REVISED DRAFT TECHNICAL REPORT

Basis of Design Report for Groundwater Injection, Monitoring and Extraction

City of Morro Bay Groundwater Replenishment and Reuse Project

September 8, 2023

Prepared for:

CITY OF MORRO BAY
INCORPORATED JULY 17, 1964

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Abbreviations and Acronyms

µg/L	microgram per liter
AFY	acre-feet per year
Basin	Lower Morro Valley Groundwater Basin
bgs	below ground surface
BWRO	brackish water reverse osmosis
DDW	California Division of Drinking Water
GRRP	Groundwater Replenishment Reuse Project
GSI	GSI Water Solutions, Inc.
IPR	indirect potable reuse
LUC	land use covenant
MCL	maximum contaminant level
mg/L	milligram per liter
RWQCB	California Regional Water Quality Control Board
SMCL	secondary maximum contaminant level
TDS	total dissolved solids
WRF	water reclamation facility

Executive Summary

The City of Morro Bay (City) has recently completed construction of its new and relocated Water Resources Center (WRC) and is continuing to pursue the development, permitting, and operation of the Indirect Potable Reuse (IPR) component of the overall Water Reclamation Facility (WRF) Program. The IPR component will use advanced-treated recycled water from the WRC to increase the City's potable water supply by injecting this water into the City's local groundwater basin. This Basis of Design (BOD) report provides documentation of work conducted to date and recommendations for development of the groundwater elements of the proposed IPR project (Project).

The City currently purchases water from the State Water Project (SWP) for the majority of its water supply, but this supply is dependent on annually variable allocations established by the California Department of Water Resources. SWP allocations are subject to significant reductions during drought periods as the City recently experienced in 2012 – 2016 and 2020 - 2022. To supplement its SWP supplies and to provide water when SWP water is unavailable, the City extracts local groundwater from six existing wells which produce from an alluvial aquifer west of Highway 1 in the Lower Morro Valley Groundwater Basin (Basin).

The IPR project concept (Project) includes injection of advanced-treated recycled water from the WRC into the Basin using several dedicated and project-specific injection wells. The injected water will travel through the aquifer and be retrieved from the City's existing production wells, as well as from proposed new production wells, after adequate residence time in the Basin in compliance with regulations from the California State Water Resources Control Board's (State Board) Groundwater Replenishment Reuse Project (GRRP) regulations. This Project, when fully implemented, will augment the groundwater supply available to the City and also provide a hydraulic barrier against potential seawater intrusion during drought periods.

The aquifer from which the City produces its local water supply and which will be targeted for the IPR project is approximately 60 to 80 feet deep and is comprised of interbedded unconsolidated alluvial deposits of gravel, sand, silt, and clay. The aquifer is overlain by an "upper layer" of alluvium which is largely comprised of fine-grained sediments such as fine sand, silt, and clay.

Currently, groundwater levels in the Basin exhibit a flow gradient from the east to the west, towards the coast. Under non-stressed conditions, groundwater flows into the Basin sediments that exist beneath the ocean, and a coastward hydraulic gradient is maintained, preventing seawater intrusion. However, during the 1988 - 1992 drought the City produced approximately 580 acre-feet per year (AFY) from its wells, and seawater intrusion was observed, exhibited as total dissolved solids (TDS) concentrations of over 3,000 parts per million in some City wells.

A groundwater model (the Model) was initially developed for use in this Project in 2016 - 2017. The Model is developed using MODFLOW, an industry standard modeling code for groundwater flow developed by the U.S. Geological Survey (USGS). The Model represents the aquifer between the Narrows and the Pacific Ocean as a two-layer aquifer, with the deep aquifer being significantly more productive than the upper layer. The Model has been used over the past several years for various purposes related to the Project, including evaluating overall project feasibility, performing transport modeling of nitrates and chlorides in the aquifer, helping to select between alternative injection well site locations, and evaluating various alternatives regarding injection and production well locations and extraction rates, assessing travel times using particle tracking under various well layouts, and other evaluations. The Model has been updated periodically since its original development as additional information has become available to update aquifer characteristics such as transmissivity, storage capacity, thickness, and other parameters. The Model is used in the analyses presented in this BOD report to provide recommendations on injection well locations and injection rates, extraction rates, travel times, and other evaluations.

A full-scale injection well, referred to as IW-1, was designed and installed in the area between Morro Creek and the PG&E/Vistra property. On December 6, a long-term injection test began, during which State Water was injected at a long-term average injection rate of 99 gallons per minute. A transducer was placed in a nearby piezometer to measure changes in electrical conductivity of groundwater as the injected State Water moved through the aquifer. Although there is some ambiguity in the observed electrical conductivity data recorded by the transducer at the nearby monitoring well, it appears as though "breakthrough" of State Water at the monitoring well occurred approximately 14 days after the injection test startup. This equates to a horizontal groundwater velocity of approximately 4 feet/day under the conditions of the test.

Aquifer transmissivity estimates near IW-1, based on the aquifer testing associated with the injection well, are lower than were previously represented in the Model. Additionally, newly available historical data indicates lower transmissivity in other parts of the Project Area. This information was used to refine the Model's transmissivity distribution in these areas.

Model runs are presented in this report that used the updated Model to simulate the proposed IPR project operations over a 38-year simulation period using monthly stress periods (456 months). Hydrologic inputs for these runs are based on historical datasets for precipitation-based recharge and streamflow. Various injection well locations and rates were iteratively simulated. Project operations are simulated for two separate 4-year drought periods, two- separate 6-month dry periods, and a 12-month dry period intended to represent a significant interruption in SWP deliveries. During these operational simulation periods, City pumping is conservatively simulated in all wells simultaneously at the full cumulative annual rate, with no periods of non-pumping or rotation of wells that would likely occur under actual operational conditions.

Project objectives simulated in the model runs are to:

(1) Inject the full anticipated buildout volumes of 887 AFY of recycled water into the alluvial aquifer,
(2) Extract as much as 900 - 1000 AFY of production (approximately 62 to 69 percent of anticipated buildout demand for the City) from the City wells.

Model results are examined for adherence to four constraints:

(1) Travel time of 4 months is maintained between injection wells and production wells,
(2) Particle tracking indicates protection against seawater intrusion,
(3) As mitigation against excessive drawdown, modeled saturated thickness is maintained at greater than 50% of original saturated thickness at modeled well cells, and
(4) Avoidance of modeled groundwater levels rising above the ground surface in the immediate vicinity of the injection wellhead.

Significant conclusions of the work include determinations that:

(1) Injection testing at the pilot injection well confirmed that injection rates of 90-100 gpm are attainable;
(2) Groundwater flow modeling indicates adequate retention time (i.e., travel time through the aquifer) is attainable to ensure that the injected water resides in the aquifer for at least 4 months during the lowest drought groundwater conditions, and most cases many more, before reaching the nearest production well under assumed City pumping of up to 900 to 1,000 AFY;
(3) Water quality sampling and geochemical modeling conducted for the Project do not indicate any anticipated adverse water quality issues; and,
(4) Project can be designed and implemented to be in compliance with State Board permitting requirements.

SECTION 1: **Project Overview**

1.1 Introduction

The City of Morro Bay (City) is planning the implementation of an Indirect Potable Reuse (IPR) project (Project) in the area south and west of the City's existing production wells as an integral component of their upgraded and relocated Water Resources Center (WRC). GSI Water Solutions (GSI) is supporting the City with well permitting, well design, groundwater modeling and injection well installation for the Project. The installation, operation and monitoring of the injection wells will be compliant with the California State Water Resources Control Board's (State Board) Groundwater Replenishment Reuse Project (GRRP) regulations for subsurface application.

To date, GSI has conducted several field hydrogeologic characterization efforts and groundwater modeling studies in support of the City's goal of successful implementation of the Project. As a result of these efforts, the area west of Highway 1 and south of Morro Creek was selected for the initial array of injection wells and monitoring wells which will constitute the Project Area as illustrated on Figure 1. Additional well locations along the Atascadero Road will provide additional injection capacity and prevent seawater intrusion.

The water supply for the IPR project will be advanced-treated recycled water from the newly constructed WRC, which includes the treatment steps of biological secondary treatment using a membrane bioreactor (thus includes membrane filtration), reverse osmosis, and ultraviolet light/advanced oxidation. The recycled water produced by this level of treatment meets the GRRP regulations for subsurface application. The water from the WRC will be conveyed through dedicated pipelines to the injection wells. Preliminary modeling has indicated that sufficient retention time (i.e., subsurface residence time of >2 months after accounting for State Board's Division of Drinking Water (DDW) mandated travel time estimation factors) can be met prior to extraction at the City's existing production wells, in compliance with the GRRP requirements. Geochemical mixing analysis has also been conducted and did not identify adverse reactions associated with the proposed injection that would preclude project implementation.

Injection testing at Injection Well #1 (IW-1), conducted from October 2022 through January 2023, has provided diagnostic information regarding both attainable injection rates and subsurface retention time. The installation of a nearby monitoring well (21P-01) was also conducted as part of this effort. Additional details on the injection well and associated testing are provided below.

During the course of several weeks of injection testing at IW-1, a sustainable injection rate of 99 gpm was demonstrated. It is anticipated that six or 7 additional injection wells will be needed to inject the maximum amount of recycled water that could be available at full Buildout of the City. These future wells could have somewhat lower or somewhat higher injection rates depending on the nature of the aquifer sediments at the location of the future injection wells. An injection rate in the range of 75 to 100 gpm is used for planning purposes for the future injection wells. Groundwater modeling studies are presented to support planning, permitting, and design efforts for the Project.

Initial coordination has been conducted with the DDW and the Regional Water Quality Control Board (Regional Board) regarding permitting requirements. Key to the permitting effort is the preparation of a Title 22 Engineering Report which will provide the Regional Board and DDW with comprehensive information regarding both the water purification system and the injection well system. This report will be used by DDW and the Regional Board to determine compliance with the relevant regulations and as a basis for approving the Project and establishing monitoring and reporting requirements. In coordination with Carollo Engineers, it is anticipated that the Final Draft Engineering Report will be completed and submitted to the Regional Board for review in late 2023.

SECTION 2: **Hydrogeologic Setting**

2.1 Morro Valley Groundwater Basin

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 (Figure 2), 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, dunes sand, and Holocene- and Pleistocene-aged terrace deposits that extend approximately 60 to 80 feet beneath the valley floor. Two aquifer zones (shallow and deep) have been identified within the Lower Basin sediments (Brown and Caldwell, 1981; Cleath & Associates, 1993).

Review of lithologic logs and aquifer testing conducted for the Project reveal that the aquifer has a large contrast in permeability between the shallow and deep zones, with the deep aquifer being more permeable and productive than the upper aquifer.

The two major sources of recharge to the aquifer are streambed percolation from Morro Creek and percolation of precipitation during rainfall events.

The City's production wells are the only wells that extract groundwater from the Lower Basin. In the past some pumping was conducted in the Lower Basin by PGE, and subsequently by the Morro Bay Mutual Water Company from two wells (#3 and #4). However, those wells have both been destroyed since 2020. No other pumpers exist in the Lower Basin nor are any anticipated to be installed. The nearest groundwater production is from private agricultural wells located in the upper Basin, upgradient from the Narrows, approximately 3/4 miles east of highway 1, and substantially upgradient of the Project. This pumping is not expected to have any impact on the Project, nor will the Project have any impact on the agricultural operations in the Upper Basin.

The Project area referenced in this text (Figure 1, Figure 7) includes the areas occupied by City production wells and planned injection wells, as well as any likely areas that injected water will travel through the aquifer during project operations. The Project area extends from Highway 1 on the east to the mean high tide line on the west, and from the permanent easement and city properties on the south up to the area of the High School wells in the north.

2.2 Target Aquifer Areas and Zones

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 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. The deep alluvial aquifer is typically overlain by finer sediments ranging from clayey silt to silty clay, creating semi-confining conditions in the Basin (Brown and Caldwell, 1981). The target aquifer zone (approximately 60 to 80 feet below ground surface [bgs]) is identified for the injection testing at IW-1 (and for future injection wells). 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 characteristics).

Using a range of available lithologic information from a large number of wells that have been installed in the area over the past few decades (Figure 3, Appendix F), three cross-sections were prepared (Figures 4, 5 and 6) which illustrate the subsurface geologic materials for the areas of the existing and future injection wells.

The injection wells for the proposed IPR project will be distributed along the southern and western boundary of the Project Area (Figure 7).

As discussed in Section 2.1, the alluvial aquifer in the Basin consists of unconsolidated alluvial sediments deposited atop the underlying bedrock formations. The base of permeable sediments (or the top of bedrock) elevation is presented in Figure 8. These data and previous investigations in the area (Cleath, 1992, 1993) indicate a paleochannel feature extending approximately from the location of the Highway 1 wellfield southwest beneath the Vistra property to the vicinity of the City's seawater intake wells along the Morro Bay channel near the T-pier. This hydrogeologic feature is represented in the groundwater model aquifer characterization.

Examination of boring log data from the City's production wells, the Pilot Injection wells, and other historical boring data indicate a zone of coarse-grained sediments at the base of alluvial material in much of the Project Area. This coarse aquifer zone is displayed in Cross Sections A-A' (Figure 5) and C-C' (Figure 7) and is represented as a discrete layer in the groundwater model. The Lower Aquifer Zone Thickness is presented in Figure 9.

2.3 Land Use

Current land use in the Project Area includes undeveloped areas, park/recreational areas, light commercial/residential and schools and covers an area of approximately 122 acres. The Project Area is essentially flat and centrally located relative to the City's infrastructure. The Project Area is adjacent to the currently planned alignment of the newly installed recycled water pipeline.

The Project Area is also adjacent to (north of) the former Morro Bay Power Plant (Power Plant) site. As a result of contamination in the past, portions of the adjacent former Power Plant site have gone through many years of assessment, remediation and monitoring under the jurisdiction of the California Department of Toxic Substances Control (DTSC). As documented in a DTSC report from June 2022, these efforts have concluded with the DTSC determinations that corrective action goals had been met and with the establishment of a land use covenant (LUC) that covers selected portions of the Power Plant property. This LUC establishes restrictions for future uses in some areas of the former Power Plant site (specifically the Area of Concern #1 [AOC1]), which is the old tank farm area located to the south of the Project Area) to allow only commercial/industrial uses. In regards to groundwater considerations, no additional corrective measures were established as the groundwater in AOC1 has been documented as appropriate for potable and non-potable use.

SECTION 3: **Regional Groundwater Conditions**

3.1 Groundwater Elevations

Water levels in the Basin tend to be at their highest each year during the wet winter months when recharge from percolation of rainfall and streamflow is occurring, and lowest during the dry summer months when recharge is limited. Water levels generally recover each year and no long-term significant declines in water levels have been observed.

Groundwater elevation data for three of the City's existing production wells (Well MB-4, Well MB-14, and Well MB-15) located in the Project Area reveal that static (non-pumping) water elevations for these three wells have fluctuated between a high of about 20 feet above mean sea level to a low of about 15 feet below mean sea level (GSI, 2017) during the period from 1994 through 2023.

The regional groundwater gradient is generally from northeast to southwest, toward the coast. Local groundwater gradients in the Project Area change in response to pumping at the City wells. When the City is using SWP water and is not pumping its wells, the groundwater gradient is toward the coast. When the City is using its wells, as it does during regularly scheduled SWP shutdowns, typically occurring in November, this pumping results in a water level depression that slopes radially towards the City wells. If groundwater pumping occurs for too long, it can lead to the landward migration of saline groundwater during extended pumping periods during drought conditions (Cleath & Associates, 2007).

During non-pumping periods, groundwater down-gradient of the Narrows flows toward the coast at a nominal hydraulic gradient of about 0.005 ft/ft. Figures 10 and 11 present groundwater elevation contour maps for fall 2020 and spring 2021.

In December 2018, GSI deployed 11 pressure transducers in several existing City production wells (including some of the City's "desalination wells"[1]) for the purpose of long-term groundwater elevation monitoring. This work was completed in support of the planned Project. The transducers were programmed to measure water level, temperature, and specific conductivity (convertible to chloride concentration) on a regular basis.

Figure 12 presents groundwater elevation hydrographs for several of the City's wells over the past several years. Seasonal fluctuations of 5 to 10 feet are apparent. Recent periods of lower groundwater elevations due to groundwater production from City wells are observed. Additionally, a period of lowered water levels is evident in late 2021 which was caused by dewatering activities near the High School wells associated with Pump Station A construction for the WRF Program.

3.2 Groundwater Quality

A series of four quarterly groundwater quality samples were collected for the purposes of the IPR project and in compliance with GRRP permit conditions from September 2020 through July 2021. The analytical results of that effort are provided in the *Results of Quarterly Groundwater Monitoring for the Proposed IPR Project, Morro Bay, California* (Appendix B). As stated in that report, all results indicated compliance with maximum contaminant level (MCL) and secondary maximum contaminant level (SMCL) limits except for nitrates (at City wells MB-3 and High School-2 due to legacy upgradient agricultural loading) and arsenic (which marginally exceeded the MCL in one analytical result from the High School-1 well). In addition, manganese

[1] The City installed a series of production wells near the coast in the 1990s for the purpose of augmenting water supply with brackish groundwater routed through the treatment plant. These wells are colloquially known as the "desalination wells". These wells have been out of service since the early 1990s and are not considered to be a component of this Project.

concentrations in some piezometers south of Morro Creek had relatively high concentrations of manganese. These will be discussed further in Section 4.4.

During installation of future injection wells in areas distant from the existing IW-1 location, careful attention to determining water quality will be conducted. The groundwater quality is not known in some of these areas, and this is currently a data gap within the project area. If substantial differences are observed, for instance at future injection well locations IW-5 or IW-6, a review of geochemical compatibility of the injection source water and native groundwater may be warranted.

To meet MCLs, the City operates a Brackish Water Reverse Osmosis (BWRO) facility that currently treats groundwater pumped for potable use from the City's wellfield. Figure 13 provides an illustration of the historical nitrate concentrations at most of the City wells. It is evident from this figure that there was a period of high nitrate loading to the basin from upstream (from the late 1990s to approximately 2015), attributed to agricultural sources that appears to have peaked. The concentrations of nitrate have been declining in recent years, in response to the reduction in nitrate loading from upstream agricultural sources. Modeling scenarios conducted by GSI regarding anticipated reductions in nitrate concentrations associated with operation of the Project (GSI, 2019) indicate that gradual reduction of nitrate in the Basin will occur over the next several years as injected water is recovered from the City's production wells as a result of the IPR project.(These modeling results assume continuous operation of the Project). It is anticipated that the nitrate concentrations will eventually decline to within the MCL, as was documented in GSI's 2019 modeling report which evaluated existing and potential future nitrate concentrations under conditions of full project operation (GSI, 2019).

TDS and chloride have been observed to have high concentrations during recent drought periods. As shown on Figures 14 and 15, there were two distinct periods when high concentrations of both of these constituents occurred at the City wells: early 1990's (at the City's Highway 1 wells) and mid-2010's to early 2020's at the High School HS-2 wells. The episode in the early 1990's was a period of sustained groundwater pumping at all the City wells during the relatively severe drought conditions at that time. During this period, the groundwater pumping caused groundwater levels to drop below sea level and caused seawater to migrate from the coast into the aquifer. It was in response to this situation the City installed the BWRO facilities.

The high concentrations of TDS and chloride at the High School wells in the period from 2015 to 2023 may be related to recent seawater intrusion. However, it is noted that when the wells were first installed in 2009, TDS was already at or above 1,000 mg/L, noticeably higher than TDS concentrations in the Highway 1 wells. Ongoing monitoring in this area should help to better characterize this issue.

3.2.1 Iron Fouling issues Associated with the City's Desal Wells

In the 1990s, a series of shallow "desalination" wells were installed in the area south of the planned IPR facilities, along the Embarcadero near Morro Bay Harbor. These wells were installed during the 1988-1992 drought. The objective of the project was to increase the City's groundwater supply by pumping brackish groundwater and treating it potable standards. This project has not been operational since the 1990s, and no plans exist for it to restart. Therefore, it is not a component of this project.

During pumping of the southern three of these wells (known as wells S1, S3 and S4), it was observed that iron fouling was occurring and causing discoloration of the water (Cleath & Associates, 2001). Investigations conducted at that time identified a native source of high iron concentrations in the southern-most wells in that area of the Basin, which is approximately half a mile from the nearest proposed injection well location. Based upon evaluations conducted at that time, during pumping at the wells containing high dissolved iron concentration, the oxygenation of the pumped water (whether by cascading water occurring in the well or simply because of coming into contact with atmospheric oxygen) caused the dissolved iron to precipitate. This was only documented to occur in the southern three wells, which are farthest from the Project Area.

Because of the low to undetected iron concentrations observed in the groundwater in the IPR project area, it is not anticipated that similar iron fouling issues will occur as part of the IPR injection and recovery activities. Careful assessment and documentation of iron concentrations will be conducted as part of the installation of future injection wells to assess any water quality challenges in those areas.

SECTION 4: **Injection Testing at IW-1**

4.1 Background

Injection testing was conducted to support the viability assessment of the proposed IPR project. Injection testing results provided diagnostic information of injection rates and capacity of the first full-scale injection well installed as part of this project. Initial injection testing consisted of constructing the injection well, performing baseline monitoring, and then conducting a long-term injection test. The location of IW-1 is shown on Figure 7. Additionally, a dedicated monitoring well (21P-01) was installed to monitor groundwater conditions in close proximity to IW-1 and to meet Regional Board permitting requirements for the IPR Program.

4.2 Injection Well Construction and Initial Testing

IW-1 was installed in September 2022. The installation effort included permitting, drilling, construction, development, and testing of the injection well. The location of the site and temporary water supply hose alignment are also shown on Figure 16. The Technical Specifications for the well drilling contractor are attached as Appendix I.

The injection well was drilled using mud-rotary drilling methods to a depth of 100 feet bgs. Following pilot hole drilling, geophysical logging of the well was conducted, consisting of a spontaneous potential, resistivity, and caliper surveys in the pilot hole. The pilot hole was then enlarged to 22-inch diameter to a depth of 90 feet, followed by installation of 12-inch diameter, Type 316 stainless steel casing and wire-wrapped screen from 60 to 80 feet bgs, with a blank stainless-steel sump installed from 80 to 90 feet bgs. The annulus within the screened interval was filled with an artificial filter pack consisting of 2.2-millimeter manufactured spherical silica beads (SiLibeads™). The concrete sanitary seal was installed in compliance with State and local standards.

The soil boring log for the 21P-01 monitoring well is provided as Figure 17 and the completed design of IW-1 is presented on Figure 18.

Following well construction, the injection well was extensively developed to remove all remaining drilling fluid from the filter pack and surrounding aquifer sediments. A test pump, drop pipe for conveyance of injection water, and sounding tube for water level measurements were installed. The IW-1 wellhead design schematic is provided as Figure 19.

A pair of pumping tests were conducted, including an 8-hour step drawdown test (Figure 20) and a 24-hour constant rate test (Figure 21) to assess the pumping performance of the well. Figure 22 is provided to illustrate the water level recovery following the constant rate test.

4.3 Injection Testing Program – Injection Rate

Following completion of the initial pumping tests, a series of injection tests were conducted by injecting treated potable drinking water from the City's water distribution system into the well for both a short-term and long-term test. During the injection testing, the injection rates were varied to assess the acceptance rates and corresponding build-up of water levels during injection. 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 H. Also included in

Appendix H is the technical report prepared by GSI ("Notice of Intent to Enroll in ASR General Order (2012-0010) for Injection Well Testing") as part of the application to enroll in the permit program. Included as attachments to this GSI report are (a) the City's DDW Permit authorizing use of their groundwater wells for municipal supply, and (b) the documentation of the EPA Well Registration as required for all injection wells.

Details regarding the injection testing are included in the *Injection Testing Work Plan for Groundwater Management Replenishment and Reuse Project, Morro Bay, California* (Appendix C).

Initially, an injection step-test was conducted on October 14, 2022, to evaluate the well's response to injection at a series of increasing rates (20, 40 70 and 90 gpm). The injection was conducted continuously with each rate held constant for 90 minutes (Figure 23). 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 long-term injection test was 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. A graph of the water level (Figure 24) illustrates the water level measurements in the injection well (lower section of figure) along with the results of tracking Specific Conductivity and Temperature at monitoring well 21P-01 (see below for discussion of travel time assessment).

Results from the injection tests were used to identify sustainable injection rates at the IW-1 location. Extrapolation of these rates to other injection well site locations will be conducted in coordination with assessment of the anticipated aquifer sediment conductivity at those sites (i.e., injection rates at future injection well sites is not necessarily anticipated to be the same as at the IW-1 site).

4.4 Injection Testing Program – Water Quality Analyses

As established in the *Injection Testing Work Plan* (Appendix C), several water quality samples were collected prior to, during and after the injection testing, in accordance with the sampling schedule in Table 1.

An aspect of the injection testing effort was to assess the changes to the chemistry of the injected water following its residence in the aquifer. To accomplish this, following the completion of the 30-day period of continuous injection, four water quality samples were collected, one week apart, from bothIW-1 and 21P-01. The analytical results from this sampling effort are presented in Appendix D. From these data, it is evident that there were not any adverse geochemical changes to the injected water quality during the time the water resided within the aquifer sediments. This result is only partially relevant to the ultimate project conditions because the SWP water used as the injection source water is geochemically different in many ways compared to the advanced-treated recycled water from the WRC that will be used in the actual IPR program. The geochemical modeling, as summarized in Section 4.6, used the anticipated water quality of the advanced-treated recycled water in the evaluation of any potential for adverse geochemical reactions.

Table 1. Sampling Schedule

Stage	Purpose	Injection Well (IW-1)	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 in the Injection Test Work Plan (Appendix C).

[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.

[3] The monitoring well will be analyzed for the reduced suite (except DPBs) unless the field parameters indicate a change, which would trigger complete suite.

One constituent, manganese, was noted to be of relatively high concentration in some of the monitoring well samples during sampling events in 2020 and 2021 (as part of the Quarterly Groundwater Monitoring program, Appendix B) and during sampling in 2023, as part of the injection testing program. The reported manganese concentrations for the initial sample collected from the injection well (1,300 µg/L, on September 29, 2022) and the 21P-01 monitoring well (2,300 µg/L, on October 3, 2022) are both relatively high. Additionally, results from the quarterly groundwater monitoring effort of 2021, elevated manganese concentrations were identified at monitoring well 20P-01 (3 sample results ranging from 1,000 to 1,100 µg/L) and monitoring well 19P-04 (3 sample results all at 1,300 µg/L). However, at both the City's High School wells and at MB-3, manganese concentrations were reported as not detected.

From these results, it appears that the area near the above referenced monitoring wells may represent a localized zone where limited groundwater movement has occurred in the recent past and the concentration of naturally-occurring manganese has slowly increased. During IPR operations, movement of the injected water through this area will dilute and reduce the manganese concentration. The manganese concentration in the water pumped at the City's wells will be a mixture of the groundwater present in the area of these monitoring wells and that from the area adjacent to the production wells. Because the pumped groundwater can be treated at the BWRO, the manganese concentration could be substantially reduced and meet all drinking water standards. Indeed, based on the sampling results from January 2023 (Appendix D), the high manganese concentrations observed from the initial sampling at both IW-1 and 21P-01, were considerably lower during the last three sampling events at these wells, indicating that the water introduced during the long-term injection test, and then the subsequent pumping resulted in reduced manganese concentrations in these areas of the Basin.

A second issue regarding manganese is the laboratory result from a sample of the SWP water being injected into IW-1 as part of the long-term injection test (Appendix D). The reported result from this sample was 770 micrograms per liter (µg/L). This appears to be anomalous and possibly some sort of lab error because all other analyses of distribution system water quality available from either the City or directly from the SWP indicate that manganese is typically not detected or detected at very low concentrations (at or near the SMCL which is 50 µg/L).

4.5 Injection Testing Program – Travel Time to Nearby Monitoring Well

A key objective for the Injection Testing Program was to determine the migration rate of the injected water through the aquifer. The nearby monitoring well (21-P01), installed 53 feet north of the injection well (see Figure 1) was valuable for this effort. By collecting water quality samples at this monitoring well during the 4 weeks of the long-term injection test, documentation of diagnostic water quality changes was possible.

As shown on Figure 18, tracking of Specific Conductivity at the monitoring well shows a distinct change, on December 19, 2022 -- a lowering of the measured concentration of specific conductivity. Based upon the 53 feet distance from the injection well to the monitoring well, this appears to correspond to a travel time of approximately 4 feet per day across this distance under the conditions and gradient of the injection test.

4.6 Geochemical Modeling

Geochemical modeling was conducted using anticipated water quality constituents for the IPR water, water quality data for the native groundwater and mineralogical analysis results from aquifer sediment samples to assess if adverse conditions may occur as a result of the proposed IPR project.

The key objectives of the geochemical compatibility analysis are the following:

a) Evaluate if water quality changes could occur in both native groundwater and injected IPR water as a result of the mixing of these two water types during injection and migration thru the aquifer;
b) Evaluate if water quality changes in the recovered water could arise as a result of geochemical reactions between the IPR water and native aquifer sediments;
c) Determine if mineral precipitation could occur and contribute to clogging of injection and/or production well screens and filter packs as well as within the aquifer sediments; and,
d) Assess the above objectives in terms of both short-term (1 year) and long-term (3 year) injection duration periods.

To meet these objectives, the following work was conducted:

a) The chemistry of the in-situ groundwater was characterized using water quality data from the City's production wells and from the newly installed injection and monitoring wells.
b) The expected chemistry of the water to be injected was based on water quality estimates from the WRF design engineer/program manager, with water quality results from the Leo van der Lans Treatment Plant in Long Beach California which was used as a representative surrogate (since the Morro Bay WRC had not completed the advanced treatment facilities portion of the facility at the time of the analysis).
c) Mineralogical analyses were conducted on sediment samples collected during drilling of the 21P-01 monitoring well to characterize the aquifer materials.

d) The data were used in a geochemical mixing model analyses to assess whether potential adverse effects may occur.

The results of this analysis have allowed for the assessment of potential problems associated with mixing of the injected recycled water and the native 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 (see Geochemical Compatibility Modeling of Morro Bay IPR Project Technical Memorandum, Appendix G).

Based upon results of soil and groundwater sampling at City wells as collected by GSI and City staff, the geochemical modeling effort determined the following:

a) The overall geochemical compatibility evaluation does not identify significant issues that might be viewed as fatal flaws to the City's IPR project planning.
b) Following injection and migration through the aquifer to the City's existing production wells, the recovered water is predicted to meet all primary drinking water standards. Recovered water is not expected to exhibit significant adverse geochemical compatibility issues, except for secondary water quality parameters (total dissolved solids (TDS) and manganese) as described below. Legacy issues associated with nitrate loading in the agricultural area upgradient of the Highway 1 wells (Figure 13) may result in continued exceedance of the MCL until sufficient dilution is achieved or until upgradient concentrations decline.
c) For TDS, the geochemical modeling indicates that the SMCL for TDS (500 milligrams per liter [mg/L]) could be exceeded in the early weeks of the injection activity but only until the native groundwater is partially to fully replaced by the injected IPR water. (This analysis assumes constant operation of the system by the City). Because the City's groundwater production system includes potential treatment of pumped groundwater at the City's BWRO facility, the TDS concentration in the recovered water could be substantially reduced prior to delivery of the water into the distribution system.
d) For manganese, the recovered water could exceed the SMCL of 50 ug/L during at least the first year of IPR operations. Manganese concentrations are naturally elevated (at or near the MCL) in some areas of the Basin as observed from water quality monitoring. Manganese concentrations are not predicted to worsen because of the IPR project, and over the course of several years, manganese concentrations are predicted to decline as the oxidized treated water becomes a greater proportion of the water recovered at the production wells. Tracking water quality results from samples at monitoring wells located between the injection wells and the production wells will provide real-time information on the trend of manganese concentrations over time.
e) Similar to the consideration of TDS concentrations discussed above, because the City's groundwater production system includes treatment of pumped groundwater at the City's BWRO facility, the manganese concentration in the pumped groundwater could be reduced to below the SMCL concentration limit prior to delivery of the water into the distribution system. Additionally, the advanced treated recycled water that will be injected as part of the IPR program will have very low levels of manganese which will be helpful in regard to tracing the movement and migration of the injected water.
f) Evaluation of geochemical reactions that could lead to aquifer clogging indicates that there is a minor potential of the precipitation of manganese oxyhydroxide as a result of the increased oxidation state of the injected (source) water compared to native groundwater. Because the model prediction was that only <0.02% change in porosity per year is possible, clogging due to manganese is not expected to be significant. Two mitigation measures that apply to this potential issue include (a) ensure dissolved oxygen content of injected water is maintained at the lowest possible amount, and (b) the treatment of the pumped groundwater using the BWRO facility.

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

The City's primary source of municipal supply water is surface water from the SWP, which is provided by the Central Coast Water Authority and San Luis Obispo County Flood Control and Water Conservation District. The water is treated at the Polonio Pass Water Treatment Plant (located near the intersection of Highways 41 and 46) and then conveyed via the Coastal Branch and Chorro Valley pipelines to the City's water distribution system.

Groundwater from the Lower Morro Basin produced by the City's network of production wells represents a secondary source of its municipal supply. Because some of the groundwater pumped from the City's wells has nitrate contaminant levels that require treatment, the City conveys the pumped groundwater to its BWRO plant for treatment prior to distribution.

Source water for the planned injection will ultimately come from the advanced-treatment component of the City's new WRC. For the purposes of the preliminary injection testing at IW-1, treated potable drinking water from the City's municipal supply system, water from the City's State Water Project supply, was used as the injection water source.

In accordance with DDW requirements, the City regularly collects groundwater samples to assess the concentrations of any radioactive, biological, inorganic (trace metals), volatile organic compound (VOC), or synthetic volatile organic compound (SVOC) contaminants. The range of contamination in the raw (i.e., untreated) well water, at times, has exceeded the drinking water standards, primarily associated with nitrate concentrations. However, because pumped groundwater is treated at the BWRO facility, contaminants are reduced to concentrations that meet drinking water quality goals.

A series of 4 quarterly groundwater samples were collected, as required by the GRRP permit, from several of the City's production wells and monitoring wells. The results are provided in Appendix B and are indicative groundwater quality that will meet the needs of the Project.

SECTION 6: **Basis of Design for Full-Scale Injection Well System**

Based on the results of the initial injection testing and subsequent groundwater modeling analysis, this section will provide the basis of design for the project's full-scale injection well system. Groundwater modeling simulation results using the Lower Morro Valley Basin Groundwater Model (LMVBGM, or the Model) developed for this project are used as the basis for selection of well locations, anticipated injection rates for future injection wells, and expected groundwater elevations in the Project Area. Generalized well design illustrations, instrumentation requirements, and potential location of additional monitoring wells are also discussed.

6.1 Groundwater Model Summary

The Lower Morro Valley Basin Groundwater Model was originally developed in 2016-2017 as part of the Feasibility Study for this Project. There have been numerous updates and revisions to the Model in the intervening years, as additional data has been collected. A summary of the history of updates to the model, model applications, and discussion of calibration and sensitivity analysis is included as a Technical Memo in Appendix A. Previous groundwater modeling reports and TMs prepared by GSI are also presented in Appendix A.

6.2 Model Scenarios and Model Evaluation Strategy

After incorporating the most recent data into the Model, a series of model scenarios were simulated for the objective of determining the recommended number, locations, and injection rates for injection wells in the project area. The following approach, criteria, and constraints were considered during iterative model simulations to arrive at recommendations for injection well locations and injection rates.

The transient Model of 456 monthly stress periods is utilized for this evaluation. However, simulation of both injection and production from City supply wells is not assumed to be constant during the 38-year simulation period. The simulations assume project operations involving both injection and production pumping during two extended drought periods to test the response of the aquifer to extended drought operations (Stress periods 97 through 144 simulating the drought period of October 1988 through September 1992, and stress periods 385 through 432 simulating the drought period of October 2012 through September 2016), one 12-month operational period intended to simulate an extended shutdown of state water availability, and two six-month operational periods during dry summer months to evaluate aquifer conditions during shorter seasonal operation of the IPR project.

Project Goals:

- The City intends to apply for permitting for an IPR project capable of cost-effectively capturing, treating and injecting the maximum amount of advanced purified water into the Basin at build-out. It was assumed that eighty percent (80%) of the build-out wastewater Average Dry Weather Flow (ADWF) flow could be captured for injection to account for losses through the Reverse Osmosis treatment process. The City's OneWater Plan (Carollo Engineers, 2018) projects that the AWDF capacity will be 0.99 million gallons per day (MGD) in 2040, the planning horizon for that document. Therefore, 887 AFY was used as the estimate for the maximum amount of advanced treated water the City could produce on an annual basis and the evaluation scenarios in this report assume an associated constant injection rate of 73.9 ac-ft/month. Further analysis of equalization and/or other storage requirements and seasonal and/or other peaking factors may impact the final injection capacity ultimately included in the City's permit application.

- The City is currently permitted to extract up to 581 ac-ft/yr of groundwater from the Basin. However, this quantity of pumping is not considered to be sustainable based on observed conditions of seawater intrusion in the early 1990s (GSI, 2019). This quantity is used as a baseline pumping amount. Modeled pumping was systematically decreased from 581 to 400 AFY without IPR injection simulated and increased from 581 AFY to 1,000 AFY with IPR injection simulated, with evaluations of all results at the interim pumping rates. However, not all interim model results are presented; the maximum feasible City pumping results are presented without presentation of the interim steps.

Model results are evaluated to determine if four constraints are met:

- MODPATH results indicate that particles placed along the coast are kept from reaching any of the City's production wells, i.e., no seawater intrusion is reaching City wells.
- Modeled residence time in the aquifer between injection and production wells is maintained greater than 4 months.
- Saturated thickness at the modeled production well cells is kept greater than 50% of the original baseline saturated thickness. This criterion is intended to indicate when pumping water levels may be reduced to the point that they may result in operational issues with pumps such as breaking suction or causing in-well cascading water to occur. It is a general indicator, and a small number of stress periods which do not meet this criterion should not be considered as a fatal flaw to the project. Full City pumpage at the indicated rates is maintained for the duration of the drought periods 24/7 in all wells, and any deviation from this conservative assumption will reduce the likelihood of this occurrence.
- Mounded groundwater levels at injection wells do not rise above land surface.

Model results are presented and discussed in the following sections.

6.2.1 Baseline Simulations

As has been discussed previously in this report, the City is currently permitted to produce up to 581 AFY of groundwater from the Basin. However, pumping at approximately this level was maintained throughout the 1980s, ultimately resulting in Total Dissolved Solids concentrations of 3,000 parts per million (ppm) and greater were observed in the City's production wells (GSI, 2019), indicating that the City cannot sustainably pump 581 AFY for extended periods of time without inducing seawater intrusion.

As a baseline demonstration of conditions before implementation of the IPR project, a transient simulation was run with 581 AFY of production simulated from City wells and no IPR injection occurring. In this simulation and all others presented hereafter, City pumping was apportioned equally amongst the two High School wells (HS-1 and HS-2), the four Highway 1 wells (MB-3, MB-4, MB-14, and MB-15), MB-13 (east of Highway 1 on Errol Street), and a new well location (NW-1) on the southeast corner of Morro Bay High School along Atascadero Road. MB-13 and NW-1 were utilized to spread out the pumping from the current 6 wells that the City operates in an attempt to mitigate anticipated drawdowns using only those six wells; concentration of pumping in the Highway 1 wellfield is expected to lead to increased local drawdown, and use of NW-1 and MB-13 is a preventative attempt to mitigate this circumstance. (It should be noted that MB-13 and NW-1 are not used as part of the City's water system at this point, but may be required for the full implementation of the IPR program.

Figure 25 presents the results of this simulation. In this simulation City production pumping is simulated as commencing at the start of the drought (Stress Period 97). Particle release time for the coastal particle array is also set at Stress Period 97 (Day 2954). Groundwater elevations on Figure 25 are for Stress Period 118, 21 months after the start of the drought; this stress period was observed to calculate the lowest groundwater elevations in the model simulation period. Groundwater elevations at all pumping wells are lower than 24 feet below sea level. Particle tracks indicate that the coastal particles reach the High School wells within about 24 months after the start of the drought.

In order to determine a City pumping production rate that would not result in seawater intrusion under “no project” conditions, a series of additional iterative simulations were run in which City pumping was set at lower total pumping rates, and particle tracking results were evaluated. Figure 26 presents water levels and particle tracking model results for total City production of 400 AFY. None of the coastal particles modeled reach the High School wells before reversing direction at the end of the drought, but they come close within 4 years. This then, may be considered a baseline level of groundwater production that could be maintained by the City.

6.2.2 IPR Injection of 887 AFY with Groundwater Production of 900 to 1,000 AFY

In these simulations, 887 ac-ft/year of injection is simulated. Because the proposed injection well locations along the coast are at lower elevations than those near IW-1, and because boring logs indicate less favorable geologic conditions for injection in different areas, it is appropriate to simulate differing injection rates for the wells. Injection wells IW-1, IW-2, and IW-3 are assigned injection rates of 90 gpm, based on results of the long-term injection testing at IW-1 reduced by 10% to account for well interference and other factors. Injection wells 4 through 6 are assigned injection rates of 70 gpm. Injection wells IW-7 and IW-8, located along Atascadero Road for the purpose of developing a more comprehensive barrier against seawater intrusion, are assigned injection rates of 35 gpm. These injection rates cumulatively amount to 887 AFY, assuming constant operation. The injection is simulated during two 48-month drought periods, two 6-month operational periods, and one 12-month operational period.

Simulated production from City wells at 900 AFY and 1,000 AFY is split equally among 8 city wells (the four Highway 1 wells, the High School wells, MB-13, and NW-1).

Inspection of transient modeling results from this and other runs indicates that stress period 118 (representative of 22 months after the start of the drought) represents the lowest water levels observed during the transient simulations. Thus, in this and other discussions of model results to come, this stress period will be displayed as representative of the most extreme results observed during the drought period, and thus can be considered a constraining case. If results from this stress period meet the criteria previously discussed, then all simulated operational conditions will meet them.

Figure 27 presents the water levels and particle tracking results for the scenario of 900 AFY of City pumping coincident with 887 AFY of injection at the injection well locations indicated on the Figure. Water levels in stress period 118 in the High School wells are lower than 14 feet below sea level. Particle tracks from particles located along the coast indicate that coastal particles are prevented from migrating inland during the simulation period. indicating that the injection wells along Atascadero Road provide an effective barrier against seawater intrusion. Particles originating at Injection wells IW-1 and IW-2 display the shortest travel times in this model scenario, at about 4.5 months. Groundwater elevations at the modeled injection wells were compared against land surface elevation and do not rise above this level.

Figure 28 presents the percent of original saturated thickness for stress period 118 for this scenario. The Highway 1 wellfield has conditions about 45 to 60% of original saturated thickness, close to the 50% criterion previously discussed. High School wells display about 50% of original saturated thickness. Well MB-13 has a lower result, with a saturated thickness about 40% of original. The Highway 1 wellfield has conditions about 35 to 40% of original saturated thickness. These results do not meet the criterion previously established for 50% of original saturated thickness. However, bear in mind that stress period 118 includes the lowest water levels in the entire simulation. Examination of transient results for the entire 96 months of drought period (over two separate droughts) indicate that only 7 months out of 96 drought months fail to meet this criterion (about 7%). This scenario simulates full pumpage of the City wells without pause for the entire 4-year drought periods, which is possibly an overly conservative assumption when considering realistic operational scenarios. Periodic rotation of well operation or other operational strategies could mitigate conditions of excessive drawdown at localized areas.

Figure 29 presents the water levels and particle tracking results for the scenario of 1,000 AFY of City pumping coincident with 887 AFY of injection at the injection well locations indicated on the Figure. Water levels in stress period 118 in the High School wells are lower than 19 feet below sea level. Particle tracks from particles located along the coast display a seaward flow direction, indicating that the injection wells along Atascadero Road provide an effective barrier against seawater intrusion. Particles originating at injection wells IW-1 and IW-2 display the shortest travel times in this model scenario, at just over 4 months. Groundwater elevations at the modeled injection wells were compared against land surface elevation and do not rise above this level.

Figure 30 presents the percent of original saturated thickness for stress period 118 for this scenario. The Highway 1 wellfield has conditions about 35 to 50% of original saturated thickness, lower than the 50% criterion previously discussed. The High School wells display about 40% of original saturated thickness. Well MB-13 has a lower result, with a saturated thickness about 30% of original. These results do not meet the criterion previously established for 50% of original saturated thickness. However, this criterion is not considered to be a fatal flaw. Bear in mind that stress period 118 includes the <u>lowest</u> water levels in the entire simulation. Examination of transient results for the entire 96 months of drought period (over two separate droughts) indicate that about 23 months out of 96 drought months fail to meet this criterion (about 24%). This scenario is more negative than the 900 AFY pumping scenario but makes the same very conservative assumptions. Periodic rotation of well operation or other operational strategies could mitigate conditions of excessive drawdown at localized areas. It may be likely to pump at this rate for shorter period of time than the 48-month drought scenario presented here.

6.2.3 Summary of Modeling Results

Simultaneous operation of IPR injection at the proposed injection wells and pumping from the City's extraction wells is modeled over two 4-year drought periods using historical hydrologic inputs. Additional shorter operational periods of 6 and 12 months were also simulated, but the extremes of the drought periods are representative of the most conservative case with the constraining results, so those results are presented in this discussion.

Based on the criteria of minimum 4 months travel time, providing a barrier against seawater intrusion, maintaining throughout most of the simulation period, daylighting of groundwater levels above land surface, and constant IPR injection of 887 AFY, City groundwater pumping of 900 AFY is feasible. There appears to be potential for periods of pumping the equivalent instantaneous rate of 1,000 AFY for shorter periods of time, based on specific meteorological and operational conditions.

6.3 Number And Location of Injection Wells

Model results indicate that in order to achieve the stated objective of developing the ability to inject all of the anticipated full-buildout annual supply of advanced purified water from the WRC of 887 AFY, it will be necessary to install eight injection wells, as shown on Figure 31. This number assumes that three wells in the vicinity of the Pilot Injection well (IW-1 through IW-3) will inject at 90 gpm, IW-4 through IW-6 will inject at 70 gpm, and IW-7 and IW-8 will inject at 35 gpm. The configuration of the proposed injection wellfield takes into consideration the results of the initial injection testing, availability of property for siting of up to eight injection wells, proximity to existing City wells, proximity to existing City infrastructure (power, water, wastewater disposal), and other logistical considerations. To achieve the goal of 900 to 1,000 AFY of City production, it may be necessary to consider future installation of new City production wells, or the use of City wells not currently in use.

6.3.1 Generalized Well Design Illustrations

During the design of the pilot injection well, the project team considered lithologic and geophysical data, use of manufactured filter pack material (“SiliBeads”), and aggressive development techniques during construction and testing to improve injection performance. The resulting injection well was capable of extended injection rates equal to the pumping rates employed during the 36-hour constant rate aquifer test, which exceeded the earlier anticipated efficiency. As a result, it is expected that the proposed injection wells will have a similar design and construction details to the pilot injection well. Figure 12 presents the design and construction details of the pilot injection well. Although site-specific details pertaining to the wellheads relating to elevation and proximity to infrastructure may change the construction of the surface components of the wells (for example, a below grade vault may be preferable to an above-ground completion in Public Right-of-Way), and well screen slot size and screen interval will depend on local geologic conditions, GSI anticipates that well materials, diameter, and general details of the wellhead will be mimicked during the construction of future injection wells.

6.3.2 Instrumentation

For each injection well, surface instrumentation and controls will include flow meters, flow control valves, air-relief valves, water level transducers, pump control panel, a wellhead pressure meter and telemetry equipment. Figure 13 illustrates the wellhead design at IW-1 which is a representative design likely useful for future injection wells.

6.4 Location of Additional Monitoring Wells

Dedicated monitoring wells are required for compliance with the GRRP permit conditions. The regulations require that monitoring wells be located “no less than two weeks but no more than six months of travel time from the GRRP” and “at least 30 days upgradient of the nearest drinking water well”. Additionally, a second monitoring well may be required by DDW in some cases to be located between the injection wells and the nearest downgradient drinking water well”.

The final number of monitoring wells will be subject to specific permit requirements negotiated with the RWQCB and DDW. However, several existing City wells and piezometers are identified that could be re-purposed to serve as monitoring wells for the program. Figure 31 illustrates the layout. Two existing piezometers (20P-01 and 21P-01) and three existing City wells (MB-1, MB-2, and Flippos) are suitable for use as monitoring wells during startup and operation of the IPR project.

New monitoring wells may need to be installed at other locations proximal to future injection wells. These monitoring well locations will be specified upon final determination of injection well locations.

SECTION 7: **Conclusions**

The City of Morro Bay's planned IPR project has been carefully evaluated, modeled, and tested (using the recently installed pilot injection well). Some of the key findings based on the work conducted to date are as follows:

- Injection testing at the pilot injection well (IW-1) confirmed that adequate injection rates are attainable. An additional long-term injection test may be considered in the fall of 2023 including concurrent pumping of the City production wells to provide a second determination of groundwater migration rates using either an added or an intrinsic tracer.
- Groundwater flow modeling indicates that adequate retention time (i.e., travel time through the aquifer) is attainable to ensure that the injected water resides in the aquifer for at least 4 months during the lowest drought groundwater conditions, and most cases many more, before reaching the nearest production well under assumed City pumping of up to 900 to 1,000 AFY.
- Model results show that in order to achieve the stated objective of maintaining the ability to inject the full 887 AFY of buildout advanced purified water from the WRC, it may require up to 8 injection wells that will be located both within the Vistra permanent easement and within City-controlled property along Atascadero Road.
- The City's Highway 1 wells are the closest supply wells to the proposed injection wells. As new supply wells are built as part of the City's infrastructure improvements, locations at the farthest feasible distance from injection wells and the coast should be prioritized. A key candidate to meet this objective is the proposed well "NW-1", which would be located north and east of the High School wells.
- Geochemical modeling and water quality sampling indicates that there is limited risk of water quality issues that would impact the effectiveness of the Project. Because of the localized areas with relatively high concentrations of manganese, close tracking of this constituent will be conducted during project development and initial operations.
- Groundwater modeling indicates that as few as two proposed injection well locations along Atascadero Road can provide an effective barrier against seawater intrusion under the most severe drought conditions.
- Communication with the Regional Board indicates that the GRRP permit conditions can be met with the proposed project.

SECTION 8: **References**

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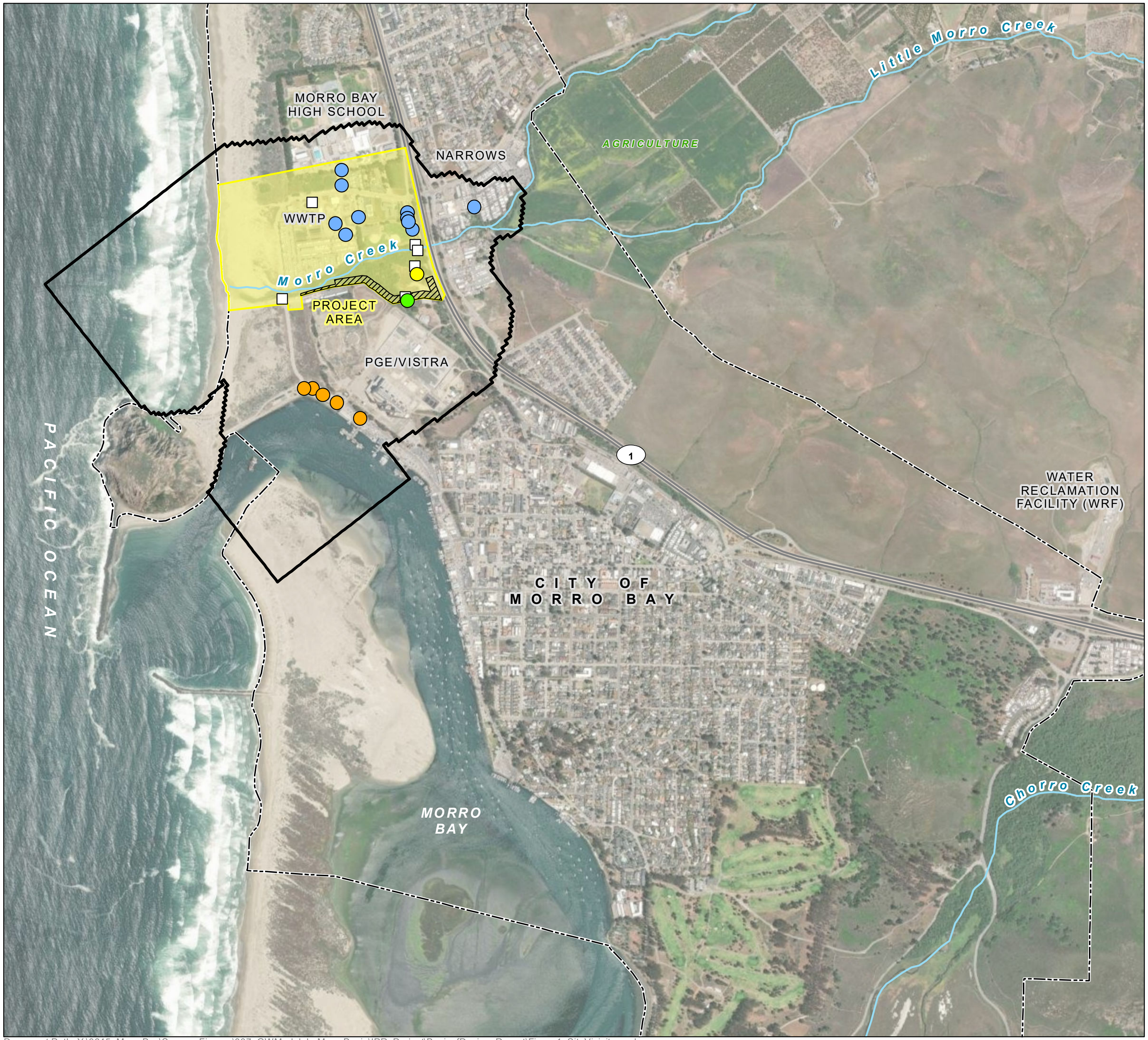

FIGURE 1

Site Vicinity Map

Morro Bay IPR Project
Basis of Design Report

LEGEND

- Morro Bay City Well
- MBMWC Well
- City Desalination Well
- Injection Well (IW-1)
- Piezometer
- Project Area
- 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 1,000 2,000
Feet

Date: August 7, 2023
Data Sources: USGS, ESRI,
City of Morro Bay, Maxar Imagery (2021)

GSI Water Solutions, Inc.

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\IPR_Project\BasisofDesign_Report\Figure1_SiteVicinity.mxd

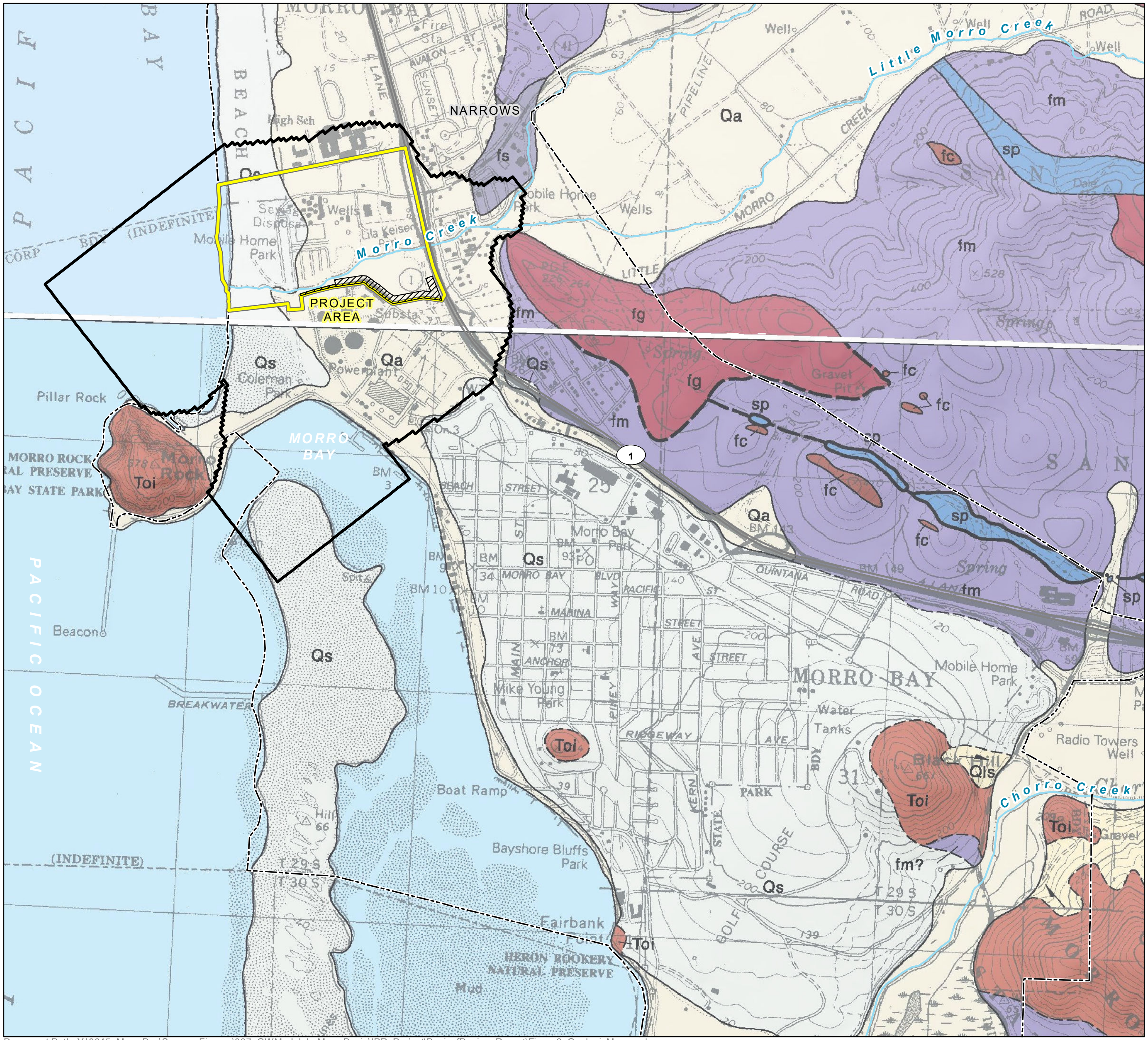

FIGURE 2

Geologic Map

Morro Bay IPR Project
Basis of Design Report

LEGEND

- Model Active Area
- Project Area
- Permanent Easement

Surficial Geology

- fm
- fs
- fc
- fg
- sp
- Toi
- Qs
- Qa

All Other Features

- City Boundary
- Major Road
- Watercourse

N

0 1,000 2,000
Feet

Date: August 4, 2023
Data Sources: USGS, ESRI, Dibblee (2006)

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Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\IPR_Project\BasisofDesign_Report\Figure2_GeologicMap.mxd

FIGURE 3

Historical Boring and Well Locations

Morro Bay IPR Project
Basis of Design Report

LEGEND

- Cross Section Line
- Gas Station Well
- Pacific Geoscience Boring
- PG&E Monitoring Wells
- Mittelhauser Boring
- Morro Bay City Well
- Cleath & Associates Boring
- Dames & Moore Boring
- PG&E Plant Well
- Sea Water Well
- Injection Well (IW-1)
- Project Area
- Permanent Easement

All Other Features

- City Boundary
- Major Road
- Watercourse

N

0 240 480 720
Feet

Date: August 7, 2023
Data Sources: BLM, ESRI, USGS, Maxar Imagery (2021), Cleath and Associates (1991)

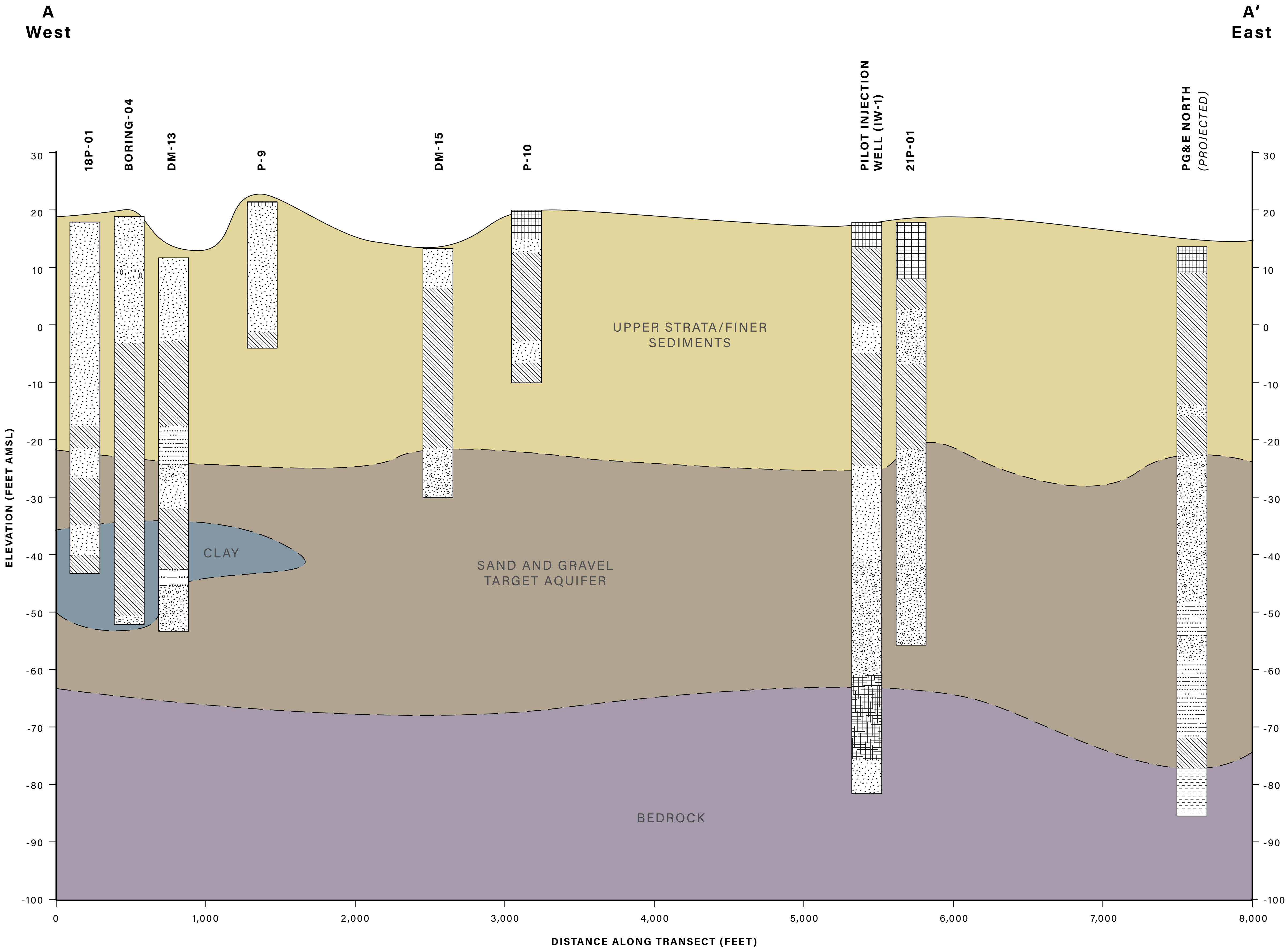
Water Solutions, Inc.

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\IPR_Project\BasisofDesign_Report\Figure3_Historical_Boring_Locs.mxd, npalmer

FIGURE 4

Cross Section A-A'

Morro Bay IPR Project
Basis of Design Report



LEGEND

Lithology

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

USCS Lithology

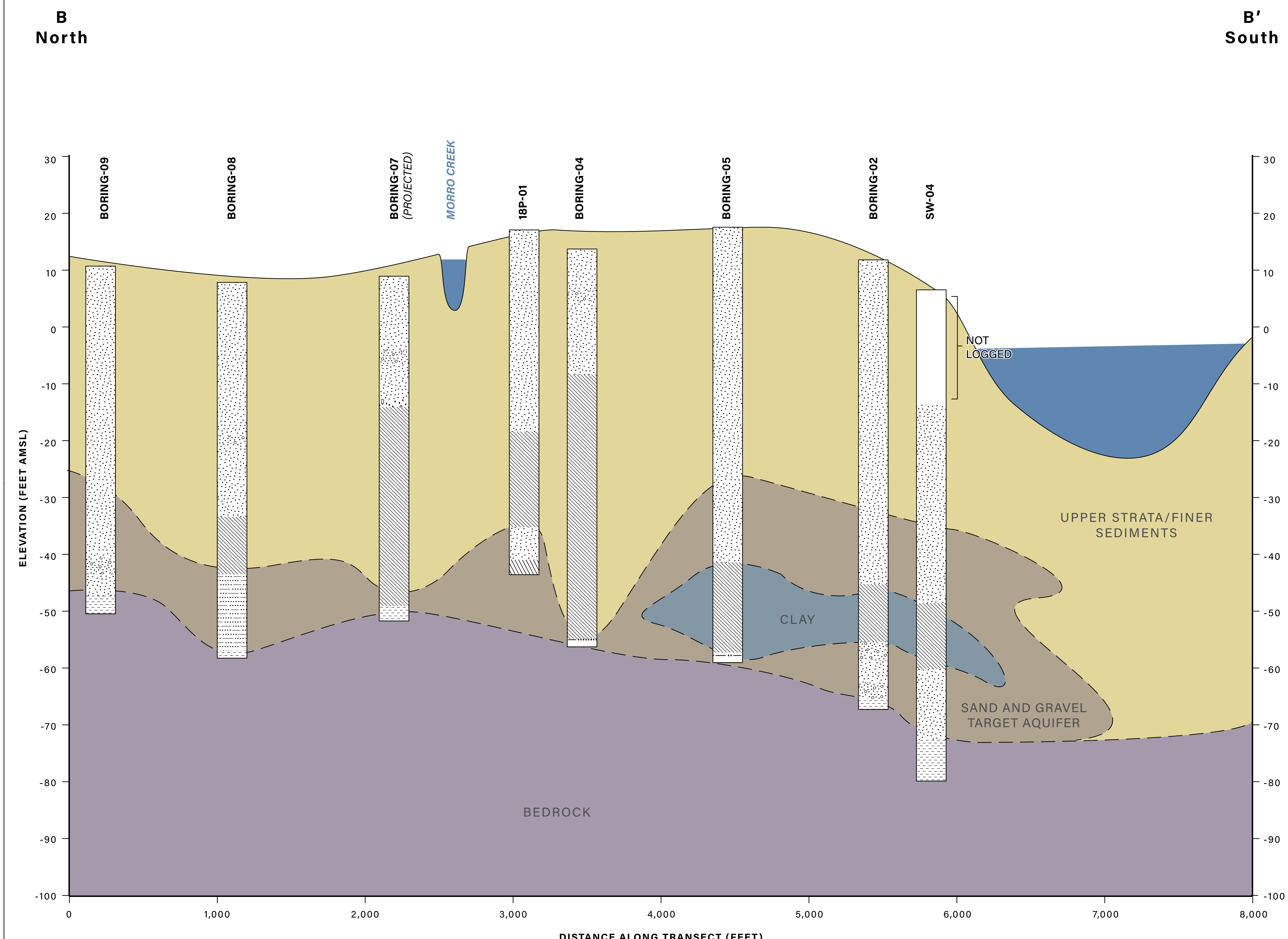
- Asphalt
- Artificial Fill
- Clays/Silts - CL, CH, OH, ML, OL, MH
- Gravelly Clay
- Gravels - GW, GP, GC, GM
- Weathered Bedrock (Kjf)
- Sand - SM, SW, SC, SP
- Shale

GSI Water Solutions, Inc.

FIGURE 5

Cross Section B-B'

Morro Bay IPR Project
Basis of Design Report



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
- Gravelly Clay
- Gravels - GW, GP, GC, GM
- Weathered Bedrock (Kjf)
- Sand - SM, SW, SC, SP
- Shale

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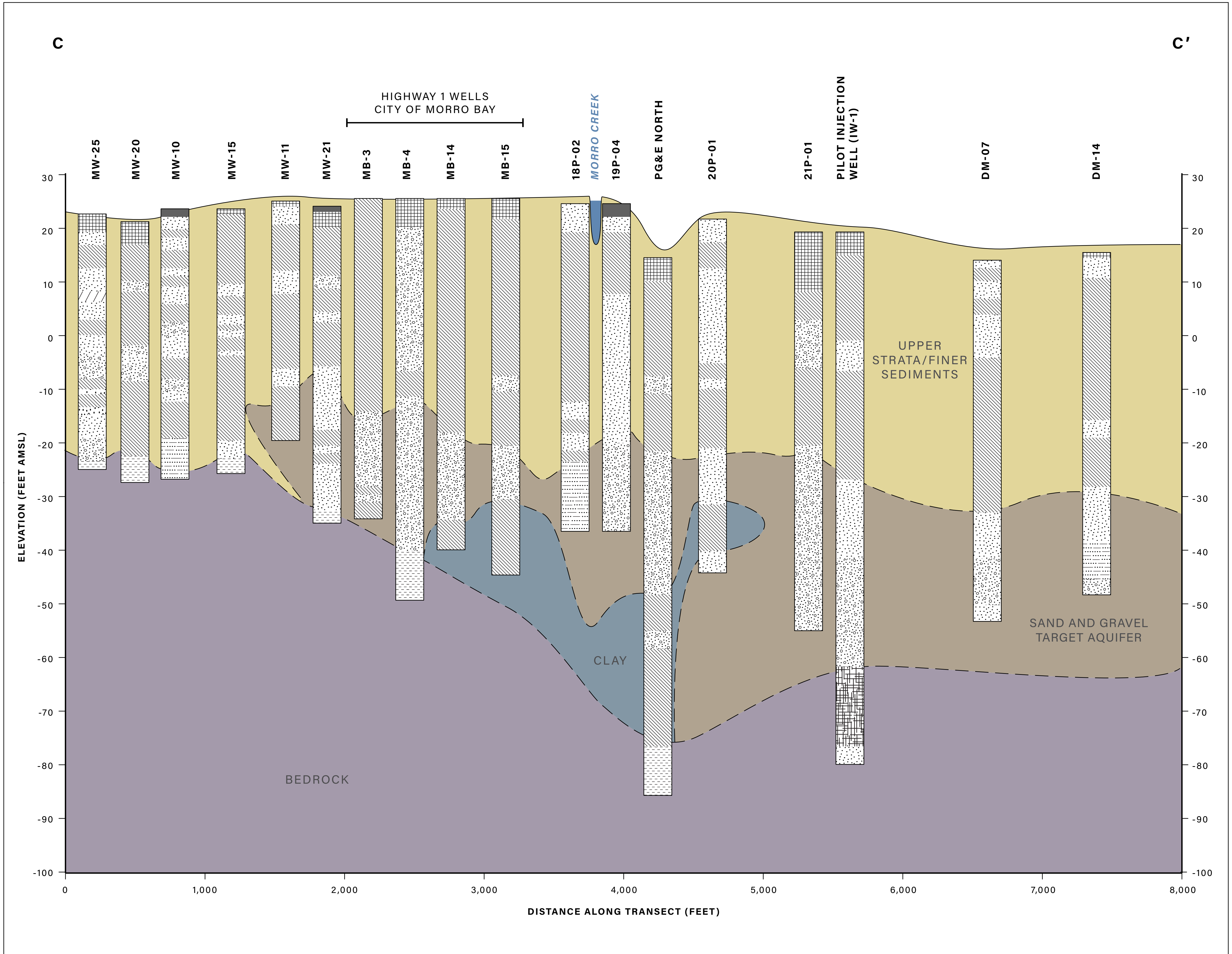
FIGURE 6

Cross Section C-C'

Morro Bay IPR Project
Basis of Design Report



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

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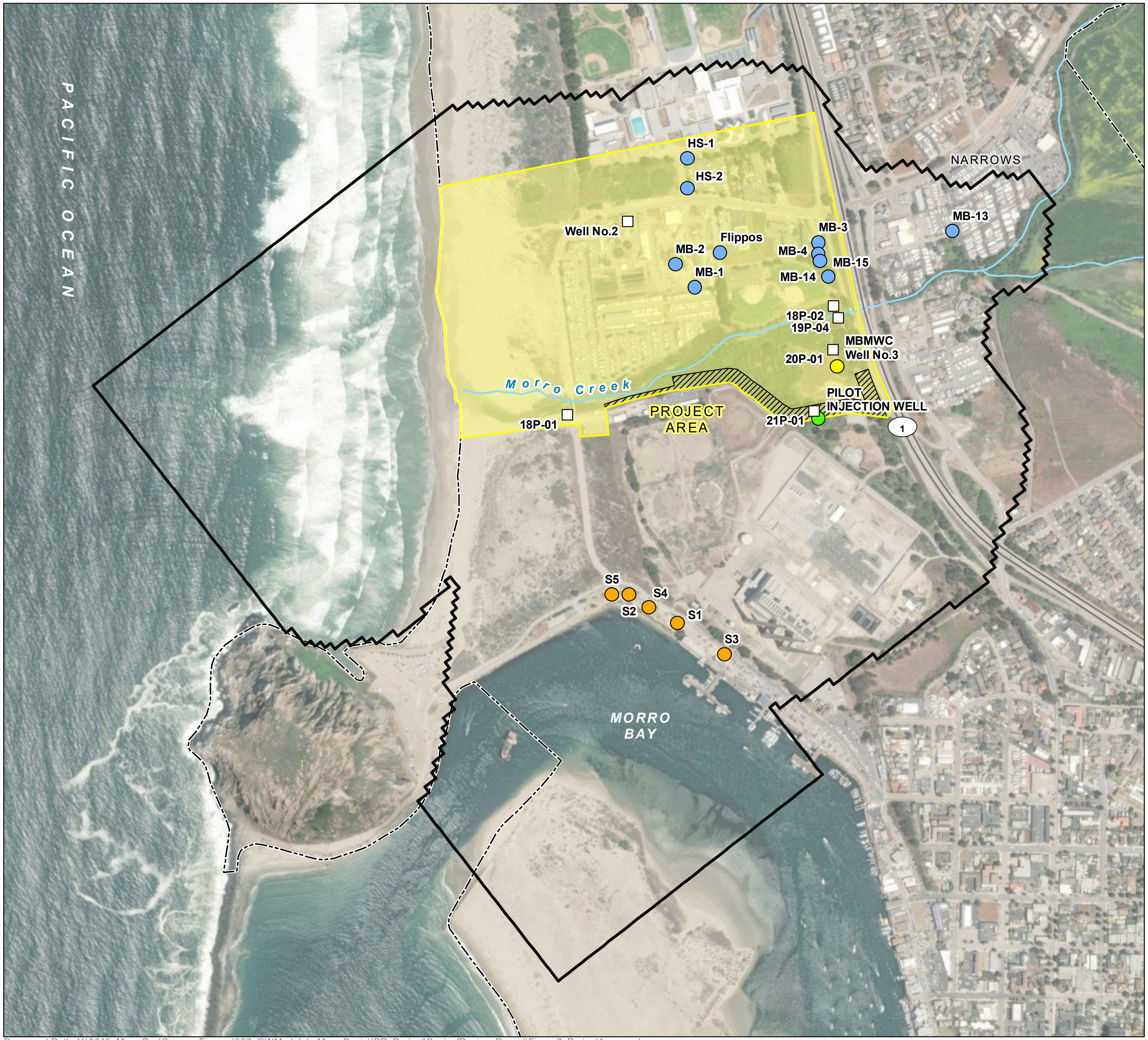


FIGURE 7

Project Area

Morro Bay IPR Project
Basis of Design Report

NOTES

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

Date: August 7, 2023
Data Sources: USGS, ESRI,
City of Morro Bay, NAIP Imagery (2022)

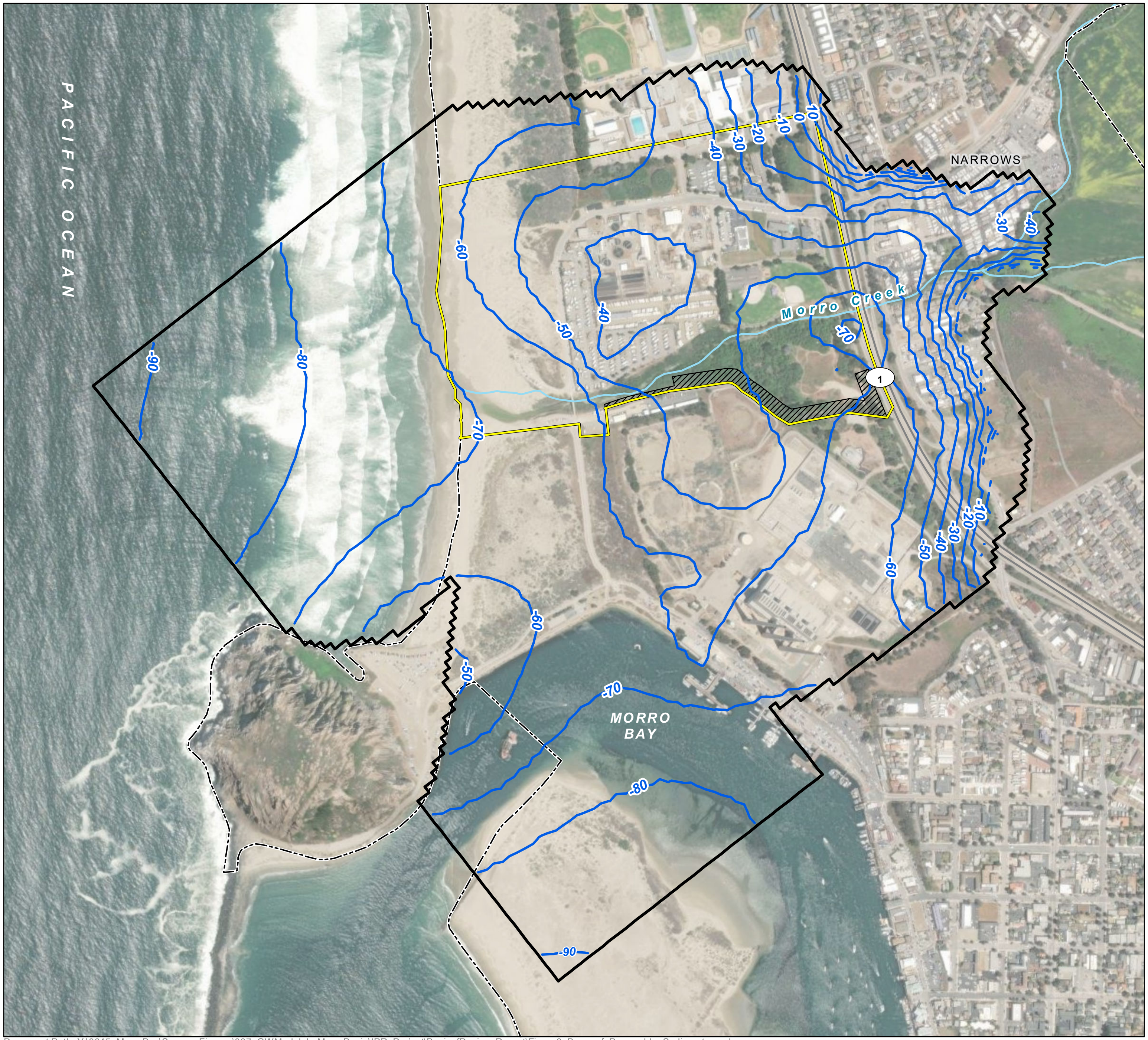


FIGURE 8

Base of Permeable Sediments

Morro Bay IPR Project
Basis of Design Report

LEGEND

- Base of Permeable Sediments 10' Contour
- Model Active Area
- Project Area
- Permanent Easement

All Other Features

- City Boundary
- Major Road
- Watercourse

N

0 1,000
Feet

Date: August 4, 2023
Data Sources: USGS, ESRI, City of Morro Bay, NAIP Imagery (2022)

GSI Water Solutions, Inc.

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\IPR_Project\BasisofDesign_Report\Figure8_Base_of_Permeable_Sediments.mxd

FIGURE 9

Lower Aquifer Zone Thickness

Morro Bay IPR Project
Basis of Design Report

LEGEND

Lower Aquifer Zone Thickness 10' Contour

Model Active Area

Project Area

Permanent Easement

All Other Features

City Boundary

Major Road

Watercourse

N

0 1,000
Feet

Date: August 4, 2023
Data Sources: USGS, ESRI, City of Morro Bay, NAIP Imagery (2022)

GSI Water Solutions, Inc.

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\IPR_Project\BasisofDesign_Report\Figure9_Lower_Aquifer_Zone_Thickness.mxd

FIGURE 10

October 2020 Groundwater Elevation Contours

Morro Bay IPR Project
Basis of Design Report

LEGEND

- City Well — Groundwater Elevation, feet
- Groundwater Elevation Contour, feet
- Groundwater Flow Direction
- Project Area
- Permanent Easement
- Major Road
- Watercourse

N

0 250 500
Feet

Date: August 7, 2023
Data Sources: ESRI, USGS, Maxar Imagery (2021)

GSI Water Solutions, Inc.

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\IPR_Project\BasisofDesign_Report\Figure10_Oct2020_GW_Elevation_Contours.mxd, npalmer

FIGURE 11

April 2021 Groundwater Elevation Contours

Morro Bay IPR Project
Basis of Design Report

LEGEND

- City Well
  Groundwater Elevation, feet
- Groundwater Elevation Contour, feet
- Groundwater Flow Direction
- Project Area
- Permanent Easement
- Major Road
- Watercourse

N

0 250 500
Feet

Date: August 7, 2023
Data Sources: ESRI, USGS, Maxar Imagery (2021)

GSI Water Solutions, Inc.

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\IPR_Project\BasisofDesign_Report\Figure11_Apr2021_GW_Elevation_Contours.mxd, npalmer

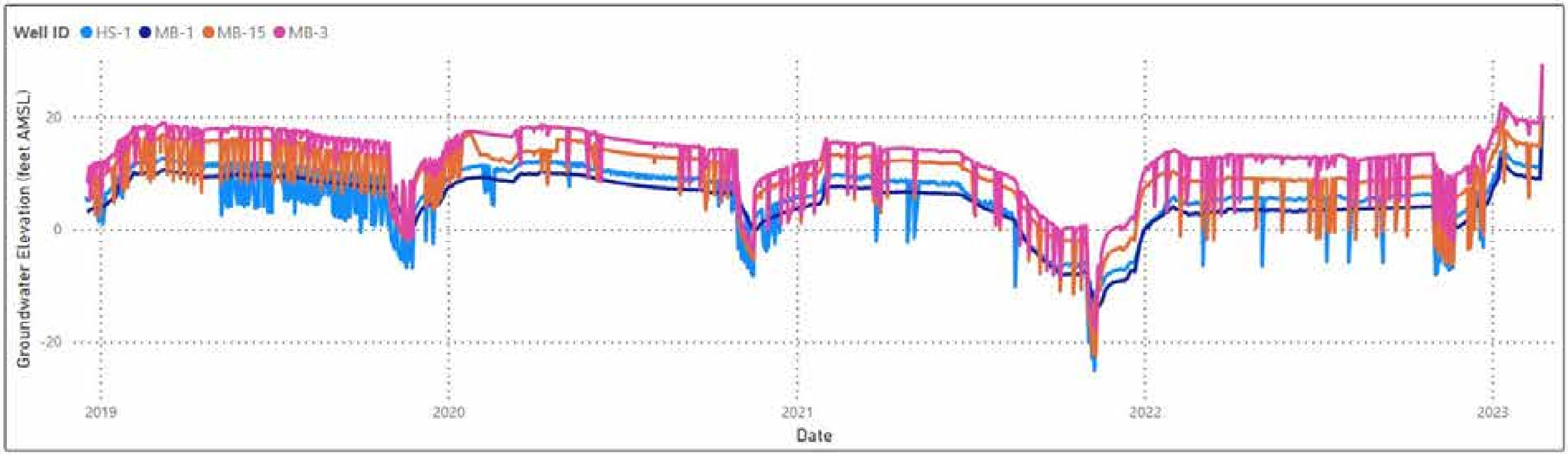


FIGURE 12

Project Site Hydrographs

Morro Bay IPR Project
Basis of Design Report

GSI Water Solutions, Inc.

Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\IPR_Project\BasisofDesign_Report

FIGURE 13

Morro Bay Well Nitrate Concentrations

Morro Bay IPR Project
Basis of Design Report

LEGEND

- Morro Bay City Well
- Project Area
- Permanent Easement
- Watercourse

N

0 200 400
Feet

Date: July 19, 2023
Data Sources: ESRI, USGS, Maxar Imagery (2021)

GSI Water Solutions, Inc.

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\IPR_Project\BasisofDesign_Report\FigureX_Morro_Bay_BASE_Results.mxd, npalmer

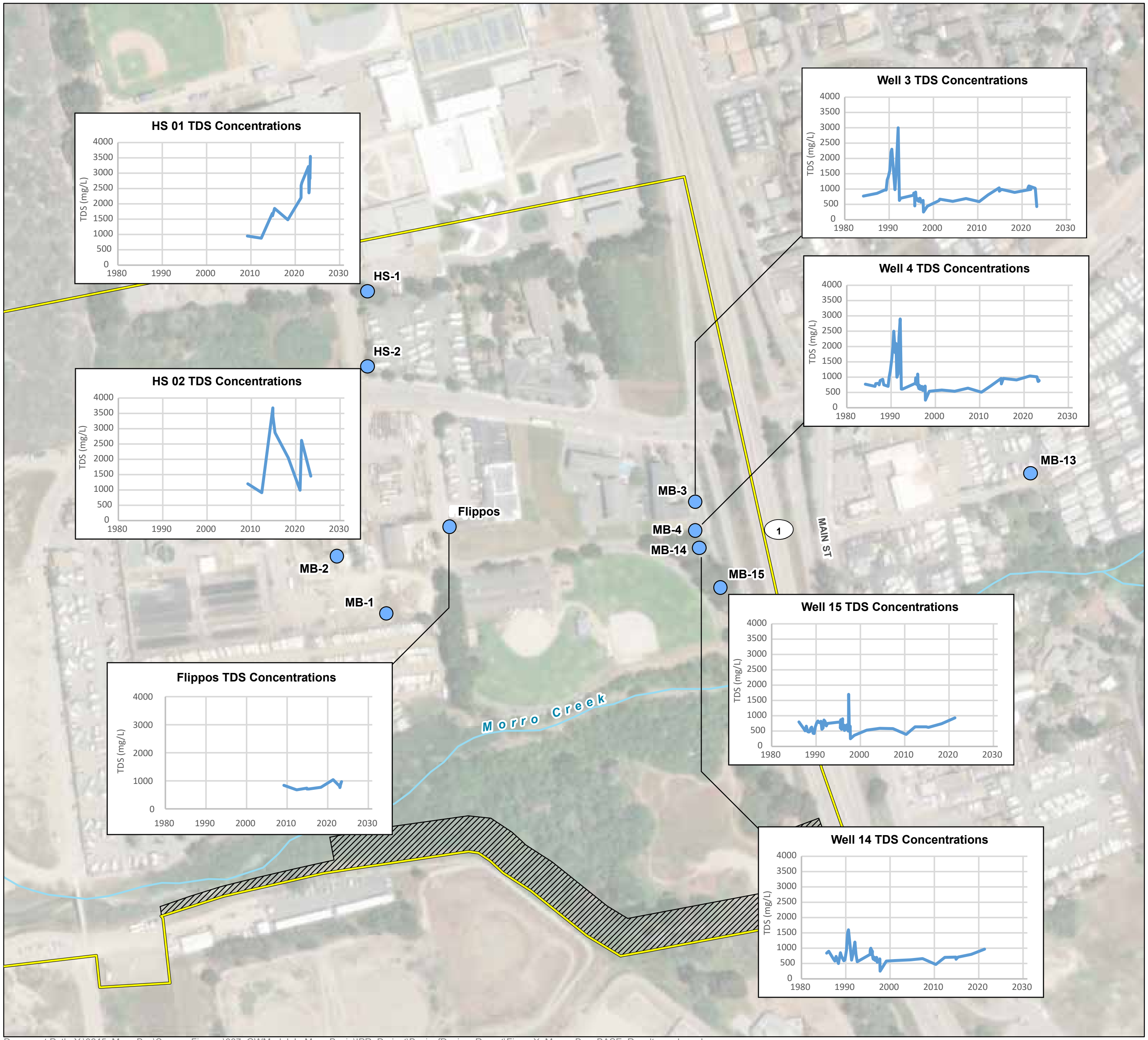


FIGURE 14

Morro Bay Well TDS Concentrations

Morro Bay IPR Project
Basis of Design Report

LEGEND

- Morro Bay City Well
- Project Area
- Permanent Easement
- Watercourse

N

0 200 400
Feet

Date: July 19, 2023
Data Sources: ESRI, USGS, Maxar Imagery (2021)

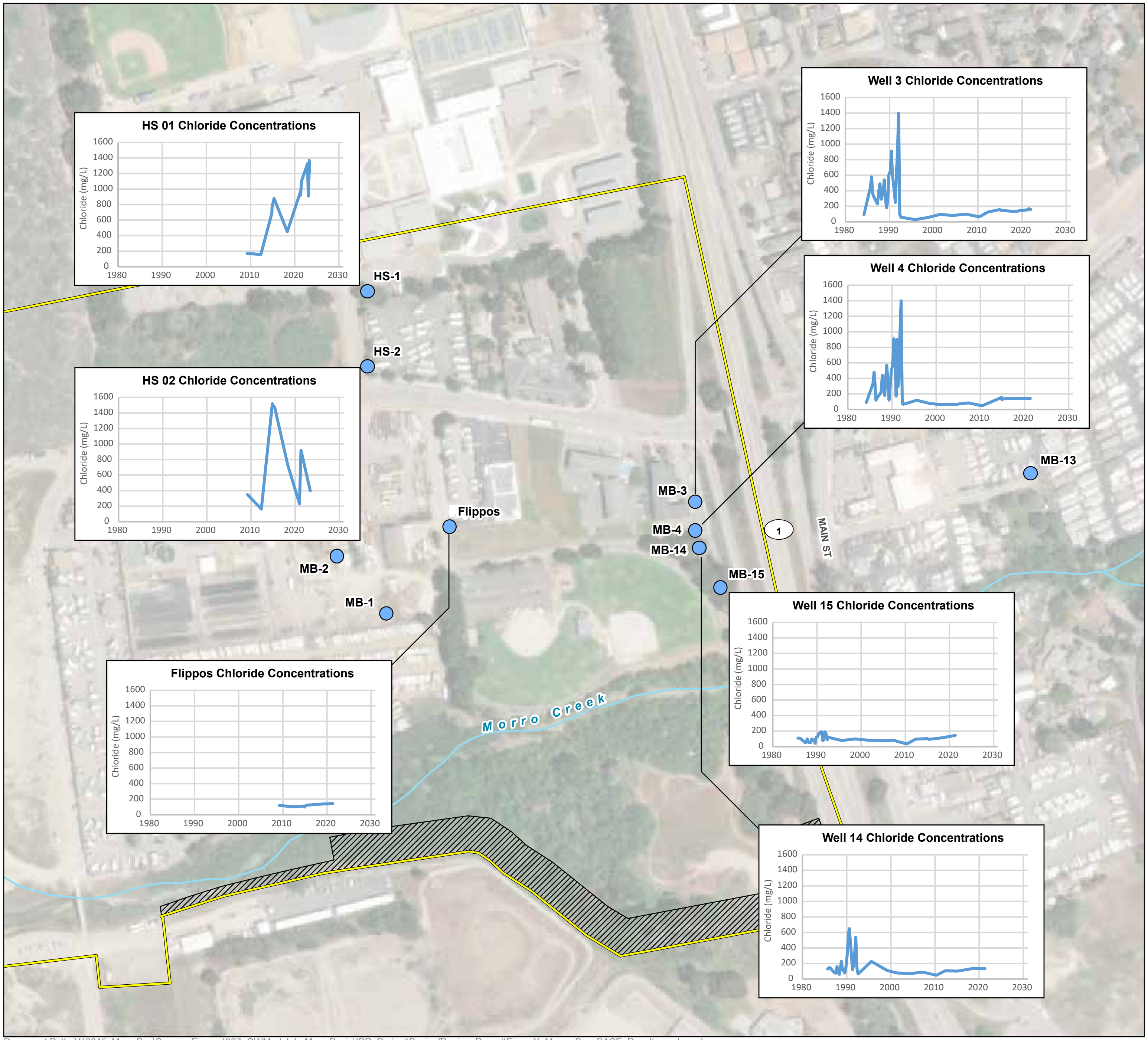
GSI Water Solutions, Inc.

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\IPR_Project\BasisofDesign_Report\FigureX_Morro_Bay_BASE_Results.mxd, npalmer

FIGURE 15

Morro Bay Well Chloride Concentrations

Morro Bay IPR Project
Basis of Design Report



LEGEND

- Morro Bay City Well
- Project Area
- Permanent Easement
- Watercourse

N

0 200 400
Feet

Date: July 19, 2023
Data Sources: ESRI, USGS, Maxar Imagery (2021)

GSI Water Solutions, Inc.

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\IPR_Project\BasisofDesign_Report\FigureX_Morro_Bay_BASE_Results.mxd, npalmer

FIGURE 16

Injection Well Site Detail

Morro Bay IPR Project
Basis of Design Report

LEGEND

- MBMWC Well (Abandoned)
- Injection Well (IW-1)
- Piezometer
- Hydrant
- Project Area
- Permanent Easement
- Bike Path
- Water Supply Line
- Gas Line
- Watercourse

NOTES

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

N

0 75 150
Feet

Date: August 7, 2023
Data Sources: USGS, ESRI, City of Morro Bay, Maxar Imagery (2021)

GSI Water Solutions, Inc.

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\IPR_Project\BasisofDesign_Report\Figure16_InjectionWellSiteDetail.mxd

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	

FIGURE 17a

Piezometer 21P-01 Boring Log

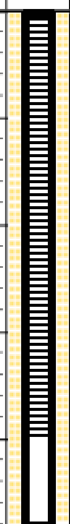
Morro Bay IPR Project
Basis of Design Report

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 56.5' - Sand with some glay 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'	

FIGURE 17b

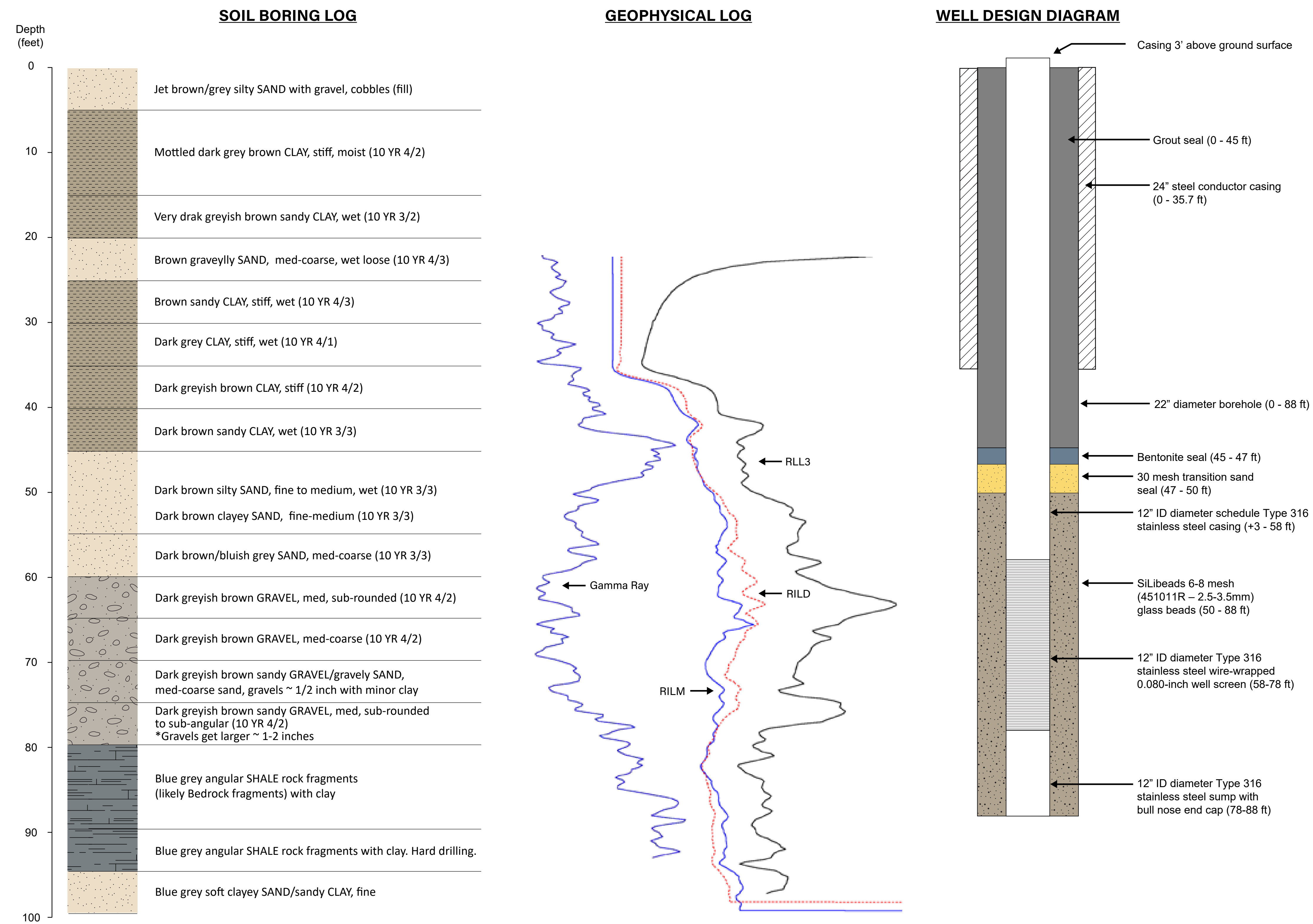
Piezometer 21P-01 Boring Log

Morro Bay IPR Project
Basis of Design Report

FIGURE 18

Injection Well (IW-1) Design

Morro Bay IPR Project
Basis of Design Report



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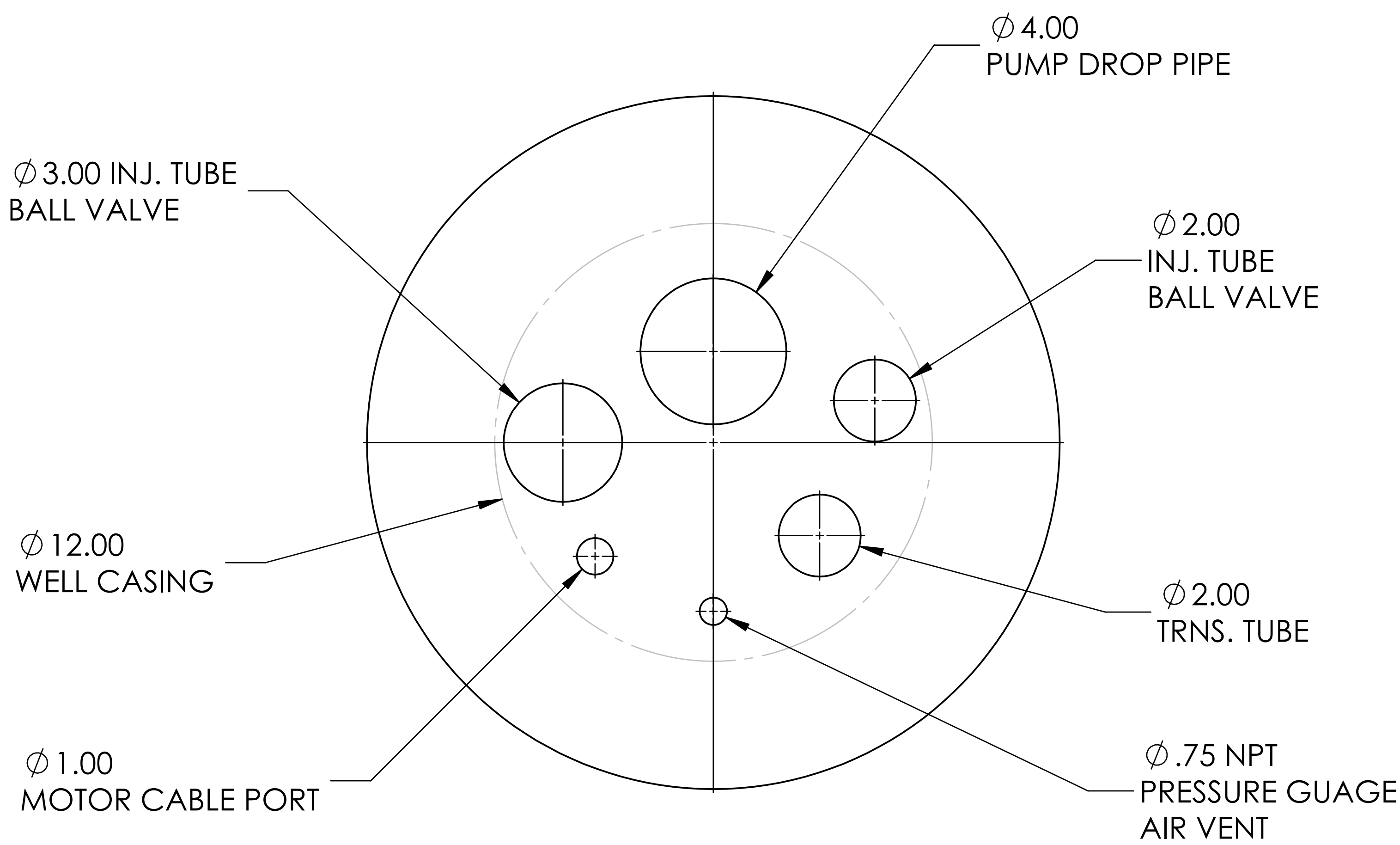
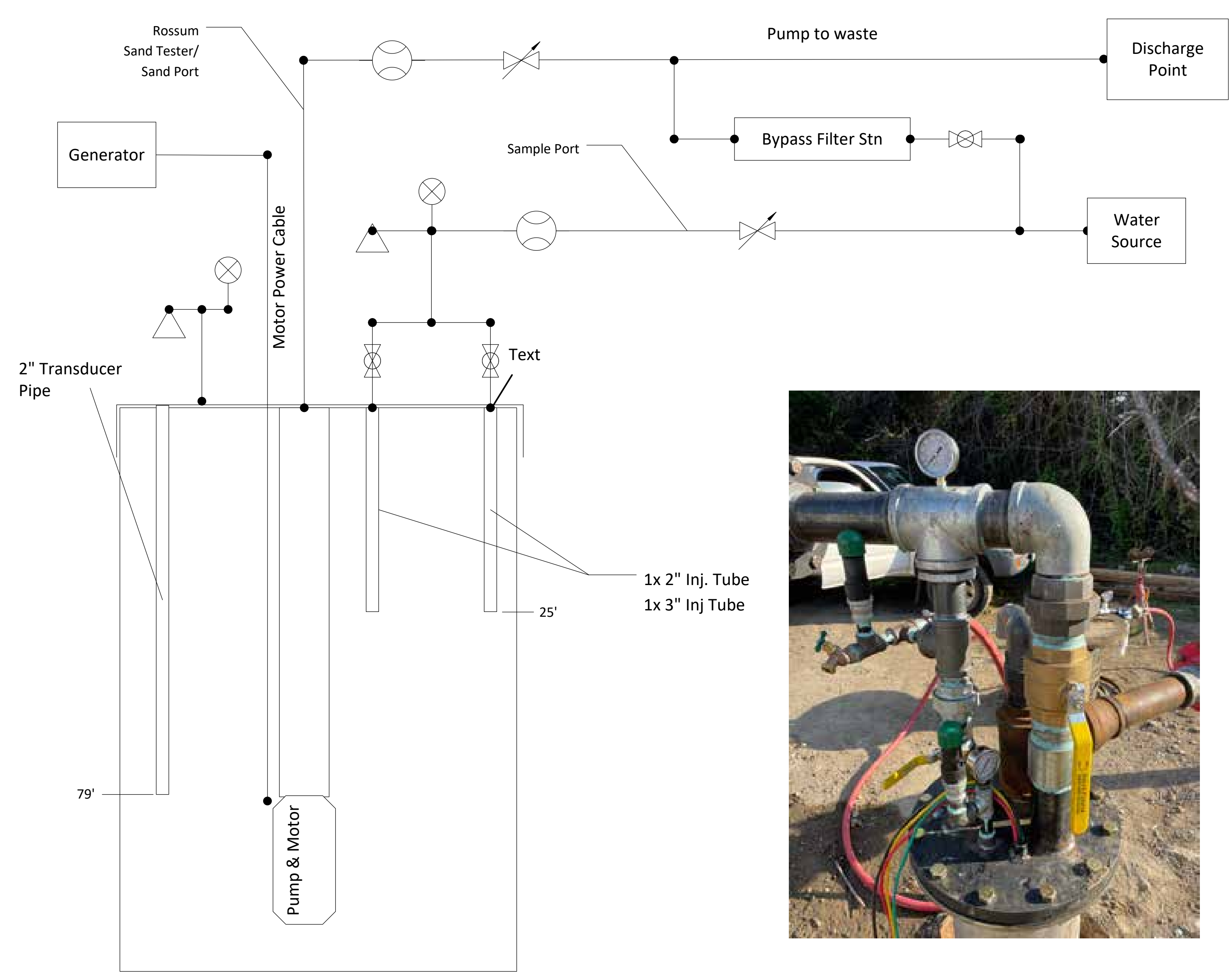
PROFILE VIEW



PLAN VIEW



LEGEND

- Flow Meter
- Pressure Gauge
- Air Vent
- Ball Valve
- Gate Valve

FIGURE 19

Well Head Design

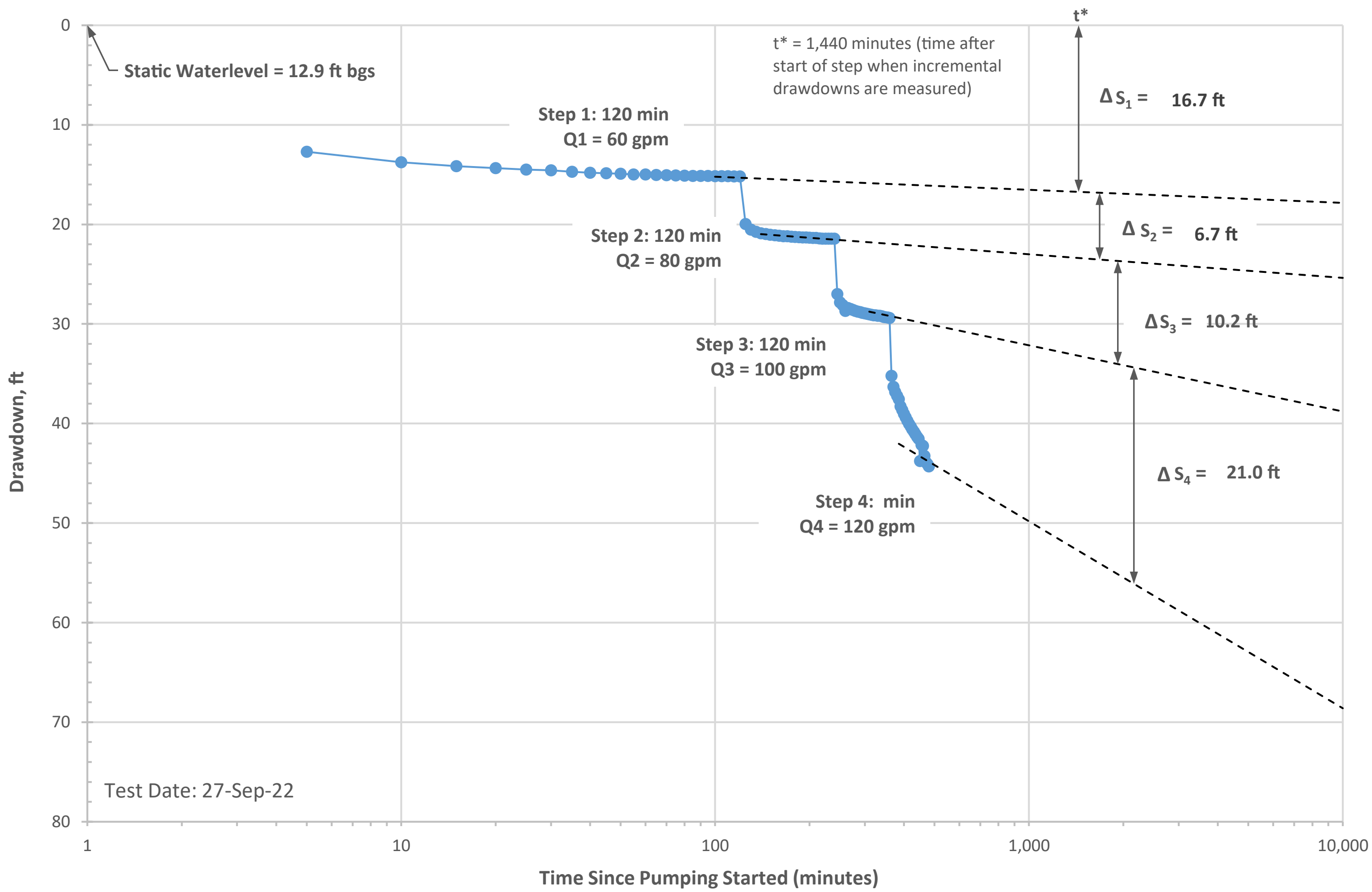
Morro Bay IPR Project
Basis of Design Report

GSI Water Solutions, Inc.

FIGURE 20

Pilot Injection Well Aquifer Test Drawdown

Morro Bay IPR Project
Basis of Design Report

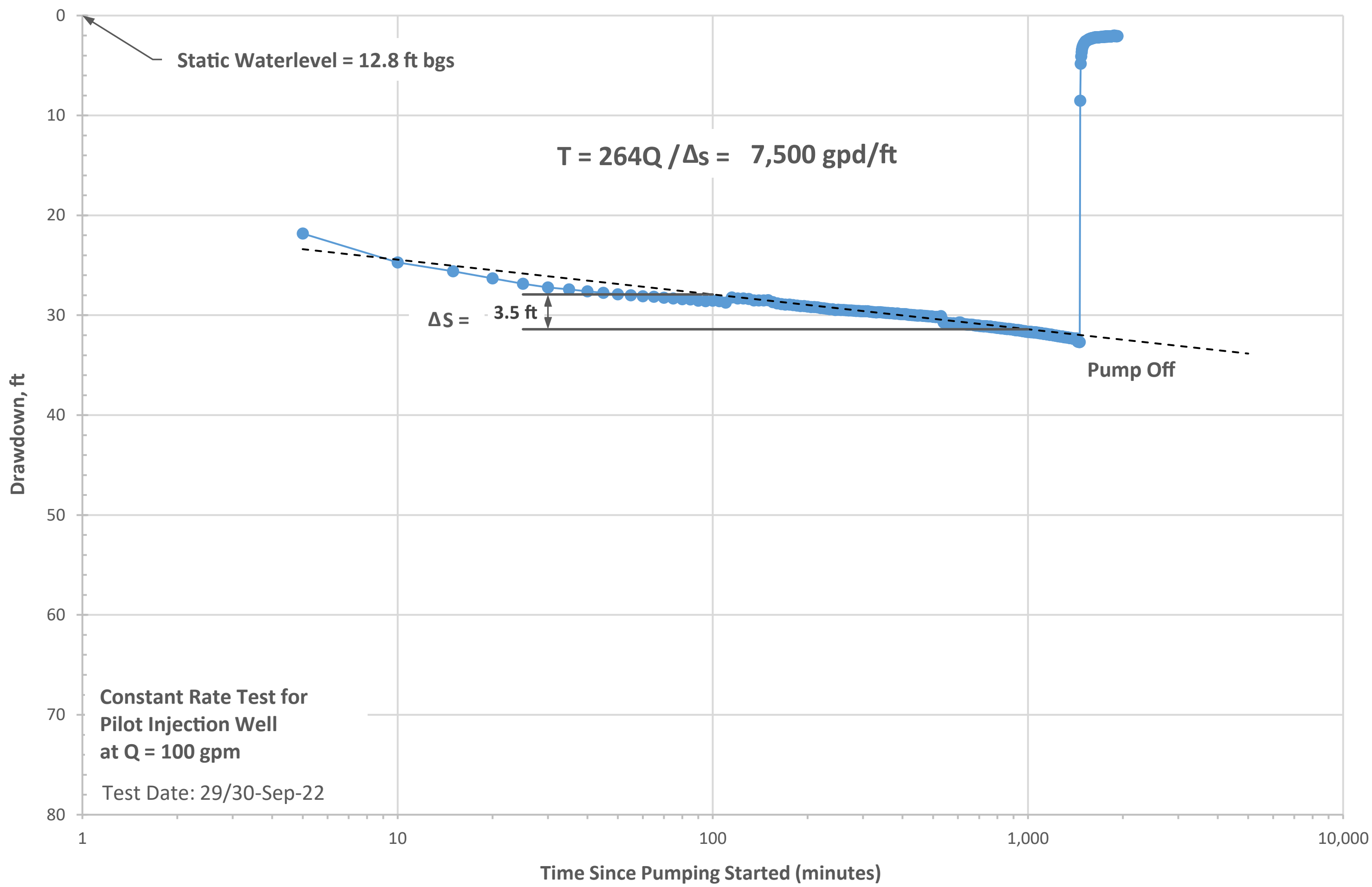


GSI Water Solutions, Inc.

FIGURE 21

Pilot Injection Well
Aquifer Constant Rate Test

Morro Bay IPR Project
Basis of Design Report

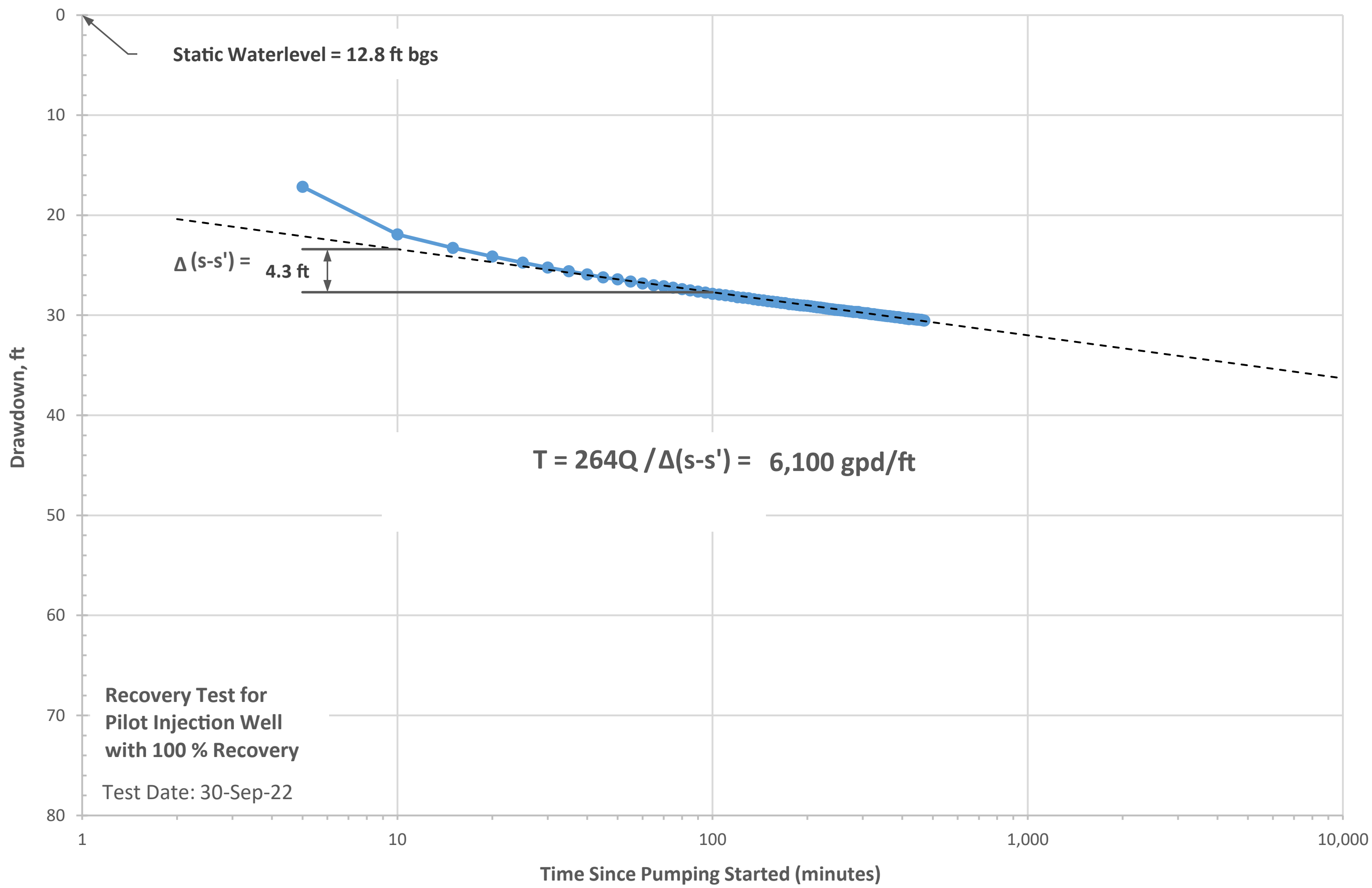


GSI Water Solutions, Inc.

FIGURE 22

Pilot Injection Well Aquifer Constant Rate Recovery Test

Morro Bay IPR Project
Basis of Design Report

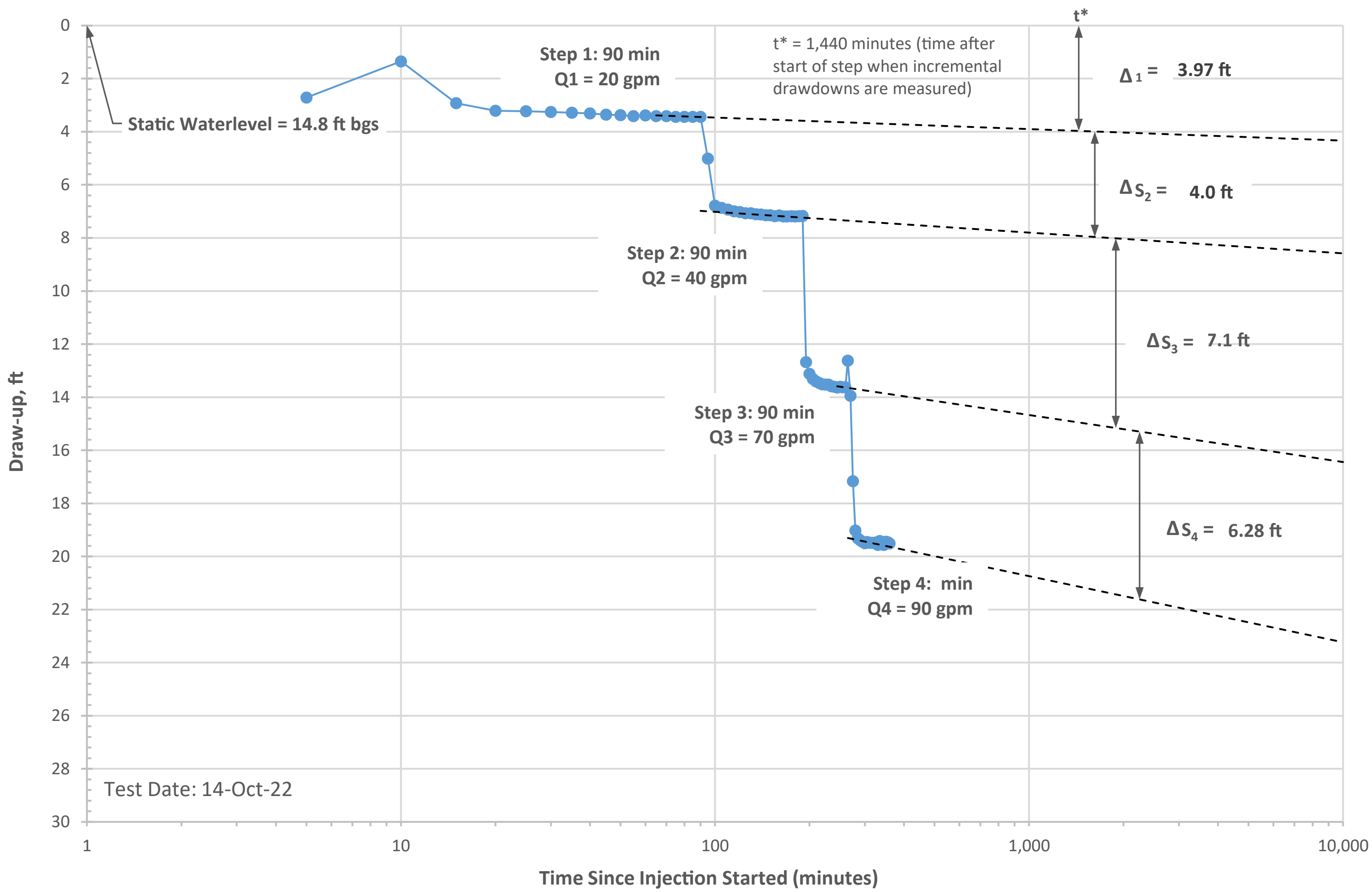


GSI Water Solutions, Inc.

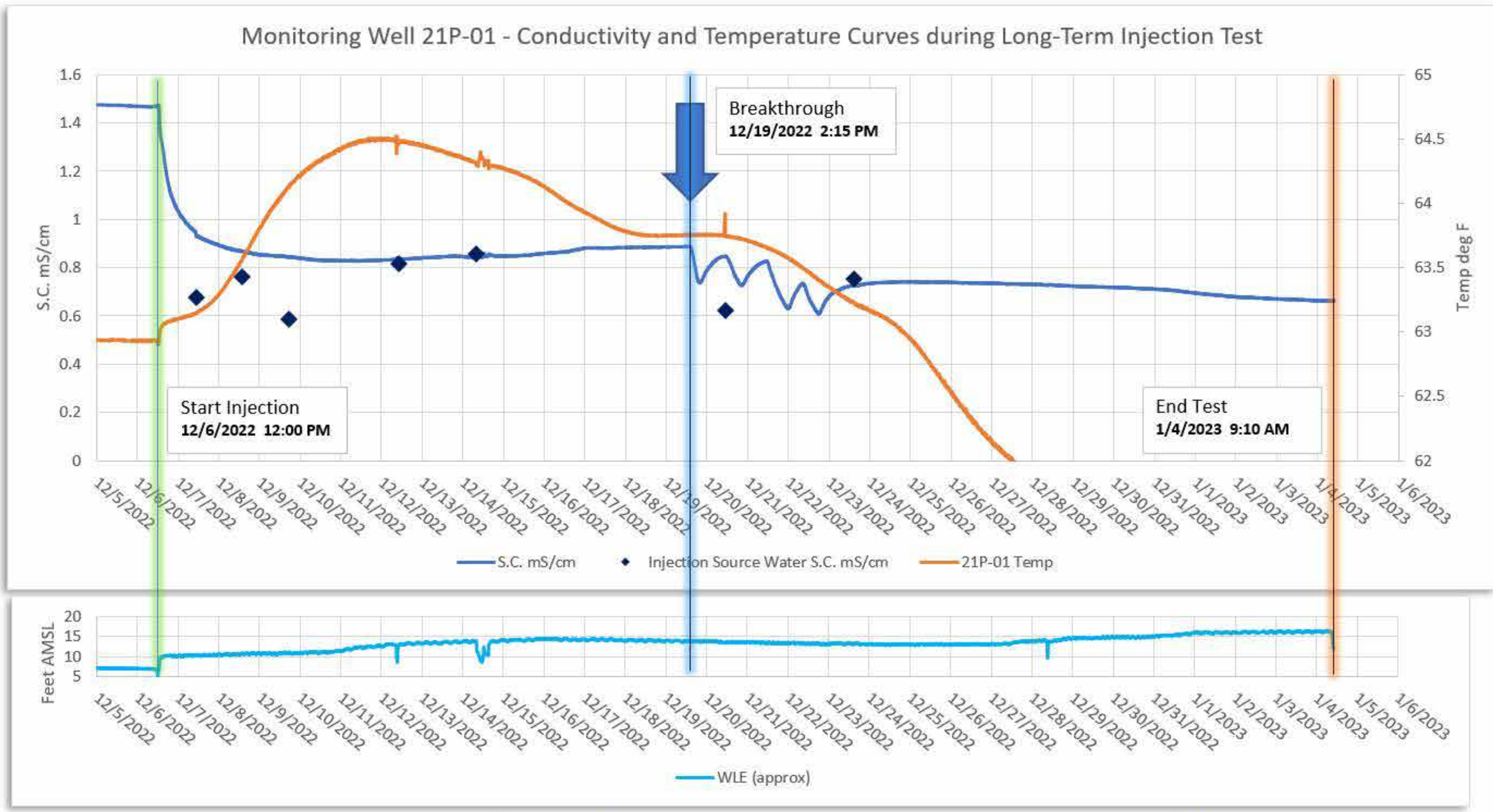
FIGURE 23

Pilot Injection Well Injection Test Draw-up

Morro Bay IPR Project
Basis of Design Report



GSI Water Solutions, Inc.



Days to breakthrough	Dist from Pilot Inj. Well			Closest MB Production Well (MB-15)
13.1	53 feet	4.05	feet/day	990 feet

FIGURE 24

Injection Long-Term Test

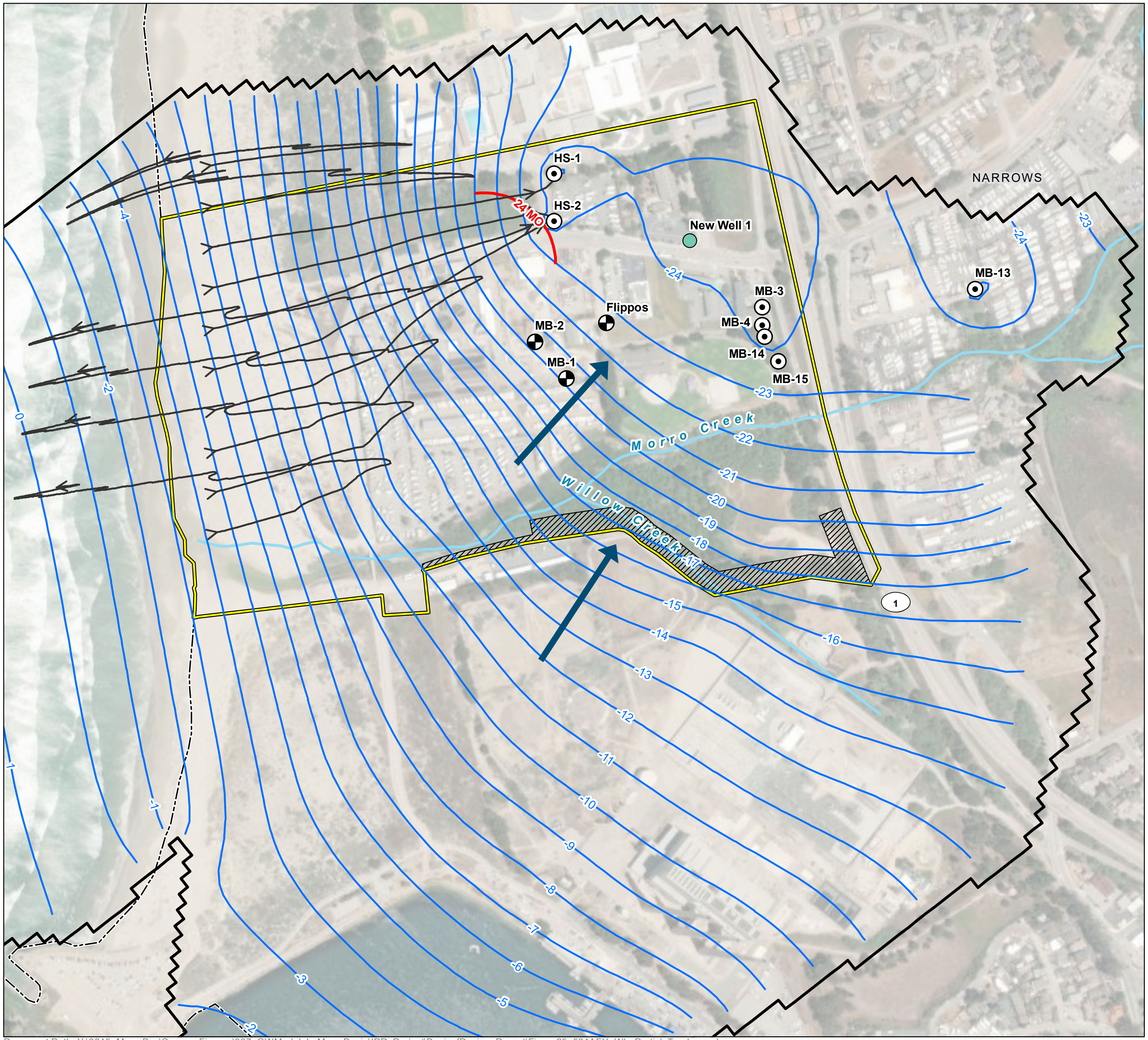
Morro Bay IPR Project
Basis of Design Report

Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\IPR_Project\BasisofDesign_Report

FIGURE 25

Model Results:
City Pumping of 581 AFY with no IPR Project – Water Levels and Particle Tracks

Morro Bay IPR Project
Basis of Design Report



Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\IPR_Project\BasisofDesign_Report\Figure25_581AFY_WL_ParticleTracks.mxd

LEGEND

- New Well 1
- Morro Bay City Well
- City Well to be Repurposed to Monitoring well
- Time of Travel (in months)
- Paticle Track
- Groundwater Elevation Contour (feet amsl)
- Groundwater Flow Direction
- Project Area
- Permanent Easement
- Model Active Area

All Other Features

- City Boundary
- Major Road
- Watercourse

NOTES

1. Water levels are from stress period 118 of the transient simulation, which represents the lowest water levels modeled during the drought.

amsl: above mean sea level
AFY: acre feet per year

N

0 315 630
Feet

Date: August 4, 2023
Data Sources: USGS, ESRI, City of Morro Bay, Maxar Imagery (2021)

GSI Water Solutions, Inc.

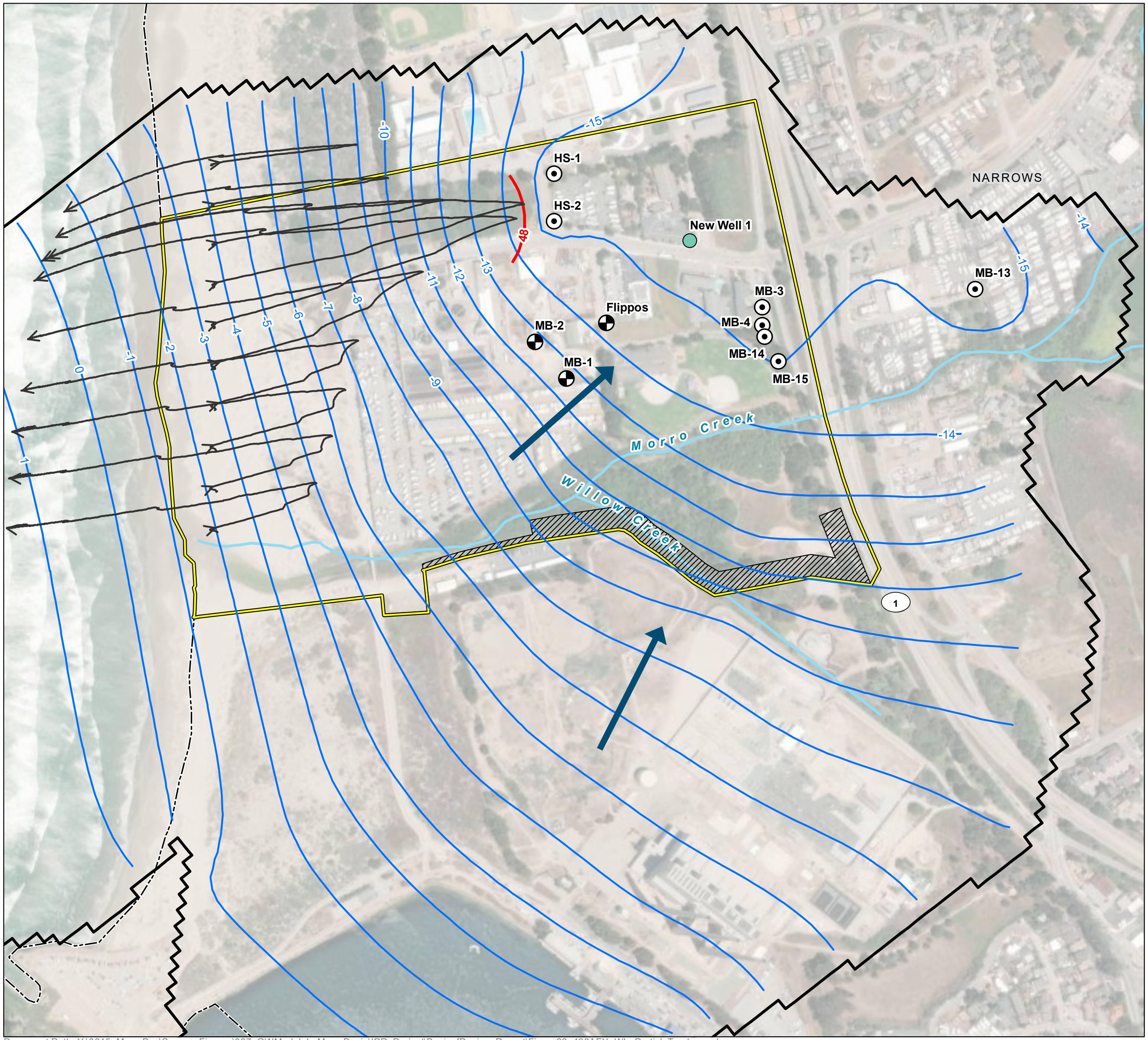


FIGURE 26

Model Results:
City Pumping of 400 AFY
with no IPR Project –
Water Levels and Particle Tracks

Morro Bay IPR Project
Basis of Design Report

LEGEND

- New Well 1
- Morro Bay City Well
- City Well to be Repurposed to Monitoring well
- Time of Travel (in months)
- Paticle Track
- Groundwater Elevation Contour (feet amsl)
- Groundwater Flow Direction
- Project Area
- Permanent Easement
- Model Active Area

All Other Features

- City Boundary
- Major Road
- Watercourse

NOTES

1. Water levels are from stress period 118 of the transient simulation, which represents the lowest water levels modeled during the drought.

amsl: above mean sea level
AFY: acre feet per year

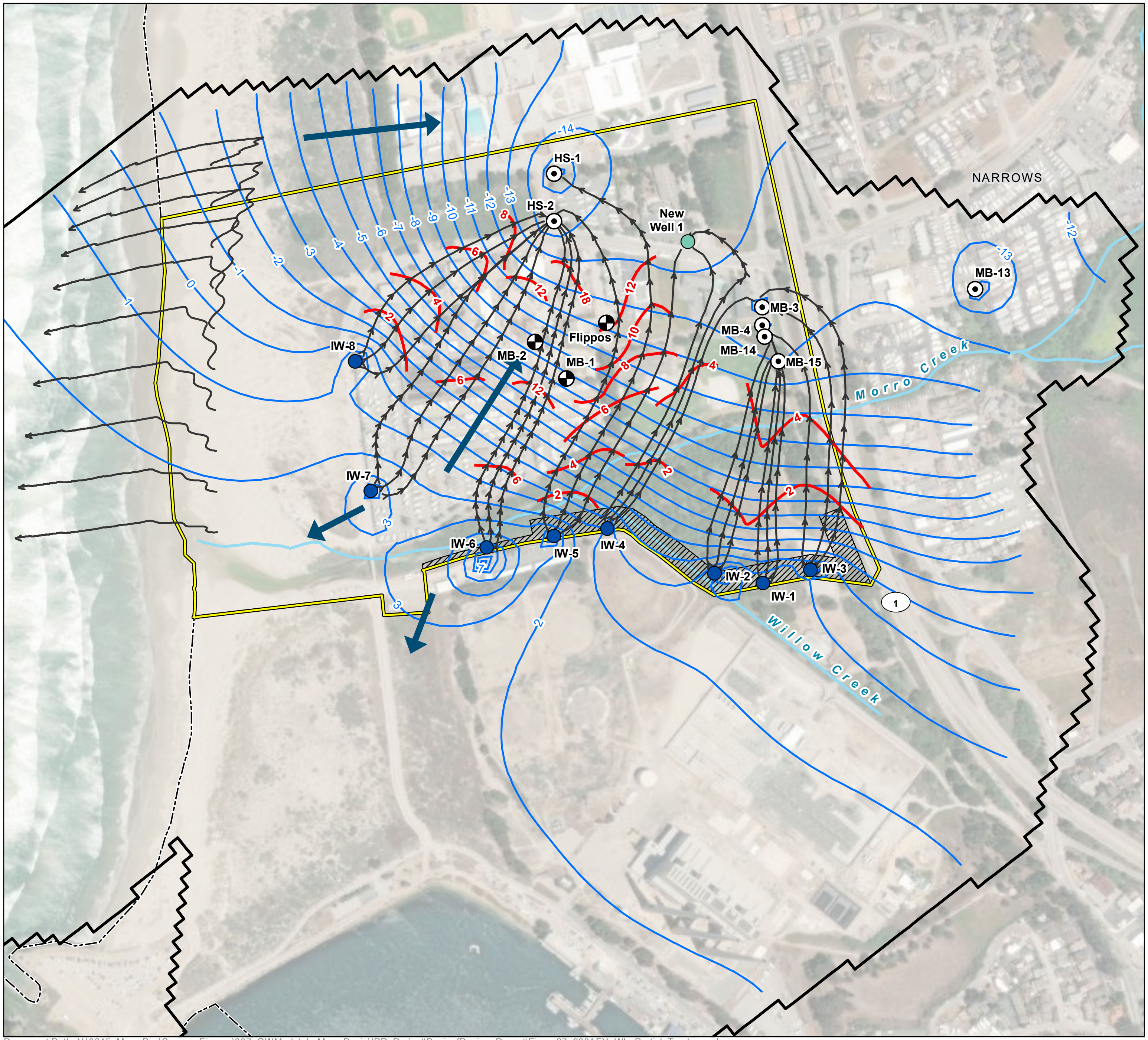
N

0 315 630
Feet

Date: August 4, 2023
Data Sources: USGS, ESRI, City of Morro Bay, Maxar Imagery (2021)

GSI Water Solutions, Inc.

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\IPR_Project\BasisofDesign_Report\Figure26_400AFY_WL_ParticleTracks.mxd



Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\IPR_Project\BasisofDesign_Report\Figure27_900AFY_WL_ParticleTracks.mxd

FIGURE 27

Model Results: City Pumping of 900 AFY and IPR Injection of 887 AFY – Water Levels and Particle Tracks

Morro Bay IPR Project
Basis of Design Report

LEGEND

- Injection Well
- New Well 1
- Morro Bay City Well
- City Well to be Repurposed to Monitoring well
- Time of Travel (in months)
- Paticle Track
- Groundwater Elevation Contour (feet amsl)
- Groundwater Flow Direction
- Project Area
- Permanent Easement
- Model Active Area

All Other Features

- City Boundary
- Major Road
- Watercourse

NOTES

1. Water levels are from stress period 118 of the transient simulation, which represents the lowest water levels modeled during the drought.

amsl: above mean sea level
AFY: acre feet per year

N

0 315 630
Feet

Date: August 7, 2023
Data Sources: USGS, ESRI, City of Morro Bay, Maxar Imagery (2021)

GSI Water Solutions, Inc.

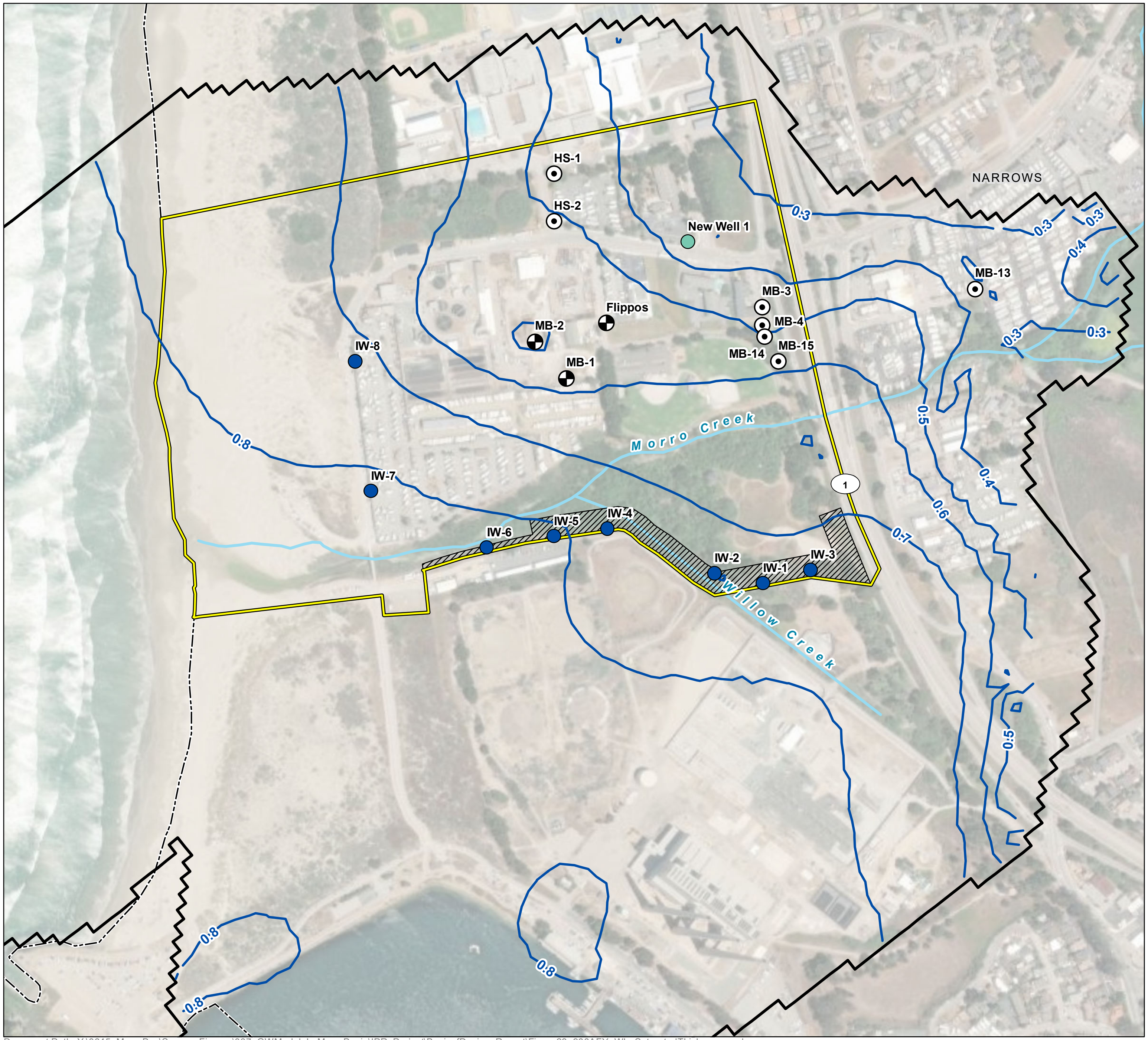


FIGURE 28

Model Results: City Pumping of 900 AFY and IPR Injection of 887 AFY – Percent Original Saturated Thickness

Morro Bay IPR Project
Basis of Design Report

LEGEND

- Injection Well
- New Well 1
- Morro Bay City Well
- City Well to be Repurposed to Monitoring well
- Percent Original Saturated Thickness (feet)
- Project Area
- Permanent Easement
- Model Active Area

All Other Features

- City Boundary
- Major Road
- Watercourse

NOTES

1. Saturated thickness is from stress period 118 of the transient simulation, which represents the lowest water levels modeled during the drought.

AFY: acre feet per year

N

0 315 630
Feet

Date: August 7, 2023
Data Sources: USGS, ESRI, City of Morro Bay, Maxar Imagery (2021)

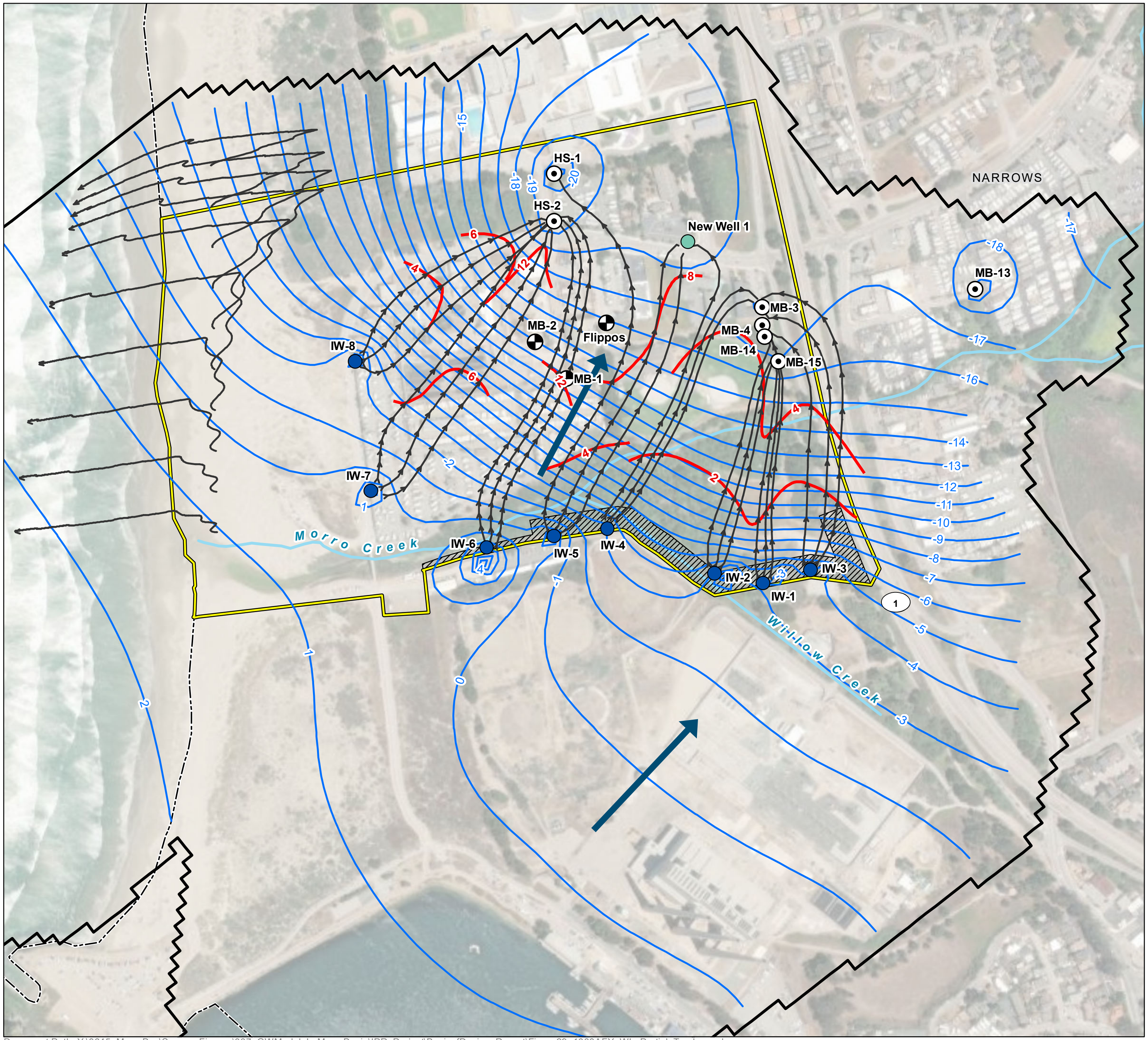
GSI Water Solutions, Inc.

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\IPR_Project\BasisofDesign_Report\Figure28_900AFY_WL_SaturatedThickness.mxd

FIGURE 29

Model Results: City Pumping of 1,000 AFY and IPR Injection of 887 AFY – Water Levels and Particle Tracks

Morro Bay IPR Project
Basis of Design Report



LEGEND

- Injection Well
- New Well 1
- Morro Bay City Well
- City Well to be Repurposed to Monitoring well
- Time of Travel (in months)
- Paticle Track
- Groundwater Elevation Contour (feet amsl)
- Groundwater Flow Direction
- Project Area
- Permanent Easement
- Model Active Area

All Other Features

- City Boundary
- Major Road
- Watercourse

NOTES

1. Water levels are from stress period 118 of the transient simulation, which represents the lowest water levels modeled during the drought.

amsl: above mean sea level
AFY: acre feet per year

N

0 315 630
Feet

Date: August 7, 2023
Data Sources: USGS, ESRI, City of Morro Bay, Maxar Imagery (2021)

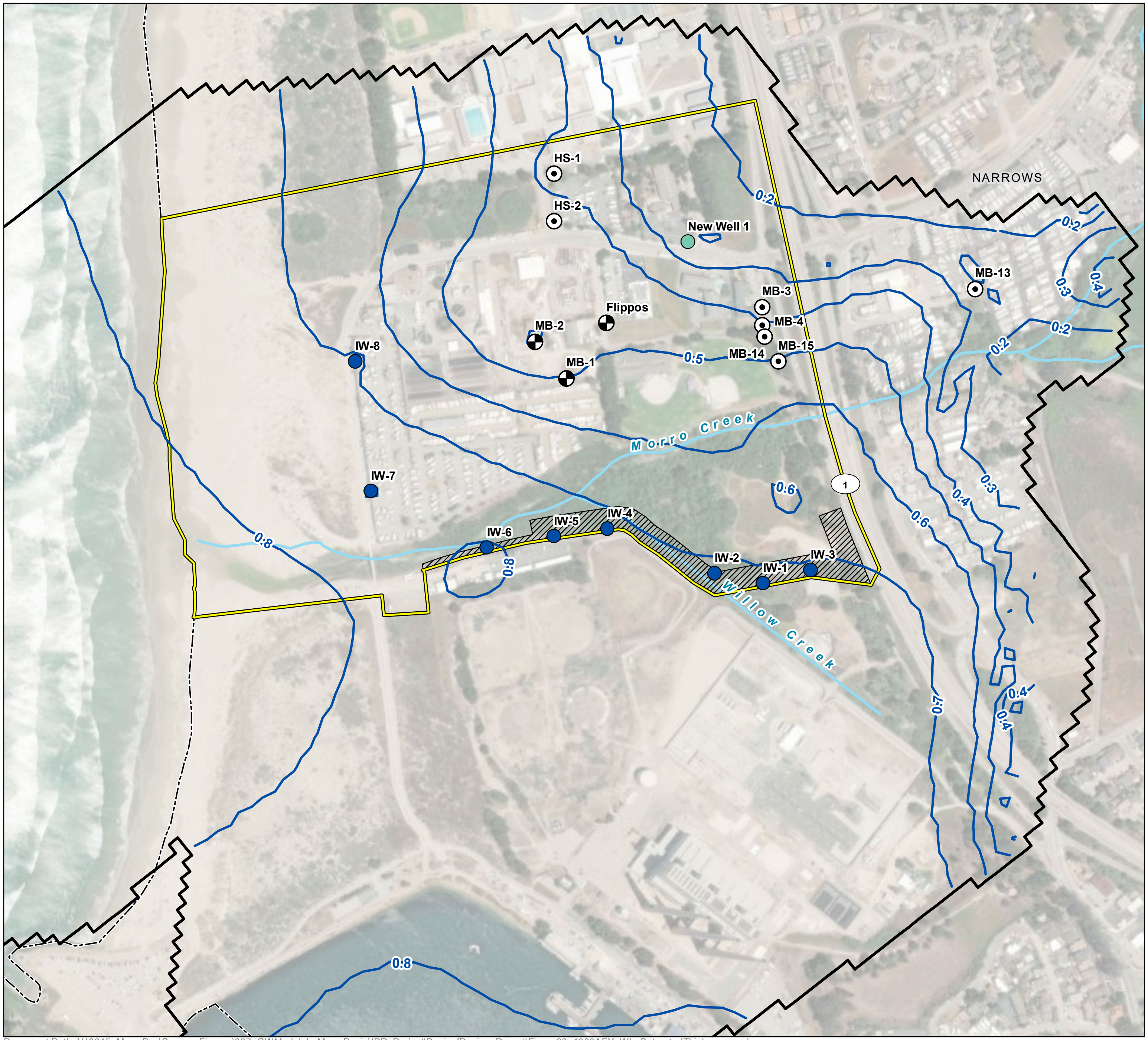
GSI Water Solutions, Inc.

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\IPR_Project\BasisofDesign_Report\Figure29_1000AFY_WL_ParticleTracks.mxd

FIGURE 30

Model Results: City Pumping of 1,000 AFY and IPR Injection of 887 AFY – Percent Original Saturated Thickness

Morro Bay IPR Project
Basis of Design Report



LEGEND

- Injection Well
- New Well 1
- Morro Bay City Well
- City Well to be Repurposed to Monitoring well
- Percent Original Saturated Thickness (feet)
- Project Area
- Permanent Easement
- Model Active Area

All Other Features

- City Boundary
- Major Road
- Watercourse

NOTES

1. Saturated thickness is from stress period 118 of the transient simulation, which represents the lowest water levels modeled during the drought.

AFY: acre feet per year

N

0 315 630
Feet

Date: August 7, 2023
Data Sources: USGS, ESRI, City of Morro Bay, Maxar Imagery (2021)

GSI Water Solutions, Inc.

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\IPR_Project\BasisofDesign_Report\Figure30_1000AFY_WL_SaturatedThickness.mxd

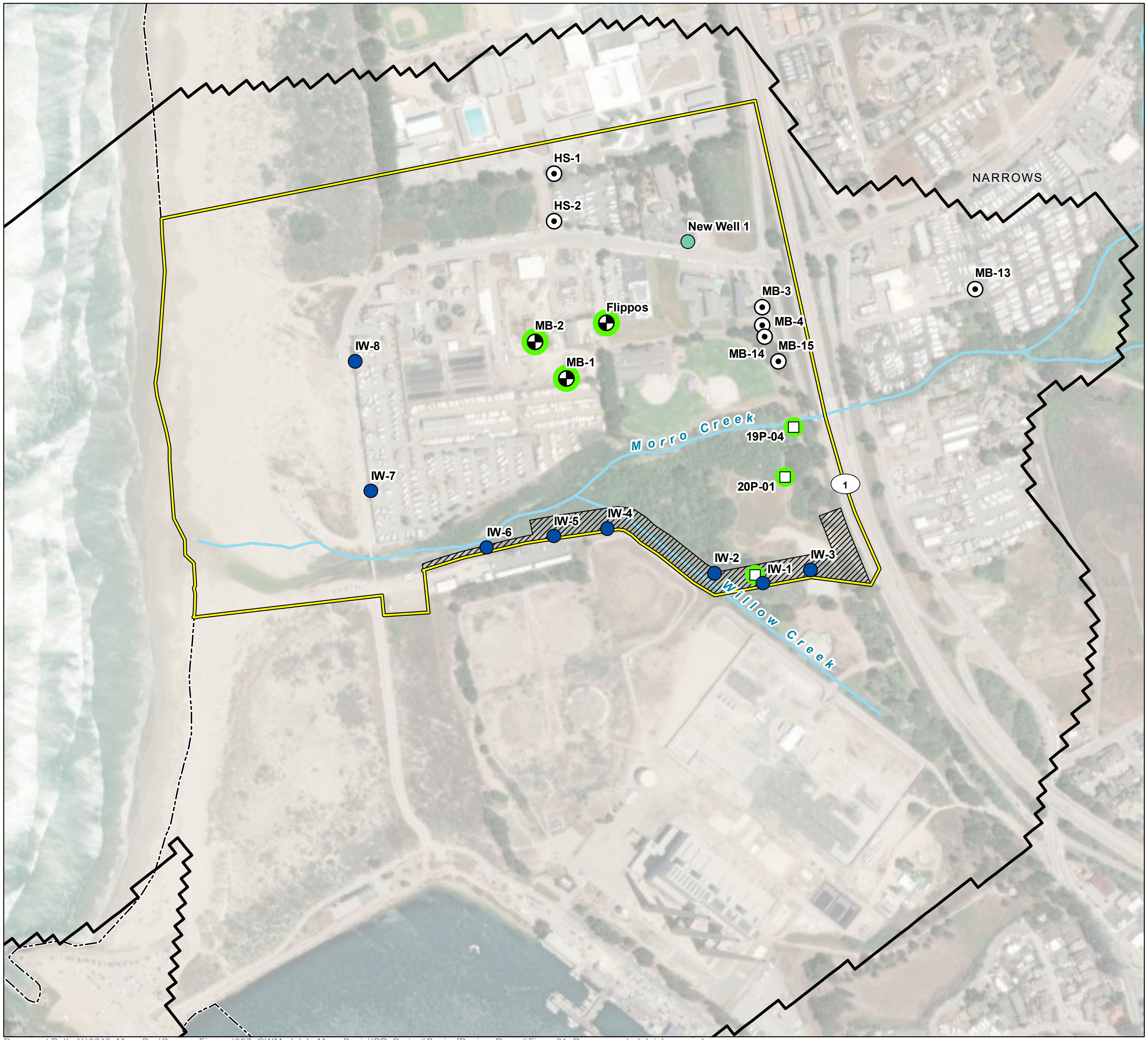


FIGURE 31

Recommended Injection Well Locations

Morro Bay IPR Project
Basis of Design Report

LEGEND

- Injection Well
- New Well 1
- Morro Bay City Well
- City Well to be Repurposed to Monitoring well
- Piezometer
- Potential Monitoring Well
- Project Area
- Permanent Easement
- Model Active Area

All Other Features

- City Boundary
- Major Road
- Watercourse

NOTES

1. Saturated thickness is from stress period 118 of the transient simulation, which represents the lowest water levels modeled during the drought.

AFY: acre feet per year

N

0 315 630
Feet

Date: August 7, 2023
Data Sources: USGS, ESRI, City of Morro Bay, Maxar Imagery (2021)

GSI Water Solutions, Inc.

Document Path: Y:\0645_MorroBay\Source_Figures\007_GWModel_L_MorroBasin\IPR_Project\BasisofDesign_Report\Figure31_Recommended_Inj_Locs.mxd