EXECUTIVE SUMMARY

INTRODUCTION

The Santa Margarita Test Injection Well (SMTIW) is part of the Monterey Peninsula Water Management District's (District) ongoing investigation of Aquifer Storage and Recovery (ASR; aka injection/recovery) in the Seaside Groundwater Basin. As applied to the Monterey Peninsula, ASR involves the diversion, treatment, and conveyance of 'excess' water from the Carmel River alluvial aquifer system to dual-purpose injection/recovery wells in the Seaside Basin for injection, storage, and subsequent recovery. The source water for injection is captured by Cal-Am facilities during periods when the flow in the river exceeds the instream requirements of the State Water Resources Control Board and Department of Fish and Game. The injected and subsequently recovered water, therefore, represents the capture, storage, and utilization of surplus water that is available for diversion without harming existing users or the environment.

The District installed the SMTIW in 2001 with a design injection capacity of 1,000 gallons per minute (gpm) to assess the hydrogeologic characteristics of the Santa Margarita Sandstone for ASR. This report documents the testing and results of operations at the SMTIW during Water Year 2003 (WY2003), and constitutes the second annual summary report of the testing performed at the SMTIW (the final WY2002 summary report was presented to the District in March 2003). A brief summary of the relevant findings developed during WY2003 is presented below.

INJECTION TESTING

Injection operations were performed at the SMTIW during WY2003 during the period of January 24 to May 15, 2003. A total volume of approximately 168 acre-feet (AF)[1] of water was successfully injected into the Santa Margarita Sandstone of the Seaside Groundwater Basin during the period.

Injection was performed at average rates ranging between approximately 988 and 1,175 (gpm) (approximately 4.4 to 5.2 acre-feet per day). During the injection season, the well maintained both injection and pumping performance. Plugging was minimal, and was successfully managed by routine backflushing of the well between injection tests.

During injection testing, the SMTIW displayed a maximum water level increase (drawup) of approximately 120 feet, with the water level in the SMTIW remaining approximately 235 feet (or greater) below ground surface; therefore, there was at all times a significant amount of additional 'freeboard' in the well casing before the water level would reach ground surface. The

[1] One acre-foot of water is approximately the amount of water used annually by 2 to 3 average-sized homes on the Monterey Peninsula.

amount of available drawup/freeboard indicates that an additional well at the site[2] injecting at a similar rate could be accommodated without causing undesirable interference effects (i.e., water levels reaching the ground surface).

Water levels in the aquifer system were monitored during the injection season at seven monitoring well locations ranging in distance from the SMTIW from several hundred to several thousand feet. Positive response to injection was observed at the monitoring wells, with increases in water levels due to injection ranging between approximately 1 and 6 feet. The observed increases were comparable to, although somewhat less than, the amount of increase calculated using the aquifer parameters utilized in Plan B. In addition, water levels remained *below* sea level at most monitored wells throughout the period, even at the peak of the injection season.

RECOVERY TESTING

Following an approximate four-month period of storage in the basin, approximately 440 AF was pumped (recovered) from the well into the Cal-Am distribution system during the period September 3 through November 4, 2003. This volume represents approximately 130 percent of the combined total volume of water injected by the SMTIW during WY2002 and WY2003 (approximately 175 AF was injected during WY2002, but was not recovered until WY2003).

Water levels were drawn down to between 10 to 50 feet *below* sea level by the pumping of other wells in the Seaside Basin and the SMTIW recovery operations during the summer/fall months. These observations suggest that it is highly unlikely that any net loss of injected water to the Pacific Ocean occurs under these hydraulic conditions. Rather, the injected water partially filled, temporarily, the significant existing water level depression in the basin, and was subsequently recovered into the Cal-Am distribution system (either by the SMTIW itself and/or Cal-Am's existing wells, such as the Paralta Well) and/or served to replenish groundwater in storage in the basin.

WATER QUALITY

During the injection, storage, and recovery operations a variety of water quality data was collected to assist with the assessment of the fate and stability of the injected waters in the subsurface. Specific findings regarding SMTIW water quality are summarized below:

- The electrical conductivity (EC) and chloride data collected during recovery suggest that the injected water is intermixing with native groundwater at the SMTIW. This is likely a result of pumping activities from the nearby Paralta and Ord Grove wells and mixing with natural inflow of groundwater from the Inland Fort Ord Subarea.

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[2] i.e.,. such as the dual-well site layouts presented in Plan B.

- Although chloride ion was identified as a suitable 'natural' tracer ion in the injectate, the variation of source waters within the Cal-Am system prohibited is quantative use in calculating dilution effects during storage and recovery.
- The hydrogen sulfide data collected during recovery suggests that injection of oxidized Carmel River waters may be capable of 'conditioning' the aquifer in the injection area, which represents an additional benefit of ASR in the Santa Margarita Sandstone by reducing the use of treatment chemicals at the Seaside Ozone Treatment Plant.
- The observed decline in THM's after month(s) of storage and subsequent recovery is consistent with other ASR sites with reduced (anaerobic) subsurface conditions. At this time, however, it is unclear to what extent the THM decline at the SMTIW is the result of bioactivity and/or adsorption-degradation and/or dilution-mixing with native groundwater. It is possible that some or all of these mechanisms play a role to some degree in the observed decline in THM's. Further study of this issue is warranted.
- No ion exchange reactions were observed during storage and recovery, indicating that clays within the geologic matrix are not reacting adversely with the injected waters.

CONCLUSIONS

Based on the findings developed during WY2003 testing of the SMTIW, we conclude the following:

- Approximately 168 AF of water was successfully injected into the Santa Margarita Sandstone of the Seaside Groundwater Basin with the SMTIW.
- The general SMTIW operational procedure of injection at a rate of 1,000 gpm, with weekly backflushing cycles, has proven to be an effective mode of operation to sustain injection well capacity and performance; no reduction in well efficiency was observed.
- Operation of the flow control valve during WY2003 ([FCV] installation of the FCV was performed in August 2002 as documented in the WY2002 Summary of Operations Report, dated March 2003) has contributed positively to the management of residual plugging at the SMTIW and enhanced injection performance relative to WY2002.
- Positive hydraulic response to injection operations was observed with increases in water levels at all of the wells monitored in the Basin during testing; although water levels in the basin remained below sea level, even at the peak/end of the injection season.
- Volumetric recovery efficiency was 100 percent. For each acre-foot of potable water injected into the basin by the SMTIW (a total of approximately 345 acre-feet to date), 1 acre-foot of potable water was recovered into the Cal-Am distribution system.

- Reductions in THM's were observed during storage and recovery of the injected water. It is unclear to what extent the observed reduction in THM's is due to dilution/mixing with the native groundwater and/or biodegradation in the subsurface.
- Reductions in the concentration of hydrogen sulfide were also observed in the recovered water (as compared to the native groundwater), even after a greater volume of water had been pumped from the well than was injected. These observations suggest that an ancillary benefit of ASR in the Santa Margarita Sandstone may include the 'conditioning' of the aquifer through the injection of Carmel River system water, which reduces the use of treatment chemicals prior to distribution.
- The available data indicate that a second well at the site could feasibly be constructed and operated with a similar, or greater (up to 2,000 gpm), injection capacity.

RECOMMENDATIONS

Based on the WY2003 injection testing results, and our experience with similar projects, we offer the following recommendations:

- Conduct additional injection operations during the 2004 water year. We estimate that between approximately 450 and 650 AFY can be injected with the SMTIW during the periods when excess Carmel River flows are available (assuming a 'normal' rainfall year).
- Based on the results of the testing, the SMTIW should be operated at a maximum injection rate of approximately 1,000 gpm with weekly backflushing to maintain performance.
- Groundwater basin response to injection and water quality issues associated with geochemical interaction and mixing of injected and native ground waters should also continue to be investigated during future injection testing.
- Sampling and analysis of disinfection byproducts (THM's and HAA's) should continue to be included in the water quality parameters monitoring program to further assess the stability and fate of these compounds during aquifer storage.
- Based on the demonstrated available 'freeboard'/drawup during injection, a second similarly constructed well at the site should be pursued.
- The District should continue to seek approvals from the various Agencies that would be required to install and test a second a second injection well at this site.
- In order to provide more water from the Cal-Am system for injection operations at another well at the site, the following capital improvements to the Cal-Am system should be also pursued:

  - Evaluate the improvements that would be needed to increase booster pumping capacity at the Luzern site.
  - Assess pipeline modifications that would be required to provide increased injectate volume to the site.
  - Assess PG&E power delivery constraints associated with siting and operating an additional well at the site.
- The following site improvements should be pursued to improve ongoing operations at the SMTIW site:
  - Routine maintenance of backflush pit.
  - Improvement of noise attenuation barriers at the well pump and Luzern booster pump.
  - Minor site improvements to improve sampling, data collection, and site access.