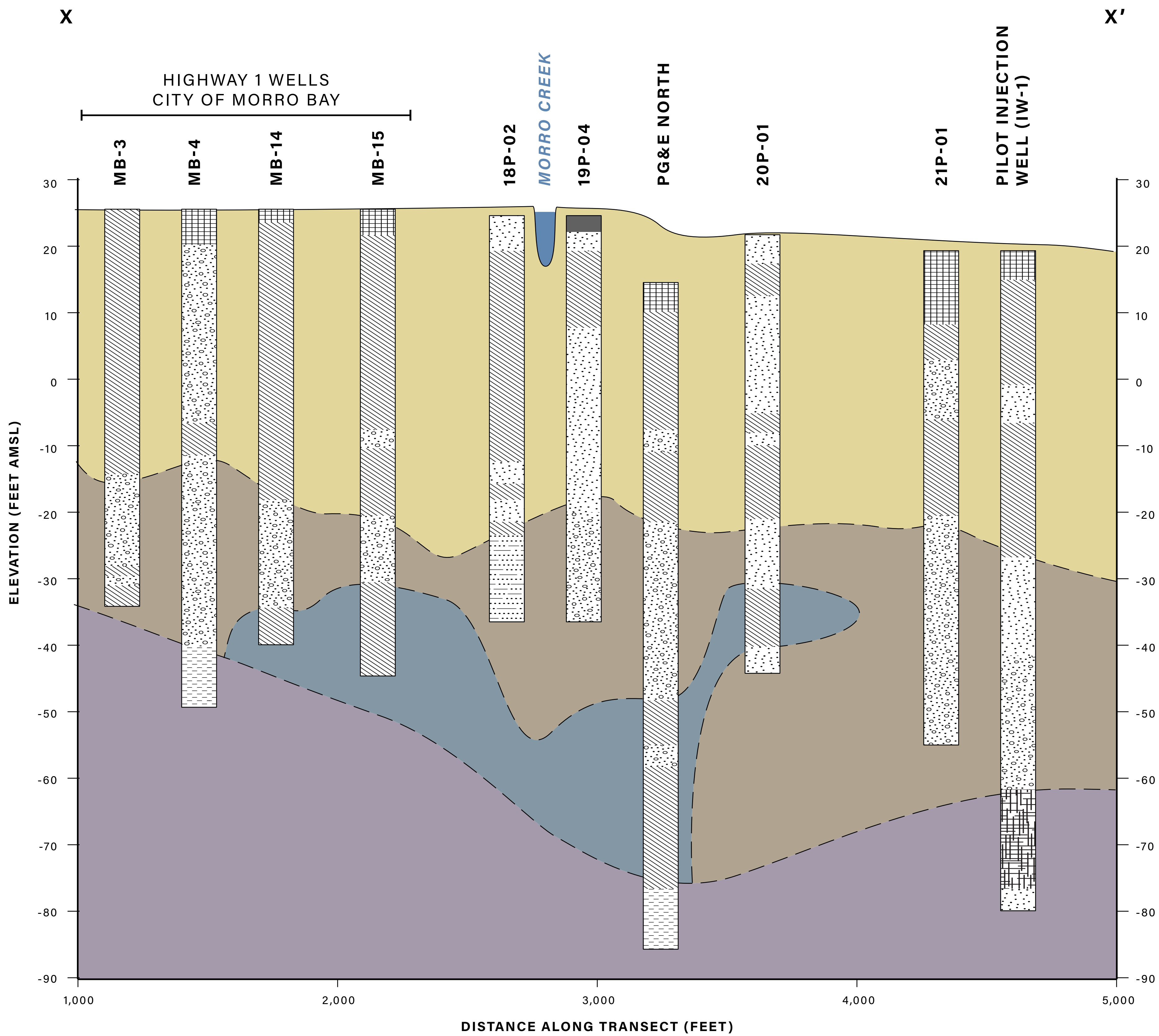
MBMWC: Morro Bay Mutual Water Company.
Well MBMWC is inactive.

N

0 95 190
Feet

Date: June 5, 2024
Data Sources: USGS, ESRI,
City of Morro Bay, Maxar Imagery (2021)

GSI Water Solutions, Inc.



Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\Interim_Tracer_Test

FIGURE 2

Cross Section X-X'

Morro Bay Interim Tracer Test

LEGEND

Lithology

- Upper Strata/Finer Sediments
- Sand and Gravel Target Aquifer
- Clay
- Bedrock

USCS Lithology

- Asphalt
- Artificial Fill
- Clays/Silts - CL, CH, OH, ML, OL, MH
- Sandy/Gravelly Clay - CL, GC
- Gravels - GW, GP, GC, GM
- Weathered Bedrock (Kjf)
- Sand - SM, SW, SC, SP
- Shale

GSI Water Solutions, Inc.

FIGURE 3

July 2021 Groundwater Elevation Contours

Morro Bay
IPR Program
Interim Tracer Test
Workplan

LEGEND

- Monitoring Well
  Groundwater Elevation, feet
- Groundwater Elevation Contour, feet
- Groundwater Flow Direction
- Major Road
- Watercourse

N

0 250 500
Feet

Date: November 15, 2021
Data Sources: ESRI, USGS, NAIP 2018

GSI Water Solutions, Inc.

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\IPR_Project\Refined_BOD_Report\Figure4_May2024_GW_Contours.mxd

FIGURE 4

May 2024 Groundwater Elevation Contours

Morro Bay IPR Project
Interim Tracer Test Workplan

LEGEND

- Morro Bay City Well
- MBMWC Well (Abandoned)
- Desalination Well
- Injection Well (IW-1)
- Piezometer
- Groundwater Elevation
- Groundwater Flow Direction
- Model Active Area
- Permanent Easement

All Other Features

- City Boundary
- Major Road
- Watercourse

NOTES

MBMWC: Morro Bay Mutual Water Company.
Well MBMWC is inactive.

N

0 500
Feet

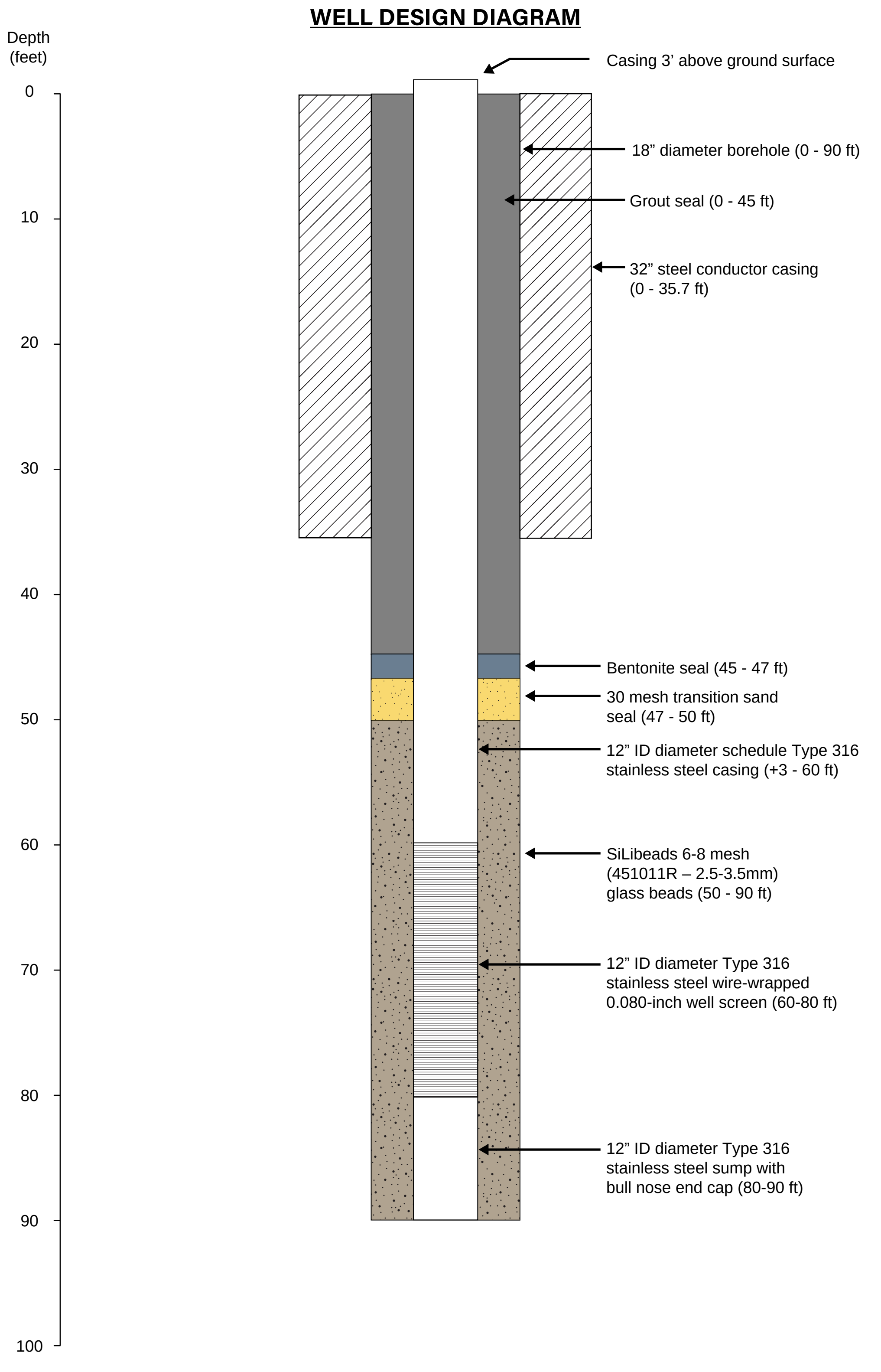
Date: June 13, 2024
Data Sources: USGS, ESRI, City of Morro Bay, NAIP Imagery (2022)

GSI Water Solutions, Inc.

Appendices

APPENDIX A

Injection Well Design



Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\Injection_Testing

FIGURE 2

Injection Well Design

Indirect Potable Reuse Program Injection Testing

Morro Bay, CA

GSI Water Solutions, Inc.

APPENDIX B

Soil Boring Log

GSI Water Solutions, Inc.

PROJECT NUMBER: 00645.007.003.01A	WELL NAME: 21P-01 SHEET 1 OF 2

SOIL BORING LOG

PROJECT : Morro Bay: GW Modeling/Injection Testing
LOCATION . Morro Bay, CA
ELEVATION : 19.21
DRILLING CONTRACTOR : ABC Drilling - Jamie M
DRILLING METHOD AND EQUIPMENT USED
COORDINATES: 35.3761 -120.8559
WATER LEVELS : 20.5' below top of 2" Casing @ 12:50
START : 7:55 END : 10:00
LOGGER : Lee Knudtson

DEPTH BELOW SURFACE (FT) / CONSTRUCTION / # BLOWS	LITHOLOGIC LOG	CORE DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS TESTS, AND INSTRUMENTATION
5' — 12-7-7		Fill Material	8" Hole Diameter 2" Well Diameter Cement Seal 0-37' Bent Seal 37-43' Sand 43-74 2" PVC Casing 43-74' Screen (050) 45-70'
10' — 17-20-25		Fill Material	
15' — 8-12-17	CL	Clay with some silt & sand Water on tip from overdrill	
20' — 8-15-18	GC	Gravel, sand, & some clay. Water @ 20' or so Medium to coarse angular gravel	
25' — 15-18-25	GC	Sand with small gravel and some clay grading to coarser clay and more gravel and clay at bottom	
30' — 20-20-20	CL	30' to 30.5' - Clay with some sand 30.5' to 31' - Clay with some sand 31' to 31.5' - Clay with some silt and sand	
35' — 8-15-25	CL	35' to 35.5' - Clay with some silt and sand 35.5 to 36' - Clay with some silt and sand 36' to 36.5' - Clay with some silt and sand	
40' — 8-17-35	CL	40' to 40.5' - Clay with coarse sand & some gravel 40.5' to 41' - Clay with medium gravel 41' to 41.5' - Sand with some silt and clay	
45' — 43-45-45	GW or SW	45' to 45.5' - Small gravel 45.5' to 46' - Small gravel with some sand 46' to 46.5' - Small Gravel with some sand & clay (Geochem sample @ 46' to 46.5')	
50' — 35-35-30	GW or SW	50' to 50.5' - Small gravel with some sand 50.5' to 51' - Small gravel withs ome coarse sand 51' to 51.5' - Small gravel with scourse sand and minor clay	

GSI Water Solutions, Inc.

PROJECT NUMBER: 00645.007.003.01A	WELL NAME: 21P-01 SHEET 2 OF 2

SOIL BORING LOG

PROJECT : Morro Bay: GW Modeling/Injection Testing
LOCATION : Morro Bay, CA
ELEVATION : 19.21
DRILLING CONTRACTOR : ABC Drilling - Jamie M
DRILLING METHOD AND EQUIPMENT USED
COORDINATES: 35.3761 -120.8559
WATER LEVELS : 20.5' below top of 2" Casing @ 12:50
START : 7:55
END : 10:00
LOGGER : Lee Knudtson

DEPTH BELOW SURFACE (FT)	CONSTRUCTION	# BLOWS	LITHOLOGIC LOG	CORE DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
55'		23-50-50+	GW or SW	55' to 55.5' - Small gravel with some coarse sand 55.5' to 56' - Small gravel & sand with some clay 56' to 58.5' - Sand with some clay to gravel (Geochem sample @ 50.5' to 51')	
60'		45-55-55+	GW or SW	60' to 60.5' - Small gravel & some sand to coarse gravel 60.5' to 61' - Small to coarse angular gravel	
65'		45-50-50+	GW or SW	65' to 65.5' - Small to medium gravel 65.5' to 66' - Small to medium gravel with some clay 66' to 66.5' - Small to medium gravel with sand & some clay (Geochem sample @ 65.5' to 66')	
70'		65-65-65+	GC	70' to 70.5' - Sand with medium gravel & some clay 70.5' ot 71' - Sand with some gravel & clay 71' to 71.5' - Sand with small gravel & clay to clay with some sand	
75'				Refusal at 74'	

APPENDIX C

Notice of Applicability for Aquifer Storage and Recovery Permit Enrollment and GSI Application Report

September 24, 2021

Sent Via Electronic Mail

Joe Mueller, Utilities Division Manager
City of Morro Bay Public Works
955 Shasta Ave.
Morro Bay, CA 93442
Email: jmueller@morrobayca.gov

Dear Mr. Mueller:

NOTICE OF APPLICABILITY, ENROLLMENT OF CITY OF MORRO BAY IN WATER QUALITY ORDER 2012-0010, *GENERAL WASTE DISCHARGE REQUIREMENTS FOR AQUIFER STORAGE AND RECOVERY PROJECTS THAT INJECT DRINKING WATER INTO GROUNDWATER*, AND TRANSMITTAL OF MONITORING AND REPORTING PROGRAM NO. R3-2021-0067

Central Coast Regional Water Quality Control Board (Central Coast Water Board) staff reviewed GSI Water Solution Inc.'s April 14, 2021 *Draft Technical Report: Notice of Intent to Enroll in ASR General Order (2012-0010) For Injection Well Testing* and GSI's August 26, 2021 *Draft Injection Testing Work Plan for Groundwater Replenishment and Reuse Project,* submitted on behalf of the City of Morro Bay. According to the information provided, the proposed pilot aquifer storage and recovery (ASR) project meets the conditions of Water Quality Order 2012-0010, *General Waste Discharge Requirements for Aquifer Storage and Recovery Projects that Inject Drinking Water into Groundwater* (General Permit). This letter serves as a notice of applicability for enrollment of a **pilot** ASR project in the General Permit. This letter also includes site-specific requirements and facility information (Attachment 1), your monitoring and reporting program requirements (Attachment 2), a copy of the notice of intent with figures (Attachment 3), and a copy of the injection testing work plan (Attachment 4).

The City of Morro Bay must comply with the following:

1. **General Permit** – The City of Morro Bay must comply with all conditions and requirements of the General Permit. As described in the General Permit, ongoing

operation, maintenance, monitoring, and reporting are required. A copy of the General Permit is available electronically at the following link:

General Permit:
https://www.waterboards.ca.gov/board_decisions/adopted_orders/water_quality/2012/wqo2012_0010_with%20signed%20mrp.pdf

2. **Monitoring and Reporting Program** – The City of Morro Bay must comply with the requirements of Monitoring and Reporting Program No. R3-2021-0067 (Attachment 2).

   Per the Monitoring and Reporting Program, you are required to submit quarterly reports for the first four quarters of operation. These quarterly reports will be due by the **first day of the third month after the quarter.** Your first quarterly report for the October-December quarter is due on **March 1, 2022**.

   In additional to the quarterly reports, annual reports are required by April 1. Your first annual report is due on **March 1, 2022,** and every year afterwards for the duration of this project.

   The City of Morro Bay is required to submit all requested information electronically in a searchable PDF format by email to RB3-WDR@Waterboards.ca.gov using the transmittal sheet found at the link below as the cover page:

   https://www.waterboards.ca.gov/centralcoast/water_issues/programs/wastewater_permitting/docs/transmittal_sheet.pdf

   Additionally, the City of Morro Bay is required to submit reports in a searchable PDF format and laboratory data in EDF format electronically via GeoTracker (see Attachment 2 for instructions). Each monitoring report must include the transmittal sheet found at the link above as the cover page.

3. **Fees** – The City of Morro Bay paid an application fee of $2,848 on May 13, 2021, for coverage in the General Permit. The application fee will be prorated according to the notice of applicability's effective date and the remainder will be applied to next year's annual fee.

   The City of Morro Bay must also pay an annual fee to maintain coverage in the General Permit. Annual fees are determined by the State Water Resources Control Board's fee program and cover the state fiscal year of July 1 through June 30. Your current annual fee is $2,848. A copy of the current state fee schedule is available electronically at the following link:

   https://www.waterboards.ca.gov/resources/fees/water_quality/

Your facility currently is assigned a threat and complexity rating of 3C.

4. **Notification** – The Central Coast Water Board will be notified of your enrollment at a regularly scheduled public meeting on December 9-10, 2021. Details about that meeting are available on our website at:

   http://www.waterboards.ca.gov/centralcoast/board_info/agendas/

5. **Future Discharge Modification** – Pursuant to California Water Code section 13260, you must inform the Central Coast Water Board at least 120 days prior to modifying your discharge. Prior to any modification of your discharge, you must submit a revised notice of intent to the Central Coast Water Board for review and approval that documents proposed changes to the potable water and injection system at the facility. If there are any significant changes in either treatment or disposal methodologies, or the volume or character of the treated wastewater, you must notify the Central Coast Water Board immediately of such changes.

6. **Regulatory Coverage Duration** – Operation of the pilot test must not extend beyond 24 months from the date this notice of applicability is issued.

7. **Responsible Party** – The City of Morro Bay is responsible for the management and disposal of the wastewater in compliance with the conditions of the General Permit. Any noncompliance with this General Permit constitutes a violation of the California Water Code and subjects the City of Morro Bay to enforcement action and/or termination of enrollment under this General Permit.

8. **Change in Ownership** – In the event of any change in control or ownership of the property, the City of Morro Bay must notify the succeeding owner or operator of the existence of this General Permit by letter. A copy of the letter must immediately be forwarded to the Central Coast Water Board so that the new owner or operatory can be enrolled in the General Permit and your enrollment in the General Permit can be terminated.

If you have any questions, please contact Monique Gaido at (805) 549-3150 or **by email at Monique.Gaido@waterboards.ca.gov** or Jennifer Epp at (805) 594-6181 or by email at Jennifer.Epp@waterboards.ca.gov.

Sincerely,

Harvey Packard

Harvey C. Packard
2021.09.24 11:15:02 -07'00'

for Matthew T. Keeling
Executive Officer

Attachments:

1. Site-specific Requirements and Facility Information
2. Monitoring and Reporting Program No. R3-2021-0067
3. Draft Technical Report: Notice of Intent to Enroll in ASR General Order (2012-0010)
4. Injection Testing Work Plan for Groundwater Replenishment and Reuse Project

cc:
Tim Nicely, GSI Water Solutions, tnicely@gsiws.com
Lydia Holmes, Carollo, lholmes@carollo.com
Brynne Weeks, Carollo, bweeks@carollo.com
Monique Gaido, Monique.Gaido@Waterboards.ca.gov
James Bishop, James.Bishop@waterboards.ca.gov
Jennifer Epp, Jennifer.Epp@Waterboards.ca.gov
Sharon Denker, Sharon.Denker@Waterboards.ca.gov
WDR Program, RB3-WDR@Waterboards.ca.gov

MG
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GeoTracker No. = WDR100053984
Rev 4/30/20
ECM Subject Name = INJECTION WELL TESTING – ENROLLMENT IN GENERAL WDR FOR AQUIFER STORAGE AND RECOVERY PROJECTS

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ATTACHMENT 1

SITE-SPECIFIC LIMITS, REQUIREMENTS, AND FACILITY INFORMATION

1. PROJECT DESCRIPTION AND FACILITY INFORMATION

A. The City of Morro Bay intends to conduct a pilot aquifer storage and recovery (ASR) project by injecting potable water into a newly constructed well, Injection Well No. 1, storing the injected water in the Lower Morro Valley groundwater basin, and monitoring changes in water quality and water table elevations at a newly installed monitoring well, 21P-01 (see NOA Attachment 3). In accordance with the requirements of the Statewide General Order 2012-0010, a pilot injection test shall not exceed a length of time of two years. The intent of this project is to assess the feasibility of a permanent groundwater recharge project that would inject advanced purified recycled water. The injectate source water of the ASR pilot will be the City's State Water Project supply, which is treated to drinking water standards at the Polonio Pass Water Treatment Plant, pursuant to the requirements in the district's State Water Resources Control Board Division of Drinking Water (DDW) permit. Facility and ownership information are shown in Table 1.

On May 11, 2021, the City submitted a draft technical report describing the proposed well installation, development and pump-testing, injectate water quality, native groundwater quality, plans for injection, and plans for water quality and sediment sample collection (NOA Attachment 3). On August 26, 2021 the City submitted its *Draft Injection Testing Work Plan for Groundwater Replenishment and Reuse Project* (NOA Attachment 4).

B. ASR Pilot Schedule: The pilot injection test will be performed to obtain site-specific, empirical data that can be used to predict long-term performance, flow rates, number of wells needed, spacing of wells, and potential impacts to water quality. First, Injection Well No. 1 and Monitoring Well 21P-01 will be drilled, installed, and developed according to the proposed workplan (NOA Attachment 3). Pressure transducers will be installed in both the monitoring and the injection wells to monitor pressure, conductivity, and temperature throughout the initial aquifer testing and pilot injection testing. An eight-hour step drawdown test will be performed at Injection Well No. 1, followed by a 24-hour constant rate aquifer test to assess aquifer properties and flow rates for injection testing. To obtain relevant site-specific data while minimizing the potential for adverse water quality impacts, the ASR pilot injection test will be conducted in a stepwise manner. Initially a step injection test will be conducted using discrete flow rates, ranging between 10 to 80 gallons per minute (GPM) for 2-hour periods. Step-test data will be used to determine the optimal injection flow rate for a seven-day constant-rate test. Additional details of the injection testing work plan are presented in NOA Attachment 4. ASR pilot test data will be used to improve the groundwater model, evaluate area of influence, recommend optimal injection rates, and determine the number of wells and spacing of wells for recharge project planning.

Table 1. Facility and ownership information for the City of Morro Bay aquifer storage and recovery pilot project

Facility Name	City of Morro Bay Aquifer Storage and Recovery Project Pilot
Owner and Permittee	City of Morro Bay
Facility Physical Address	955 Shasta Ave, Morro Bay, CA 93442
Owner of Facility	City of Morro Bay
Operator of Facility	City of Morro Bay
Legally Responsible Official of Owner	Joe Mueller
Owner Mailing Address	955 Shasta Ave, Morro Bay, CA 93422
Employee Contact for Owner	Joe Mueller, Water System Manager
Employee Contact Phone	(805) 564-5571
Employee Contact Email	jmueller@morrobayca.gov

C. **ASR Sampling Schedule:** Prior to any injection activities, native groundwater quality samples will be collected from both Injection Well No. 1 and Monitoring Well 21P-01 on the last day of the constant-rate pumping test. During ASR pilot testing, Injection Well No. 1 will be sampled on the first and last day of the constant rate injection test to characterize injectate water quality and groundwater quality. Injection Well No. 1 will be tested weekly for the full suite of testing constituents for four weeks following injection testing to monitor changes in groundwater quality. Groundwater quality will be monitored at Monitoring Well 21P-01 using pressure, conductivity and temperature data obtained by the transducer. If transducer data indicate changes in groundwater quality, samples will be collected at Monitoring Well 21P-01 on the 3rd, 5th and 7th day of the constant-rate injection test and weekly for four weeks after the test completion for a full suite of testing constituents listed in NOA Attachment 4. If transducer data do not indicate changes in groundwater quality, samples will be collected weekly after the injection test has concluded for a reduced list of constituents. Sampling schedule and constituents are detailed in NOA Attachment 4.

D. **Geochemical Sampling and Testing:** Undisturbed sediment samples will be collected from the target aquifer zone at monitoring well 21P-01 for laboratory testing. The objectives of this testing are twofold: 1) to assess the potential for geochemical reactions that could clog the well screens and or soil pores during testing and 2) to assess the potential for adverse groundwater quality in the recovered water. Both native groundwater samples and treated injectate water will be used in the testing. The City of Morro Bay's consultant will also incorporate the USGS geochemical modeling package PHREEQC to investigate potential geochemical reactions occurring as a result of mixing water from two sources with the local aquifer sediments.

2. SITE-SPECIFIC REQUIREMENTS AND LIMITS

A. **Injection Rate Limits:** Maximum injection rate at Injection Well No. 1 must not exceed 350 GPM.

B. **Groundwater Limitations:** The City of Morro Bay must manage the operation to comply with the *Water Quality Control Plan for the Central Coastal Basin*[1] (Basin Plan). Specifically, the city must comply with section 3.3.4, Objectives for Groundwater, which currently includes:

   i. General objectives for tastes and odors and radioactivity for all groundwaters.

   ii. Objectives for municipal/domestic supply including organic chemicals, inorganic chemicals, and radio nucleotides, which are established at the drinking water Maximum Contaminant Levels (MCLs) as defined in California Code of Regulations, title 22, division 4, chapter 15[2].

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[1] The 2019 edition of the Water Quality Control Plan for the Central Coastal Basin can be accessed on the Internet via the following webpage:
https://www.waterboards.ca.gov/centralcoast/publications_forms/publications/basin_plan/docs/2019_basin_plan_r3_complete_webaccess.pdf

[2] Current MCLs are available at:
https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/MCLsandPHGs.html

3. GROUNDWATER BASIN AND AQUIFER TARGET INJECTION ZONE

A. **Groundwater Basin:** Injection will occur into the Lower Morro Valley Groundwater Basin, basin number 3-41 per the numbering convention of the Department of Water Resources. The Basin Plan refers to this groundwater basin as the Morro Valley groundwater subbasin.

B. **Aquifer Target Injection Zone:** Treated surface water will be injected into the Lower Morro Valley Groundwater Basin (LMVGB). The LMVGB consists of two hydrostratigraphic units; both consist of unconsolidated sands and gravels. The target aquifer zone is the older, deeper alluvial aquifer, called the Lower Basin, at 60 to 80 feet below ground surface (bgs). The lower target aquifer is overlain by finer-grained deposits, creating confined conditions. Previous aquifer test results have shown the Lower Basin to have higher permeability than the shallower younger alluvial deposit. GSI's groundwater monitoring data have shown that the basin's major source of recharge is from Morro Creek streambed percolation. Water levels are also influenced by City extraction wells located north of Morro Creek (NOA Attachment 3). Injection Well No. 1 proposed construction includes a screened interval from 60-80 feet bgs, entirely within the Lower Basin. Proposed construction information for Injection Well No. 1 is shown in Table 2. Non-pumping groundwater flow direction is believed to be from northeast to southwest.

Table 2. City of Morro Bay proposed injection well location, well depth, screened intervals, and injection rate

Well name	Latitude	Longitude	Well depth (ft)	Screened interval depths (ft)	Injection Rate (GPM)
Injection Well No. 1	35.375999	-120.85584	90-100	60-80	350

4. INJECTATE WATER QUALITY AND SOURCE

A. **Water Treatment:** The City's primary water source is surface water from the State Water Project, which is sometimes blended with local groundwater. The City obtains State Water Project water from the Central Coast Water Authority's treatment plant located at 10923 Antelope Road, Shandon, San Luis Obispo County. Treatment of injectate water to drinking water standards is the responsibility of the Central Coast Water Authority. Groundwater extracted from the Lower Morro Valley Groundwater Basin will not be used in this pilot study. State Water Project water quality data is shown in Table 3.

B. Injectate Water Quality: According to the information provided, all of the treated water quality constituents of concern (as shown in Table 3) meet primary state and federal drinking water standards. The Basin Plan does not designate Basin-specific water quality objectives for the Lower Morro Valley Groundwater Basin.

5. AMBIENT GROUNDWATER QUALITY

Ambient groundwater quality reported for the City's well field complies with drinking water standards for all constituents except for nitrate and total dissolved solids. These constituents exceed the recommended concentrations for drinking water. The Basin Plan does not specify basin-specific water quality objectives for the Lower Morro Valley Groundwater Basin. Native groundwater quality for select constituents is shown in Table 3.

6. GROUNDWATER QUALITY MONITORING WELLS

A. To verify that injection water is not impairing groundwater quality, the City of Morro Bay will monitor groundwater quality in monitoring well 21P-01, located approximately 80 feet from Injection Well No. 1. The injection well and Monitoring Well 21P-01 will be monitored for temperature, pressure, and conductivity with dedicated transducers throughout the pilot project. Groundwater will be sampled at both locations during the constant rate aquifer test, prior to any injection activities, and weekly for four weeks after injection testing. Well 21P-01 will be drilled and screened entirely within the LMVGB with similar construction to Injection Well No. 1. The proposed location and construction details are summarized in Table 4.

Table 3. Groundwater Limitations, Anticipated Injectate Water Quality, and Native Groundwater Quality

Constituent	Units	Groundwater Limitations	Injectate Concentration[a]	Native Groundwater[b]
Arsenic	µg/L	10[c]	ND	3
Boron	mg/L	0.75[d]	ND	125
Chloride	mg/L	106[e]	73	238
Specific Conductance	µmhos /cm	900[f]	503	1,749
Iron	µg/L	300[g]	No data	No data
Manganese	µg/L	50[g]	No data	No data
Nitrate as N	mg/L	10[c]	ND	15
Sodium	mg/L	69[e]	56	94
Sulfate	mg/L	250[g]	63	127
Total Dissolved Solids	mg/L	500[g]	280	1,175
Haloacetic acids[h]	µg/L	60[c]	13	14.6
Trihalomethanes[i]	µg/L	80[c]	40	35

µg/L = micrograms per liter
mg/L = milligrams per liter
µmhos/cm = micromhos/centimeter
ND = non-detect
NA = not applicable

a. Injectate water data are reported for 2020 in the City of Morro Bay Annual Consumer Confidence Report.
b. Native groundwater data are raw water results taken from all City of Morro Bay groundwater wells as reported in the 2020 City of Morro Bay Annual Consumer Confidence Report. Note that nitrate and dissolved arsenic samples were for 2018.
c. US EPA and California Primary Maximum Contaminant Levels.
d. Central Coast Basin Plan Table 3-2 Water Quality Objectives for Agricultural Use
e. Central Coast Basin Plan Table 3-1. Guidelines for Interpretation of Quality of Water for Irrigation, Specific ion toxicity from foliar absorption.
f. California Code of Regulations, Title 22, Div 4, Chapter 15, Article 16 Recommended consumer acceptance contaminant levels
g. California Code of Regulations, Title 22, Div 4, Chapter 15, Article 16 Secondary Drinking Water Standards
h. Haloacetic acids include bromoacetic acid, chloroacetic acid, dibromoacetic acid, dichloroacetic acid, and trichloroacetic acid.

i. Trihalomethanes include bromodichloromethane, bromoform, chloroform, and dibromochloromethane.

Table 4. Aquifer Monitoring Wells for Groundwater Quality

Well Name	Latitude	Longitude	Distance from Injection Well No. 1 (ft)	Proposed Well Depth (ft)	Proposed Screened Interval (ft bgs)	Aquifer Zone Completed
21P-01	35.37621	-120.855932	80.4	90-100	60-80	LMVGB

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL COAST REGION
895 Aerovista Place, Suite 101
San Luis Obispo, California 93401

MONITORING AND REPORTING PROGRAM NO. R3-2021-0067

for
THE CITY OF MORRO BAY'S
AQUIFER STORAGE AND RECOVERY PILOT PROJECT
SAN LUIS OBISPO COUNTY

This Monitoring and Reporting Program (MRP) describes requirements for monitoring an aquifer storage and recovery pilot project operated by the City of Morro Bay. This MRP is issued pursuant to Water Code section 13267. The City of Morro Bay must not implement any changes to this MRP unless and until a revised MRP is issued by the Central Coast Water Quality Control Board (Central Coast Water Board) Executive Officer.

The City of Morro Bay receives State Water Project water from the Polonio Pass Water Treatment Plant (PPWTP), which is owned and operated by the Central Coast Water Authority. The City of Morro Bay is subject to the Central Coast Water Board's notice of applicability, dated September 24, 2021, for Water Quality Order 2012-0010-DWQ, *General Waste Discharge Requirements for Aquifer Storage and Recovery Projects that Inject Drinking Water Into Groundwater* (General Permit).

1. SUPPLEMENTAL MONITORING AND REPORTING FOR ASR PILOT PROJECT

On August 26, 2021, GSI Water Solutions, Inc. submitted the updated *Draft Injection Testing Work Plan for Groundwater Replenishment and Reuse Project, Morro Bay, California*, which describes a water quality monitoring and reporting program for the ASR pilot testing. The Central Coast Water Board has reviewed and approves the proposed monitoring and reporting program submitted by the City of Morro Bay. The City of Morro Bay must at all times comply with this monitoring and reporting program and to the Draft Injection Testing Work Plan.

2. SAMPLING AND ANALYSIS

Within 90 days after issuance of the notice of applicability, the City of Morro Bay must submit a Sampling and Analysis Plan (SAP) to the Central Coast Water Board for approval. All samples must be representative of the volume and nature of the injected potable water or matrix of materials sampled. The name of the sampler, sample type (grab or composite), time, date, location, bottle type, and any preservative used for each sample must be recorded on the sample chain of custody form. The chain of custody form must also contain all custody information including date, time, and to whom the samples were relinquished. If composite samples are collected, the basis for sampling (time or flow weighted) must be approved by the Central Coast Water Board. Unless otherwise specified, sampling must be performed as specified in Table 1.

Table 1. Sampling Schedule

Monitoring Period	Sample Collection Month
Monthly	Each Calendar Month
Quarterly	February, May, August, November

Field instruments (such as those used to test pH, dissolved oxygen, and electrical conductivity) may be used provided that they are operated by a State Water Board California Environmental Laboratory Accreditation Program (ELAP) certified laboratory, or each of the following requirements are met:

1. The operator is trained in the proper use of the instrument;
2. The instruments are field calibrated prior to each use;
3. Instruments are serviced and/or calibrated by the manufacturer at the recommended frequency; and
4. Field calibration reports are submitted as described in the "Reporting" section of this MRP.

3. INJECTION WELL MONITORING

Injection wells must be monitored when water is being injected into the aquifer. Monitoring of the injection wells must include the constituents and parameters shown in Table 2. Injection wells to be monitored are shown in Table 3.

Table 2. Injection Well Monitoring

Parameter	Units	Type of Sample	Sampling Frequency
Well Operational Status	N/A	Recorded	Daily
Daily Average Injection Rate	gpd	Meter	Continuous
Injected Water, cumulative total for year to date	ac•ft/yr	Meter	Continuous
Extracted Water, cumulative total for year to date	ac•ft/yr	Meter	Continuous

Parameters must be reported for each well associated with the ASR project.
Injection activity must be recorded daily.
N/A = not applicable
gpd = gallons per day
ac•ft/yr = acre-feet per year

Table 3. Proposed Injection Well to be Monitored

Well name	State Well ID	Latitude	Longitude	Well depth (feet)	Screened interval depth (feet)
Injection Well No. 1	Not yet issued	35.375999	-120.855744	90-100	60-80

4. INJECTED WATER MONITORING

Injected water quality must be monitored at the wellhead inflow line when water is being injected into the aquifer. Monitoring of the injection well must include the constituents and frequencies shown in Tale 4. Sampling events will be timed according to injection activities as described in NOA Attachment 4. The sampling schedule includes four weekly sampling events following the injection testing at both the injection well and the monitoring well. If transducer data indicate changes in groundwater quality at the monitoring well, additional sampling during the aquifer test will occur as described in NOA Attachment 4. If transducer data do not show changes in groundwater quality at the monitoring well, weekly testing following the injection test will occur at the monitoring well for a reduced list of constituents as specified in NOA Attachment 4. If the City of Morro Bay chooses to continue injection testing activities, the City may request an alternative reduced frequency sampling schedule for injected water quality.

Table 4. Injection Water Monitoring

Constituent/Parameter	Units	Type of Sample	Sampling Frequency[a]
Dissolved Oxygen	mg/L	Meter	Quarterly
ORP	mV	Meter	Quarterly
pH	pH units	Meter	Quarterly
Specific Conductance	µmhos/cm	Meter	Quarterly
Arsenic (dissolved)	µg/L	Grab	Quarterly
Iron (dissolved)	µg/L	Grab	Quarterly
Manganese (dissolved)	µg/L	Grab	Quarterly
Nitrate (as Nitrogen)	mg/L	Grab	Quarterly
Total Dissolved Solids	mg/L	Grab	Quarterly
Haloacetic acids	µg/L	Grab	Quarterly
Trihalomethanes	µg/L	Grab	Quarterly

[a] Injected water sampling is not required for any monitoring period during which injection did not occur.

mg/ L = milligrams per liter

ORP = oxidation-reduction potential

mV = millivolts
μg/L = micrograms per liter

5. EXTRACTION WELL MONITORING

The City of Morro Bay's injection well will also serve as an extraction well. An extraction well must be monitored if either of the following conditions apply:

1. An extraction well was used for injection the previous calendar year
2. An extraction well that is pumping a substantial amount of previously injected water

After four sampling events consistent with the frequencies described in this MRP, the City of Morro Bay may request annual extraction well monitoring. Monitoring of each extraction well must include the constituents and parameters shown in Table 5.

Table 5. Extraction Well Monitoring

Constituent/Parameter	Units	Type of Sample	Sampling Frequency[c]
Well Activity[a]	N/A	Recorded	Daily
Daily Average Pumping Rate	gpd	Meter	Continuous
Extracted Water/Year[b]	ac•ft/yr	Meter	Continuous
Specific Conductance	μmhos/cm	Meter	Quarterly
Arsenic (dissolved)	μg/L	Grab	Quarterly
Iron (dissolved)	μg/L	Grab	Quarterly
Manganese (dissolved)	μg/L	Grab	Quarterly
Nitrate (as Nitrogen)	mg/L	Grab	Quarterly
Total Dissolved Solids	mg/L	Grab	Quarterly
Haloacetic acids	μg/L	Grab	Quarterly
Trihalomethanes	μg/L	Grab	Quarterly

[a] - Well Activity must be reported for all wells associated with the ASR project. Injection/extraction activity must be recorded on a daily basis.
[b] - Extracted Water/Year represents the total amount of water extracted from a well for the calendar year.
[c] - Extracted water sampling is not required for any quarter during which extraction did not occur.
μmhos/cm = micromhos per centimeter

6. AQUIFER MONITORING FOR GROUNDWATER QUALITY

To verify that injection water is not impairing groundwater quality, the City will monitor groundwater quality at one monitoring well before, during, and after this ASR pilot project. The installation and development of the injection and monitoring well pair will occur in the initial phase of this pilot test project. The monitoring well and corresponding injection well are shown in Table 6.

Table 6. Aquifer Monitoring Wells for Water Quality

Monitoring Well Name	Latitude	Longitude	Injection Well Name	Distance from Injection Well (ft)	Well Depth (ft)	Screened Intervals (ft bgs)
21P-01	35.37621	-120.855932	Injection Well No. 1	80.4	90-100	60-80

All aquifer monitoring samples must be collected using approved EPA methods. Groundwater elevations must be measured to determine injection-related drawup and radius of hydraulic influence for each injection well as well as regional groundwater gradient and direction of flow.

Prior to sampling, the groundwater elevations must be measured as described in section 7 below, and the wells must be purged of at least three well casing volumes until temperature, pH, and electrical conductivity have stabilized. Use of low flow or passive sampling methods that do not require well purging are acceptable if described in the approved SAP. Samples must be filtered using a 0.45-micron filter for dissolved constituents such as metals. Groundwater monitoring must include the constituents and frequencies described in Table 7. Groundwater quality monitoring must be conducted in accordance with Table 7 for each quarter that injection testing has occurred.

7. REPORTING

In reporting monitoring data, the City of Morro Bay must arrange the data in tabular form so that the date, sample type (e.g., source water, injection well, extraction well, etc.), and reported analytical result for each sample are readily discernible. The data must be summarized in such a manner to clearly illustrate compliance with the General Permit, notice of applicability (NOA), and Basin Plan. The results of any monitoring done more frequently than required at the locations specified in this MRP must be reported in the next scheduled monitoring report.

As required by the California Business and Professions Code sections 6735, 7835, and 7835.1, all groundwater monitoring reports must be prepared under the supervision of a registered professional engineer or geologist and signed by the registered professional.

Table 7. Aquifer Monitoring Parameters and Constituents for Groundwater Quality

Constituent/Parameter	Units	Type of Sample	Sampling Frequency[c]
Groundwater Depth	Feet	Measuring Tape	Quarterly
Groundwater Elevation	Feet NAVD88	Recorded	Quarterly
Specific Conductance	µmhos/cm	Meter	Quarterly
Dissolved Oxygen	mg/L	Meter	Quarterly
ORP	mV	Meter	Quarterly
pH	pH units	Meter	Quarterly
Arsenic (dissolved)	µg/L	Grab	Quarterly
Iron (dissolved)	µg/L	Grab	Quarterly
Manganese (dissolved)	µg/L	Grab	Quarterly
Nitrate (as Nitrogen)	mg/L	Grab	Quarterly
Total Dissolved Solids	mg/L	Grab	Quarterly
Haloacetic acids	µg/L	Grab	Quarterly
Trihalomethanes	µg/L	Grab	Quarterly

A letter transmitting monitoring reports must accompany each report. The letter must summarize the numbers and severity of violations found during the reporting period, and actions taken or planned to correct the violations and prevent future violations. The transmittal letter must contain the following penalty of perjury statement and must be signed by the Administrator or the Administrator's authorized agent:

> "I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of the those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment."

The transmittal letter can be accessed via the following website:
https://www.waterboards.ca.gov/centralcoast/water_issues/programs/wastewater_permitting/docs/transmittal_sheet.pdf

A. QUARTERLY MONITORING REPORT

The City of Morro Bay must **submit quarterly monitoring reports** for the first year of operation and annually thereafter. The monitoring period and corresponding report due date are described in Table 8. Quarterly monitoring reports must be submitted to the Central Coast Water Board by the **1st day of the third month after the quarter.** Quarterly reporting must occur in accordance with Table 8.

Table 8. Quarterly Reporting Schedule

Report	Monitoring Period	Report Due Date
First Quarter	January 1 to March 31	June 1
Second Quarter	April 1 to June 30	September 1
Third Quarter	July 1 to September 31	December 1
Fourth Quarter	October 1 to December 31	March 1

The quarterly monitoring report must include the following:

1. A discussion of compliance with the general order and a description of any violations.

2. A discussion of the status (dates of injection, extraction, storage, and idle time) for all extraction/injection wells associated with the ASR project.

3. A narrative description of all preparatory, monitoring, sampling, and analytical testing activities for the injection, extraction, and groundwater monitoring. The narrative must be sufficiently detailed to verify compliance with the General Permit, the NOA, this MRP, and the Standard Provisions and Reporting Requirements. The narrative must be supported by field logs for each monitoring well documenting depth to groundwater; parameters measured before, during, and after purging; method of purging; calculation of casing volume; and total volume of water purged.

4. Calculation of groundwater elevations, an assessment of groundwater flow direction and gradient on the date of measurement, comparison of previous flow direction and gradient data, and discussion of seasonal trends, if any.

5. Calculation of maximum groundwater drawup and maximum hydraulic radius of influence for each injection well.

6. Results of groundwater monitoring (analytical results tabulated with reporting limits for nondetectable results).

7. A narrative discussion of the analytical results for all groundwater locations monitored including spatial and temporal trends, with reference to summary data tables, graphs, and appended analytical reports (as applicable).

8. A comparison of monitoring data to the groundwater limitations presented in the NOA and an explanation of any violation of those requirements. Any other violation of the General Permit with explanation and corrective action to prevent future violations.

9. Summary data tables of historical and current groundwater elevations and analytical results.

10. A scaled map showing relevant structures and features of the facility, the locations of monitoring wells and any other sampling stations, and groundwater elevation contours referenced to mean sea level datum.

11. Copies of laboratory analytical report(s) for groundwater monitoring.

12. The Central Coast Water Board executive officer may modify the reporting requirements by issuing a revised MRP at any time.

B. ANNUAL MONITORING REPORT

The annual monitoring report must be submitted to the Central Coast Water Board by **March 1** each year, in accordance with Table 9.

Table 9. Annual Reporting Schedule

Report	Monitoring Period	Report Due Date
Annual Report	January 1 to December 31	March 1

The first year's annual monitoring report must summarize the first four quarters of reporting. Each annual monitoring report after the first year must include all the components that are required of quarterly monitoring reports. In addition, all annual reports must include the following:

1. **Water Quality and Public Health Goal Report**
   The annual water quality report and public health goal report published during the calendar year (if required by the Division of Drinking Water).

2. **Data Tables and Graphs**
   Tabular and graphical summaries of all monitoring data collected during the year.

3. **ASR Project Activity**
   Projected ASR project activity for the next calendar year.

4. **Compliance and Performance Discussion**
   - A discussion of compliance and corrective actions taken, as well as any planned or proposed actions needed to bring the discharge into full compliance with the General Permit and/or the notice of applicability.
   - An evaluation of water treatment facilities' performance, including concentration of the main pollutants (boron, chloride, sulfate, etc.) over time, nuisance conditions, system problems, etc.
   - An evaluation of treatment.
   - Note any changes or upgrades that were made over the past year (or need to be made) to the treatment plant to improve performance.
   - Groundwater elevation maps, flow direction, and concentration contours.

8. ELECTRONIC SUBMITTAL

The City of Morro Bay must submit all requested information electronically in a searchable PDF format using the transmittal sheet found in the link below as the cover page.

https://www.waterboards.ca.gov/centralcoast/water_issues/programs/wastewater_permitting/docs/transmittal_sheet.pdf

Electronic submittals should be made to the State Water Resources Control Board's GeoTracker[3] database for the City of Morro Bay's aquifer storage and recovery project in San Luis Obispo County, GeoTracker No. WDR100053984. This information must be submitted via the internet at:

http://www.waterboards.ca.gov/ust/electronic_submittal/index.shtml

Table 10 below summarizes all the electronic reporting requirements. Staff may request submittal of some documents on paper, particularly drawings or maps that require a large size to be readable, or in other electronic formats where evaluation of data is required.

[3] Information for first-time GeoTracker users is available here:

https://www.waterboards.ca.gov/ust/electronic_submittal/docs/beginnerguide2.pdf

Table 10. GeoTracker Electronic Submittal Information (ESI) Data Requirements

Electronic Submittal	Description of Action	Action	Frequency
Reports and Documents	Complete copy of all documents including monitoring reports (in searchable PDF format) and any other associated documents related to the facility.	Upload directly to GeoTracker all monitoring reports (in searchable PDF format) and any other associated documents.	On or before the due dates required by this General Permit and for other documents when requested by Central Coast Water Board staff.
Laboratory Data	All analytical data (including geochemical data) in electronic deliverable format (EDF). This includes all water samples collected when monitoring.	Direct your State Certified Laboratory staff to upload all laboratory data directly to GeoTracker.	On or before the due date of the required monitoring report.
Location Data (Geo XY)	Survey and mark all permanent sampling locations (i.e., monitoring wells, drinking water wells, and permanent injection source water sampling locations). These data points are required prior to laboratory data uploads.	Upload the survey data to the GeoTracker Geo_XY file.	Every time a permanent monitoring point is established.
Depth to groundwater	Monitoring wells must have the depth-to-water information reported.	Upload depth-two-water information to the GeoTracker GEO_WELL file.	On or before the due date of the required monitoring report.
Elevation data (Geo Z)	Survey and mark the elevation at the top of the groundwater well casing for all permanent groundwater wells. These points are required prior to depth-two-water data uploads.	Upload the survey data to the GeoTracker GEO_Z file.	One-time, for all groundwater monitoring wells.
Geo Map	Site layout, map of facilities, potable water treatment system, and disposal area(s).	Upload the Site layout PDF to the GeoTracker site plan file.	Year one and every five years thereafter and when the facilities are modified.

9. LEGAL REQUIREMENTS

Water Code section 13267 states, in part:

> "In conducting an investigation specified in subdivision (a), the regional board may require that any person who has discharged, discharges, or is suspected of having discharged or discharging, or who proposes to discharge waste within its region, or any citizen or domiciliary, or political agency or entity of this state who has discharged, discharges, or is suspected of having discharged or discharging, or who proposes to discharge, waste outside of its region that could affect the quality of waters within its region shall furnish, under penalty of perjury, technical or monitoring program reports which the regional board requires. The burden, including costs, of these reports shall bear a reasonable relationship to the need for the report and the benefits to be obtained from the reports. In requiring those reports, the regional board shall provide the person with a written explanation with regard to the need for the reports, and shall identify the evidence that supports requiring that person to provide the reports."

Water Code section 13268 states, in part:

> "(a) Any person failing or refusing to furnish technical or monitoring program reports as required by subdivision (b) of section 13267, or failing or refusing to furnish a statement of compliance as required by subdivision (b) of section 13399.2, or falsifying any information provided therein, is guilty of a misdemeanor and may be liable civilly in accordance with subdivision (b).
>
> (b)(1) Civil liability may be administratively imposed by a regional board in accordance with article 2.5 (commencing with section 13323) of chapter 5 for a violation of subdivision (a) in an amount which shall not exceed one thousand dollars ($1,000) for each day in which the violation occurs."

The burden and cost of preparing the reports is reasonable and consistent with the intent of the state in maintaining water quality. These reports are necessary to ensure that the City of Morro Bay complies with the NOA and General Permit. Pursuant to Water Code section 13267, the City of Morro Bay must implement this MRP and must submit the monitoring reports described herein.

The City of Morro Bay must implement the above monitoring program as of the effective date of enrollment in the General Permit.

Ordered by:

Harvey Packard Harvey C. Packard
Water Boards 2021.09.24 11:16:42 -07'00'

for Matthew T. Keeling
Executive Officer

MG
ECM/CIWQS Place = 868768
GeoTracker No. = GT-WDR100053984
ECM Subject Name = City of Morro Bay NOA Order WQ 2012-0010 pilot

R:\RB3\Shared\WDR\WDR Facilities\San Luis Obispo Co\City of Morro Bay IPR and ASR\City of Morro Bay ASR pilot\NOA for ASR GO - Pilot Test\Morro_Bay_NOA_ASR_Pilot_final.docx

ATTACHMENT 3

DRAFT TECHNICAL REPORT

City of Morro Bay

Notice of Intent to Enroll in ASR General Order (2012-0010) for Injection Well Testing

City of Morro Bay Groundwater Replenishment and Reuse Project

April 14, 2021

Prepared by:
GSI Water Solutions, Inc.
418 Chapala Street, Suite H, Santa Barbara, CA 93101

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Abbreviations and Acronyms

µg/L	microgram per liter
AFY	acre-feet per year
Basin	Morro Valley Groundwater Basin
bgs	below ground surface
BWRO	Brackish Water Reverse Osmosis
CCRWQCB	Central Coast Regional Water Quality Control Board
CEQA	California Environmental Quality Act
COC	chemical of concern
DDW	California Department of Drinking Water
DTSC	California Department of Toxic Substances Control
EIR	environmental impact report
ft	feet
GRRP	Groundwater Replenishment Reuse Project
GSI	GSI Water Solutions, Inc.
in	inches
IPR	indirect potable use
LUC	land use covenant
LUST	leaking underground storage tank
MBMWC	Morro Bay Mutual Water Company
MBTE	methyl tertiary butyl ether
MCL	maximum contaminant level
mg/L	milligram per liter
NAVD88	North American Vertical Datum of 1988
PCA	potentially contaminating activity
PG&E	Pacific Gas and Electric
PHG	public health goal
ROWD	Report of Waste Discharge
RWQCB	California Regional Water Quality Control Board
SMP	soil management plan
SWRCB	California State Water Resources Board
TDS	total dissolved solids
THM	trihalomethanes
TPH	petroleum hydrocarbon
UST	underground storage tank
WQ	water quality
WRF	water recycling facility

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SECTION 1: **Project Overview**

1.1 Background

The City of Morro Bay (City) is seeking permitting compliance from the California Regional Water Quality Control Board (RWQCB) for injection testing at a new injection well proposed to be installed on City-owned property within the Lower Morro Groundwater Basin in the vicinity of the City's existing production wells. GSI Groundwater Solutions, Inc. (GSI), is supporting the City with permitting and installation of the planned indirect potable use (IPR) project. The installation and operation of a series of injection wells is planned and will comply with the Groundwater Replenishment Reuse Project (GRRP) regulations for subsurface application.

Results of injection testing will provide diagnostic information of injection rates at the first injection well currently planned for this project. The installation of a nearby monitoring well (21P-01) will also be conducted as part of this effort. Injection testing will be conducted at the proposed Injection Well No. 1 site, located on vacant property along the west side of Highway 1, as shown on Figure 1.

To date, GSI has conducted hydrogeologic evaluations and modeling in support of the City's goal of establishing an IPR project. After consideration of cost-effective alternative uses of the highly treated recycled water to enhance the City's water supply from the new water recycling facility (WRF) currently under construction, two areas were evaluated for the planned IPR project. These areas are referred to as the Narrows Project Area (east of Highway 1, along Morro Creek), and the Western Project Area (west of Highway 1, also along Morro Creek). Both are located within the lower Morro Valley Groundwater Basin. The Western Project Area was selected as the preferred location.

Subsequent hydrogeologic assessments, including field characterization and groundwater modeling, support the selection of the Western Project Area (Figure 1). The water supply for the IPR project will be highly treated recycled water from the WRF, which will include the advanced treatment steps of microfiltration, reverse osmosis, and ultraviolet light advanced oxidation to produce purified effluent that meets the California State Water Resources Board's (SWRCB's) GRRP regulations. The water from the WRF will be conveyed to the several planned injection wells for subsurface application. Preliminary modeling has indicated that the requirement for adequate retention time, in compliance with the GRRP requirements, can be met prior to extraction at the City's production wells. Geochemical mixing analysis will also be conducted to assess the potential for any adverse reactions associated with the proposed injection.

The proposed WRF will be completed in 2023. The source water for injection testing at Injection Well No. 1 will be supplied from the City of Morro Bay's treated drinking water supply system, using the City's State Water supply (rather than groundwater pumped from the City's groundwater wells. Using the City's State Water Project water will more closely represent the conditions expected under full-scale IPR operations.

1.2 Statement of Intent

As part of this project, this technical report provides the data and information necessary to complete the Notice of Intent to comply with the terms and conditions of the SWRCB Water Quality (WQ) Order 2012-0010 (General Waste Discharge Requirements for Aquifer Storage and Recovery Projects that Inject Drinking Water into Groundwater). The purpose of this report is to demonstrate the compliance by the City of Morro Bay with the General Waste Discharge Requirements in WQ Order 2012-0010 to test a single injection well (Injection Well No. 1) in the lower portion of the Morro Valley Groundwater

Basin in the vicinity of the City's existing production wells. This report also provides additional information needed to describe and characterize the IPR project and anticipated effects on groundwater quality (Attachment C of the Order).

1.3 Public Outreach and Coordination

As part of the permitting required for a GRRP, there will be a Report of Waste Discharge (ROWD) prepared for submittal to RWQCB.

As part of the ROWD and GRRP approval process, there are public outreach and notification requirements to be followed. In compliance with the anticipated ROWD, the City will (1) provide notification via U.S. Postal Service mail to the owners of record for properties adjacent to injection well site and area, (2) include notification of the project via the City monthly newsletter to its customers, and (3) give two presentations at City Council meetings. The City will use the newsletters and meetings to provide project updates and notify interested parties of changes in operation. Newsletters are also available online and via free subscription. The City's community outreach activities include updates to its website to provide information on water quality, water supply, and relevant topics that may affect customers.

SECTION 2: **Hydrogeologic Setting**

2.1 Morro Valley Groundwater Basin

The Morro Valley Groundwater Basin (Basin) (DWR Bulletin 118 basin 3-41) is a shallow alluvial basin that encompasses approximately 1.9 square miles and is bounded on the west by the Pacific Ocean and surrounded and underlain on all other sides by consolidated and impermeable rocks of the Franciscan Complex (Jurassic to Cretaceous age). The Basin is further divided into lower and upper parts by a restriction in the valley commonly referred to as the Narrows, located approximately 1,000 feet (ft) east of Highway 1, where the alluvium underlying Morro Creek is constrained by the bedrock to a narrow corridor about 300 ft wide. The principal water-bearing units in the Lower Basin are younger alluvium, dunes sand, and Holocene- and Pleistocene-aged terrace deposits that extend approximately 60 to 80 ft beneath the valley floor. Two aquifer zones (shallow and deep) have been identified within the Lower Basin sediments (Brown and Caldwell, 1981; Cleath, 1993).

Groundwater monitoring conducted by GSI for the proposed project refined the inflow and outflow of the existing water conditions in the groundwater basin (GSI, 2017). The primary source of recharge to the Lower Basin is mostly from Morro Creek streambed percolation. Morro Creek is predominantly a losing stream (i.e., water in the creek is usually percolating down into and recharging the underlying aquifer). However, during wet periods, portions of Morro Creek can become a gaining stream (i.e., water from the underlying aquifer rises up enough to discharge into the stream and support its flow). The volume of Morro Creek percolation is believed to be partly affected by City pumping from its existing wells. The higher the rate of pumping, the more water Morro Creek loses to the aquifer, because groundwater levels decrease and do not support the creek flow.

Aquifer testing on existing wells conducted during GSI modeling studies for the GRRP revealed that the aquifer has a large contrast in permeability between the upper (shallow) and lower (deep) aquifers, with the lower aquifer being more permeable than the upper aquifer.

2.2 Target Aquifer Zones

Recent alluvial deposits are the primary water-bearing unit in the Lower Morro Valley Basin and are composed primarily of unconsolidated sand, silt, and clay. The hydrostratigraphy of the Lower Basin has been divided into hydrostratigraphic zones based on data from geologic and geophysical logs. The zones that produce meaningful amounts of groundwater include a younger shallow alluvial aquifer and an older deep alluvial aquifer, both of which consist of well-graded sand and gravels. The deep alluvial aquifer is typically overlain by finer sediments ranging from clayey silt to silty clay, creating confining conditions in the Lower Basin area (B&C, 1981). The target aquifer zone (approximately 60 to 80 ft below ground surface [bgs]) for the injection testing of Injection Well No. 1 (and for future injection wells will be the deep alluvial aquifer. As discussed above, modeling of these two sub-aquifer units favors the deep alluvial aquifer for injection purposes (because of its higher permeability and higher hydraulic conductivity values).

2.3 Area of Hydrologic Influence

Planned injection wells for the proposed IPR project will be distributed along the southern boundary of the Western Project Area. Predictive numerical modeling scenarios performed by GSI suggest the area of hydrologic influence during full-scale injection operations will predominantly cover the areas between the planned injection wells and the City's existing wells to the north. Figures 2a and 2b were adapted from GSI's January 2021 technical memorandum, *Characterization and Selection of Project Area for Injection Testing*, and show the modeled heads and particle tracking results for the pumping scenario of baseline pumping (pumping 581 AFY from the City's 7 existing production wells) plus 75 percent of total injection volume (1,200 acre-feet per year [AFY]) from planned injection wells during dry and wet conditions. The extent of hydrologic influence will depend on the duration, volume, and frequency of future injection. For injection testing, the area of hydrologic influence is anticipated to be much smaller than the full-scale project, and will likely not extend outside those areas of influence at full-scale injection operations, as shown on Figures 2a and 2b.

2.4 Land Use

Current land use in the Western Project Area (area of planned injection for the initial injection well and testing) of the Lower Basin is undeveloped and covers an area of approximately 17 acres. The Western Project Area is essentially flat and centrally located relative to the City's infrastructure. The Western Project Area is adjacent to the currently planned alignment of the forthcoming recycled water pipeline. The Western Project Area is also adjacent to (north of) the former Morro Bay Power Plant (Power Plant) site (shown by a light blue triangle on Figure 4). Portions of the adjacent former Power Plant site are going through land use covenant (LUC) procedures associated with its closure by the California Department of Toxic Substances Control (DTSC). This proposed LUC procedure would restrict some areas of the former Power Plant site outside of the project area to future commercial/industrial uses. The Western Project Area is not located within these areas and therefore is not subject to the forthcoming LUC. This is discussed in more detail in Section 3.3.

The existing land use designations for the proposed injection well area (i.e., the Western Project Area) and surrounding areas are depicted in Figure 3.

SECTION 3: **Regional Groundwater Conditions**

3.1 Groundwater Elevations

Groundwater elevation data for three of the City's existing production wells (Well MB-4, Well MB-14, and Well MB-15) located near the proposed injection area reveal that static (non-pumping) water elevations for these three wells have fluctuated between a high of about 20 ft above mean sea level to a low of about 15 ft below mean sea level (GSI, 2017) during the period of observed data between 1994 and 2016. Water levels tend to be at their highest each year during the wet winter months when rainfall recharge is higher, and deepest during the dry summer months when rainfall recharge is limited. Water levels generally appear to recover each year; no significant declines in water level were apparent.

Groundwater movement in the Lower Basin is largely controlled by the City wells. Pumping from the City wells develops a water level depression that slopes radially towards the City wells, and can include seawater during drought (Cleath, 2007). The regional groundwater gradient is generally from northeast to southwest. During non-pumping periods, groundwater flows below the Narrows toward the coast at a nominal hydraulic gradient of 0.005 ft/ft (Aqui-Ver, 2005). This gradient reflects the migration of water from the recharge areas mostly in the areas above the Narrows toward the areas where significant pumping occurs in the Lower Basin.

In December 2018, GSI installed 11 pressure transducers in existing City production and desalination wells for the purpose of long-term groundwater elevation monitoring. This work was completed in support of the IPR project proposed for the City. The transducers are programmed to measure water pressure (convertible to water level), temperature, and specific conductivity (convertible to chloride concentration) every 4 hours to document aquifer water levels and quality. The data will also provide warning of any potential seawater intrusion.

3.2 Groundwater Quality Trends and Constituents of Concern

General water quality data collected from City water supply production wells between 2011 and 2015 are summarized in Table 1, along with California Department of Drinking Water (DDW) maximum contaminant levels (MCLs), including primary and secondary drinking water standards; and public health goals (PHGs) (MKN, 2017)[10]. More recent water quality results for the City's existing wells (i.e., the average and range of detections) as presented in the City's *Annual Water Quality Report 2019* (City of Morro Bay, 2020) are also shown on Table 1. The data indicate nitrates and seawater intrusion are the predominant concerns for water quality (MKN, 2017; MNS, 2016).

Nitrate levels are elevated due to agricultural application of nitrogen fertilizers in the watershed, which is restricting the City's ability to use groundwater as a potable water supply. In the past 20 to 30 years, pumpage has been significantly reduced from its permitted amount due in part to elevated nitrate concentrations observed in groundwater pumped from City wells. Historically, Basin wells have experienced elevated nitrate concentrations as high as 110 milligrams per liter (mg/L) as nitrate (MKN, 2017). The current primary MCL for nitrate (as nitrogen) is 10 mg/L for potable domestic use; nitrate also has a PHG of 10 mg/L. Periodically, high iron (which has a secondary MCL of 300 micrograms per liter [μg/L]) and manganese (with a secondary MCL of 50 μg/L) levels have

[10] Table 1 has been adapted from the *Morro Bay Water Reclamation Facility Draft Environmental Impact Report* (ESA, 2018) and from the *Annual Water Quality Report 2019* (City of Morro Bay, 2020).

also been detected. To meet MCLs, the City operates a brackish water reverse osmosis facility that treats water pumped for potable use from the City's Well Field.

In general, under natural conditions, the seaward movement of freshwater prevents seawater from encroaching on coastal aquifers (USGS, 2018). An interface between freshwater and seawater is maintained with denser seawater underlying freshwater. When groundwater is pumped from a coastal aquifer, lowered water levels can cause seawater to be drawn toward the freshwater zones of the aquifer. The intruding seawater decreases the freshwater storage in the aquifers. In the mid-1980s, total dissolved solids (TDS) concentrations in groundwater downstream of the Narrows near Highway 1 began to exceed 1,000 mg/L seasonally due to seawater intrusion and tidal influences (MNS, 2016).

In 2007, TDS concentrations in the Basin were typically between 400 and 800 mg/L and increasing toward the coast, except for an area beneath agricultural fields in the lower valley where TDS concentrations reached 1,000 mg/L, and nitrate concentrations reached 220 mg/L as nitrate (MNS, 2016). Groundwater wells in the Basin have experienced elevated levels of salinity during dry periods, with TDS levels as high as 4,000 mg/L, exceeding the secondary MCL of 1,000 mg/L by factor of four.

Historical data and groundwater modeling indicate that the City's wells are at risk of seawater intrusion if the full permitted pumpage is produced with no corresponding injection. Predictive modeling scenarios indicate that an injection well layout in the Western Project Area would mitigate against seawater intrusion during pumping of City wells. Predictive nitrate modeling scenarios indicate that, during combined IPR injection and City pumping, all City wells will have improved water quality over time with significantly lower nitrate concentrations.

3.3 Contamination

A preliminary inventory of past and current potentially contaminating activities (PCAs) was compiled using readily available data for the proposed injection well field. An initial assessment was performed using the RWQCB GeoTracker website, which provides a compilation of environmentally impacted sites, and is also linked to the DTSC EnviroStor website that shows sites for cleanup, land disposal, waste permits, permitting underground storage tanks (USTs), and leaking underground storage tanks (LUSTs).

Figure 4, Potentially Contaminating Activity Sites, shows the locations of PCAs in the general area of the proposed injection area. The GeoTracker and EnviroStor websites show there are four closed LUST sites with a half-mile radius of the Western Project Area. The sites listed gasoline and/or diesel as the "potential contaminant of concern" and generally listed groundwater as the "potential media of concern." At these four closed LUST sites, cleanup actions have been completed and the case has been closed by that lead agency. All four sites, delineated by red squares with an "X" through them, are located east of Highway 1, as shown on Figure 4.

In 1999, methyl tertiary butyl ether (MTBE) was discovered in groundwater in the Basin, and in 2000, SWRCB issued an order prohibiting the use of the City's five Lower Basin wells. The source of the MTBE was found to be the Shell gasoline service station on Main Street at Highway 41; this site is more than 1,500 ft northeast of the proposed injection area, as well as northeast of the City's wells that will recover the injected water. The Central Coast Regional Water Quality Control Board (CCRWQCB) required the Shell service station owner to install monitoring wells and to conduct groundwater and soil sampling. Subsequent investigations confirmed the MTBE contamination originated from this Shell service station. The USTs and gasoline-impacted soils beneath the USTs were removed from the location in January 2002. The owner implemented extensive remedial actions after the discovery of the contamination, which included the excavation of contaminated soil, addition of an oxygen-releasing compound to the UST excavation backfill, soil vapor extraction, and onsite and offsite groundwater extraction and treatment. Extensive monitoring conclusively demonstrated that the City's Well Field was never impacted, even prior to MTBE plume stabilization. On September 26, 2008, RWQCB sent a case closure letter to Shell Oil Company and the City's municipal water supply wells were reinstated for use as a safe water supply for Morro Bay residents.

The Morro Bay Power Plant, located on property south and adjacent to the proposed injection area (Figure 4) was a power generation facility that started producing power in the 1950s under the ownership of Pacific Gas and Electric (PG&E), and was subsequently acquired by Duke Energy in 1998, LS Power in 2006, and Dynegy in 2007. In 2014, operations at the Power Plant ceased, and the plant was shut down. The site was sold in 2018 to Vistra Energy, which currently owns the approximately 90-acre property.

Various environmental investigations have been conducted at the Power Plant since the 1990s. Human health and ecological risk assessments initially identified the chemicals of concern (COCs) in soil and shallow groundwater as petroleum hydrocarbons (TPH) and arsenic, concentrations of which were above commercial screening levels. Subsequent groundwater monitoring evaluations were performed on the Power Plant via sampling from several monitoring wells. The DTSC-approved human health and ecological risk assessment concluded that constituents in groundwater at the site do not pose unacceptable risks to ecological or human health receptors and further evaluation was not warranted (Jacobs, 2018). A request for termination of the groundwater monitoring program on the Vistra site was approved by DTSC in January 2019.

The corrective action objectives and proposed final remedy for the Vistra site recommends that LUC be recorded to address total petroleum hydrocarbons and arsenic at the site in soil and groundwater. The LUC would restrict land use and groundwater uses on the Vistra site and would require a soil management plan (SMP) to verify soil at the site will be managed in the manner protective of human health and the environment. In addition, annual inspections would occur to verify the protectiveness of the remedy over time (DTSC, 2020).

Groundwater flow is generally from northeast to southwest across the site, and thus away from the proposed injection area for the City towards the Pacific Ocean.

3.4 Basin Plan Management Goals and Objectives

The RWQCB regulates GRRPs under numerous state laws and regulations, including the *Water Quality Control Plan for the Central Coast Basin* (Basin Plan) (Central Coast RWQCB, 2019) and SWRCB policies. The Basin Plan includes water quality objectives for municipal and domestic supply groundwater supplies, including the following:

- **Taste and odors:** shall not adversely affect beneficial uses
- **Bacteria:** <2.2/100 milliliter median concentration over any 7-day period
- **Organic chemicals:** shall not exceed MCLs
- **Inorganic chemicals (trace metals):** shall not exceed MCLs
- **Radioactivity:** shall not exceed MCLs

There are no additional water quality objectives for the Basin.

The Basin Plan also applies the SWRCB Antidegradation Policy,[11] which has been further interpreted pursuant to the 2019 SWRCB Water Quality Control Policy for Recycled Water (SWRCB, 2019). Per the Anti-degradation Policy, if the existing water quality of a water body is better than the objectives defined in the Basin Plan, the existing quality shall be maintained. Pertaining to this particular project for the City, the modeling results and the simple basics of reverse osmosis-based purification allow the team to conclude that improvements in groundwater quality will occur due to the very low levels of TDS and nitrogen (including nitrate) in the purified water (compared to the Basin groundwater). An assessment of anti-degradation aspects is provided in Table 2.

Drinking water from the City's existing water supply system will be the source water for injection testing; therefore, it is not anticipated that injection water will be of lesser quality than the existing quality of the Basin groundwater.

[11] Available at https://www.waterboards.ca.gov/plans_policies/antidegradation.html. (Accessed April 13, 2021.)

SECTION 4: **Injection Well Initial Testing**

4.1 Background

Injection testing will be performed to support the assessment of the potential viability of the proposed IPR project that would use highly treated recycled water from the City's planned WRF for groundwater supply augmentation. Injection testing will provide diagnostic information of injection rates and capacity of the first full-scale injection well as part of this project. Initial injection testing will consist of constructing an initial injection well, performing baseline monitoring, and long-term injection tests. The proposed location of the initial injection well is shown on Figure 1. Additionally, the installation of a dedicated monitoring well (21P-01) will also be conducted as part of this effort to support DDW permit requirements.

4.2 Injection Well Construction and Initial Testing

One complete and fully operational, injection well will be installed for this early phase of the overall project. The installation effort will include drilling, construction, development, testing, and completion of the injection well. This work is proposed to begin in May 2021. The new injection well will be located on a vacant property owned by Vistra along the west side of Highway 1 as shown on Figure 1. The location of the site, including the temporary construction areas and temporary discharge hose alignment, are also presented on Figure 1.

The injection well will be drilled by mud-rotary drilling methods to an estimated depth of 90 to100 ft bgs. Following pilot hole drilling, geophysical logging of the well will be conducted, consisting of a spontaneous potential, resistivity, and caliper surveys in the pilot hole. The pilot hole will then be enlarged to 18-inch diameter, followed by installation of 12-inch diameter Type 316 stainless steel casing and wire-wrapped screen. The annulus within the screened interval will be filled with gravel pack gradation consisting of 1.7-to-2.5-millimeter SiLibeads. A concrete sanitary seal will be installed in compliance with state and local standards. The design of the proposed injection well is presented on Figure 5.

Following well construction, the injection well will be developed to remove accumulated drilling fluids. A test pump, drop pipe for conveyance of injection water, and sounding tube for water level measurements will be installed. The pump will be capable of discharging up to 350 gallons per minute. A pair of pumping tests will be conducted, including an 8-hour step drawdown test, and a 24-hour constant rate test to assess pumping performance characteristics of the wells.

4.3 Injection Testing Program

Following completion of the initial pumping tests, a series of injection tests will be conducted by injecting treated potable drinking water from the City's existing municipal supply system into the well for a series of short- and long-term periods for a total duration of up to 4 weeks. During the injection tests, the injection rates will be varied to assess the acceptance rates and variability of the specific capacity during injection. All testing and monitoring will be conducted in compliance with permitting requirements. Details regarding the planned injection testing is included in the *Injection Testing Work Plan for Groundwater Management Replenishment and Reuse Project, Morro Bay, California* (*Injection Testing Work Plan*) (Appendix A of this report).

Results from these analyses will be used to identify potential injection rates, which will be used to estimate the anticipated yield of the full-scale injection wellfield and the ultimate the number of wells needed for the full-scale project. Recommendations will be provided for anticipated operational scheduling and for an approach to minimize adverse consequences while maximizing the benefits of the proposed injection program.

4.4 Geochemical Modeling

The geochemical analysis will use the mineralogical analysis results from a specialized analytical laboratory and the water quality data from the native groundwater and predicted IPR water to assess any potential deleterious conditions associated with the project activities. To obtain these data, the following will be conducted:

1. The chemistry of the in-situ groundwater will be characterized using existing water quality data from the City's production wells, and chemical analysis of water samples collected from the newly installed injection and monitoring wells.
2. The expected chemistry of the water to be injected will be based on water quality estimates from the WRF design engineer/program manager.
3. To characterize the aquifer materials, mineralogical analyses will be conducted on sediment samples collected during drilling of the monitoring well.
4. The data will be used in a geochemical mixing model analyses to assess whether potential deleterious effects may occur.

The results of this analysis will allow GSI to assess potential problems associated with mixing of the injected water and the aquifer materials, including dissolution or precipitation of minerals through geochemical reactions, which can cause clogging in the both the well screen and the pore space of the aquifer. Recommendations will be provided for water quality treatment or operational approaches, if needed, to minimize any potential adverse consequences of the proposed injection program. Additional details of this effort are included in the attached *Geochemical Work Plan for Groundwater Management Replenishment and Reuse Project, Morro Bay, California* (*Geochemical Work Plan*) (Appendix B).

4.5 Injection Testing and Reporting Schedule

The injection testing will be conducted following the completion of the well installation and pumping tests. It is anticipated that injection will begin late May 2021 and require approximately 6 weeks to complete. The results will be provided in a technical memorandum, anticipated to be completed approximately 1 month after completion of the field work (by the end of July), if the proposed drilling and injection testing schedules are met.

The results of this injection testing plan will be incorporated into the Title 22 Engineering Report being prepared by the City. Additionally, the results of the pilot injection testing will be provided in an addendum to this report to complete the information needs of the Notice of Intent.

SECTION 5: **Injection Water and Groundwater Quality**

Source water for planned injection purposes will ultimately come from the proposed WRF, which is under construction until 2023. For the purposes of injection testing at the initial injection well, treated potable drinking water from the City's municipal supply system will be used as the injection water source.

The City's primary source of municipal supply water is surface water from the State Water Project, which is administered locally by the Central Coast Water Authority. The water is treated at the Polonio Pass Water Treatment Plant near Highways 41 and 46 and then conveyed via the Chorro Valley pipeline for use by the City. The State Water Project supply can be augmented by and blended with water pumped from existing City production wells in the Basin.

Some of the well water has nitrate contaminant levels that require treatment through blending or filtration. The City uses its Brackish Water Reverse Osmosis (BWRO) plant to remove nitrates from groundwater and all well water has a disinfectant added prior to distribution. During 2019, State Water Project water made up 90 percent of the City's drinking water and the wells provided the remaining 10 percent with all of this well water being treated by the Brackish Water Reverse Osmosis (BWRO) plant (Morro Bay, 2019).

In accordance with State of California Division of Drinking Water (DDW) requirements, the City regularly collects water samples to determine the presence of radioactive, biological, inorganic (trace metals), volatile organic compound (VOC), or synthetic volatile organic compound (SVOC) contaminants. The range of contamination in the raw well water, at times, has exceeded the drinking water standards, but drinking water served to the public had contaminant levels reduced through either blending or treatment. Detections of constituents from the most recent drinking water samples collected by the City are presented in the *Annual Water Quality Report 2019* (City of Morro Bay, 2019); Table 1 has been adapted from this report and shows a comparison of water quality data results from both City groundwater wells and State Water Project supply for 2019. The presence of these constituents in the water does not necessarily pose a health risk, as DDW allows the City to monitor for certain contaminants less frequently than once per year because the concentration of these contaminants do not change frequently. As shown on this table, municipal supply water for the City meets or exceeds all DDW drinking water MCLs and PHGs.

SECTION 6: **Groundwater Degradation Assessment**

6.1 Constituents of Concern

As discussed in Section 3.2 of this technical report, the primary chemical constituents of concern for the proposed injection testing are nitrate and TDS. Recent and historical measured concentrations of these chemical constituents from existing City wells in the Basin were compiled and used to establish the baseline conditions. Table 1 shows the applicable water quality objectives and the median and range of concentrations for both City well water and State Water Project water sources. None of the listed constituents for State Water Project water are shown to exceed Basin water quality objectives. As discussed in Section 5 above, State Water Project water is a primary water source for the City and will be the source water for initial injection testing purposes for Injection Well No. 1. Thus, injection testing is not anticipated to have any potential impact on the basin groundwater quality and is expected to meet all Basin water quality objectives.

6.2 Impact on Assimilative Capacity

The expected quality of the City water used for injection is discussed in Section 5 and summarized in Table 1. Injection water will meet or exceed all primary and secondary MCLs, state Notification Levels (NLs), and Basin Plan Objectives (BPOs). Using these water quality data, groundwater quality impacts relative to assimilative capacity are not expected to occur as a result of injection of City product water at Injection Well No. 1 during initial injection testing. The results of geochemical modeling analysis from samples collected during injection testing (described in Section 4.4) will allow an assessment of the potential for problems associated with mixing of the injected IPR water, native groundwater, and the aquifer sediments, including dissolution or precipitation of minerals through geochemical reactions, which can cause clogging in the both the well screen and the pore spaces immediately adjacent to the well.

6.3 Impact on Seawater Intrusion and Nitrates

The City's existing wells are approximately one-half mile from the Pacific Ocean. As such, they are at risk of seawater intrusion in times of severe drought, or if the groundwater flow gradient reverses from its natural direction for a significant period of time. Water quality sampling documented in the *Seawater Intake Evaluation Report* (GSI, 2017b) indicates that the nearby seawater intake wells along the Embarcadero boundary show TDS concentrations that range from about 5,000 mg/L to 17,000 mg/L. Evaluation of sampling records from wells on the adjacent Vistra site indicate that that wells have a concentration of about 1,000 mg/L on the northern edge of the site. Baseline TDS concentrations in the City's Highway 1 wells are in the 600 to 800 mg/L range. Groundwater modeling indicates that, under full permitted pumping scenarios, the City wells are susceptible to degradation of water quality due to seawater intrusion. Injection scenarios input into the groundwater model resulted in reducing all the instances of elevated TDS concentrations that had been evident in baseline modeling concentrations (i.e., in scenarios with no injection). Injection conducted at wells located in the Western Project Area would provide benefits to preventing seawater intrusion for the nearby City wells.

Nitrate concentrations have also increased in City wells due in part to the decades-long use of land upstream for agriculture and the growth in that land use. A few years after the establishment of upgradient vegetable fields, significant concentrations of nitrates began to be detected in the City's wellfield. Groundwater modeling scenarios performed by GSI using injection wells in the Western Project Area results in significant reductions in nitrate concentrations at the Highway 1 well field.

6.4 Impact on Existing Contaminant Plumes

As discussed in Section 3.3, groundwater quality in some parts of the Basin has been affected by PCAs in some areas, including the at Vistra property to the southwest of the injection site. In discussions with the City, DTSC determined that it was unlikely that contamination from the Vistra property would affect the planned injection by the City (DTSC, 2020).

As stated in the DTSC (2020) letter, based on groundwater sampling performed at the Vistra property over 9 years and documented in investigative reports, no significant plume of contaminants in groundwater has been found (DTSC, 2020). While there were a few Vistra property wells that when sampled, groundwater contaminants were found above unrestricted use screening levels, these wells were not near proposed Injection Well No. 1 or other planned injection sites on the Vistra property, and nearby wells surrounding these historically sampled wells were free from contaminants.

Vistra is proposing to evaluate groundwater at the site. Vistra submitted an evaluation to DTSC on September 24, 2020, but DTSC has not yet provided a response or comment as of the writing of this report. Continued review of relevant groundwater monitoring investigative reports for the Vistra property will be conducted as they are published by DTSC and/or others.

6.5 Disinfection

In compliance with the DDW, State Water Project water is treated at the Polonio Pass Water Treatment Plant before it conveyed to the City. During groundwater pumping, disinfectant (chlorination) is added to pumped water at the City's BWRO plant prior to distribution to the City's public system. Total residual chlorine has a DDW MCL and PHG of 4 mg/L. Total residual chlorine and total coliform bacteria are measured at the plant before distribution to the City's public system.

6.6 Disinfection By-Products

The City's potable water meets all primary state and federal drinking water standards, including standards for disinfection by-products such as haloacetic acids and trihalomethanes that form when chlorine reacts with naturally occurring organic matter in the surface water supply and/or with organic carbon compounds that may be naturally present in the aquifer. These disinfection by-products continue to remain well below state and federal drinking water standards (see Table 1). These constituents will be monitored during and after the injection testing, as stated in the *Injection Testing Work Plan* (Appendix A).

6.7 Metals Mobilization

In an effort to assess the potential of metals mobilization in response to the IPR project, geochemical analyses as stated in the *Geochemical Work Plan* will be conducted (see Appendix B). A key element of this will be the retrieval of injected water over a period of 4 weeks following the injection test to assess the geochemical changes that have occurred to the injected water. The procedure and suggested analytes for this sampling are provided in the *Injection Testing Work Plan* (Appendix A).

SECTION 7: Proposed Changes to Monitoring and Reporting Program

Injection operations at full-scale of the proposed IPR project will adhere to the Monitoring and Reporting Program outlined in Order WQ 2012-0010. For initial pilot injection testing, a work plan that includes monitoring and reporting protocols for the initial injection testing is attached to this report as Appendix A.

SECTION 8: **State and Federal Requirements for Groundwater Replenishment Projects**

8.1 California Environmental Quality Act

Per the California Environmental Quality Act (CEQA), a Draft Environmental Impact Report (EIR) was prepared and issued for comment in March 2018 for the proposed Morro Bay WRF. The Draft EIR found the following:

> "operation of the proposed project would implement the beneficial reuse of a renewable resource – recycled water. This renewable resource would provide a benefit to the City of Morro Bay in the form of a new water supply, improving reliability of the City's water supply portfolio through the use of local resource and decreasing the degree of dependency on imported water through the State Water Project."

The draft EIR was available for public and agency comment and received 35 comment letters that don't significantly change the findings. The Final EIR was published in June 2018 and was certified and adopted by the Morro Bay City Council in August 2018. Injection well construction and operation are included in the proposed IPR project discussed above, and therefore, this injection well construction and testing meet CEQA requirements.

Based on initial studies and modeling scenarios performed by GSI, this initial injection testing would cause no significant impacts to hydrology or water quality in the project area; therefore, mitigation measures are not required.

8.2 Division of Drinking Water Permits

The City currently holds a DDW permit for the City water system and its wells. The City's Public Water Supply ID is CA4010011. The California Division of Drinking Water Permit is provided in Appendix C.

8.3 Underground Injection Well Registration (EPA Region 9)

The City has submitted a registration with the U.S. Environmental Protection Agency Region 9 for the initial injection well as a Class V well. The Class V Injection Well Notification Documentation is attached to this report as Appendix D.

SECTION 9: **Conclusions**

The City of Morro Bay's planned IPR project has been carefully evaluated and modeled. The next key step in the development process is to install and test the first injection well. Approval for this effort through this permitting process will support moving forward with the project.

Careful monitoring during the injection testing will track water level and water quality responses to the injection. Results from the monitoring will be used to plan for the installation of the additional wells needed for the overall project. Information developed as part of the geochemical analyses will be used to refine the project operations, if necessary.

SECTION 10: **References**

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Table 1

City Groundwater and Surface Water Quality (2019)

CONSTITUENT	Units	MCL	PHG	YEAR SAMPLED	STATE WATER		GROUNDWATER		
					AVERAGE AMOUNT[1]	RANGE LOW-HIGH[1]	AVERAGE AMOUNT[1,2]	RANGE LOW-HIGH[1,2]	MAXIMUM ANNUAL DETECTED RANGE (All Wells)[3] 2011 to 2015
Primary Drinking Water Standards									
Aluminum	mg/L	1	0.6	2019	0.056	ND - 0.094	ND	ND	ND-0.01
Arsenic	µg/L	10	0.004	2018	ND	ND	3	ND-4	–
Barium	mg/L	1	2	2018	ND	ND	0.135	0.107-0.198	0.0128-100
Total Chromium	µg/L	50	100	2018	ND	ND	15	13-18	–
Fluoride	mg/L	2	1	2018	ND	ND	0.2	0.2	0.2-0.3
Nickel	µg/L	100	12	2018	–	–	–	–	ND-10
Nitrate (as Nitrogen)	mg/L	10	10	2018	ND	ND	15	2-22.8	20.34-37.41
Selenium	µg/L	50	30	2016	ND	ND	20	ND-27	ND-19
Secondary Drinking Water Standards									
Chloride	mg/L	500		2019	59	13-146	238	71-729	64-1480
Color	color units	300		–	–	–	–	–	ND-20
Corrosivity	Aggressivity Index	NA		2019	12	12	12.3	11.6-12.4	–
Manganese	µg/L	50		–	–	–	–	–	ND-30
Specific Conductance	µmhos/cm	1600		2019	403	138-762	1749	1030-3370	715-5050
Sulfate	mg/L	500		2019	46	46	127	63.6-163	36-149
Total Dissolved Solids	mg/L	1000		2019	260	260	–	–	423-2870
Turbidity	NTU	5		2019	0.05	ND-0.12	1.2	0.2-6.8	0.11-11.7
Unregulated and Other Constituents									
2-Methylisborneol	ng/L			2019	0.2	ND-1	–	–	–
Alkalinity	mg/L			2019	56	30-80	393	370-430	–
Boron	µg/L			2019	ND	ND	125	100-200	–
Calcium	mg/L			2019	19	19	107	172	–
Geosmin	mg/L			2019	2.8	ND-6	–	–	–
Hardness (as CaCO3)	mg/L			2019	82	26-144	706	464-1090	533-1800
Heterorophic Plate Count (HPC)	cfu/ml			2019	0	0-2	3.9	1-65	–
Potassium	mg/L			2019	3.1	3.1	0	ND-1	–
pH	Units			2019	8.4	7.7-8.7	7.3	6.7-7.7	–
Sodium	mg/L			2019	58	58	94	53-239	42-317
Total Organic Carbon	mg/L			2019	1.9	1.5-3	NA	NA	–
Vanadium	µg/L			2019	ND	ND	8	6-19	–
Disinfection By-Products and Residual Disinfectants									
Haloacetic Acids	µg/L	60	NA	2019	15 (highest LRAA 15.5)	7.4-25	14	4-21	–
Total Trihalomethanes (TTHMs)	µg/L	80	NA	2019	45 (highest LRAA 47.8)	27-75	30	18-52	–
Total Residual Chlorine	mg/L	4	4	2019	2.47	0.33-3.5	2	0.03-3.95	–
Total Coliform Bacteria	# of positive samples	0	0	2019	0	0	0	0	–

Notes:

1. From City of Morro Bay. 2019. Annual Water Quality Report 2019. Prepared by the City of Morro Bay. PWS ID# CA4010011
2. Sampling from well water is for raw water results. Samples are taken prior to either treatment or blending. Sample dates are from 2018.
3. Adapted from Table 3.9-1 General Groundwater Quality from Morro Bay Reclamation Facility Draft Environmental Impact Report. 2018. and MKN. 2017.

mg/l - milligrams per liter
µg/L - micrograms per liter
ng/L - nanograms per liter
cfu/ml - colony forming units per ml
µmhos/cm - micromhos per cm
NTU - nepheloid turbidity units
MCL - maximum contaminant level
PHG - public health goal
AL - action level
ND - Not Detected

Table 2
Anti-Degradation Assessment

SWRCB Resolution No. 68-16 Component	Anti-Degradation Assessment Result
Water quality changes associated with proposed project are consistent with the maximum benefit of the people of the State.	Water quality changes associated with proposed project in the Lower Morro Basin are consistent with the maximum benefit of the people of the State.
The water quality changes associated with proposed project will not unreasonably affect present and anticipated beneficial uses.	The water quality changes associated with injection will not unreasonably affect present and anticipated beneficial uses.
The water quality changes will not result in water quality less than prescribed in the Basin Plan.	The water quality changes associated with injection will not result in water quality less than prescribed in the Basin Plan. Per the Basin Plan's Anti-degradation Policy, if existing water quality of a water is better than the objectives defined in the Basin Plan, the existing quality shall be maintained. For this project, drinking water from the City's existing water supply system will be the source water for injection testing, so it is not anticipated that injection water will be of lesser quality than existing groundwater quality of the Basin.
The projects are consistent with the use of best practicable treatment or control to avoid pollution or nuisance and maintain the highest water quality consistent with the maximum benefit to the people of the State.	The City project is consistent with the use of the best practicable treatment or control to avoid pollution or nuisance and maintain the highest water quality consistent with the maximum benefit to the people of the State.
The proposed project is necessary to accommodate important economic or social development.	The City project is necessary to accommodate important economic and social development. Given the reliability uncertainties and increasing costs of imported water, increasing use of groundwater storage ensures a diversified and more reliable water supply. The City project provides a sustainable and reliable water source to replenish the groundwater basin, maintains high-quality groundwater, complies with pertinent regulatory requirements by employing an institutionally feasible approach, minimizes costs to customers using groundwater, and engages stakeholders in the decision-making process.
Implementation measures are being or will be implemented to help achieve Basin Plan Objectives in the future.	Injection water will meet drinking water quality standards, thus ensuring Basin Plan Objectives are being met during injection testing.

FIGURE 2a

Area of Hydrologic Influence - Dry Conditions

Morro Bay
Indirect Potable Reuse
Program Injection Testing

LEGEND

- City of Morro Bay Well
- Pumping Well
- Simulated Injection Well Location
- Particle Track Arrow (1 month)
- Particle Track
- Month Indicator
- Groundwater Elevation Contour (ft)
- Modeled Groundwater Flow Direction
- Active Area
- Potential Project Area
- Major Road
- Watercourse

NOTES

AFY: acre feet per year
Each travel time arrow along particle track represents 1 month.

Figure is adapted from Figure 14 of GSI "Characterization of Selection of Project Area for Injection Testing, City of Morro Bay" (GSI. 2021).

N

0 350 700
Feet

GSI Water Solutions, Inc.

Date: March 23, 2021
Data Sources: NAIP Imagery, ESRI

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\ASR_General_Order\TM\Figure2-1_Area_of_Hydrologic_Influence_Dry.mxd

FIGURE 2b

Area of Hydrologic Influence - Wet Conditions

Morro Bay
Indirect Potable Reuse
Program Injection Testing

LEGEND

- City of Morro Bay Well
- Pumping Well
- Simulated Injection Well Location
- Particle Track Arrow (1 month)
- Particle Track
- Month Indicator
- Groundwater Elevation Contour (ft)
- Modeled Groundwater Flow Direction
- Active Area
- Potential Project Area
- Major Road
- Watercourse

NOTES

AFY: acre feet per year
Each travel time arrow along particle track represents 1 month.

Figure is adapted from Figure 15 of GSI "Characterization of Selection of Project Area for Injection Testing, City of Morro Bay" (GSI, 2021).

N

0 350 700
Feet

Date: March 23, 2021
Data Sources: NAIP Imagery, ESRI

GSI
Water Solutions, Inc.

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\ASR_General_Order\TM\Figure2-2_Area_of_Hydrologic_Influence_Wet.mxd

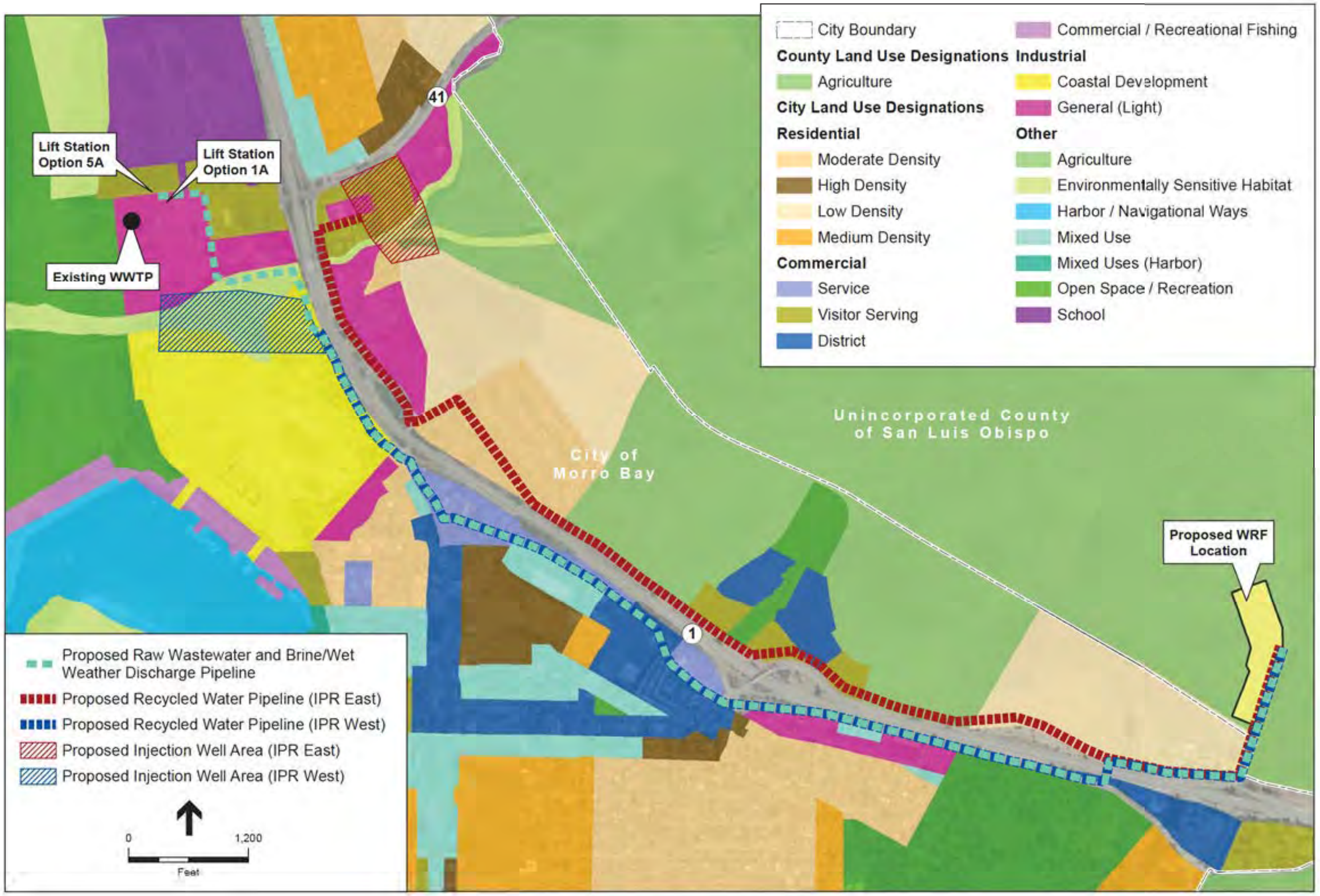

FIGURE 3

City and County Land Use Designation

Morro Bay
Indirect Potable Reuse
Program Injection Testing

NOTES
WRF: Water Reclamation Facility
WWTP: Waste Water Treatment Plant

Adapted from Figure 3.10-1 of "Morro Bay WRF Draft Environmental Impact Report" (ESA 2018)

Data Sources: City of Morro Bay, San Luis Obispo County, ESRI 2016

GSI Water Solutions, Inc.

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FIGURE 4

Potentially Contaminating Activity Sites

Morro Bay
Indirect Potable Reuse Program
Injection Testing

LEGEND

- Injection Well No. 1
- DTSC Cleanup Site
- Closed LUST Cleanup Site
- Western Project Area
- Major Road
- Watercourse

NOTES

DTSC: Department of Toxic Substances Control
LUST: Leaking Underground Storage Tank

N

0 350 700
Feet

Date: April 1, 2021
Data Sources: NAIP Imagery, ESRI, GeoTracker

GSI Water Solutions, Inc.

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\ASR_General_Order\TM\Figure4_Potentially_Contaminating_Activity_Sites.mxd

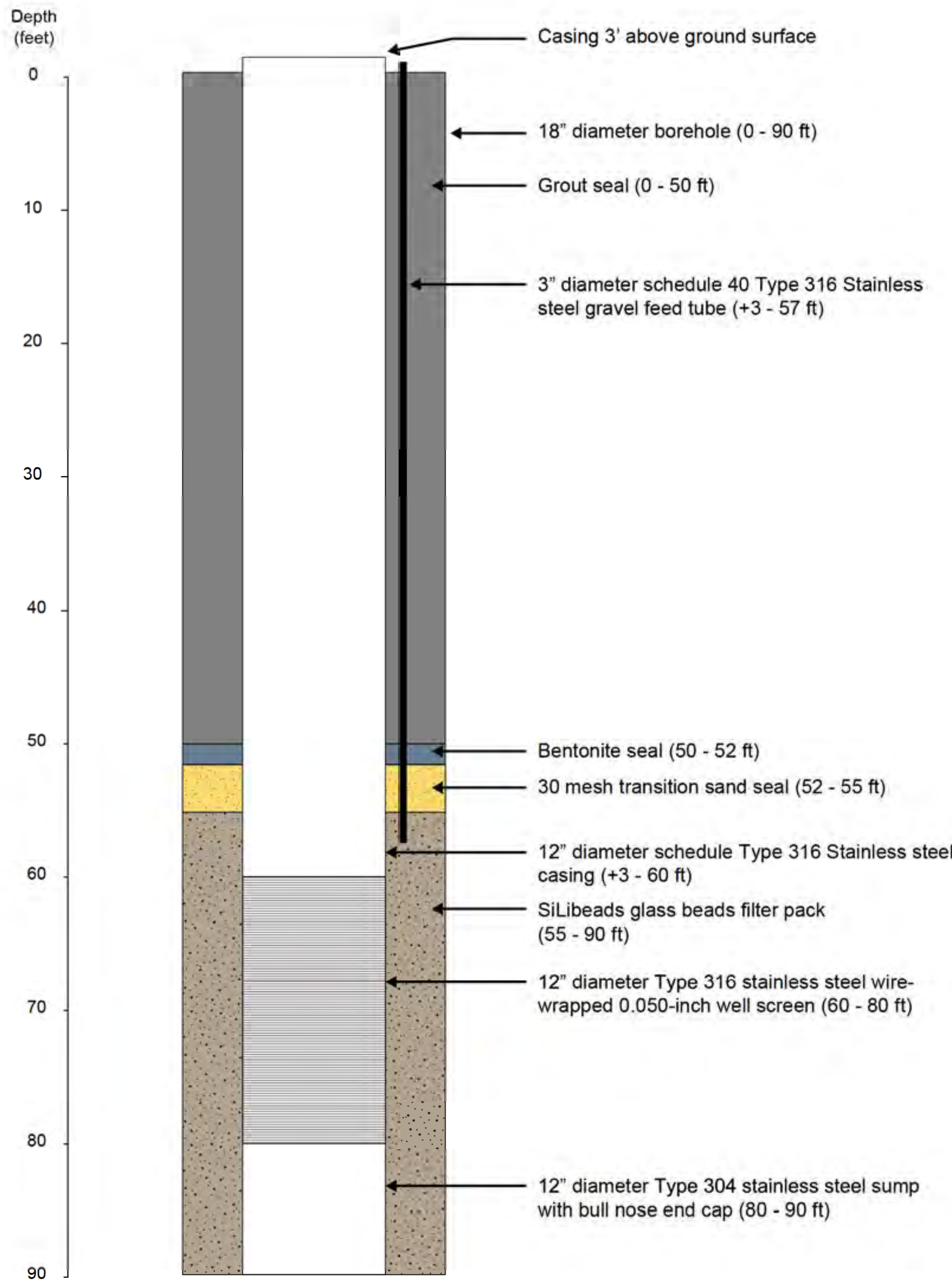

FIGURE 5

Proposed Injection Well Design

Indirect Potable Reuse Program Injection Testing
Morro Bay, CA

GSI Water Solutions, Inc.

Water Solutions, Inc.

DRAFT TECHNICAL MEMORANDUM

DRAFT Injection Testing Work Plan for Groundwater Replenishment and Reuse Project, Morro Bay, California

To:	Lydia Holmes and Anthony Cemo, Carollo Engineers
From:	Tim Thompson and Tim Nicely, GSI Water Solutions
CC:	Brynne Weeks and Andrew Salveson, Carollo Engineers
Attachments:	Figure Water Quality Sampling Constituents Table
Date:	April 9, 2021

Introduction and Purpose

GSI Water Solutions (GSI) is supporting the City of Morro Bay with the implementation of a planned indirect potable reuse (IPR) project, which will use highly treated recycled water from the City's forthcoming Water Reclamation Facility (WRF). The installation and operation of a Groundwater Replenishment Reuse Project (GRRP) using injection wells is a key part of the overall project. This memorandum presents the work plan for testing at a new injection well proposed to be installed in Spring 2021.

The injection testing presented in this work plan is a portion of work being performed by GSI for the City of Morro Bay in the lower portion of the Morro Valley Groundwater Basin, which also includes injection well design and installation, groundwater monitoring, permitting support, and groundwater flow modeling.

Injection Work Plan

The injection testing presented in this work plan provides diagnostic information regarding injection rates, aquifer response, and water quality at anticipated injection rates for a single well. Injection testing will be conducted at a newly constructed injection well located as shown on Figure 1.

Injection Testing

A series of injection tests will be conducted by conveying water from the City's municipal water supply distribution system into the new injection well. The injection tests will consist of an 8-hour injection step test and a 7-day injection constant rate test, operated by the Contractor. The wellhead will be sealed and capable of maintaining injection pressures up to 20 psi with anticipated injection pressures of up to 10 psi during testing in order to observe and maintain a range of injection rates. The injected water will consist of chlorinated water provided by the City from their State Water Project source.

City staff will install an outlet fitting and backflow prevention device onto the nearby City distribution pipeline located east of the nearby bike path for the purposes of this project. City staff will also construct a trench across the bike path and install a short section of piping that daylights west of the bike path and, for security purposes, west of the fence within the Dynegy/Vistra property. The drilling Contractor will connect to this fitting, the location of which is shown approximately on Figure 1 and run a temporary pipeline that will convey

the water to the injection well for the testing. The pipeline conveying the injection water to the well will be equipped by the Contractor with a flow control valve, flow meter, sampling port, pressure gauge, and a bypass filter. The bypass filter allows for monitoring of the turbidity of the injected water and will verify if turbid water is being injected (which is undesirable because of clogging potential) -- GSI will provide guidance to the Contractor for the materials and setup of this filter. A pressure transducer will be installed by the Contractor in the well to collect continuous water level data, and manual water level (and wellhead pressure) measurements will also be collected. All conveyance piping, measurement devices, and downhole equipment will be installed, maintained, and operated by the Contractor. GSI staff will be onsite to oversee the installation of the equipment. The Contractor will be required to provide temporary fencing around the immediate wellhead, which is assumed to require a 12- by 20-foot fenced area.

The following sections provide details for each phase of the injection testing program. The injection testing activities will be conducted following the drilling, construction, and pump testing of the injection well. The pump testing component will consist of both a step test and a constant rate test using a temporary pump installed and operated by the drilling contractor. The step test will involve pumping the well at 4 successively higher flow rates for 1 to 2 hours each while carefully monitoring water level drawdowns in the injection well and at the nearby monitoring well. The drawdown results of the step test will be used to establish the pumping rate used in the 24-hour constant rate pumping test.

Injection Step Test

The data collected during the pumping tests will be used by GSI to select the injection rates for the injection step test. This initial injection test will consist of four steps conducted at a series of discrete flow rates that will each last approximately 2 hours. The steps for the injection rates will be selected based on the drawdown results of the constant rate aquifer pumping test performed as part of the injection well installation. They will likely vary from approximately 10 to 80 gpm, but final rates will be determined after installation and testing of the injection well. The injection rate will be increased incrementally for each of the steps while simultaneously monitoring the water level in the well. Water level measurements will be recorded both at the injection well and at the nearby monitoring well with transducer and manual measurements. The results of the injection step test will be analyzed to determine appropriate injection rate for the constant rate injection test.

Injection Constant Rate Test

After the well has fully recovered from the injection step test, the constant rate injection test will be run at a continuous injection rate for various durations and ultimately for a continuous period of up to 7 days. During the tests, measurements of the flow rate, and corresponding water level shall be made at both the injection well and the nearby monitoring well. During the injection tests, a pressure transducer will record continuous water level data throughout the test. Manual measurement of water levels will also be collected at the following times relative to the start of the test:

- Every 5 minutes until 30 minutes have elapsed.
- Every 10 minutes until one hour has elapsed.
- Every 20 minutes until two hours have elapsed.
- Every hour until 24 hours have elapsed.
- Every two hours until 48 hours have elapsed.
- Every 4 to 6 hours until the end of the 7-day test.

Immediately after termination of the test, the rate of recovery of the water level shall be monitored for a period of 48 hours at both the injection and monitoring wells. The water levels will be recorded at the same time intervals (logarithmic) as the start of the constant rate injection test.

Analysis of Injection Testing Results

Following the completion of injection testing, data will be analyzed to estimate aquifer properties and provide a range of operational injection rates for the well. This information will also be used to update the groundwater model to evaluate project build out options.

Following updates to groundwater model, a series of scenarios will be developed in coordination with the City and Carollo Engineers to assess the ultimate number and location of wells required for the full project. Additional information from the modeling scenarios will include assessment of retention time within the aquifer, water level changes during and following injection periods and identification of any potential adverse conditions.

Recommendations will be provided for anticipated operational scheduling and approaches to minimize any potential adverse consequences and maximize the benefits of the proposed injection program.

Water Quality Sampling and Geochemical Evaluation

In addition to the collection of aquifer data collected during the tests, water quality samples will be collected at both the Injection well and/or the nearby monitoring well at the following times and analyzed for the list of constituents identified in the attached table:

- Collect samples at both the Injection and monitoring well just prior to the end of the constant rate pumping test (to establish the baseline aquifer water quality)
- Collect a sample at the Injection well during the early phase of injection to document water quality of source water (at the end of the first day of the constant rate injection test)
- Collect a sample at the Injection well during the late phase injection source water (during the final day of the constant rate injection test)
- Samples will be collected from the monitoring well during the constant rate injection test during day 3, day 5, and day 7 (three sampling events). Results from these analyses will be used to assess if water quality changes indicate if injected water has reached the monitor well during the duration of the test.
- After completion of the constant rate injection test, groundwater samples will be collected once a week at the Injection well for four consecutive weeks. For each sampling episode, the well will be pumped to waste until parameters stabilize prior to sampling.

Water quality results for key constituents will be evaluated to identify mixing relationships and/or the presence of geochemical reactions. These field results will be used to verify the findings of the geochemical modeling described in the Geochemical Work Plan for Groundwater Replenishment and Reuse Project (GSI, 2021).

Injection Testing Schedule and Reporting

The injection testing will be conducted following the completion of the well installation and constant rate aquifer test. It is anticipated that the injection testing will begin by late May 2021 and require approximately 6 to 7 weeks to complete, including the 4 weeks of post-testing water quality sampling. Following the completion of the injection testing program, the Contractor will be responsible for removing all equipment and conveyance pipelines. The Contractor will not be provided final payment until the site condition is deemed satisfactory by the City and the terms of the project Technical Specifications are met.

The testing results will be provided in a technical memorandum (TM). This TM is anticipated to be completed by the end of July, approximately one month following the completion of the field work if the proposed drilling and injection testing schedules are met.

FIGURE 1

Site and Well Location Map

Morro Bay
Indirect Potable Reuse Program
Injection Testing

LEGEND

InjWell

- Injection Well No. 1
- Well Construction Site
- Cuttings and Drilling Fluids Disposal
- Bike Path
- Piezometer
- Temporary Hose
- MBMWC Well
- Yeh Piezometer
- PG&E Property Boundary
- Western Project Area, 17 Acres
- Watercourse

NOTE

MBMWC: Morro Bay Mutual Water Company

N

0 150 300
Feet

Date: March 19, 2021
Data Sources: NAIP Imagery, ESRI

GSI Water Solutions, Inc.

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\Pilot_Inject_Well\Figure1_Western_Project_Site_Injection_Well_2021.mxd

Parameter Type	Parameter	Method
Field	Dissolved oxygen	YSI 556 or similar
	pH	EPA 150.1
	Oxidation-Reduction Potential	SM2580B
	Specific Conductance	EPA 120.1
	Temperature	YSI 556 or similar
	Turbidity	EPA 180.1
Inorganics	Alkalinity	SM2320B
	Ammonia	SM4500NH3G
	Bicarbonate	SM2320B
	Carbonate	SM2320B
	Chloride	EPA 300.0
	Cyanide (HCN)	EPA 335.4
	Fluoride	EPA 300.0
	Hardness	EPA 200.8
	Nitrate+Nitrite (total N)	EPA 300.0
	Nitrate (as N)	EPA 300.0
	Nitrite-N	EPA 300.0
	Orthophosphate as P	EPA 300.0
	Total Silica (as SiO2)	EPA 200.7
	Dissolved Silica (as SiO2)	EPA 200.7
	Sulfate	EPA 300.0
	Sulfide	SM4500S2F
Metals (Dissolved)	Aluminum	EPA 200.7
	Antimony	EPA 200.8
	Arsenic	EPA 200.8
	Barium	EPA 200.8
	Beryllium	EPA 200.8
	Cadmium	EPA 200.8
	Calcium	EPA 200.7
	Chromium	EPA 200.8
	Cobalt	EPA 200.8
	Copper	EPA 200.8
	Iron	EPA 200.7
	Lead	EPA 200.8
	Lithium	EPA 200.8
	Magnesium	EPA 200.7
	Manganese	EPA 200.8
	Mercury	EPA 245.7
	Molybdenum	EPA 200.8
	Nickel	EPA 200.8
	Potassium	EPA 200.7
	Selenium	EPA 200.8
	Silver	EPA 200.8
	Sodium	EPA 200.7
	Strontium	EPA 200.8
	Thallium	EPA 200.8

	Uranium	EPA 200.8
	Vanadium	EPA 200.8
	Zinc	EPA 200.8
Miscellaneous	Chemical Oxygen Demand	EPA 410.4
	Color	SM 2120B
	Corrosivity	Langelier Index
	Dissolved Organic Carbon	SM 5310C
	Foaming Agents (MBAs)	SM5540C
	Methane	RSK175
	Odor	2150B
	Oxidation-Reduction Potential	SM2580B
	pH	EPA 150.1
	Specific Conductance	EPA 120.1
	Total Dissolved Solids	SM 2540C
	Total Organic Carbon	SM5310C
	Total Suspended Solids	SM 2540D
	Turbidity	EPA 180.1
	Asbestos	Microscope: Hitachi 7000FA
DBPs	Residual Chlorine	SM 4500CL-G
	Dibromoacetic Acid (HAA)	SM6251B
	Dichloroacetic Acid (HAA)	SM6251B
	Monobromoacetic Acid (Bromoacetic acid) (HAA)	SM6251B
	Monochloroacetic Acid (HAA)	SM6251B
	Trichloroacetic Acid (HAA)	SM6251B
	Total Haloacetic Acids (Total HAA's)	SM6251B
	Bromodichloromethane (THM)	EPA 524.3
	Bromoform (THM)	EPA 524.3
	Chloroform (THM)	EPA 524.3
	Dibromochloromethane (THM)	EPA 524.3
	Total Trihalomethane (TTHM)	EPA 524.3
	Chlorite	EPA 300
Other	Bromate	EPA 317
	Hexavalent Chromium	EPA 218.7

GSI Water Solutions, Inc.

DRAFT TECHNICAL MEMORANDUM

DRAFT Geochemical Work Plan for Groundwater Replenishment and Reuse Project, Morro Bay, California

To: Lydia Holmes and Anthony Cemo; Carollo Engineers

From: Tim Thompson and Tim Nicely; GSI Water Solutions

CC: Brynne Weeks and Andrew Salveson; Carollo Engineers

Date: April 7, 2021

Introduction and Purpose

GSI Water Solutions (GSI) is supporting the City of Morro Bay with permitting and installation of a planned indirect potable reuse (IPR) project, which will use highly treated recycled water from the City's forthcoming Water Reclamation Facility (WRF). The installation and operation of a Groundwater Replenishment Reuse Project (GRRP) using IPR (subsurface application) is central to the overall project. As a part of this project, this memo presents our work plan to characterize significant subsurface geochemical parameters that may impact the project.

Background

As part of the installation of the monitoring well that will be installed along with the initial injection well, undisturbed physical samples of the aquifer sediments from the primary injection zone will be collected. These samples will be submitted for geochemical analysis by a specialized analytical laboratory (Minerology, Inc). Results of this analysis will be used along with native groundwater water quality and anticipated injection water quality to model the potential for geochemical reactions in the aquifer soil matrix that may occur during project operations.

Two important objectives of this work will be to assess (a) the potential for the injection well screens and filter pack to become clogged due to reactions between injected water, native groundwater, and the aquifer matrix in the vicinity of the injection wells, and (b) the potential for geochemical reactions to occur which could generate adverse groundwater quality in the recovered groundwater. These analyses will assess the potential geochemical reactions that may occur both through reactions associated with the mixing of two different waters (native groundwater and the advanced treated recycled water), and through the chemical reactions of the injected water with the sediments comprising the aquifer.

Additionally, as described in the Injection Testing Work Plan, a series of water quality samples will be collected and analyzed during the injection well testing to assess any changes in water quality following the injection. A series of sampling events will be conducted to ascertain changes in the injected water quality following residence within the aquifer for up to several weeks. The results of this analysis will be used in tandem with the analyses described below to better understand the potential for adverse geochemical reactions to occur.

Laboratory Analyses

The soil samples collected during installation of the new monitoring well to be located near the proposed injection well will be sent to a specialty laboratory (Mineralogy, Inc) for analysis by the following methods:

- X-Ray Diffraction (XRD): This method analyzes soil mineralogy, which is used to evaluate potential mineral-water reactions.
- X-Ray Fluorescence (XRF): This method analyzes soil chemical composition, which provides the abundances of elements not identified by XRD.
- SEM & Thin Section Petrography: Microscopy is used to identify mineral occurrences present below XRD detection limits; it also informs on mineral sizes, reactive coatings, and morphology.
- Particle Size Distribution: This method analyzes the clay content of soil.
- Cation Exchange Capacity: This method quantifies the abundance of reactive cation exchange sites on clay.

We will also send samples to a standard analytical laboratory for analysis of the following constituents:

- Hexavalent Chromium, Total Arsenic, Total Organic Carbon (TOC), Total Selenium, Total Sulfides, and Total Solids

Results from these analyses will be used in combination with the anticipated water quality of the recycled water to be injected to identify potential geochemical reactions that may occur.

Geochemical Modeling

To assess the potential for chemical reactions that could be problematic for injection well operations, GSI's subcontractor SS Papadopoulos & Associates, Inc. will employ the USGS geochemical modeling package PHREEQC to evaluate potential aqueous geochemical calculations. PHREEQC is a widely accepted geochemical modeling tool and is based on an ion-association aqueous model and has capabilities for speciation and saturation-index calculations, reaction-path and advective-transport calculations, mixing of solutions, mineral and gas equilibria, and other geochemical calculations. If the chemistry of the injected advanced treated water and the in-situ groundwater are known, and the minerology of the aquifer is characterized, the modelling package allows a detailed chemical analysis of the expected reaction products between the mixed waters and with the minerals comprising the aquifer sediments.

The chemistry of the in-situ groundwater will be characterized using existing water quality data from the City's production wells, and chemical analysis of the newly installed test and monitoring wells. The expected chemistry of the water to be injected will be based on water quality estimates from the WRF design engineer. To characterize the aquifer materials, mineralogical analyses will be conducted on core samples collected during drilling of the monitoring wells. The results of this analysis will allow GSI to assess the potential for potential problems associated with mixing of the injected water and the aquifer materials including dissolution or precipitation of minerals through geochemical reactions, which can cause clogging in both the well screen and the pore space of the aquifer skeleton itself.

Results

Utilizing the (a) mineralogical analysis results from Minerology Inc., (b) the water quality information of the native groundwater and predicted IPR water, and (c) the water quality results collected during the Injection Well Testing, the geochemical analysis will be conducted and used to develop the assessment of any potentially deleterious conditions associated with the project activities. Recommendations will be provided for water quality treatment or operational approaches to minimize any potential adverse consequences of the proposed injection program.

Schedule

The aquifer sediment sample will be collected during monitoring well installation in late April. . Samples will be sent to Minerology, Inc. for analysis, a process that takes 2-3 weeks. Results will be received and used along with water quality data in the geochemical modeling which will occur over the following 4 weeks. A technical memorandum (TM) will be prepared documenting the work. This TM is anticipated to be complete by the end of May, if the proposed drilling and laboratory analysis schedules are met.

CA Drinking Water Watch

Links

- PS Code Transition
- Water System Details
- Water System Facilities
- Monitoring Schedules
  - Old Format
  - New Format
- Monitoring Results
- Monitoring Results By Analyte
- Lead And Copper Sampling
  - Summaries
  - Next Sampling Due Dates
  - All Lead Sampling Results
  - All Copper Sampling Results
- Violations/Enforcement Actions
- Site Visits
- Consumer Confidence Reports
  - 2019
  - 2018
  - 2017
  - 2016
- Lead Service Line Documents
  - Certified Form

Water System Details

Water System No. :	CA4010011	**Federal Type :**	C
Water System Name :	MORRO BAY PW DEPT - WATER DIVISION	**State Type :**	C
Principal County Served :	SAN LUIS OBISPO	**Primary Source :**	SWP
Status :	A	**Activity Date :**	03-22-1979
Distribution System Classification :	D3	**Max Treatment Plant Classification :**	T2

Water System Contacts			
Type	Address	Phone	Email - Web Address
Physical Location Contact	CA4010011-MORRO BAY PW DEPT - WATER DIV 955 SHASTA AVENUE MORRO BAY,CA 93442	805-772-6261	www.morrobayca.gov There is no web address
Administrative Contact	955 Shasta Avenue MORRO BAY,CA 93442		

Division of Drinking Water District / County Health Dept. Info

Name	Phone	Email	Address
DISTRICT 06 - SANTA BARBARA	805-566-1326	dwpdist06@waterboards.ca.gov	1180 EUGENIA PLACE SUITE 200 CARPENTERIA CA 93013

Annual Operating Periods & Population Served

Start Month	Start Day	End Month	End Day	Population Type	Population Served
1	1	12	31	R	10234

Service Connections

Type	Count	Meter Type	Meter Size Measure
CB	5532	ME	0

Sources of Water

Service Areas

Return Links

Water System Search

County Map

Glossary

Contact Info

Name	Type Code	Status
CALIFORNIA MENS COLONY	CC	A
CCWA - TREATED	CC	A
FLIPPOS WELL	WL	A
HIGH SCHOOL WELL 01	WL	A
HIGH SCHOOL WELL 02	WL	A
WELL 03	WL	A
WELL 04	WL	A
WELL 11A	WL	A
WELL 14	WL	A
WELL 15	WL	A
DESAL RAW - SEAWATER - STANDBY-INACTIVE	IN	I
GOLF COURSE WELL - INACTIVE	WL	I
PG&E WELL 02 - INACTIVE	WL	I
WELL 01 - INACTIVE	WL	I
WELL 02 - INACTIVE	WL	I
WELL 05 - ABANDONED	WL	I
WELL 06 - ABANDONED	WL	I
WELL 07 - ABANDONED	WL	I
WELL 08 - ABANDONED	WL	I
WELL 09 - INACTIVE	WL	I
WELL 09A - INACTIVE	WL	I
WELL 10 - INACTIVE	WL	I
WELL 10A - INACTIVE	WL	I
WELL 11 - DESTROYED	WL	I
WELL 12 -	WL	I

Code	Name
R	RESIDENTIAL AREA

ABANDONED		
WELL 13 - INACTIVE	WL	I
WELL 16 - INACTIVE	WL	I

Water Purchases

Seller Water System No.	Water System Name	Seller Facility Type	Seller State Asgn ID No.	Buyer Facility Type	Buyer State Asgn ID No.
CA4010830	CALIFORNIA MENS COLONY	IN	001	CC	033
CA4210030	CENTRAL COAST WATER AUTHORITY			CC	024

Underground Injection Well Registration for the Pacific Southwest (Region 9)

Resources

- **Underground Injection Control in Region 9**
- **General Inquiries** or send email to R9iWells@epa.gov
  (Be sure to include your e-mail address if you'd like a response)

Register any class of injection well using the inventory form below.

On this page:

How to Register Injection Wells

If you own, operate or plan to construct one or more injection wells, you are required to register those features, also known as injection wells, with the Underground Injection Control program. This requirement applies to deep and shallow subsurface disposal systems as defined in 40 CFR part 144. Compliance with the federal Underground Injection Control (UIC) regulations includes fulfilling two basic requirements: (1) - register injection well(s) and (2) - do not use injection wells in a manner that will contaminate underground sources of drinking water.

These instructions and e-Form were developed to assist injection well owners in Arizona, California, Hawaii, and Indian Tribes of the desert southwest comply with the federal UIC regulations. Other state and local regulations may apply. See the regulations at 40 CFR part 144 for more information, at the U.S. Government Printing Office.

Frequently Asked Questions

My runoff discharges to a swale, pond or ditch. Is this injection?

If there is no subsurface (buried) discharge component to the system, then it is not subject to UIC requirements, however it may be subject to Clean Water Act requirements or other water protection regulations.

The injection well serves a single family home. Do I have to register the well?

Injection wells serving single family homes do not have to submit inventory information unless they are used by a home-based business, such as car repair, pet boarding, medical services or other businesses that generate a liquid waste stream that is to be disposed underground.

I have a septic system with multiple leachfield lines. Does each leachfield pipe count as a different injection well?

No, if all of the leachfields receive effluent from the same septic tank or other treatment device, they count as components of one injection well or subsurface fluid distribution system.

Is registering the injection well my only obligation?

Some injection activities are subject to state and local requirements and/or permits. Single-family onsite sewage systems are generally regulated by county environmental health agencies. Large capacity sanitary waste disposal and industrial discharges may be regulated by local or state water quality agencies. If your injection well(s) are subject to a discharge permit from the state, please list that permit number in the comments box to help reduce duplicative requirements.

Depending on multiple factors, such as your location in relation to drinking water supply wells or the type of injectate, your injection well(s) may be subject to additional federal requirements. These requirements may include sampling, characterization, permitting or closure of injection wells. Shallow injection of hazardous waste, untreated sewage and motor vehicle repair fluids is **prohibited** except in ongoing remedial actions overseen by regulatory agencies. See the regulations for more information. **IMPORTANT:** You must notify EPA if the ownership, well operating status or injectate changes.

How does EPA use the information?

EPA will use this information to notify you of applicable regulatory requirements or best management practices to prevent contamination. EPA shares the data with other water quality agencies, public water supply agencies, and in response to Freedom of Information Act requests for the data.

For more information, contact your EPA or state UIC program or email R9iWells@epa.gov.

Injection Well Inventory Form

After submitting this form, a confirmation email with the submitted form data will be sent to the Email address provided.

Transaction Type (choose one): ◯ First time entry ◯ Change

---------- Facility Information ----------

Facility Name: (Required)

City of Morro Bay

This is a private residence ◯ true ◯ false

Street:

955 Shasta Ave

Street 2:

City: (Required)

Morro Bay

State: (Required) CA

Zip: (Required) 93442

Facility Phone: 805-772-6261

---------- Facility Location ----------

County CA-San Luis Obispo

Land ID:

RCRA ID, APN, or TMK or leave blank

066-331-046

Indicate the land ownership of the property: (Required)

◯ Private
◯ Government-local, state
◯ Government-federal
◯ Government-tribal
◯ Non-Profit

If Tribal select Tribe name: - None -

NAICS Code

Numbers only, please. For industry/business, find NAICS code at www.census.gov

Latitude

Latitudes in American Samoa should be entered as *negative* numbers. Free lat/long finder is latlong.net

35.376036 °N

Longitude

Enter positive numbers for degrees longitude east or negative numbers for longitude west, in this field.

120.856095

Longitude (W or E)
Specify "W" for longitudes in the U.S., or "E" for longitudes in Guam & the Northern Mariana Islands.

W

---- Legal Contact Information: Owner or Other Responsible Party ----

Owner Contact Name:

Joe Mueller

Email: (Required)

jmueller@morrobayca.gov

Organization: (Required)

City of Morro Bay

Street:

955 Shasta Ave

Street 2:

City: (Required)

Morro Bay

State: CA

Zip: (Required) 93442

---------- Well Details ----------

Total number of injection wells at this site: (Required)
If you would like to report other types of wells at this site, please submit this form, then use the back button to modify this entry or start over.

1

Number of identical wells reported below (Required)

Well Operating Status of your well(s):

- ○ Planned/under construction
- ○ Active
- ○ Inactive/not plugged
- ○ Plugged and approved by regulator
- ○ Plugged and abandoned without approval

Plugged & Abandoned?

Plugged & Abandoned?

If well(s) have been plugged and abandoned enter the *numerical* year only.

Injection Well Depth
(# of feet below ground surface)

- < 50
- 50 - 500
- > 500

Injection Purpose

- Disposal
- Energy production
- Hydraulic barrier
- Oil or mineral recovery
- Remediation
- Recharge
- Water supply storage and withdrawal

Injectate
Select the primary constituent of injected fluids.

- Storm drainage
- Irrigation runoff
- Non-contact cooling water
- Brine
- Combined industrial/sanitary
- Disinfected Tertiary Effluent (CA Title 22)
- Geothermal fluids
- Industrial Non-hazardous (describe in comments)
- Mine lixiviant
- Potable water
- Remedial fluids/air
- Septic tank effluent
- Untreated sewage

Dispersal Direction
Select the predominant plumbing orientation of the injection well(s): horizontal such as a leachfield; vertical such as a drywell or seepage pit

- horizontal
- vertical

Injectate Sources
Please select one.

- From this site only
- This site and others

Comments
Please list any local or state permits that authorize, monitor, or otherwise affect the reported injection well(s). If this site is subject to any relevant local or state permits, or if you have any operational considerations for the injection well(s) that you would like to note, please list them here.

Your Name
If you are NOT the owner listed above, please enter your name here.

Chris Wick

Your Email (Required)

cwick@gsiws.com

Your Organization
Your organization if other than the contact above.

GSI Water Solutions, Inc.

Submit Registration

LAST UPDATED ON AUGUST 21, 2020

ATTACHMENT 4

GSI Water Solutions, Inc.

DRAFT TECHNICAL MEMORANDUM

DRAFT Injection Testing Work Plan for Groundwater Replenishment and Reuse Project, Morro Bay, California

To: Lydia Holmes and Anthony Cemo, Carollo Engineers

From: Tim Thompson and Tim Nicely, GSI Water Solutions

CC: Brynne Weeks and Andrew Salveson, Carollo Engineers

Attachments: Figure
Water Quality Sampling Constituents Table

Date: August 26, 2021

Introduction and Purpose

GSI Water Solutions (GSI) is supporting the City of Morro Bay with the implementation of a planned indirect potable reuse (IPR) project, which will use highly treated recycled water from the City's forthcoming Water Reclamation Facility (WRF). The installation and operation of a Groundwater Replenishment Reuse Project (GRRP) using injection wells is a key part of the overall project. This memorandum presents the work plan for testing at a new injection well proposed to be installed in Spring 2021.

The injection testing presented in this work plan is a portion of work being performed by GSI for the City of Morro Bay in the lower portion of the Morro Valley Groundwater Basin, which also includes injection well design and installation, groundwater monitoring, permitting support, and groundwater flow modeling.

Injection Work Plan

The injection testing presented in this work plan provides diagnostic information regarding injection rates, aquifer response, and water quality at anticipated injection rates for a single well. Injection testing will be conducted at a newly constructed injection well located as shown on Figure 1.

Injection Testing

A series of injection tests will be conducted by conveying water from the City's municipal water supply distribution system into the new injection well. The injection tests will consist of an 8-hour injection step test and a 7-day injection constant rate test, operated by the Contractor. The wellhead will be sealed and capable of maintaining injection pressures up to 20 psi with anticipated injection pressures of up to 10 psi during testing in order to observe and maintain a range of injection rates. The injected water will consist of chlorinated water provided by the City from their State Water Project source.

City staff will install an outlet fitting and backflow prevention device onto the nearby City distribution pipeline located east of the nearby bike path for the purposes of this project. City staff will also construct a trench across the bike path and install a short section of piping that daylights west of the bike path and, for security purposes, west of the fence within the Dynegy/Vistra property. The drilling Contractor will connect to this fitting, the location of which is shown approximately on Figure 1 and run a temporary pipeline that will convey

the water to the injection well for the testing. The pipeline conveying the injection water to the well will be equipped by the Contractor with a flow control valve, flow meter, sampling port, pressure gauge, and a bypass filter. The bypass filter allows for monitoring of the turbidity of the injected water and will verify if turbid water is being injected (which is undesirable because of clogging potential) – GSI will provide guidance to the Contractor for the materials and setup of this filter. A pressure transducer will be installed by the Contractor in the well to collect continuous water level data, and manual water level (and wellhead pressure) measurements will also be collected. All conveyance piping, measurement devices, and downhole equipment will be installed, maintained, and operated by the Contractor. GSI staff will be onsite to oversee the installation of the equipment. The Contractor will be required to provide temporary fencing around the immediate wellhead, which is assumed to require a 12- by 20-foot fenced area.

The following sections provide details for each phase of the injection testing program. The injection testing activities will be conducted following the drilling, construction, and pump testing of the injection well. The pump testing component will consist of both a step test and a constant rate test using a temporary pump installed and operated by the drilling contractor. The step test will involve pumping the well at 4 successively higher flow rates for 1 to 2 hours each while carefully monitoring water level drawdowns in the injection well and at the nearby monitoring well. The drawdown results of the step test will be used to establish the pumping rate used in the 24-hour constant rate pumping test.

Injection Step Test

The data collected during the pumping tests will be used by GSI to select the injection rates for the injection step test. This initial injection test will consist of four steps conducted at a series of discrete flow rates that will each last approximately 2 hours. The steps for the injection rates will be selected based on the drawdown results of the constant rate aquifer pumping test performed as part of the injection well installation. They will likely vary from approximately 10 to 80 gpm, but final rates will be determined after installation and testing of the injection well. The injection rate will be increased incrementally for each of the steps while simultaneously monitoring the water level in the well. Water level measurements will be recorded both at the injection well and at the nearby monitoring well with transducer and manual measurements. The results of the injection step test will be analyzed to determine appropriate injection rate for the constant rate injection test.

Injection Constant Rate Test

After the well has fully recovered from the injection step test, the constant rate injection test will be run at a continuous injection rate for various durations and ultimately for a continuous period of up to 7 days. During the tests, measurements of the flow rate, and corresponding water level shall be made at both the injection well and the nearby monitoring well. During the injection tests, a pressure transducer will record continuous water level data throughout the test. Manual measurement of water levels will also be collected at the following times relative to the start of the test:

- Every 5 minutes until 30 minutes have elapsed.
- Every 10 minutes until one hour has elapsed.
- Every 20 minutes until two hours have elapsed.
- Every hour until 24 hours have elapsed.
- Every two hours until 48 hours have elapsed.
- Every 4 to 6 hours until the end of the 7-day test.

Immediately after termination of the test, the rate of recovery of the water level shall be monitored for a period of 48 hours at both the injection and monitoring wells. The water levels will be recorded at the same time intervals (logarithmic) as the start of the constant rate injection test.

Analysis of Injection Testing Results

Following the completion of injection testing, data will be analyzed to estimate aquifer properties and provide a range of operational injection rates for the well. This information will also be used to update the groundwater model to evaluate project build out options.

Following updates to groundwater model, a series of scenarios will be developed in coordination with the City and Carollo Engineers to assess the ultimate number and location of wells required for the full project. Additional information from the modeling scenarios will include assessment of retention time within the aquifer, water level changes during and following injection periods and identification of any potential adverse conditions.

Recommendations will be provided for anticipated operational scheduling and approaches to minimize any potential adverse consequences and maximize the benefits of the proposed injection program.

Water Quality Sampling and Geochemical Evaluation

In addition to the collection of aquifer data collected during the tests, water quality samples will be collected at both the Injection well and/or the nearby monitoring well at the following times and analyzed for the list of constituents identified in the attached table:

- Collect samples at both the Injection and monitoring well on the last day of the constant rate pumping test (to establish the baseline aquifer water quality)
- Collect a sample at the Injection well at the end of the first and last day of contestant rate injection to document water quality of source water
- Samples will be collected from the monitoring well during the constant rate injection test during day 3, day 5, and day 7 (three sampling events). If groundwater quality changes occur based on field parameters (indicating that the injected water has reached the monitor well), the samples will be analyzed for a reduced suite of parameters.
- After completion of the constant rate injection test, groundwater samples will be collected once a week at the Injection well and monitoring well for four consecutive weeks. For each sampling episode, the well will be pumped to waste until parameters stabilize prior to sampling.

Water quality results for key constituents will be evaluated to identify mixing relationships and/or the presence of geochemical reactions. These field results will be used to verify the findings of the geochemical modeling described in the Geochemical Work Plan for Groundwater Replenishment and Reuse Project (GSI, 2021).

Table 1. Sampling Schedule

Stage	Purpose	Injection Well	Monitoring Well 21P-01
		Constituents	**Constituents**
Pumping constant rate (end)	Baseline groundwater quality	Complete suite	Complete suite
Injection Day 1 (end of day)	Source water quality	Complete suite	Field parameters [2]
Injection Day 3	Source water quality changes	--	Field parameters [2]
Injection Day 5	Source water quality changes	--	Field parameters [2]
Injection Day 7	Residence time	Complete suite	Complete suite
Post-Injection Weeks 1, 2, 3 and 4	Geochemical reactions	Complete suite [1]	Reduced / Complete suite [3]

Notes:
Complete and reduced suite defined in Water Quality Testing Constituents attached.
[1] If any trends are evident, a further complete sample will be collected at 6 weeks.
[2] Water quality samples will be collected for reduced suite if field-measured groundwater quality parameters changes.
[2] The monitoring well will be analyzed for the reduced suite (except DPBs) unless the field parameters indicate a change, which would trigger complete suite,

Injection Testing Schedule and Reporting

The injection testing will be conducted following the completion of the well installation and constant rate aquifer test. It is anticipated that the injection testing will begin by late May 2021 and require approximately 6 to 7 weeks to complete, including the 4 weeks of post-testing water quality sampling. Following the completion of the injection testing program, the Contractor will be responsible for removing all equipment and conveyance pipelines. The Contractor will not be provided final payment until the site condition is deemed satisfactory by the City and the terms of the project Technical Specifications are met.

The testing results will be provided in a technical memorandum (TM). This TM is anticipated to be completed by the end of July, approximately one month following the completion of the field work if the proposed drilling and injection testing schedules are met.

FIGURE 1

Site and Well Location Map

Morro Bay
Indirect Potable Reuse Program
Injection Testing

LEGEND

- Injection Well No. 1
- Well Construction Site
- Cuttings and Drilling Fluids Disposal
- Bike Path
- Piezometer
- Temporary Hose
- MBMWC Well
- Yeh Piezometer
- PG&E Property Boundary
- Western Project Area, 17 Acres
- Watercourse

NOTE

MBMWC: Morro Bay Mutual Water Company

N

0 150 300
Feet

Date: August 26, 2021
Data Sources: NAIP Imagery, ESRI

GSI Water Solutions, Inc.

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\Pilot_Inject_Well\Figure1_Western_Project_Site_Injection_Well_2021.mxd

Parameter Type	Parameter	Method
Field	Dissolved oxygen	YSI 556 or similar
	pH	EPA 150.1
	Oxidation-Reduction Potential	SM2580B
	Specific Conductance	EPA 120.1
	Temperature	YSI 556 or similar
	Turbidity	EPA 180.1
Inorganics	Alkalinity	SM2320B
	Ammonia	SM4500NH3G
	Bicarbonate	SM2320B
	Carbonate	SM2320B
	Chloride	EPA 300.0
	Cyanide (HCN)	EPA 335.4
	Fluoride	EPA 300.0
	Hardness	EPA 200.8
	Nitrate+Nitrite (total N)	EPA 300.0
	Nitrate (as N)	EPA 300.0
	Nitrite-N	EPA 300.0
	Orthophosphate as P	EPA 300.0
	Total Silica (as SiO2)	EPA 200.7
	Dissolved Silica (as SiO2)	EPA 200.7
	Sulfate	EPA 300.0
	Sulfide	SM4500S2F
Metals (Dissolved)	Aluminum	EPA 200.7
	Antimony	EPA 200.8
	Arsenic	EPA 200.8
	Barium	EPA 200.8
	Beryllium	EPA 200.8
	Cadmium	EPA 200.8
	Calcium	EPA 200.7
	Chromium	EPA 200.8
	Cobalt	EPA 200.8
	Copper	EPA 200.8
	Iron	EPA 200.7
	Lead	EPA 200.8
	Magnesium	EPA 200.7
	Manganese	EPA 200.8
	Mercury	EPA 245.7
	Molybdenum	EPA 200.8
	Nickel	EPA 200.8
	Potassium	EPA 200.7
	Selenium	EPA 200.8
	Silver	EPA 200.8

	Sodium	EPA 200.7
	Strontium	EPA 200.8
	Thallium	EPA 200.8
	Uranium	EPA 200.8
	Vanadium	EPA 200.8
	Zinc	EPA 200.8
Miscellaneous	Chemical Oxygen Demand	EPA 410.4
	Color	SM 2120B
	Corrosivity	Langelier Index
	Dissolved Organic Carbon	SM 5310C
	Foaming Agents (MBAs)	SM5540C
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	Odor	2150B
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	Turbidity	EPA 180.1
	Asbestos	Microscope: Hitachi 7000FA
DBPs	Residual Chlorine	SM 4500CL-G
	Dibromoacetic Acid (HAA)	SM6251B
	Dichloroacetic Acid (HAA)	SM6251B
	Monobromoacetic Acid (Bromoacetic acid) (HAA)	SM6251B
	Monochloroacetic Acid (HAA)	SM6251B
	Trichloroacetic Acid (HAA)	SM6251B
	Total Haloacetic Acids (Total HAA's)	SM6251B
	Bromodichloromethane (THM)	EPA 524.3
	Bromoform (THM)	EPA 524.3
	Chloroform (THM)	EPA 524.3
	Dibromochloromethane (THM)	EPA 524.3
	Total Trihalomethane (TTHM)	EPA 524.3
Other	Bromate	EPA 317
	Hexavalent Chromium	EPA 218.7

Parameter Type	Parameter	Method
Field	Dissolved oxygen	YSI 556 or similar
	pH	EPA 150.1
	Oxidation-Reduction Potential	SM2580B
	Specific Conductance	EPA 120.1
	Temperature	YSI 556 or similar
	Turbidity	EPA 180.1
Inorganics	Chloride	EPA 300.0
Metals (Dissolved)	Arsenic	EPA 200.8

Miscellaneous	Odor Oxidation-Reduction Potential pH Specific Conductance Total Dissolved Solids Total Organic Carbon Total Suspended Solids Turbidity	2150B SM2580B EPA 150.1 EPA 120.1 SM 2540C SM5310C SM 2540D EPA 180.1
DBPs	Residual Chlorine Dibromoacetic Acid (HAA) Dichloroacetic Acid (HAA) Monobromoacetic Acid (Bromoacetic acid) (HAA) Monochloroacetic Acid (HAA) Trichloroacetic Acid (HAA) Total Haloacetic Acids (Total HAA's) Bromodichloromethane (THM) Bromoform (THM) Chloroform (THM) Dibromochloromethane (THM) Total Trihalomethane (TTHM)	SM 4500CL-G SM6251B SM6251B SM6251B SM6251B SM6251B SM6251B EPA 524.3 EPA 524.3 EPA 524.3 EPA 524.3 EPA 524.3
Other	Hexavalent Chromium	EPA 218.7

APPENDIX D

Fluorescein Safety Data Sheet

Kingscote
CHEMICALS

Safety Data Sheet

Issue Date: 09-Jan-2013 **Revision Date:** 03-Jan-2017 **Version Number:** 1.3

1. Identification

Product Identifiers
Product Name: Bright Dyes ® FLT Yellow-Green Powder

Product Number: 105001

Recommended Use & Restrictions on Use
Water tracing & leak detection dye

Manufacturer/Supplier
Kingscote Chemicals, Inc.
3334 South Tech Blvd.
Miamisburg, OH 45342
U.S.A.

Emergency Telephone Number

Company Telephone Number:	(937) 886-9100
Emergency Telephone (24 hr):	INFOTRAC (800) 535-5053 (North America) +1-352-323-3500 (International)

2. Hazards Identification

Classification
This chemical does not meet the hazardous criteria set forth by the 2012 OSHA Hazard Communication Standard (29 CFR 1910.1200). However, this Safety Data Sheet (SDS) contains valuable information critical to the safe handling and proper use of this product. This SDS should be retained and available for employees and other users of this product.

3. Composition/Information on Ingredients

This product is not hazardous according to OSHA 29 CFR 1910.1200. Components not listed are not hazardous or are below reportable limits.

4. First-Aid Measures

First-Aid Measures

Eye Contact	Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. If eye irritation persists: Get medical advice/attention.
Skin Contact	Wash thoroughly with plenty of soap and water. If skin irritation occurs: Get medical advice/attention.
Inhalation	Remove to fresh air. If breathing is difficult, administer oxygen; seek medical attention immediately.

Ingestion Rinse mouth. DO NOT induce vomiting. Drink plenty of water. Never give anything by mouth to an unconscious person. Get medical attention if large quantities were ingested or if nausea occurs.

Most Important Symptoms and Effects

Symptoms Will cause staining of the skin on contact. May cause eye irritation. Inhalation of dust may cause respiratory irritation. Ingestion may cause urine to be a yellow/green color until the dye has been washed through the system.

Indication of Any Immediate Medical Attention and Special Treatment Needed

Notes to Physician Treat symptomatically.

5. Fire-Fighting Measures

Suitable Extinguishing Media
Water spray (fog). Carbon dioxide (CO2). Dry chemical. Regular foam.

Unsuitable Extinguishing Media
Not determined

Specific Hazards Arising from the Chemical
Remote possibility of dust explosion. Burning may produce oxides of carbon and nitrogen (NOx).

Protective Equipment and Precautions for Firefighters
Wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear.

6. Accidental Release Measures

Personal Precautions, Protective Equipment and Emergency Procedures

Personal Precautions Use personal protective equipment as recommended in Section 8.

Environmental Precautions Prevent from entering into soil, ditches, sewers, waterways and/or groundwater. See Section 12 and Section 13.

Methods and Material for Containment and Cleaning Up

Methods for Containment Prevent further leakage or spillage if safe to do so.

Methods for Cleaning Up Sweep up and collect into suitable containers for disposal. Flush area with water.

7. Handling and Storage

Precautions for Safe Handling

Advice on Safe Handling Handle in accordance with good industrial hygiene and safety practices. Use personal protection recommended in Section 8. Avoid contact with skin, eyes, or clothing. Avoid breathing dusts. Contaminated clothing should be thoroughly washed before reuse.

Conditions for Safe Storage, Including Incompatibilities

Storage Conditions	Keep container tightly closed and store in a cool, dry, and well-ventilated area. Store away from heat, sparks, open flame or any other ignition source.
Incompatible Materials	None known based on information supplied.

8. Exposure Controls / Personal Protection

Exposure Guidelines
This product, as supplied, does not contain any hazardous materials with occupational exposure limits established by the region specific regulatory bodies.

Engineering Controls
Ensure adequate ventilation, especially in confined areas. Eyewash stations. Showers.

Individual Protection Measures, Such as Personal Protective Equipment:

Eye/Face Protection	Avoid contact with eyes.
Skin & Body Protection	Rubber gloves. Suitable protective clothing.
Respiratory Protection	Use NIOSH-approved dust mask if dusty conditions exist.
Hygiene Measures	Handle in accordance with good industrial hygiene and safety practices.

9. Physical and Chemical Properties

Information on Basic Physical and Chemical Properties

Physical State	Solid	**Odor**	None apparent
Appearance	Red-orange powder	**Odor Threshold**	Not determined
Color	Red-orange		

Property	Values
pH	Not applicable
Melting/Freezing Point	Not applicable
Boiling Point/Range	Not applicable
Flash Point	Not applicable
Evaporation Rate	Not applicable
Flammability (solid, gas)	Non-flammable
Upper Flammability Limits	Not applicable
Lower Flammability Limits	Not applicable
Vapor Pressure	Not applicable
Vapor Density	Not applicable
Relative Density	Not applicable
Specific Gravity	Not applicable
Solubility	Soluble in water
Partition Coefficient	Not determined
Auto-ignition Temperature	Not determined
Decomposition Temperature	Not determined
Viscosity	Not determined

10. Stability and Reactivity

Reactivity
Not reactive under normal conditions.

Chemical Stability
Stable under recommended storage conditions.

Possibility of Hazardous Reactions
None under normal processing.

Conditions to Avoid
Keep out of reach of children.

Incompatible Materials
None known based on information supplied.

Hazardous Decomposition Products
Oxides of carbon and nitrogen (NOx).

11: Toxicological Information

Information on Likely Routes of Exposure

Inhalation	Avoid inhalation of dust.
Ingestion	Do not ingest.
Skin Contact	May cause an allergic skin reaction.
Eye Contact	Avoid contact with eyes.

Delayed, Immediate, and Chronic Effects from Short- and Long-Term Exposure
May cause an allergic skin reaction.

Numerical Measures of Toxicity
Not determined

Symptoms Associated with Exposure
See Section 4 of this SDS for symptoms.

Carcinogenicity

NTP	None
IARC	None
OSHA	None

12. Ecological Information

Ecotoxicity
This product is not classified as environmentally hazardous. However, this does not exclude the possibility that large or frequent spills can have a harmful or damaging effect on the environment.

Component Information
Not available

Persistence/Degradability
Not determined

Bioaccumulation
Not determined

Mobility
Not determined

Other Adverse Effects
Not determined

13. Disposal Considerations

Waste Disposal Methods
Dispose of in accordance with federal, state, and local regulations.

Contaminated Packaging
Do not re-use empty containers. Dispose of containers in accordance with federal, state, and local regulations.

14. Transport Information

Note
See current shipping paper for most up-to-date shipping information, including exemptions and special circumstances.

DOT	Not regulated
IATA	Not regulated
OMDG	Not regulated

15: Regulatory Information

International Inventories
All ingredients in this product are listed in the U.S. EPA TSCA Inventories.

U.S. Federal Regulations

CERCLA	This material, as supplied, does not contain any substances regulated as hazardous substances under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (40 CFR 302) or the Superfund

Amendments and Reauthorization Act (SARA) (40 CFR 355).

SARA 313 Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA). This product does not contain any chemicals which are subject to the reporting requirements of the Act and Title 40 of the Code of Federal Regulations, Part 372.

CWA (Clean Water Act) This product does not contain any substances regulated as pollutants pursuant to the Clean Water Act (40 CFR 122.21 and 40 CFR 122.42).

U.S. State Regulations

California Proposition 65 This product does not contain any Proposition 65 chemicals.

U.S. State Right-to-Know This product does not contain any substances regulated under applicable state right-to-know regulations.

16: Other Information

HMIS

Health Hazards	Flammability	Instability	Special Hazards
1	0	0	Not determined

NFPA

Health Hazards	Flammability	Physical Hazards	Personal Protection
1	0	0	B

Issue Date 09-Jan-2013

Revision Date 03-Jan-2019

Revision Note Biennial Review

Disclaimer

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

End of Safety Data Sheet

APPENDIX E

Ozark Underground Laboratory Inc. -- Procedures and Criteria

Analysis Of Fluorescent Dyes

PROCEDURES AND CRITERIA
ANALYSIS OF FLUORESCENT DYES
IN WATER AND CHARCOAL SAMPLERS:

FLUORESCEIN, EOSINE, RHODAMINE WT, AND SULFORHODAMINE B DYES

Revision Date:
March 3, 2015

Thomas Aley, PHG, PG
President
and
Shiloh L. Beeman, PG
Sr. Hydrogeologist

Ozark Underground Laboratory, Inc.
1572 Aley Lane
Protem, Missouri 65733
417-785-4289
contact@ozarkundergroundlab.com

INTRODUCTION

This document describes standard procedures and criteria currently in use at the Ozark Underground Laboratory (OUL) as of the date shown on the title page. Some samples may be subjected to different procedures and criteria because of unique conditions; such non-standard procedures and criteria are identified in reports for those samples. Standard procedures and criteria change as knowledge and experience increases and as equipment is improved or up-graded. The OUL maintains a summary of changes in standard procedures and criteria.

TRACER DYES AND SAMPLE TYPES

Dye Nomenclature

Dye manufacturers and retailers use a myriad of names for the dyes. This causes confusion among dye users and report readers. The primary dyes used at the OUL and described in this document are included in Table 1 below.

Table 1. Primary OUL Dye Nomenclature.

OUL Common Name	Color Index Number	Color Index Name	Other Names
Fluorescein	45350	Acid Yellow 73	uranine, uranine C, sodium fluorescein, fluorescein LT and fluorescent yellow/green
Eosine	45380	Acid Red 87	eosin, eosine OJ, and D&C Red 22
Rhodamine WT	None assigned	Acid Red 388	fluorescent red (but not the same as rhodamine B)
Sulforhodamine B	45100	Acid Red 52	pontacyl brilliant pink B, lissamine red 4B, and fluoro brilliant pink

The OUL routinely provides dye for tracing projects. Dyes purchased for groundwater tracing are always mixtures that contain both dye and an associated diluent. Diluents enable the manufacturer to standardize the dye mixture so that there are minimal differences among batches. Additionally, diluents are often designed to make it easier to dissolve the dye mixture in water, or to produce a product which meets a particular market need (groundwater tracing is only a tiny fraction of the dye market). The percent of dye in "as-sold" dye mixtures often varies dramatically among manufacturers and retailers, and retailers are sometimes incorrect about the percent of dye in their products. The OUL subjects all of its dyes to strict quality control (QC) testing. Table 2 summarizes the as-sold dye mixtures used by the OUL.

Table 2. As-Sold Dye Mixtures at the OUL.

OUL Common Name	Form	Dye Equivalent
Fluorescein	Powder	75% dye equivalent, 25% diluent
Eosine	Powder	75% dye equivalent, 25% diluent
Rhodamine WT	Liquid	20% dye equivalent, 80% diluent
Sulforhodamine B	Powder	75% dye equivalent, 25% diluent

Analytical results are based on the as-sold weights of the dyes provided by the OUL. The use of dyes from other sources is discouraged due to the wide variability of dye equivalents within the market. However, if alternate source dyes are used, a sample should be provided to the OUL for quality control and to determine if a correction factor is necessary for the analytical results.

Types of Samples

Typical samples that are collected for fluorescent tracer dye analysis include charcoal samplers (also called activated carbon or charcoal packets) and water samples.

The charcoal samplers are packets of fiberglass screening partially filled with 4.25 grams of activated coconut charcoal. The charcoal used by the OUL is Calgon 207C coconut shell carbon, 6 to 12 mesh, or equivalent. The most commonly used charcoal samplers are about 4 inches long by 2 inches wide. A cigar-shaped sampler is made for use in very small diameter wells (such as 1-inch diameter piezometers); this is a special order item and should be specifically requested in advance when needed. All of the samplers are closed by heat sealing.

In specialized projects, soil samples have been collected from soil cores and analyzed for fluorescent tracer dyes. Project-specific procedures have been developed for projects such as these. For additional information, please contact the OUL.

FIELD PROCEDURES

Field procedures included in this section are intended as guidance, and not firm requirements. Placement of samplers and other field procedures require adjustment to field conditions. Personnel at the OUL are available to provide additional assistance for implementation of field procedures specific to specialized field conditions.

Placement of Samplers

Charcoal samplers are placed so as to be exposed to as much water as possible. Water should flow through the packet. In springs and streams they are typically attached to a rock or other anchor in a riffle area. Attachment of the packets often uses plastic tie wires. In swifter water galvanized wire (such as electric fence wire) is often used. Other types of anchoring wire can be used. Electrical wire with plastic insulation is also good. Packets are attached so that they extend outward from the anchor rather than laying flat against it. Two or more separately anchored packets are typically used for sampling springs and streams. The placement of multiple packets is recommended in order to minimize the chance of loss during the sampling period. The use of fewer packets is discouraged except when the spring or stream is so small that there is not appropriate space for placing multiple packets.

When pumping wells are being sampled, the samplers are typically placed in sample holders made of plastic pipe fittings. Brass hose fittings can be at the end of the sample holders so that the sample holders can be installed on outside hose bibs and water which has run through the samplers can be directed to waste through a connected garden hose. The samplers can be unscrewed in the middle so that charcoal packets can be changed. The middle portions of the samplers consist of 1.5 inch diameter pipe and pipe fitting.

Charcoal packets can be lowered into monitoring wells for sampling purposes. In general, if the well is screened, samplers should be placed approximately in the middle of the screened interval. Due to the typically lower volume of water that flows through a well, only one charcoal sampler should be used per well. However, multiple packets can be placed in a single well at depths to test different depth horizons when desirable. A weight should be added near the charcoal packet to ensure that it will not float. The weight should be of such a nature that it will not affect water quality. One common approach is to anchor the packets with a white or uncolored plastic cable tie to the top of a dedicated weighted disposable bailer. We typically run nylon cord from the top of the well to the charcoal packet and its weight. ***Do not use colored cord*** since some of them are colored with fluorescent dyes. Nylon fishing line should not be used since it can be readily cut by a sharp projection in the well.

In some cases, especially with small diameter wells and appreciable well depths, the weighted disposable bailers sink very slowly or may even fail to sink because of friction and floating of the anchoring cord. In such cases a weight may be added to the top of the disposable bailer. Stainless steel weights are ideal, but are not needed in all cases. All weights should be cleaned prior to use; the cleaning approach should comply with decontamination procedures in use at the project site.

Optional Preparation of Charcoal Samplers

Charcoal packets routinely contain some fine powder that washes off rapidly when they are placed in water. While not usually necessary, the following optional preparation step is suggested if the fine charcoal powder is problematic.

Charcoal packets can be triple rinsed with distilled, demineralized, or reagent water known to be free of tracer dyes. This rinsing is typically done by soaking. With this approach, approximately 25 packets are placed in one gallon of water and soaked for at least 10 minutes. The packets are then removed from the water and excess water is shaken off the packets. The packets are then placed in a second gallon of water and again soaked for at least 10 minutes. After this soaking they are removed from the water and excess water is shaken off the packets. The packets are then placed in a third gallon of water and the procedure is again repeated. Rinsed packets are placed in plastic bags and are placed at sampling stations within three days. Packets can also be rinsed in jets of water for about one minute; this requires more water and is typically difficult to do in the field with water known to be free of tracer dyes.

Collection and Replacement of Samplers

Samplers are routinely collected and replaced at each of the sampling stations. The frequency of sampler collection and replacement is determined by the nature of the study. Collections at one week intervals are common, but shorter or longer collection frequencies are acceptable and sometimes more appropriate. Shorter sampling frequencies are often used in the early phases of a study to better characterize time of travel. As an illustration, we often collect and change charcoal packets 1, 2, 4, and 7 days after dye injection. Subsequent sampling is then weekly.

The sampling interval in wells at hazardous wastes sites should generally be no longer than about a week. Contaminants in the water can sometimes use up sorption sites on the charcoal that would otherwise adsorb the dye. This is especially important if the dye might pass in a relatively short duration pulse.

Where convenient, the collected samplers should be briefly rinsed in the water being sampled to remove dirt and accumulated organic material. This is not necessary with well samples. The packets are shaken to remove excess water. Next, the packet (or packets) are placed in a plastic bag (Whirl-Pak® bags are ideal). The bag is labeled on the outside with a black permanent type felt marker pen, such as a Sharpie®. ***Use only pens that have black ink***; colored inks may contain fluorescent dyes. The notations include station name or number and the date and time of collection. Labels must not be inserted inside the sample bags.

Collected samplers are kept in the dark to minimize algal growth on the charcoal prior to analysis work. New charcoal samplers are routinely placed when used charcoal packets are collected. The last set of samplers placed at a stream or spring is commonly not collected.

Water Samples

Water samples are often collected. They should be collected in either glass or plastic; the OUL routinely uses 50 milliliter (mL) research-grade polypropylene copolymer Perfector Scientific vials (Catalog Number 2650) for such water samples. No more than 30 mL of water is required for analysis. The sides of the vials should be labeled with the project name, sample ID, sample date and time with a black permanent felt tip pen. ***Do not label the lid only***. The vials should be placed in the dark and refrigerated immediately after collection, and maintained under refrigeration until shipment. The OUL supplies vials for the collection of water samples.

Sample Shipment

When water or charcoal samplers are collected for shipment to the OUL they should be shipped promptly. We prefer (and in some studies require) that samples be refrigerated with frozen re-usable ice packs upon collection and that they be shipped refrigerated with frozen ice packs by overnight express. ***Do not ship samplers packed in wet ice*** since this can create a potential for cross contamination when the ice melts. Our experience indicates that it is not essential for samplers to be maintained under refrigeration; yet maintaining them under refrigeration clearly minimizes some potential problems. A product known as "green ice" should not be used for maintaining the samples in a refrigerated condition since this product contains a dye which could contaminate samples if the "green ice" container were to break or leak.

We receive good overnight and second day air service from both UPS and FedEx. The U.S. Postal Service does not typically provide next day service to us. DHL does not provide overnight service to us. FedEx is recommended for international shipments. The OUL does not receive Saturday delivery.

Each shipment of charcoal samplers or water samples ***must be accompanied by a sample custody document***. The OUL provides a sheet (which bears the title "Samples for Fluorescence Analysis") that can be used if desired. These sheets can be augmented by a client's chain-of-custody forms or any other relevant documentation. OUL's custody document works well for charcoal samplers because it allows for both the placement date and time as well as the collection date and time. Many other standard chain-of-custody documents do not allow for these types of samples. Attachment 1 includes a copy of OUL's Sample Collection Data Sheet.

Please write legibly on the custody documents and ***use black ink***. Check the accuracy of the sample sheet against the samples prior to shipment to identify and correct errors that may delay the analysis of your samples following receipt at the laboratory.

Supplies Provided by the OUL

The OUL provides supplies for the collection of fluorescent tracer dyes. Supplies provided upon request are charcoal packets, Whirl-Pak® bags (to contain the charcoal packets after collection for shipment to the laboratory), and water vials. These supplies are subjected to strict QA/QC procedures to ensure the materials are free of any potential tracer dye contaminants. The charge for these materials is included in the cost of sample analysis. Upon request, coolers and re-freezable ice packs are also provided for return shipment of samples.

The OUL also has tracer dyes available for purchase. These dyes are subject to strict QA/QC testing. All analytical work is based upon the OUL as-sold weight of the dyes.

LABORATORY PROCEDURES

The following procedures are followed upon receipt of samples at the laboratory.

Receipt of Samples

Samplers shipped to the OUL are logged in and refrigerated upon receipt. Prior to cleaning and analysis, samplers are assigned a laboratory identification number.

It sometimes occurs that there are discrepancies between the sample collection data sheet and the actual samples received. When this occurs, a "Discrepancy Sheet" form is completed and sent to the shipper of the sample for resolution. The purpose of the form is to help resolve discrepancies, even when they may be minor. Many discrepancies arise from illegible custody documents. ***Please write legibly*** on the custody documents and ***use black ink***. Check the accuracy of the sample sheet against the samples prior to shipment to identify and correct errors that may delay the analysis of your samples following receipt at the laboratory.

Cleaning of Charcoal Samplers

Samplers are cleaned by spraying them with jets of clean water from a laboratory well in a carbonate aquifer. OUL uses non-chlorinated water for the cleansing to minimize dye deterioration. We do not wash samplers in public water supplies. Effective cleansing cannot generally be accomplished simply by washing in a conventional laboratory sink even if the sink is equipped with a spray unit.

The duration of packet washing depends upon the condition of the sampler. Very clean samplers may require less than a minute of washing; dirtier samplers may require several minutes of washing.

Elution of the Charcoal

There are various eluting solutions that can be used for the recovery of tracer dyes. The solutions typically include an alcohol, water, and a strong basic solution such as aqueous ammonia and /or potassium hydroxide.

The standard elution solution used at the OUL is a mixture of 5% aqua ammonia and 95% isopropyl alcohol solution and sufficient potassium hydroxide pellets to saturate the solution. The isopropyl alcohol solution is 70% alcohol and 30% water. The aqua ammonia solution is 29% ammonia. The potassium hydroxide is added until a super-saturated layer is visible in the bottom of the container. This super-saturated layer is not used for elution. Preparation of eluting solutions uses dedicated glassware which is never used in contact with dyes or dye solutions.

The eluting solution will elute fluorescein, eosine, rhodamine WT, and sulforhodamine B dyes. It is also suitable for separating fluorescein peaks from peaks of some naturally present materials found in may be found in samplers.

Fifteen mL of the eluting solution is poured over the washed charcoal in a disposable sample beaker. The sample beaker is capped. The sample is allowed to stand for 60 minutes. After this time, the liquid is carefully poured off the charcoal into a new disposable beaker which has been appropriately labeled with the laboratory identification number. A few grains of charcoal may inadvertently pass into the second beaker; no attempt is made to remove these from the second sample beaker. After the pouring, a small amount of the elutant will remain in the initial sample beaker. After the transfer of the elutant to the second sample beaker, the contents of the first sample beaker (the eluted charcoal) are discarded. Samples are kept refrigerated until analyzed.

pH Adjustment of Water Samples

The fluorescence intensity of several of the commonly used fluorescent tracer dyes is pH dependent. The pH of samples analyzed for fluorescein, eosine, and pyranine dyes are adjust to a target pH of greater than 9.5 in order to obtain maximum fluorescence intensities.

Adjustment of pH is achieved by placing samples in a high ammonia atmosphere for at least two hours in order to increase the pH of the sample. Reagent water standards are placed in the same atmosphere as the samples. If dye concentrations in a sample are off-scale and require dilution for quantification of the dye concentration, the diluting water used is OUL reagent water that has been pH adjusted in a high ammonia atmosphere. Samples that are only analyzed for rhodamine WT or sulforhodamine B are not required to be pH adjusted.

Analysis on the Shimadzu RF-5301

The OUL uses a Shimadzu spectrofluorophotometer model RF-5301. This instrument is capable of synchronous scanning. The OUL also owns a Shimadzu RF-540 spectrofluorometers that is occasionally used for special purposes.

A sample of the elutant or water is withdrawn from the sample container using a disposable polyethylene pipette. Approximately 3 mL of the sample is then placed in disposable rectangular polystyrene cuvette. The cuvette has a maximum capacity of 3.5 mL. The cuvette is designed for fluorometric analysis; all four sides and the bottom are clear. The acceptable spectral range of these cuvettes is 340 to 800 nm. The pipettes and cuvettes are discarded after one use.

The cuvette is then placed in the RF-5301. This instrument is controlled by a programmable computer and operated by proprietary software developed for dye tracing applications.

Our instruments are operated and maintained in accordance with the manufacturer's recommendations. On-site installation of our first instrument and a training session on its use was provided by the instrument supplier. Repairs are made by a Shimadzu-authorized repairman.

Our typical analysis of an elutant sample where fluorescein, eosine, rhodamine WT, or sulforhodamine B dyes may be present includes synchronous scanning of excitation and emission spectra with a 17 nm separation between excitation and emission wavelengths. For these dyes, the excitation scan is from 443 to 613 nm; the emission scan is from 460 to 630 nm. The emission fluorescence from the scan is plotted on a graph. The typical scan speed setting is “fast” on the RF-5301. The typical sensitivity setting used is "high."

Table 3. Excitation and emission slit width settings routinely used for dye analysis.

Parameter	Excitation Slit (nm)	Emission Slit (nm)
ES, FL, RWT, and SRB in elutant	3	1.5
ES, FL, RWT, and SRB in water	5	3

Note: ES = Eosine. FL = Fluorescein. RWT = Rhodamine WT. SRB = Sulforhodamine B.

The instrument produces a plot of the synchronous scan for each sample; the plot shows emission fluorescence only. The synchronous scans are subjected to computer peak picks using proprietary software; peaks are picked to the nearest 0.1 nm. Instrument operators have the ability to manually adjust peaks as necessary based upon computer-picked peaks and experience. All samples run on the RF-5301 are stored electronically with sample information. All samples analyzed are recorded in a bound journal.

Quantification

We calculate the magnitude of fluorescence peaks for fluorescein, eosine, rhodamine WT, and sulforhodamine B dyes in both elutant and water samples. Dye quantities are expressed in microgram per liter (parts per billion; ppb). The dye concentrations are calculated by separating fluorescence peaks due to dyes from background fluorescence on the charts, and then calculating the area within the fluorescence peak. This area is proportional to areas obtained from standard solutions.

We run dye concentration standards each day the RF-5301 is used. Six standards are used; the standard or standards appropriate for the analysis work being conducted are selected. All standards are based upon the as-sold weights of the dyes. The standards are as follows:

1) 10 ppb fluorescein and 100 ppb rhodamine WT in well water from the Jefferson City-Cotter Formation
2) 10 ppb eosine in well water from the Jefferson City-Cotter Formation
3) 100 ppb sulforhodamine B in well water from the Jefferson City-Cotter Formation.
4) 10 ppb fluorescein and 100 ppb rhodamine WT in elutant.
5) 10 ppb eosine in elutant.
6) 100 ppb sulforhodamine B in elutant.

Preparation of Standards

Dye standards are prepared as follows:

Step 1. A small sample of the as-sold dye is placed in a pre-weighed sample vial and the vial is again weighed to determine the weight of the dye. We attempt to use a sample weighing between 1 and 5 grams. This sample is then diluted with well water to make a 1% dye solution by weight (based upon the as-sold weight of the dye). The resulting dye solution is allowed to sit for at least four hours to ensure that all dye is fully dissolved.

Step 2. One part of each dye solution from Step 1 is placed in a mixing container with 99 parts of well water. Separate mixtures are made for fluorescein, rhodamine WT, eosine, and sulforhodamine B. The resulting solutions contain 100 mg/L dye (100 parts per million dye mixture). The typical prepared volume of this mixture is appropriate for the sample bottles being used; we commonly prepare about 50 mL of the Step 2 solutions. The dye solution from Step 1 that is used in making the Step 2 solution is withdrawn with a digital Finnpipette which is capable of measuring volumes between 0.200 and 1.000 mL at intervals of 0.005 mL. The calibration certificate with this instrument indicates that the accuracy (in percent) is as follows:

At 0.200 mL, 0.90%

At 0.300 mL, 0.28%

At 1.000 mL, 0.30%

The Step 2 solution is called the long term standard. OUL experience indicates that Step 2 solutions, if kept refrigerated, will not deteriorate appreciably over periods of less than a year. Furthermore, these Step 2 solutions may last substantially longer than one year.

Step 3. A series of intermediate-term dye solutions are made. Approximately 45 mL. of each intermediate-term dye solution is made. All volume measurements of less than 5 mL are made with a digital Finnpipette. (see description in Step 2). All other volume measurements are made with Rheinland Kohn Geprufte Sicherheit 50 mL capacity pump dispenser which will pump within plus or minus 1% of the set value. The following solutions are made; all concentrations are based on the as-sold weight of the dyes:

1) 1 ppm fluorescein dye and 10 ppm rhodamine WT dye.

2) 1 ppm eosine.

3) 10 ppm sulforhodamine B dye.

Step 4. A series of six short-term dye standards are made from solutions in Step 3. These standards were identified earlier in this section. In the experience of the OUL these standards have a useful shelf life in excess of one week. However, in practice, Step 4 elutant standards are made weekly, and Step 4 water standards are made daily.

Dilution of Samples

Samples with peaks that have arbitrary fluorescence unit values of 500 or more are diluted a hundred fold to ensure accurate quantification.

Some water samples have high turbidity or color which interferes with accurate detection and measurement of dye concentrations. It is often possible to dilute these samples and then measure the dye concentration in the diluted sample.

The typical dilutions are either 10 fold (1:10) or 100 fold (1:100). A 1:10 dilution involves combining one part of the test sample with 9 parts of water (if the sample is water) or elutant (if the sample is elutant). A 1:100 dilution involves combining one part of the test sample is combined with 99 parts of water or elutant, based upon the sample media. Typically, 0.300 mL of the test solution is combined with 29.700 mL of water (or elutant as appropriate) to yield a new test solution.

All volume measurements of less than 5 mL are made with a digital Finnpipette. All other volume measurements are made with Rheinland Kohn Geprufte Sicherheit 50 mL capacity pump dispenser which will pump within plus or minus 1% of the set value.

The water used for dilution is from a carbonate aquifer. All dilution water is pH adjusted to greater than pH 9.5 by holding it in open containers in a high ammonia concentration chamber. This adjustment takes a minimum of two hours.

Quality Control

Laboratory blanks are run for every sample where the last two digits of the laboratory numbers are 00, 20, 40, 60, or 80. A charcoal packet is placed in a pumping well sampler and at least 25 gallons of unchlorinated water is passed through the sampler at a rate of about 2.5 gallons per minute. The sampler is then subjected to the same analytical protocol as all other samplers.

System functioning tests of the analytical instruments are conducted in accordance with the manufacturer's recommendations. Spiked samples are also analyzed when appropriate for quality control purposes.

All materials used in sampling and analysis work are routinely analyzed for the presence of any compounds that might create fluorescence peaks in or near the acceptable wavelength ranges for any of the tracer dyes. This testing includes approximately 1% of materials used.

Project specific QA/QC samples may include sample replicates and sample duplicates. A replicate sample is when a single sample is analyzed twice. A sample duplicate is where two samples are collected in a single location and both are analyzed. Sample replicates and duplicates are run for QA/QC purposes upon request of the client. These results are reported in the Certificate of Analysis.

Reports

Sample analysis results are typically reported in a Certificate of Analysis. However, specialized reports are provided in accordance with the needs of the client. Certificates of Analysis typically provide a listing of station number, sample ID, and dye concentrations if detected. Standard data format includes deliverables in MS Excel and Adobe Acrobat (.pdf) format. Hard copy of the data package, and copies of the analytical charts are available upon request.

Work at the OUL is directed by Mr. Thomas Aley. Mr. Aley has 45 years of professional experience in hydrology and hydrogeology. He is certified as a Professional Hydrogeologist (Certificate #179) by the American Institute of Hydrology and licenced as a Professional Geologist in Missouri, Arkansas, Kentucky, and Alabama. Additional details regarding laboratory qualifications are available upon request.

Waste Disposal

All laboratory wastes are disposed of according to applicable state and federal regulations. Waste elutant and water samples are collected in 15 gallon poly drums and disposed with a certified waste disposal facilityas non-hazardous waste.

In special cases, wastes for a particular project may be segregated and returned to the client upon completion of the project. These projects may have samples that contain contaminants that the client must account for all materials generated and disposed. These situations are managed on a case-by-case basis.

CRITERIA FOR DETERMINATION OF POSITIVE DYE RECOVERIES

Normal Emission Ranges and Detection Limits

The OUL has established normal emission fluorescence wavelength ranges for each of the four dyes described in this document. The normal acceptable range equals mean values plus and minus two standard deviations. These values are derived from actual groundwater tracing studies conducted by the OUL.

The detection limits are based upon concentrations of dye necessary to produce emission fluorescence peaks where the signal to noise ratio is 3. The detection limits are realistic for most field studies since they are based upon results from actual field samples rather than being based upon values from spiked samples in a matrix of reagent water or the elutants from unused activated carbon samplers. In some cases detection limits may be smaller than reported if the water being sampled has very little fluorescent material in it. In some cases detection limits may be greater than reported; this most commonly occurs if the sample is turbid due to suspended material or a coloring agent such as tannic compounds. Turbid samples are typically allowed to settle, centrifuged, or, if these steps are not effective, diluted prior to analysis.

Table 4 provides normal emission wavelength ranges and detection limits for the four dyes when analyzed on the OUL’s RF-5301 for samples analyzed as of March 3, 2015.

Table 4. RF-5301 Spectrofluorophotometer. Normal emission wavelength ranges and detection limits for fluorescein, eosine, rhodamine WT, and sulforhodamine B dyes in water and elutant samples.

Fluorescent Dye	Normal Acceptable Emission Wavelength Range (nm)		Detection Limit (ppb)	
	Elutant	**Water**	**Elutant**	**Water**
Eosine	539.3 to 545.1	532.5 to 537.0	0.050	0.015
Fluorescein	514.1 to 519.2	505.9 to 509.7	0.025	0.002
Rhodamine WT	564.6 to 571.2	571.9 to 577.2	0.170	0.015
Sulforhodamine B	575.2 to 582.0	580.1 to 583.7	0.080	0.008

Note: Detection limits are based upon the as-sold weight of the dye mixtures normally used by the OUL. Fluorescein and eosine detection limits in water are based on samples pH adjusted to greater than 9.5.

It is important to note that the normal acceptable emission wavelength ranges are subject to change based on instrument maintenance, a change in instrumentation, or slight changes in dye formulation. Significant changes in normal acceptable emission wavelength ranges will be updated in this document as they occur.

Fluorescence Background

Due to the nature of fluorescence analysis, it is important to identify and characterize any potential background fluorescence at dye introduction and monitoring locations prior to the introduction of any tracer dyes.

There is generally little or no detectable fluorescence background in or near the general range of eosine, rhodamine WT, and sulforhodamine B dyes encountered in most groundwater tracing studies. There is often some fluorescence background in or near the range of fluorescein dye present at some of the stations used in groundwater tracing studies.

Criteria for Determining Dye Recoveries

The following sections identify normal criteria used by the OUL for determining dye recoveries. The primary instrument in use is a Shimadzu RF-5301.

EOSINE

Normal Criteria Used by the OUL for Determining Eosine Dye Recoveries in Elutants from Charcoal Samplers

Criterion 1. There must be at least one fluorescence peak in the range of 540.0 to 545.8 nm in the sample.

Criterion 2. The dye concentration associated with the fluorescence peak must be at least 3 times the detection limit. The eosine detection limit in elutant samples is 0.050 ppb, thus this dye concentration limit equals 0.150 ppb.

Criterion 3. The dye concentration must be at least 10 times greater than any other concentration reflective of background at the sampling station in question.

Criterion 4. The shape of the fluorescence peak must be typical of eosine. Much background fluorescence yields low, broad, and asymmetrical fluorescence peaks rather than the more narrow and symmetrical fluorescence peaks typical of eosine. In addition, there must be no other factors which suggest that the fluorescence peak may not be eosine dye from our groundwater tracing work.

Normal Criteria Used by the OUL for Determining Eosine Dye Recoveries in Water Samples

Criterion 1. In most cases, the associated charcoal samplers for the station should also contain eosine dye in accordance with the criteria listed above. This criterion may be waived if no charcoal sampler exists.

Criterion 2. There must be no factors which suggest that the fluorescence peak may not be eosine dye from our groundwater tracing work. The fluorescence peak should generally be in the range of 532.8 to 537.3 nm.

Criterion 3. The dye concentration associated with the fluorescence peak must be at least three times the detection limit. Our eosine detection limit in water samples is 0.015 ppb, thus this dye concentration limit equals 0.045 ppb.

Criterion 4. The dye concentration must be at least 10 times greater than any other concentration reflective of background at the sampling station in question.

FLUORESCEIN

Normal Criteria Used by the OUL for Determining Fluorescein Dye Recoveries in Elutants from Charcoal Samplers

Criterion 1. There must be at least one fluorescence peak in the range of 514.5 to 519.6 nm in the sample.

Criterion 2. The dye concentration associated with the fluorescence peak must be at least 3 times the detection limit. The fluorescein detection limit in elutant samples is 0.025 ppb, thus this dye concentration limit equals 0.075 ppb.

Criterion 3. The dye concentration must be at least 10 times greater than any other concentration reflective of background at the sampling station in question.

Criterion 4. The shape of the fluorescence peak must be typical of fluorescein. Much background fluorescence yields low, broad, and asymmetrical fluorescence peaks rather than the more narrow and symmetrical fluorescence peaks typical of fluorescein. In addition, there must be no other factors which suggest that the fluorescence peak may not be fluorescein dye from our groundwater tracing work.

Normal Criteria Used by the OUL for Determining Fluorescein Dye Recoveries in Water Samples

Criterion 1. In most cases, the associated charcoal samplers for the station should also contain fluorescein dye in accordance with the criteria listed above. This criterion may be waived if no charcoal sampler exists.

Criterion 2. There must be no factors which suggest that the fluorescence peak may not be fluorescein dye from our groundwater tracing work. The fluorescence peak should generally be in the range of 506.8 to 510.6 nm.

Criterion 3. The dye concentration associated with the fluorescence peak must be at least three times the detection limit. Our fluorescein detection limit in water samples is 0.002 ppb, thus this dye concentration limit equals 0.006 ppb.

Criterion 4. The dye concentration must be at least 10 times greater than any other concentration reflective of background at the sampling station in question.

RHODAMINE WT

Normal Criteria Used by the OUL for Determining Rhodamine WT Dye Recoveries in Elutants from Charcoal Samplers

Criterion 1. There must be at least one fluorescence peak in the sample in the range of 565.2 to 571.8 nm.

Criterion 2. The dye concentration associated with the rhodamine WT peak must be at least 3 times the detection limit. The detection limit in elutant samples is 0.170 ppb, thus this dye concentration limit equals 0.510 ppb.

Criterion 3. The dye concentration must be at least 10 times greater than any other concentration reflective of background at the sampling station in question.

Criterion 4. The shape of the fluorescence peak must be typical of rhodamine WT. In addition, there must be no other factors which suggest that the fluorescence peak may not be dye from the groundwater tracing work under investigation.

Normal Criteria Used by the OUL for Determining Rhodamine WT Dye Recoveries in Water Samples

Criterion 1. In most cases, the associated charcoal samplers for the station should also contain rhodamine WT dye in accordance with the criteria listed above. These criteria may be waived if no charcoal sampler exists.

Criterion 2. There must be no factors which suggest that the fluorescence peak may not be rhodamine WT dye from the tracing work under investigation. The fluorescence peak should generally be in the range of 572.4 to 577.7 nm.

Criterion 3. The dye concentration associated with the fluorescence peak must be at least three times the detection limit. Our rhodamine WT detection limit in water samples is 0.015 ppb, thus this dye concentration limit is 0.045 ppb.

Criterion 4. The dye concentration must be at least 10 times greater than any other concentration reflective of background at the sampling station in question.

SULFORHODAMINE B

Normal Criteria Used by the OUL for Determining Sulforhodamine B Dye Recoveries in Elutants from Charcoal Samplers

Criterion 1. There must be at least one fluorescence peak in the sample in the range of 576.4 to 583.2 nm.

Criterion 2. The dye concentration associated with the sulforhodamine B peak must be at least 3 times the detection limit. The detection limit in elutant samples is 0.080 ppb, thus this dye concentration limit equals 0.240 ppb.

Criterion 3. The dye concentration must be at least 10 times greater than any other concentration reflective of background at the sampling station in question.

Criterion 4. The shape of the fluorescence peak must be typical of sulforhodamine B. In addition, there must be no other factors which suggest that the fluorescence peak may not be dye from the groundwater tracing work under investigation.

Normal Criteria Used by the OUL for Determining Sulforhodamine B dye Recoveries in Water Samples

Criterion 1. In most cases, the associated charcoal samplers for the station should also contain sulforhodamine B dye in accordance with the criteria listed earlier. This criterion may be waived if no charcoal sampler exists.

Criterion 2. There must be no factors which suggest that the fluorescence peak may not be sulforhodamine B dye from the tracing work under investigation. The fluorescence peak should generally be in the range of 580.8 to 584.4 nm.

Criterion 3. The dye concentration associated with the fluorescence peak must be at least three times the detection limit. The detection limit in water is 0.008 ppb, thus this dye concentration limit equals 0.024 ppb.

Criterion 4. The dye concentration must be at least 10 times greater than any other concentration reflective of background at the sampling station in question.

Standard Footnotes

Sometimes not all the criteria are met for a straight forward determination of tracer dye in a sample. For these reasons, the emission graph is scrutinized carefully by the analytical technician and again during the QA/QC process. Sometimes the emission graphs require interpretation as to whether or not a fluorescence peak represents the tracer dye or not. Background samples from each of the sampling stations aid in the interpretation of the emission fluorescence graphs. When the results do not meet all the criteria for a positive dye detection, often the fluorescence peak is quantified and flagged with a footnote to the result as not meeting all the criteria for a positive dye detection. Standard footnotes are as follows:

Single asterisk (*): A fluorescence peak is present that does not meet all the criteria for a positive dye recovery. However, it has been calculated as though it were the tracer dye.

Double asterisk (**): A fluorescence peak is present that does not meet all the criteria for this dye. However, it has been calculated as a positive dye recovery.

Other footnotes specific to the fluorescence signature are sometimes also used. These footnotes are often developed for a specific project.

The quantification of fluorescence peaks that do not meet all the criteria for a positive dye detection can be important for interpretation of the dataset as a whole.

ATTACHMENT 1

Sample Collection Data Sheet

OZARK UNDERGROUND LABORATORY, INC.

1572 Aley Lane Protem, MO 65733 (417) 785-4289 fax (417) 785-4290 email: contact@ozarkundergroundlab.com

SAMPLE COLLECTION DATA SHEET for FLUORESCENCE ANALYSIS

Project ______________________________ **Week No:** ___ **Samples Collected By:** ______________________________

Samples Shipped By: ______________________________ **Samples Received By:** ______________________________

Date Samples Shipped: ______________ **Date Samples Received:** ______________ **Time Samples Received:** ___________ **Return Cooler? Yes** ☐ **No** ☐

Bill to: ______________________________ **Send Results to:** ______________________________

Analyze for: ☐ **Fluorescein** ☐ **Eosine** ☐ **Rhodamine WT** ☐ **Other** ______________ **Ship cooler to:** ______________________________

OUL use only		***Please indicate stations where dye was visible in the field*** *for field technician use - use black ink only*						*OUL use only*
# CHAR REC'D	LAB NUMBER	STATION NUMBER 1-4 Numbers	STATION NAME	PLACED DATE	PLACED TIME	COLLECTED DATE	COLLECTED TIME	# WATER REC'D

COMMENTS ____

____

This sheet filled out by OUL staff? Yes ☐ **No** ☐ **Charts for samples on this page proofed by OUL:** ______________________________

OUL Project No. _______ **Date Analyzed:** ________________ **Analyzed By:** ______________________________