TECHNICAL MEMORANDUM

BUILDING A BETTER WORLD

To:	Coachella Valley Salt and Nutrient Management Plan Technical Group	**Date:**	February 27, 2015
From:	MWH	**Reference:**	10505158
Subject:	FINAL - Technical Memorandum No. 2 Ambient Water Quality		

1 Introduction

The Coachella Valley Water District (CVWD), Desert Water Authority (DWA), and Indio Water Authority (IWA) have initiated the preparation of a Salt and Nutrient Management Plan (SNMP) for the Whitewater (Indio), Mission Creek, Garnet Hill, and Desert Hot Springs Groundwater Subbasins. The preparation of the plan is in response to the requirements of the California Recycled Water Policy (Policy). The first technical memorandum (TM-1) described the methodology to be used in the development of the SNMP. This technical memorandum, TM-2, summarizes the results of the ambient water quality (AWQ) analysis, a requirement to determine the assimilative capacity of a basin, based on the methodology described in TM-1.

TM-1 and TM-2 will be used to support the development of the SNMP. The SNMP will include summaries of TM-1 and TM-2; a salt and nutrient source identification; trend summary; assimilative capacity analysis; loading estimates; anti-degradation analysis; water recycling and stormwater recharge/use goals and objectives; and monitoring plans.

Based on feedback from stakeholders, this Final TM-2 includes changes to the method and the baseline period used to calculate the ambient water quality, and hence the ambient water quality value. Descriptions of the final methods and results and presented herein; note these methods also differ from those outlined in TM-1.

1.1 BACKGROUND

In February 2009, the State Water Resources Control Board (SWRCB) adopted Resolution No. 2009-0011 which established the Policy. It requires the SWRCB and the nine Regional Water Quality Control Boards (RWQCBs) to exercise the authority granted to them by the legislation to encourage the use of recycled water, consistent with state and federal water quality laws. To achieve this goal, the Policy provides direction to California’s nine RWQCBs on appropriate criteria to be used in regulating recycled water projects (SWRCB, 2009, 2013). One objective of the Policy is that salts and nutrients from all sources be managed on a basin-wide or watershed-wide basis that ensures meeting water quality objectives and protection of beneficial uses. The Policy states that the SWRCB finds the most appropriate way to address salt and nutrient issues through the development of regional salt and nutrient management plans, as opposed to establishing requirements solely on individual recycled water projects.

1.2 SALT AND NUTRIENT MANAGEMENT PLANNING AREA

The planning area for the SNMP includes most of the Coachella Valley subbasins and subareas as shown on **Figure 1-1**. Subbasins are subdivisions, or groundwater basins within the larger Coachella Valley Basin. Subareas are further subdivisions of subbasins based on geology, water quality, areas of confined ground water, and groundwater divides (DWR, 1964). The study area is defined as the Coachella Valley floor and underlying groundwater basins, extending from the Riverside County boundary at the northern end, to the Salton Sea at the southeast end. The planning area is bounded on the west end by the jurisdictional boundary separating Desert Water Agency and Mission Springs Water District (MSWD) from the San Gorgonio Pass Water Agency. This location also corresponds to the boundary between the Whitewater River and the San Gorgonio Pass subbasins. The planning area is bounded to the northeast by the Little San Bernardino Mountains and on the southwest by the San Jacinto and Santa Rosa mountain ranges. This area is coincident with the planning area of the Coachella Valley Integrated Regional Water Management Plan. **Figure 1-2** also shows the management zones that comprise the Coachella Valley Groundwater Basin. Management zones are the areas established in the SNMP to evaluate and manage groundwater quality within the Coachella Valley. The determination of these zones is discussed in further detail in TM-1.

1.3 TECHNICAL MEMORANDUM NO. 2 CONTENTS

TM-2 presents the documentation of the determination of ambient water quality. The resulting analysis will be used in the preparation of the SNMP. TM-2 is organized as follows:

Section 1 – Introduction: This section provides an introduction to TM-2 and defines the role it plays in the development of the SNMP.

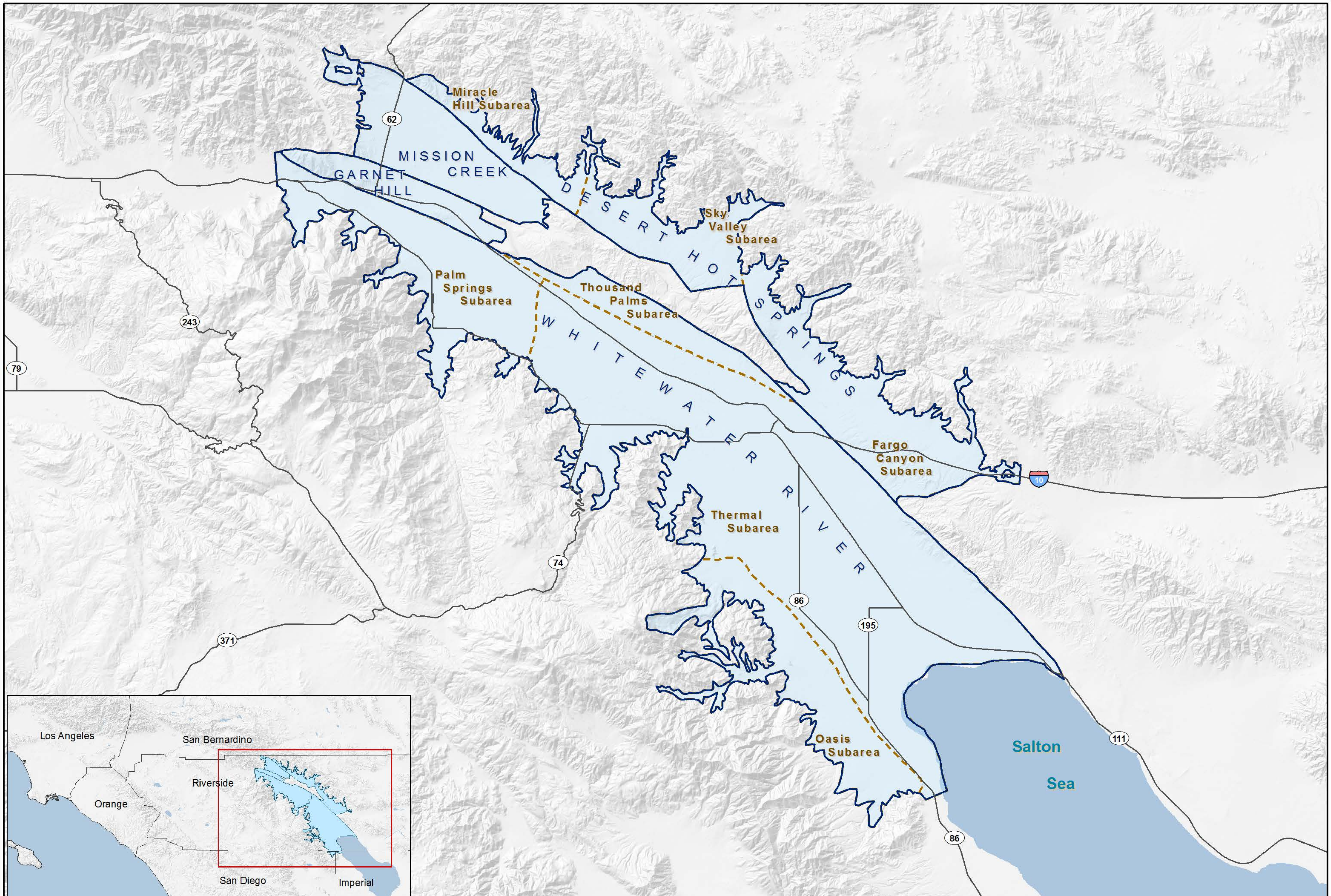
Section 2 – Ambient Water Quality Methods: Methods to calculate the AWQ within management zones are described.

Section 3 – Ambient Water Quality Results: This section summarizes the results of AWQ determination and provides summary statistics of AWQ for each management zone.

Attachment A – Determination of Data Adequacy for Ambient Water Quality Calculation: This section describes the methods applied to determine how management zones and aquifer layers ambient water quality will be represented.

Attachment B - Effective Porosity Approximation for the Volume-Weighted Average Calculation: This section describes the method to approximate effective porosity and ranges of effective porosity for similar lithologic conditions.

Attachment C – Response to Comments on Draft TM-2: Summarizes all comments received for Draft TM-2 and responses to comments.



Key to Features

Subbasins

Subareas

N

0 2.5 5 Miles

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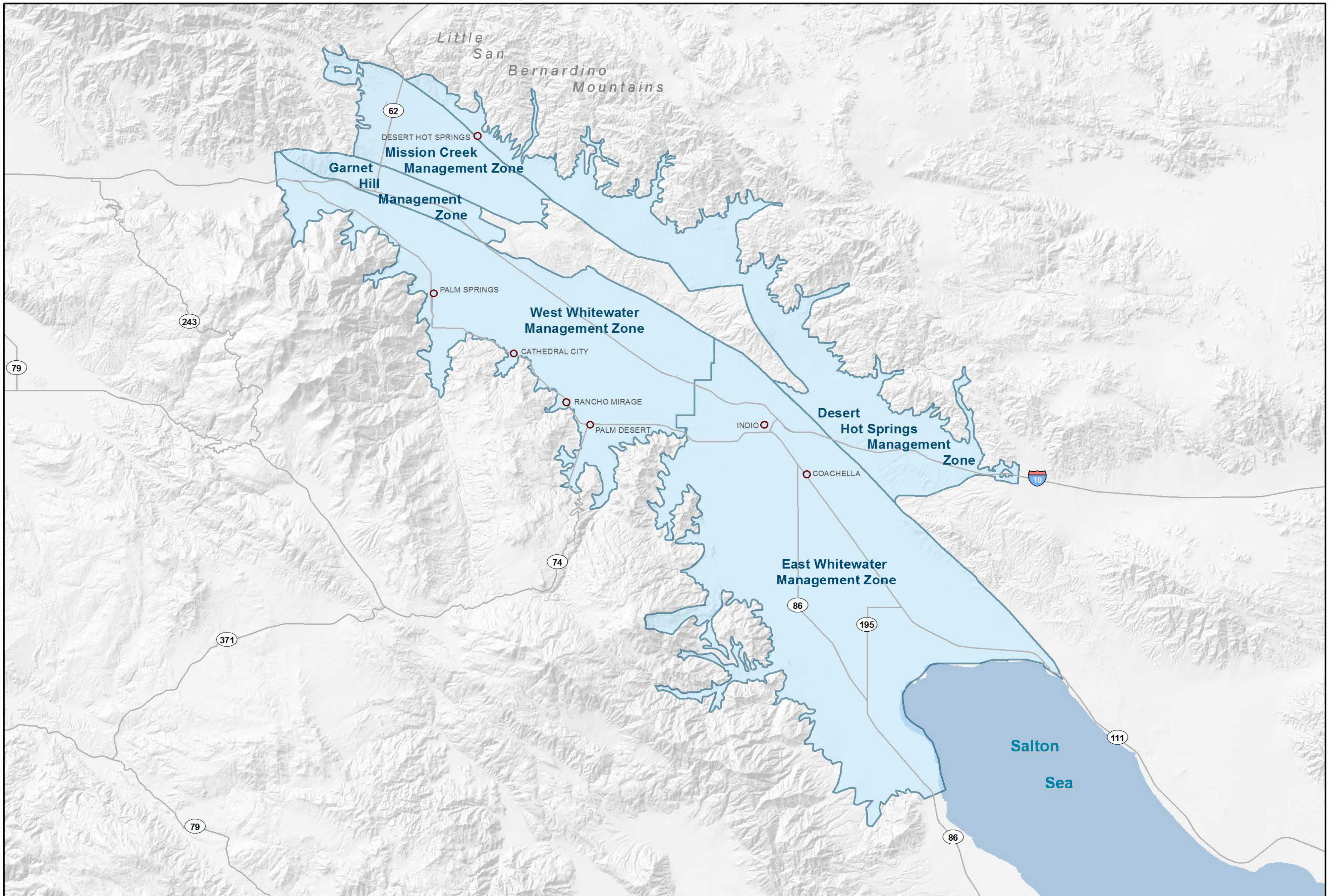
Date: Oct 2014

Coachella Valley Subbasins and Subareas

MWH

Figure 1-1



Key to Features

City

Management Zone

0 2.5 5 Miles

N

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Date: Feb 2015

Coachella Valley Management Zones

MWH

Figure 1-2

2 Ambient Water Quality Methods

AWQ is a single concentration value that is representative of the water quality within a management zone for a particular constituent and time. The Policy does not address ambient water quality or outline a method to determine ambient water quality, but does state "the available assimilative capacity shall be calculated by comparing the mineral water quality objective with the average concentration of the basin/sub-basin…" As outlined in TM-1, use of a single average value is proposed when data permits, or a statistical summary when data is limited. The approach of using a single value is consistent with the approaches used across the state (Todd Engineers, 2014; Santa Clara Valley Water District, 2014; Wildermuth Environmental, 2000; Los Angeles County Department of Public Works, 2014) and is recommended in *Guidance Document for Salt and Nutrient Management Plans for the San Francisco Bay Region* (Sonoma Valley County Sanitation District, 2013). The AWQ is a prerequisite for determining basin-wide assimilative capacity. Determination of the assimilative capacity is a requirement of the Policy in order to evaluate new projects. Under the Policy, planned recycled water projects are permitted to use no more than 10 percent of the available assimilative capacity for a single project and no more than 20 percent for multiple projects; those planned projects using more assimilative capacity will require additional investigation.

The AWQ is determined for TDS and nitrate (as NO_3) for this SNMP, as these constituents are representative of salts and nutrients in the Coachella Valley within this SNMP. **Figure 2-1** shows the steps leading to AWQ approximation. These data collection was discussed within TM-1, the following steps are described in greater detail in the following subsections.

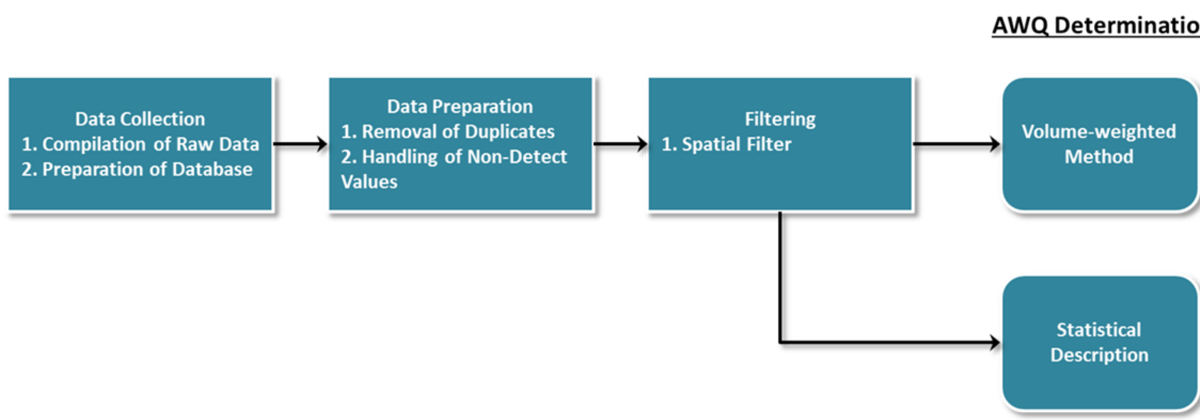


Figure 2-1
Diagram of Generalized AWQ Determination

2.1 DATA PREPARATION

Available groundwater quality data are compiled prior to the analysis of AWQ. The sources of data are presented in Section 4.2.2 – Groundwater Quality Data of TM-1. Since that time, these data have been augmented with hard copy files from the Regional Water Quality Control Board (RWQCB) and electronic data from the County of Riverside Waste Management Department, Cabazon Band of Mission Indians, Valley Sanitary District, CVWD, and DWA. These data are typically shallow wells constructed for specific projects, e.g., landfills.

Because groundwater quality data are obtained from a variety of sources, duplicates can occur and are removed as to not count a particular record more than once (duplicates are the same measurement at the same time from two different databases). Duplicates are determined by generating unique identifiers for each particular record that includes the well name, record date, and analyte concentration. Those unique identifiers that occur more than once are removed such that only one record remains.

In addition, data sources may report non-detect (ND) values in several different ways. Some examples include:

- non-detect, i.e. "ND", with method detection limit;
- non-detect, i.e. "ND", with no method detection limit;
- zero value, i.e. "0"; and
- less than method detection limit, i.e. "< MDL".

For the AWQ calculation, all nitrate non-detects are represented as half the most common minimum detection limit, 0.01 mg/L as NO_3, for three reasons:

1. not all data has a method detection limit available for each record;
2. numerical values for all results allow the calculation of summary statistics; and
3. all non-detects are treated in the same way.

This approach is consistent with the substitution method presented in the United States Environmental Protection Agency (EPA) guidelines – Data Quality Assessment: Statistical Methods for Practitioner (EPA, 2006).

2.2 FILTERING

A temporal filter and spatial filter are applied to the original dataset, hereafter referred to as the unfiltered dataset, to generate a filtered dataset on which AWQ analyses will be conducted. The reason for spatial filtering is to eliminate bias introduced by the nature of sampling. These biases are (1) frequency bias, (2) age/type bias, and (3) location bias. Note that even though a filtered dataset is used for AWQ determination, unfiltered data summaries are provided for transparency and to show the effects of filtering. Each dataset, filtered and unfiltered, has inherent uncertainties, but used together they can provide insight into the variability of groundwater quality. A review of the data and the filtering to create the filtered dataset is provided in the following sections.

When considering the time period for the AWQ calculation, the quantity of data points gained from using older records must be balanced with the desire characterize current water quality (less data). To evaluate the potential impact of older data a trend analysis was completed. Water quality trends were reviewed in TM-1 that considered historical and vertical records throughout the Valley. Trends indicated lower concentrations typically with depth and increasing concentration typically with time. To evaluate trends quantitatively, a Mann-Kendall analysis was completed herein. A Mann-Kendall trend analysis tests for statistically significant trending in water quality records.

A Mann-Kendall test is a widely used method for evaluating trends that compares samples for a particular well and tests for a positive (increasing) or negative (decreasing) trend result for a particular level of statistical significance; see Data Quality Assessment: Statistical Methods for Practitioner (EPA, 2006). Only records with a prescribed number of well records could be considered, hence not all wells in the Valley could be evaluated. The results of the Mann-Kendall trend analyses for TDS and nitrate are shown on **Figure 2-2** and **Figure 2-3**, respectively. Note both analyses indicate an increasing trend in concentration with time. Based on this consistent result, using older records may underestimate the AWQ if the objective is to represent current water quality. Therefore, to obtain the most representative AWQ, the most recent measurements are used for each well.

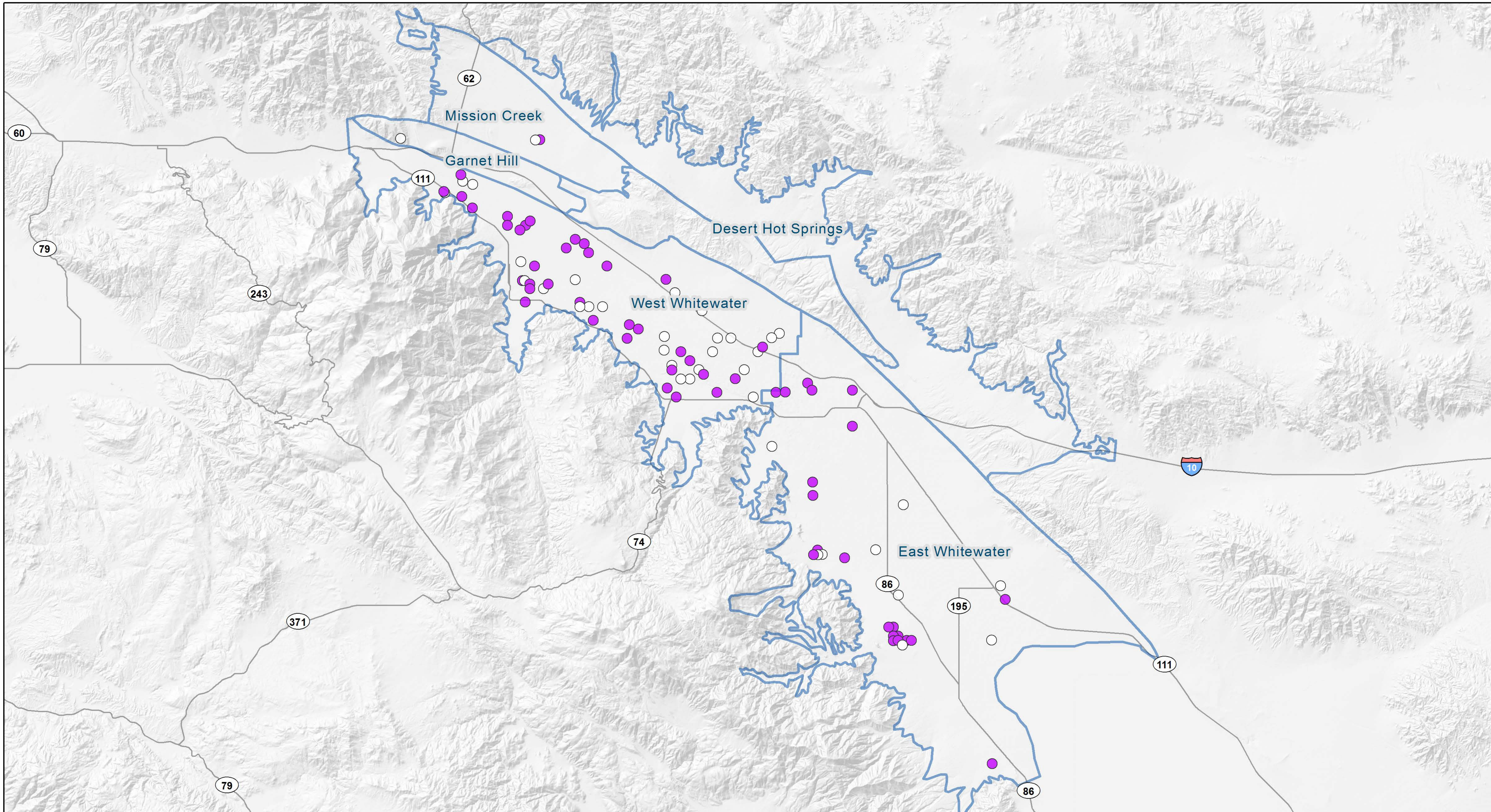
The use of the most recent measurements is a change in approach from the first draft of TM-2 and the method outlined in TM-1. Note that due to the change in approach, the filtered dataset statistical summaries have changed from the draft version of TM-2.

2.2.1 Temporal Filter

The most recent measurement of TDS or nitrate for a well is used to represent the concentration for that well. If there is more than one measurement in the same year of the most recent measurement, the median of those measurements is used; this reduces the chance of selecting a statistical outlier for a particular well. This temporal filter avoids underestimating water quality for wells showing trends and leverages the median for wells with significantly more data to minimize the selection of statistical outliers. Using a representative value for each well minimizes the frequency and age/type biases discussed above as each well contributes equally. This value is referred to as the *baseline well concentration*.

2.2.2 Spatial Filter – Location Bias

A significant portion of the data used is from drinking water supply wells. In general, these production wells are sited in areas close to a water distribution system, i.e., near developed communities and in areas having reasonably good water quality. Similarly, production wells are typically drilled sufficiently deep to produce the desired yield and avoid layers of poor quality. Therefore, water quality data will cluster around these areas. Using all the wells in the calculation of AWQ will skew results towards the water quality around dense well zones. To address this, a 1,000 foot by 1,000 foot grid is applied to group well data within a grid cell. If screen interval data exist for wells in a particular management zone, groundwater model layers or sub-layers are used to subdivide data into aquifer layers such that baseline well concentrations are grouped by cell and layer. For continuity with previous groundwater modeling, the grid cells and layering from the Coachella Valley groundwater model (Fogg *et al.*, 2002) or Mission Creek groundwater model (Psomas, 2013) are used. The mean of baseline well concentrations for each cell are used to obtain the final filtered dataset. A conceptual diagram of the spatial filter is shown on **Figure 2-4**.



Key to Features

Management Zone — Highway

Mann-Kendall test at 5% significance level

- Decreasing
- No Trend
- Increasing

N

0 5 10 Miles

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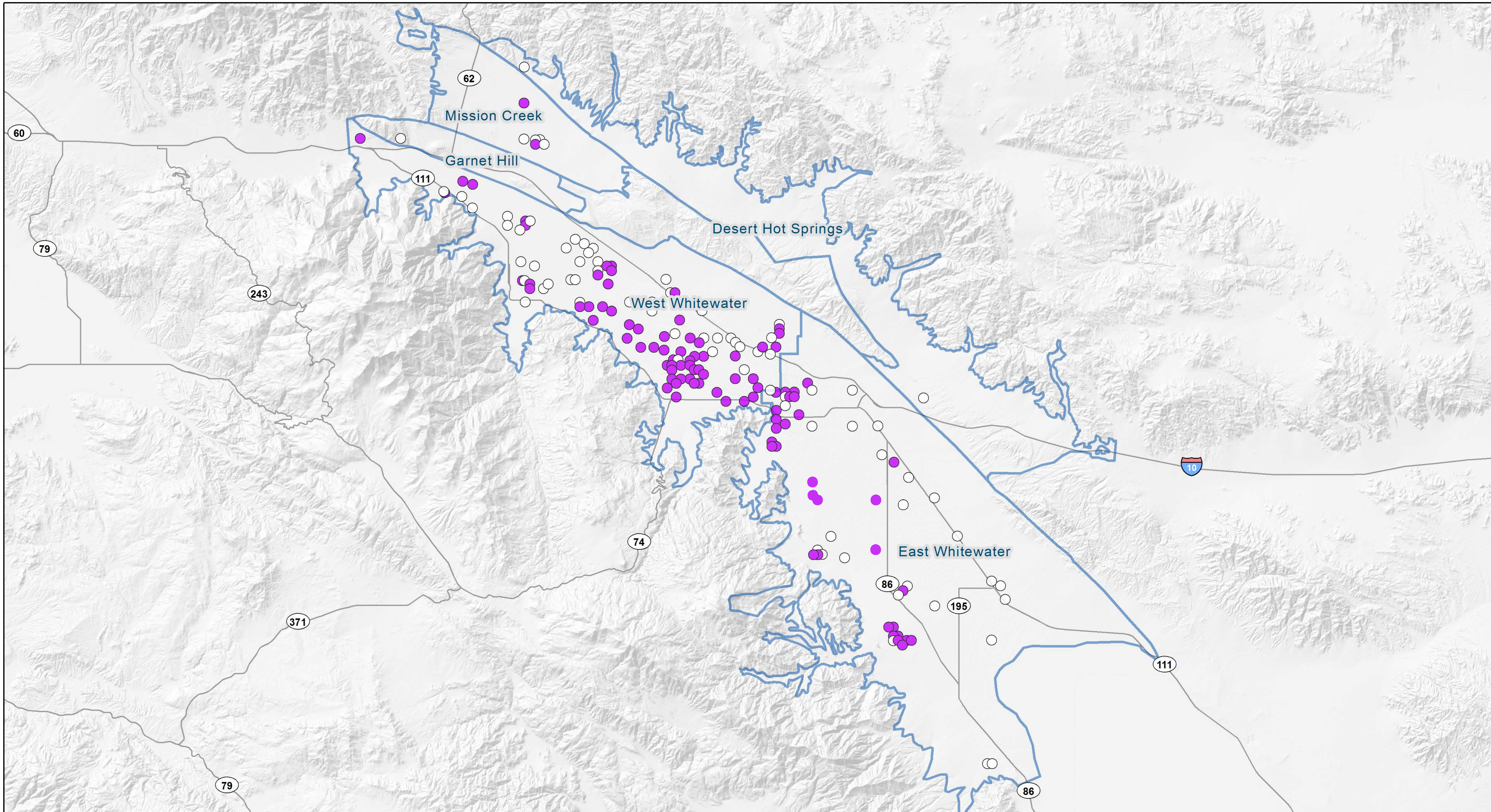
Date: February 10, 2014

Total Dissolved Solids Mann-Kendall Trend Analysis 1980 - 2014

MWH

Figure 2-2

This map has been designed to print size 11'' by 17''.



Key to Features

Management Zone — Highway

Mann-Kendall test at 5% significance level

- Decreasing
- No Trend
- Increasing

N 0 5 10 Miles

Document: \\Usirv1s01\Projects\Coachella Valley WD\SNMP\AWQ\CVWD_AWQ_V3\MXD\WQ_MannKendall.mxd

Date: February 10, 2014

Nitrate Mann-Kendall Trend Analysis 1980 - 2014

MWH

Figure 2-3

This map has been designed to print size 11'' by 17''.

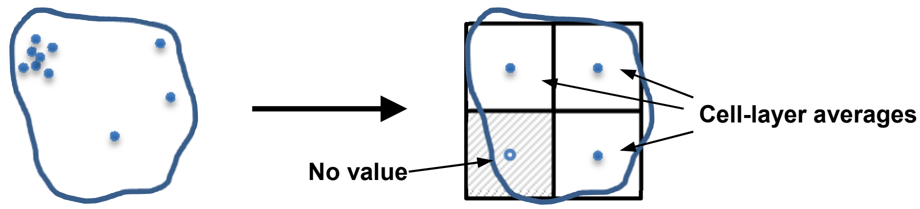


Figure 2-4
Conceptual Diagram of the Spatial Filter that Occurs for Each Management Zone and Layer if Applicable

2.3 METHODS TO DETERMINE AMBIENT WATER QUALITY

Two methods are used for the determination of AWQ. A statistical description of AWQ is presented for each management zone and a volume-weighted AWQ is computed for management zones with adequate data to support the volume-weighted method. Data required for the volume-weighted method includes sufficient water quality data for wells with known depth information, aquifer thickness and effective porosity, and groundwater level.

2.3.1 Data Adequacy for Ambient Water Quality Calculation

During the development of this document, stakeholders made several comments regarding the determination of when contouring should be applied to approximate management zone water quality. The determination of data adequacy for contouring water quality within a management zone to thereby apply the volume-weighted AWQ method, is not a simple question to answer. In fact, this quantification has not has not been made within any other SNMPs within the state; rather, it is typically based on professional judgment. That being said, **Attachment A** describes the methods applied to help determine how management zones and aquifer layers ambient water quality will be represented, specifically, if there is sufficient data to contour water quality. This subject is discussed in detail within the attachment, but the basis of the determination is the following key factors:

- Spatial distribution of data points – The two dimensional arrangement of the data points within a management zone or aquifer layer has a marked effect on the ability to approximate values with certainty. Are data point numerous but grouped in the same location? Are data points evenly distributed across the management zone?
- The assumption of autocorrelation – Autocorrelation assumes that value of a surface are more closely related to nearby points and less related to distant points. If the points are related inferences can be made regarding values between the points.
- Supporting statistics – the underlying summary statistics must support high or low auto correlation and can assist in the decision to develop a contoured surface.

The question of data adequacy is largely dependent on the amount of data available. Therefore, the baseline period chosen has large consequences. **Attachment A** evaluates the key factors above for a 5-, 10-, 15-, and 20-Year baseline period. The goal is to use the shortest baseline period possible that supports the contouring of groundwater quality necessary for the volume-weighted method (see **Section 2.3.3**) to minimize the occurrence of older data; e.g., the most recent data for a certain well may be old if it was destroyed or abandoned.

Based on this evaluation, 5- and 10-Year baseline periods, it was determined that these periods were too short, i.e., too few data points, to support groundwater contouring The 15-Year period was often sufficient. Accordingly, the results presented in **Section 3** use the most recent measurements for any well no older than in the 15 years (1999 to 2013) for filtered data, and all records in the same 15-Year period for unfiltered data. See **Attachment A** for a thorough discussion of all recommendations from the data adequacy evaluation.

2.3.2 Statistical Description

Statistical analyses of water quality data are performed and summarized for each management zone over the period of 1999 to 2013. The statistical descriptions are useful for management zones that lack significant well depth information or have limited water quality data, as there is not sufficient water quality and aquifer information to complete the volume-weighted method.

Descriptive statistics are provided for both unfiltered and filtered datasets. AWQ is evaluated based on the filtered dataset; a 95 percent two-tailed confidence interval on the mean filtered water quality data may be used to determine a range for AWQ in management zones where the volume-weighted method is not appropriate. **Table 2-1** presents definitions of the statistical analyses performed for the management zone statistical description.

Table 2-1
Statistical Descriptors Used to Describe Ambient Water Quality

Statistical Descriptor	Definition in this SNMP	As the Descriptor relates to:	
		Unfiltered Data	**Filtered Data**
Count	The total number of data points available for a particular constituent and time period within a management zone	Number of individual lab analysis results	Number of filtered data points (as defined in filtering methods)
Mean	The arithmetic mean of all results, or the sum of the results divided by the count	Average of all lab results	Average of filtered data points
Median	The value separating the upper half of all results from the lower half	Middle value of all lab results	Middle value of filtered data points
Mode	The value that appears most often in a set of results	Most common lab result (if one exists)	Most common filtered data point (if one exists)
Standard Deviation	A measure of the amount of variation or dispersion from the average; a lower standard deviation implies that the individual results are closer to the mean of the results	Variation of all lab results	Variation of filtered data points
Range	The lowest and highest result in the dataset	Lowest and highest lab result	Lowest and highest filtered data point; filtered data range will always be less than or equal to the range of unfiltered data
Confidence Interval	An estimated range of values which is likely to include the mean of the population; the width of the confidence interval indicates the possible uncertainty of the mean; e.g., a 95 percent confidence interval has a 95 percent probability of containing the population mean	Measure of how certain the computed mean is compared to the true mean; a wider interval indicates lower certainty	Filtered confidence interval will typically be greater than the confidence interval for unfiltered data due to the reduced size of data points

2.3.3 Volume-weighted Method

The volume-weighted method for determination of AWQ is used when an adequate amount of data exist for a particular management zone. This method weights the average water quality by the amount of mass of a consentient in storage.

2.3.3.1 Approximating Water Quality

If there is enough data to contour water quality constituents, the following steps are taken to prepare contour maps. Upon completion of data preparation and filtering, the filtered dataset is contoured, which provides inferred concentration values in areas where no wells (or water quality data) are present. Water quality is contoured initially by interpolating the filtered dataset with the Kriging method (Matheron, 1978). The Kriging method is a widely-accepted geostatistical interpolation method that attempts to express trends suggested in the underlying data. The contours generated by this method are then refined by hand. The hand contouring considers horizontal and vertical trends, water quality from wells with no available depth information (for management zones contoured by layer) and knowledge of the underlying geology, groundwater flow direction, recharge activity, land use, and professional judgment. The final contours are the result of an iterative process with numerical interpolation and hand contouring.

Resulting cell concentrations are multiplied by the volume of water in storage in each cell, the results are totaled and then divided by the total water volume in the management zone to obtain a volume-weighted AWQ. In management zones where data availability supports layering, this process is completed at the model layer/aquifer level. A conceptual diagram of the steps involved in the volume-weighted method is shown on **Figure 2-5**.

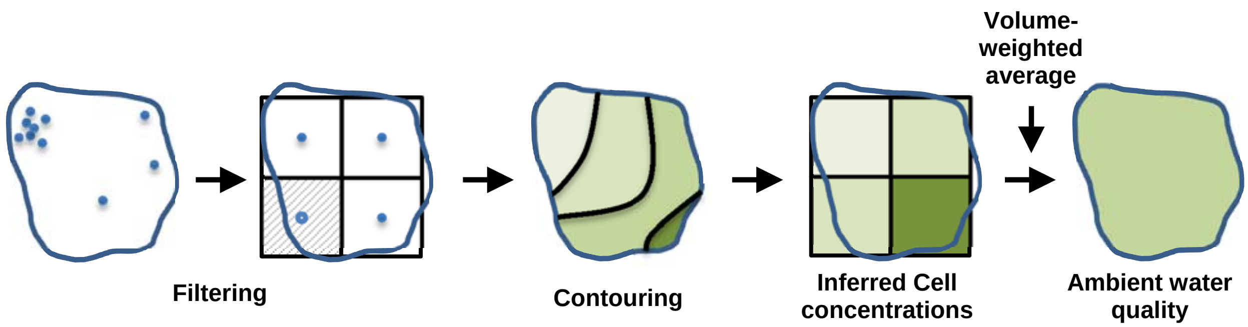


Figure 2-5
Conceptual Diagram of the Volume-weighted Method

In addition to water quality, groundwater level data is also filtered and contoured in a similar fashion. The water level contours are then used to generate a water level surface and values from the surface at the cell centers are assigned to each cell within the management zone.

To determine the volume of water in each cell volume between the water level surface and the base of the aquifer, the effective porosity for each cell and layer is needed. Total porosity is defined as the ratio of void space to the total volume of a geologic formation. The effective porosity is the portion of the void space of a porous material that is capable of transmitting (and thereby mixing) a fluid and excludes clay-bound water (water that is electrochemically attached to clay particles that does not contribute to flow). Effective porosity occurs because a fluid in a saturated porous media will not flow through all voids, but only through the voids which are interconnected. Effective porosity is typically higher than specific yield (the volume of water that can be drained by gravity). The method used to determine the effective porosity of each cell and layer is summarized in **Attachment B**. **Attachment A** discusses the particular layering used for each management zone and all special circumstances associated with data gaps; these are also described in **Section 3**.

The volume of water in each cell is calculated as:

$$Vol_{i,j} = (n_e)_{i,j} \times Area_i \times (H_{sat})_{i,j} ,$$

where i is the cell, j is the layer, n_e is the effective porosity of the cell and layer, and H_{sat} is the saturated thickness of the cell and layer.

The effective porosity is already corrected for lithostatic loading as a function of depth in the model calibration for hydraulic conductivities. **Table 2-2** lists the total area and total water in storage by management zone. **Figure 2-6** shows a conceptual representation of the cells and layers.

The AWQ of a management zone is the total mass in all cells and layers divided by the total volume of water in storage in all cells and layers:

$$AWQ_{volume-weighted} = \frac{\sum_i \sum_j \left(C_{i,j} \times Vol_{i,j}\right)}{\sum_i \sum_j Vol_{i,j}} ,$$

where $C_{i,j}$ is the concentration in cell i and layer j. This method requires sufficient water quality data for wells with known depth information; aquifer properties such as layer thickness, effective porosity, and groundwater level; and well-distributed data in both the horizontal and vertical.

Table 2-2
Summary of Management Zone Area and Total Storage

Management Zone	Total Gridded Area (mi^2)	Volume in Storage (AF)	Grid Cells
West Whitewater River	151	23,626,936	4,212
East Whitewater River	265	54,191,116	7,388
Mission Creek	49	4,618,693	1,365
Garnet Hill	20	N/A	559
Desert Hot Springs	114	N/A	3,189

N/A indicates that aquifer properties are not available and volume-weighted method is not determined for Garnet Hill Management Zone or Desert Hot Springs Management Zone.

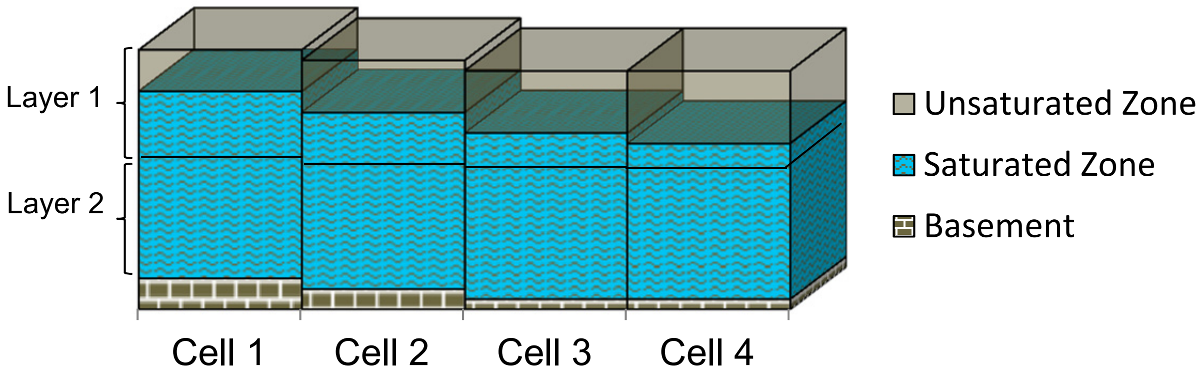


Figure 2-6
Conceptual Representation of Model Cells and Layers

2.3.4 Recommended Methods for Each Management Zone

Attachment A describes the methods applied to help determine how management zones and aquifer layers ambient water quality will be represented, specifically, if there is sufficient data to contour water quality. The analysis also provides recommendations for each management zone base on spatial distribution of data points, autocorrelation, and supporting summary statistics. Listed below are the recommended AWQ methods for each management zone.

West Whitewater MZ: Three layers were evaluated within this management zone. For Layer 2 and Layer 3, use the most current data in any cell, apply temporal filters as needed. Check the most current data point to determine if it is an outlier or consistent with older records or continuing a trend. Use older records to 15 years to fill areas of poor spatial distribution.

Regarding Layer 1, all baseline periods failed to provide enough data for contouring. Given the lack of available data, it is recommended that in place of contouring a range of constant value be assumed for Layer 1 to calculate the volume weighted AWQ. Use of the minimum and maximum for the 15-Year baseline is proposed. Using these single values for Layer 1 will provide a range of AWQ for the aggregated West Whitewater Management Zone AWQ value.

East Whitewater MZ: Three layers were evaluated within this management zone. For Layers 1 through 3, the most current data in each cell should be used, apply temporal filters as needed. Check the most current data point to determine if it is an outlier or consistent with older records or continuing a trend. Use older records to 15 years to fill areas of poor spatial distribution.

Mission Creek MZ: Two layers were evaluated within this management zone. Sufficient data was not present to support two aquifer layers. Therefore, the recommendation is to limit the contouring and AWQ calculation to the eastern portion of the management zone. To limit the area, use half the distance between a boundary and the nearest well with water quality data. For this portion, use the most current data in any cell. Check the most current data point to determine if it is an outlier or constant with older records or continuing a trend. Use older records to 15 years if needed to fill areas of poor spatial distribution.

Garnet Hill MZ: No spatial autocorrelation could be evaluated for any baseline period within Garnet Hill Management Zone due to a lack of data. The recommendation for this management zone is to provide a statistical summary and range for AWQ.

Desert Hot Springs MZ: Spatial autocorrelation could not be evaluated for the Miracle Hill or Sky Valley Subareas within Desert Hot Springs Management Zone due to a lack of data. Similarly, spatial distribution in these areas is limited by data availability. Within Fargo Canyon, a strong positive spatial autocorrelation is observed for TDS in all baseline periods. Nitrate shows strong positive spatial autocorrelation in the 5-Year baseline period. Spatial distribution in these areas is poor due to limited data availability. The recommendation for this management zone is to provide a statistical summary and range of AWQ.

3 Ambient Water Quality Results

This section summarizes the results of the AWQ determination. All analyses used water quality data for wells during the 15-Year period of 1999 to 2013. As discussed in TM-1, this baseline period is selected because it represents the most recent twenty-year period having water quality data. A twenty-year period is used to ensure a statistically significant sample of the historical water quality data because TDS is normally sampled once every three years.

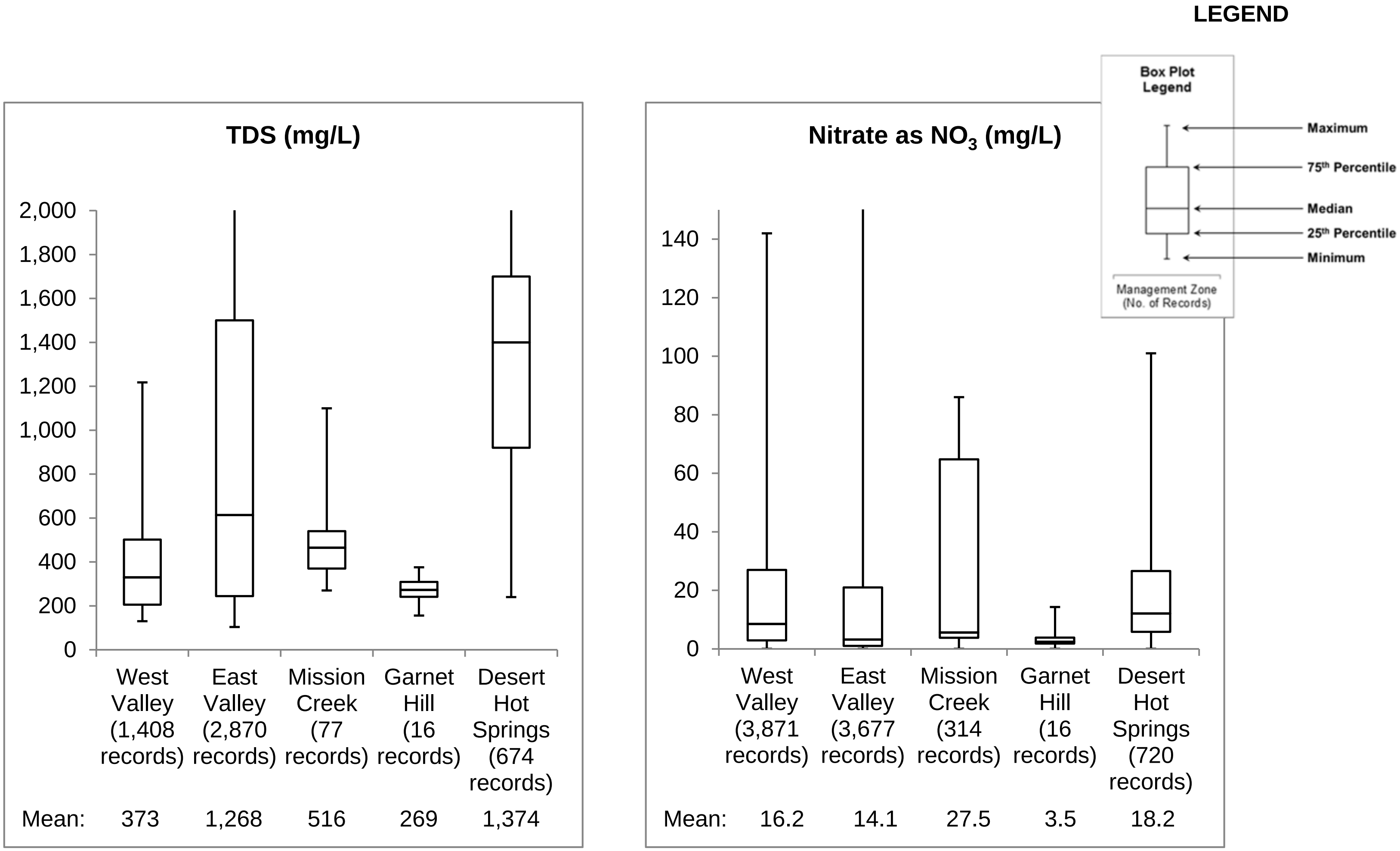
Two sets of statistical descriptions of AWQ are prepared for each management zone: the first set provides statistical descriptions of the unfiltered data within a management zone, and the second set will describe AWQ using the filtered dataset within a management zone. These two sets are presented to demonstrate the effects of the data filtering methods and to provide a deeper understanding of the AWQ. The statistical descriptors presented in this section follow from Section 2.3.1.

Box plots are shown in **Figure 3-1** to illustrate the range of water quality from the unfiltered dataset by management zone. This figure provides convenient visual summaries of the unfiltered data and shows the following:

- The median, or center, of the data (the line contained within the box)
- The range, or variation, of the data (total box height)
- The extreme values in the data (the vertical lines extending from the box)

In addition to the statistical descriptions, a volume-weighted AWQ is calculated for those management zones with adequate horizontal and vertical groundwater quality, aquifer parameter, and water level data. The AWQ for West Whitewater River, East Whitewater River, and Mission Creek management zones include this volume-weighted analysis.

Figure 3-1
Box Plots for of Unfiltered Data for Each Management Zone (1994-2013)



Note:
Maximum recorded TDS concentration for East Valley is 29,000 mg/L;
Maximum recorded TDS concentration for Desert Hot Springs is 2,570 mg/L.

Note:
Maximum recorded nitrate (as NO_3) concentration for East Valley is 260 mg/L.

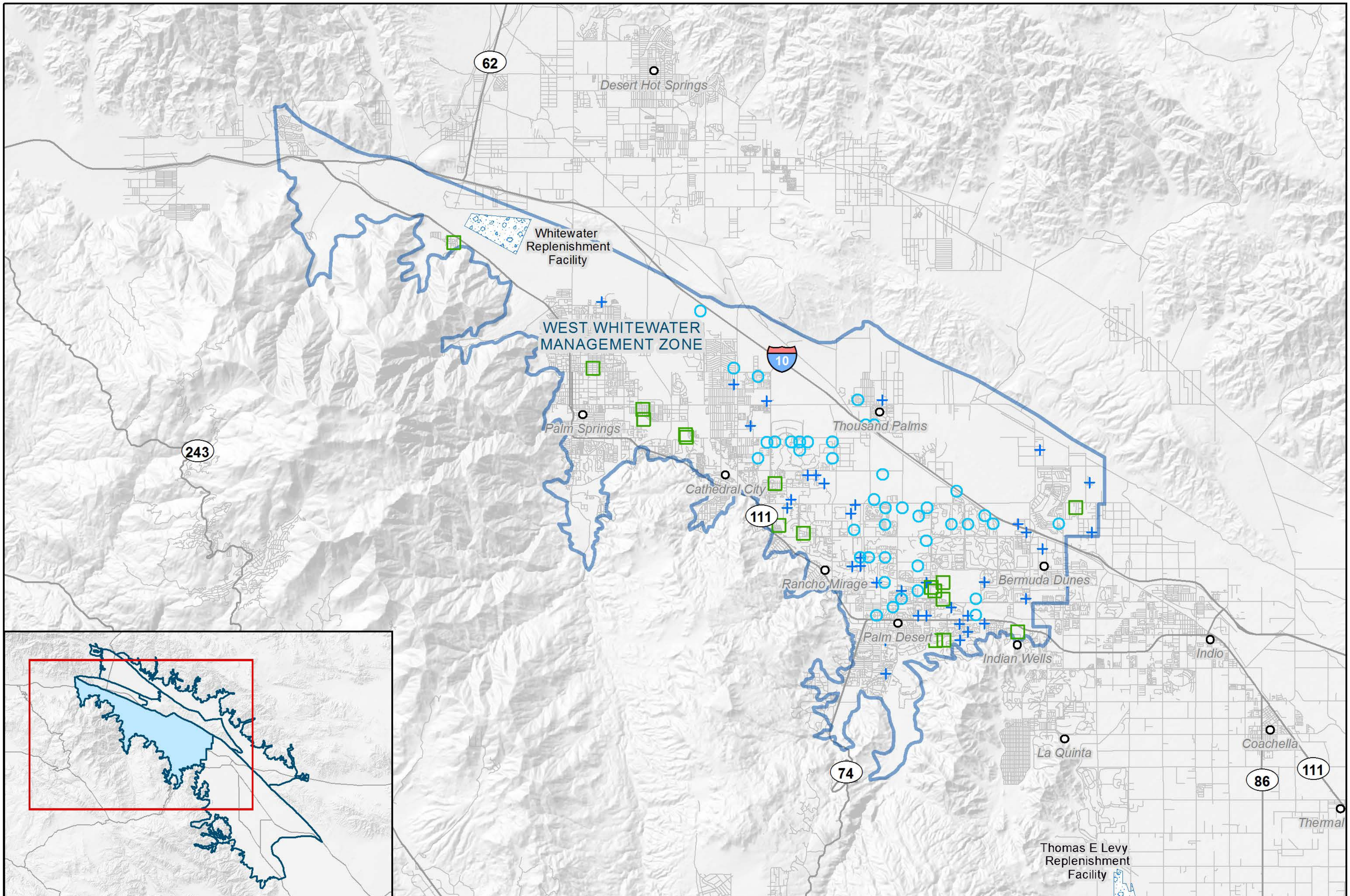
3.1 WEST WHITEWATER RIVER MANAGEMENT ZONE

The West Whitewater River Management Zone is comprised of the Palm Springs Subarea, the Thousand Palms Subarea, and the northern portion of the Thermal Subarea of the Whitewater River Subbasin. It lies south of the Garnet Hill Fault, west of the Indio Hills, east of the San Jacinto Mountains, and extends southeast to approximately Indian Wells. Groundwater is unconfined in this management zone. The fill materials within this area are essentially heterogeneous alluvial fan deposits with little sorting, with some finer clay layers present in the southern portion of the management zone near Palm Desert and Indian Wells. The thickness of these water bearing materials is not known because no wells extend to bedrock; however, it exceeds 1,000 feet (CVWD, 2010). Gravity survey data indicate the basement rock is in excess of 12,000 ft in the Whitewater River subbasin near the San Andreas Fault (DWR, 1964). The Ocotillo conglomerate underlies Holocene (Recent) fanglomerate in the Subarea at depths ranging from 300 to 400 feet (DWR, 1964).

All results are summarized by the layers used in the volume-weighted method. West Whitewater River Management Zone is separated into three layers. The upper portion of the aquifer, approximately less than 450 feet below ground surface, is grouped into Layer 1; the middle of the aquifer, approximately 450 to 750 feet below ground surface, into Layer 2; and the bottom of the aquifer, depths greater than approximately 750 feet below ground surface, is Layer 3.

3.1.1 Summary of Unfiltered Data

The unfiltered dataset for the West Whitewater River Management Zone consists of 1,843 water quality records during the period of 1999 to 2013. The locations of wells with water quality records used in the AWQ determination are illustrated on **Figure 3-2**. The unfiltered dataset for West Whitewater River Management Zone contains 584 TDS records and 1,259 nitrate records. Nitrate is more frequently monitored in wells than TDS because groundwater is typically more likely to see short term changes in nitrate levels. The statistical summary of unfiltered data for the West Whitewater River Management Zone is presented on **Table 3-1**.



Key to Features

Management Zone
City
Highway
Local Roads

Groundwater Well Location
Type of Aquifer Penetrated

Layer 1
Layer 2
Layer 3

N
0 2.5 5 Miles

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Date: 2/27/2015

West Whitewater Wells with Water Quality Records in 1999-2013

MWH

Figure 2-2

Table 3-1
Descriptive Statistics of Unfiltered Data for West Whitewater River (1999-2013)

	Layer 1		Layer 2		Layer 3	
Statistic	**Total Dissolved Solids**	**Nitrate as NO_3**	**Total Dissolved Solids**	**Nitrate as NO_3**	**Total Dissolved Solids**	**Nitrate as NO_3**
Count	364	383	58	323	162	553
Mean (mg/L)	550	24.7	370	28.6	199	9.5
Median (mg/L)	525	12	361	29.7	190	3
Mode (mg/L)	540	11	400	32	200	3
Std. Dev. (mg/L)	161	29	175	19.7	61	13
Range (mg/L)	140 to 1,100	ND to 142	169 to 842	1.6 to 120	140 to 770	ND to 112
95% Confidence Interval (mg/L)	534 to 567	21.7 to 27.6	324 to 416	26.4 to 30.7	189 to 208	8.4 to 10.6

ND = non-detect

3.1.2 Statistical Description of Ambient Water Quality

The filtered dataset (temporal and spatial filter) for West Whitewater River Management Zone consists of 80 TDS values and 81 nitrate values. The statistical summary of filtered data for the West Whitewater River Management Zone is presented on **Table 3-2**.

TDS in West Whitewater River Management Zone typically decreases with depth. Higher TDS appears in the shallower part of the aquifer down gradient of the Whitewater Recharge Facility and in wells from Rancho Mirage to Palm Desert. Some higher TDS also occurs within the Thousand Palms Subarea at the very east of the management zone (cities, subareas, and management zones are shown on Figure 1-1 and Figure 1-2).

Nitrate concentrations within West Whitewater River Management Zone are generally less than the MCL except for high nitrates observed in wells of varying depths between Rancho Mirage and Palm Desert. There is a general decrease in nitrate concentrations with depth.

The true mean TDS of the filtered dataset falls within the interval of 426 to 656 mg/L, 336 to 492 mg/L, and 188 to 220 mg/L for Layer 1, Layer 2, and Layer 3, respectively, with a probability of 95 percent; for nitrate (as NO_3), this interval is from 10.9 to 52.7 mg/L, 22.8 to 51 mg/L, and 3.6 to 12.8 mg/L for Layer 1, Layer 2, and Layer 3, respectively. The higher nitrates that appear from Rancho Mirage to Palm Desert have a large effect on the summary statistics of West Whitewater River Management Zone.

Table 3-2
Descriptive Statistics of Filtered Data for West Whitewater River (1999-2013)

	Layer 1		Layer 2		Layer 3	
Statistic	**Total Dissolved Solids**	**Nitrate as NO_3**	**Total Dissolved Solids**	**Nitrate as NO_3**	**Total Dissolved Solids**	**Nitrate as NO_3**
Count	14	14	28	29	38	38
Mean (mg/L)	544	31.8	414	36.9	204	8.2
Median (mg/L)	520	10.4	375	28.5	195	3.2
Mode (mg/L)	N/A	N/A	302	2.7	210	3
Std. Dev. (mg/L)	194	36.2	201	37	49	14
Range (mg/L)	201 to 1,060	1.2 to 101	169 to 842	1.6 to 120	160 to 420	1.9 to 76
95% Confidence Interval (mg/L)	432 to 656	10.9 to 52.7	336 to 492	22.8 to 51	188 to 220	3.6 to 12.8

ND = non-detect

3.1.3 Volume-weighted Ambient Water Quality

For the determination of volume-weighted ambient water quality, West Whitewater River MZ is separated into three layers. The upper portion of the aquifer, approximately less than 450 feet below ground surface, is grouped into Layer 1; the middle of the aquifer, approximately 450 to 750 feet below ground surface, into Layer 2; and the bottom of the aquifer, depths greater than approximately 750 feet below ground surface, is Layer 3. Water quality is estimated for each layer based on water quality information specific to that layer. Adjacent layer data and wells perforated in multiple aquifers are also used as a reference to approximate water quality concentrations. Note that these depths vary with location according to the model grid described in earlier TM-1 to take advantage of known aquifer geometry.

Shallow groundwater quality data is a known data gap in West Whitewater River Management Zone. For this reason, Layer 1 is not contoured, and instead the 15-year minimum and maximum values for TDS and nitrate found for Layer 1 in **Table 3-2** are used as a low and high range for the average water quality in Layer 1, yielding a low and high total AWQ.

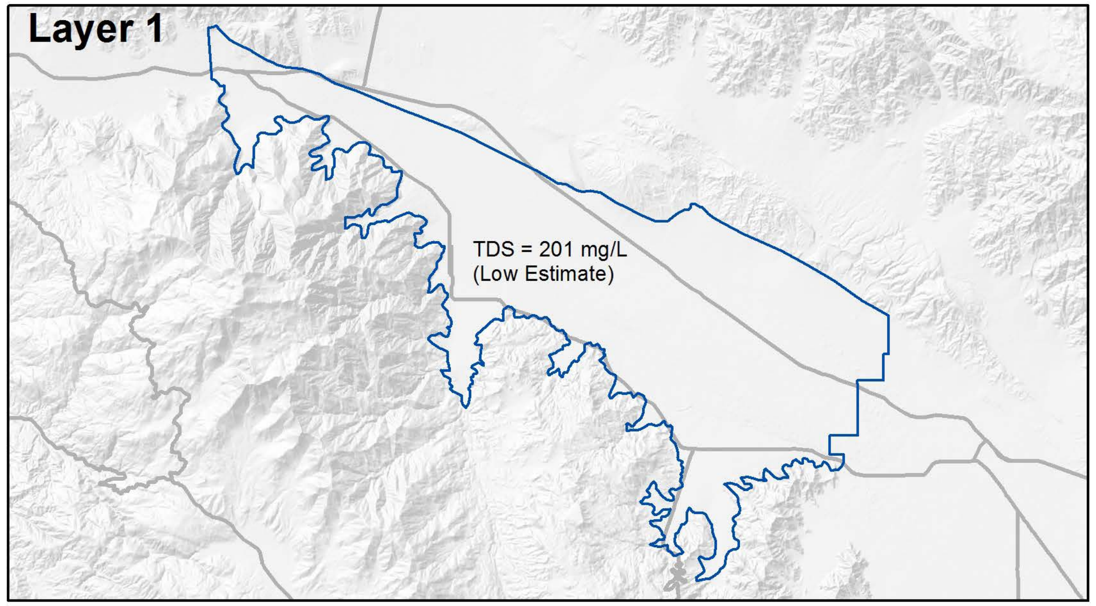
Table 3-3 summarizes the results of the volume-weighted AWQ determination for West Whitewater River Management Zone. Water quality is contoured by layer and TDS/nitrate concentrations are assigned to each cell by layer. Layers are then aggregated using the volume-weighted method to generate the total volume-weighted AWQ. **Figure 3-3** and **Figure** illustrate the relative TDS and nitrate concentrations, respectively, in the West Whitewater River Management Zone by layer and an aggregated total.

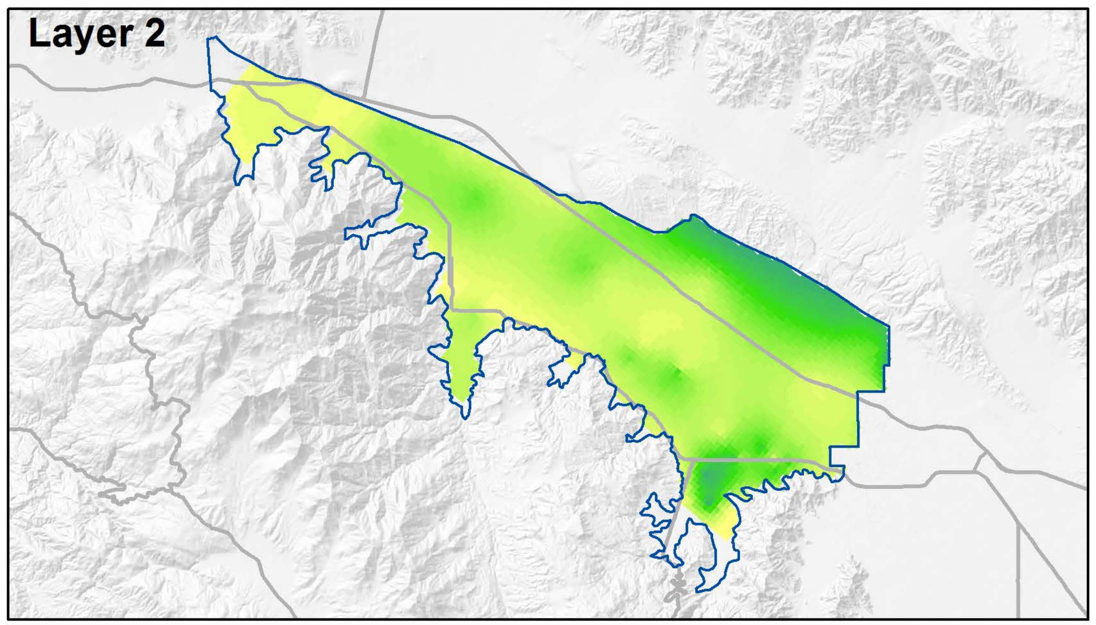
Table 3-3
Volume-weighted Ambient Water Quality for West Whitewater River Management Zone

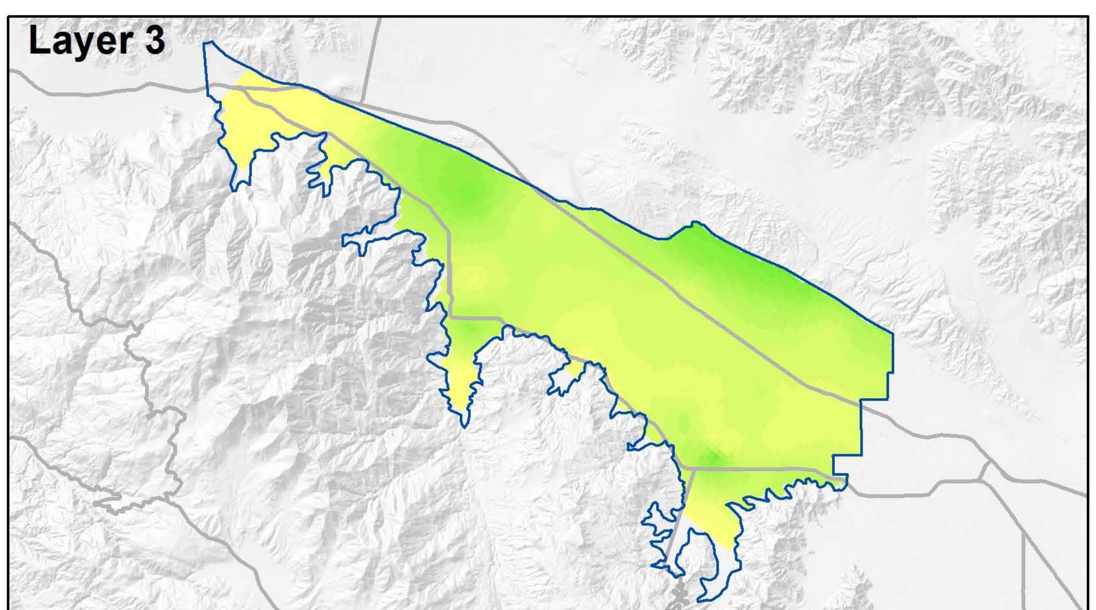
Aquifer Zone	Total Dissolved Solids (mg/L)	Nitrate as NO_3 (mg/L)
Layer 1	201 to 1,060	1.2 to 101
Layer 2	323	14.3
Layer 3	224	5.0
Total	**252 to 450**	**7 to 30**

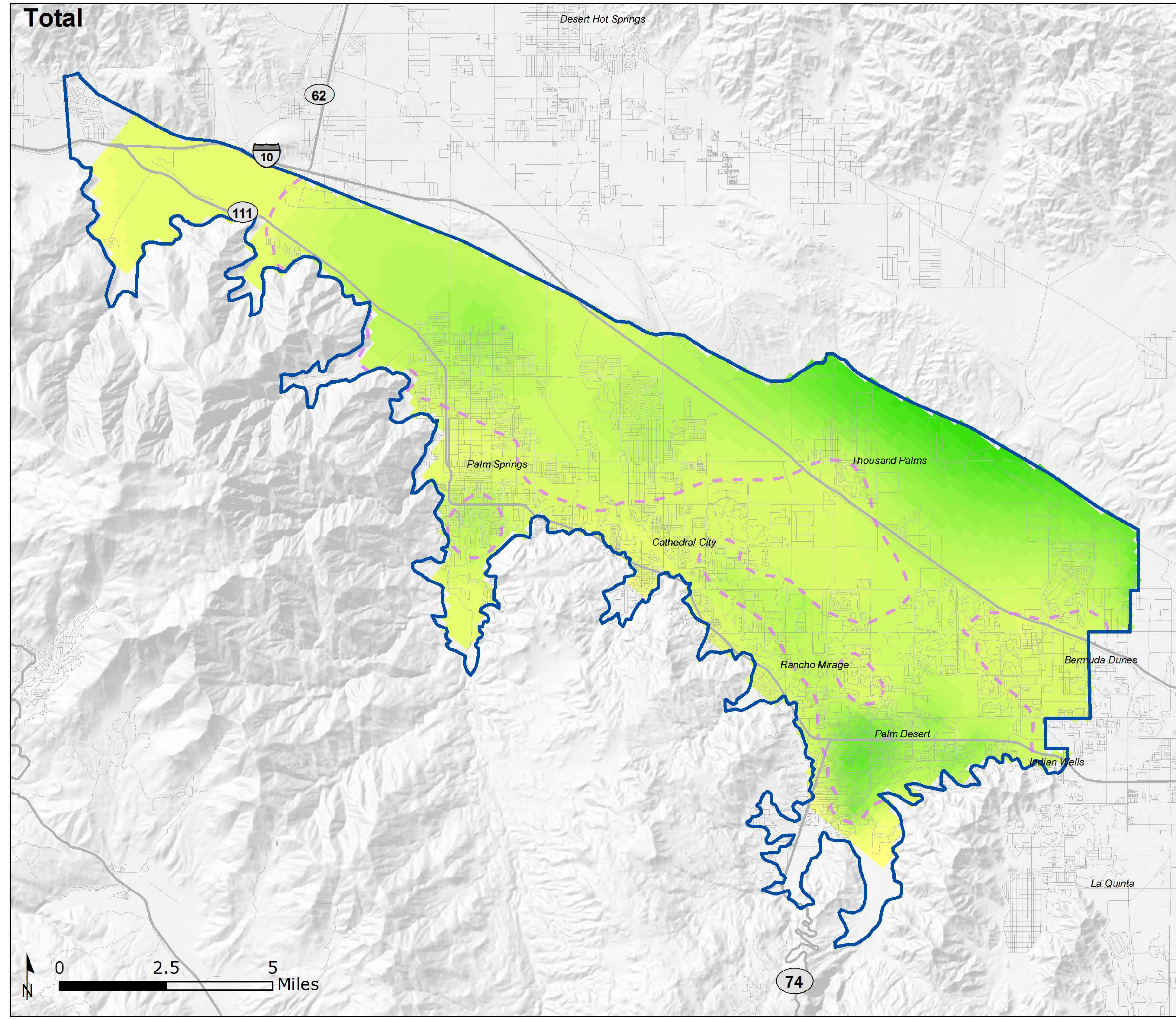
The volume-weighted AWQ for TDS in West Whitewater River Management Zone is between 252 and 450 mg/L. TDS concentrations are generally low throughout West Whitewater River. The TDS exceeds the volume-weighted AWQ in three areas: (1) north of Palm Springs to the southeast of the Whitewater Recharge Facility, (2) areas in Thousand Palms Subarea, and (3) in the vicinity of Palm Desert and Indian Wells.

The volume-weighted AWQ for nitrate (as NO_3) in West Whitewater River Management Zone is between 7 and 30 mg/L. Nitrate concentrations are generally below the volume-weighted AWQ from the north end of West Whitewater River to Cathedral City. The Thousand Palms Subarea and surrounding areas are also relatively low in nitrate. The region above the nitrate AWQ is on the southern boundary of West Whitewater River Management Zone just southeast of Palm Springs extending to Palm Desert and the East Whitewater River Management Zone.









Total Dissolved Solids

100 mg/L
1,500 mg/L
1,500 mg/L
19,100 mg/L

Estimated Ambient Water Quality Contour

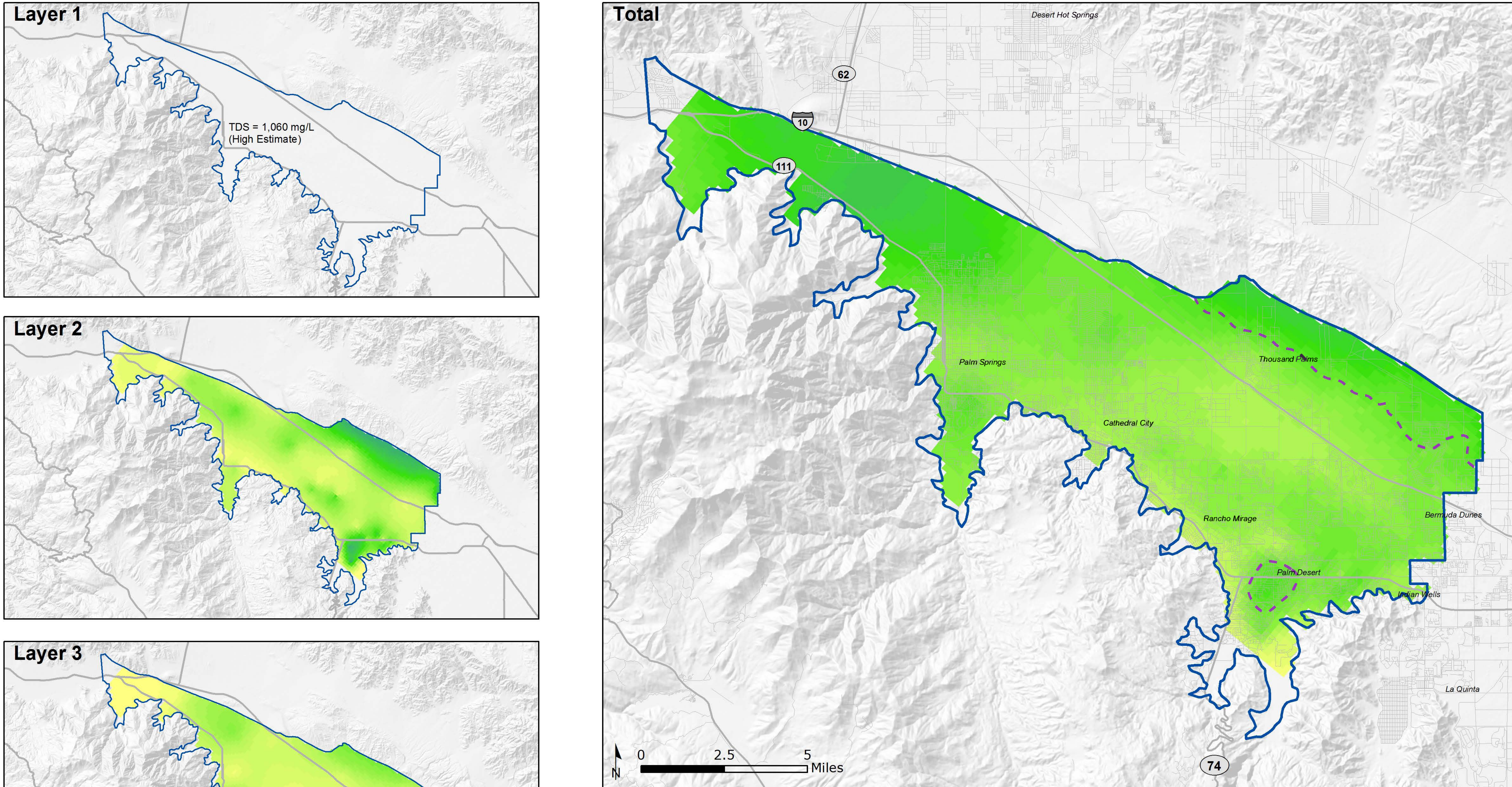
252 mg/L

Portions of the management zone that do not have an estimated concentration lie outside the extent of known aquifer properties required for the volume-weighted AWQ method; additionally, these areas lack substantial water quality data. They have been identified as data gaps and will be further described as a data need in the final SNMP.

West Whitewater Volume-Weighted Ambient Water Quality for Total Dissolved Soilds (Low Estimate)

MWH

Figure 3-3a



Total Dissolved Solids

100 mg/L — 1,500 mg/L

1,500 mg/L — 19,100 mg/L

Estimated Ambient Water Quality Contour

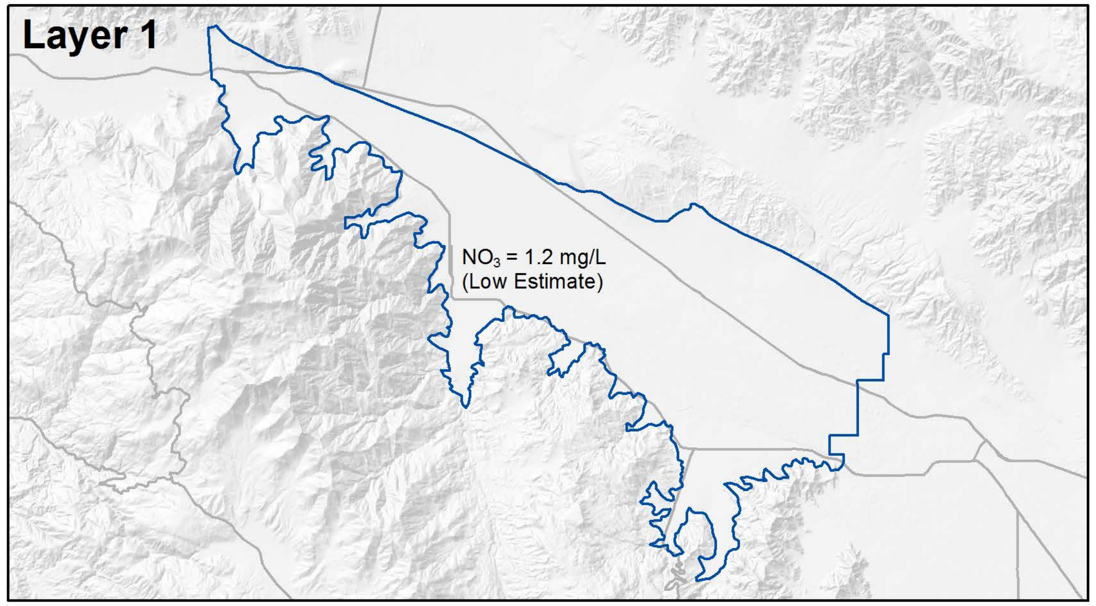
450 mg/L

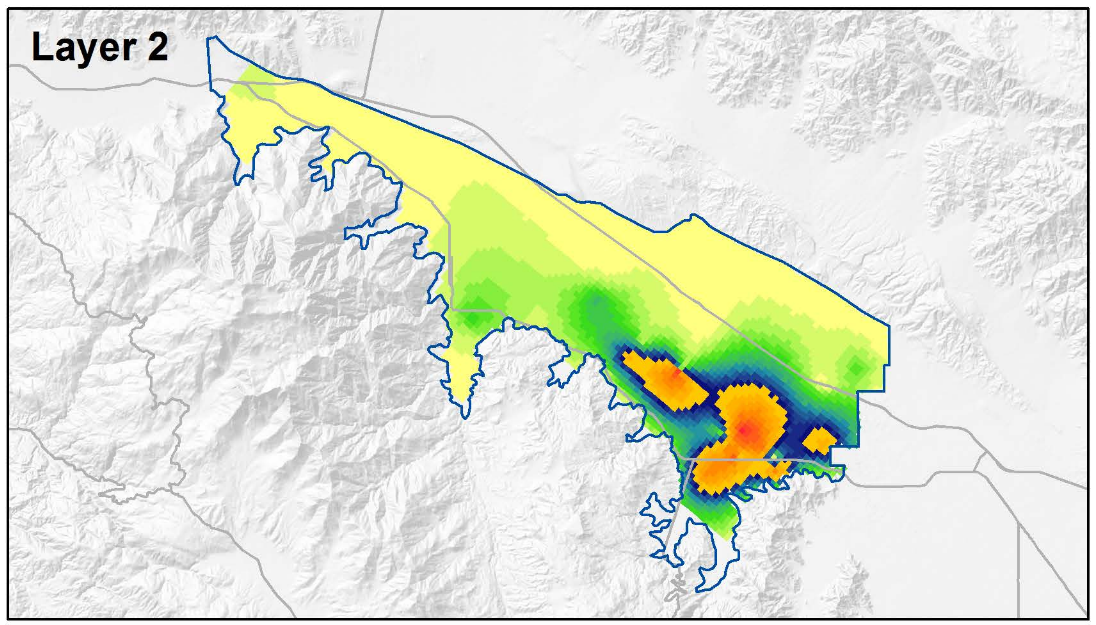
Portions of the management zone that do not have an estimated concentration lie outside the extent of known aquifer properties required for the volume-weighted AWQ method; additionally, these areas lack substantial water quality data. They have been identified as data gaps and will be further described as a data need in the final SNMP.

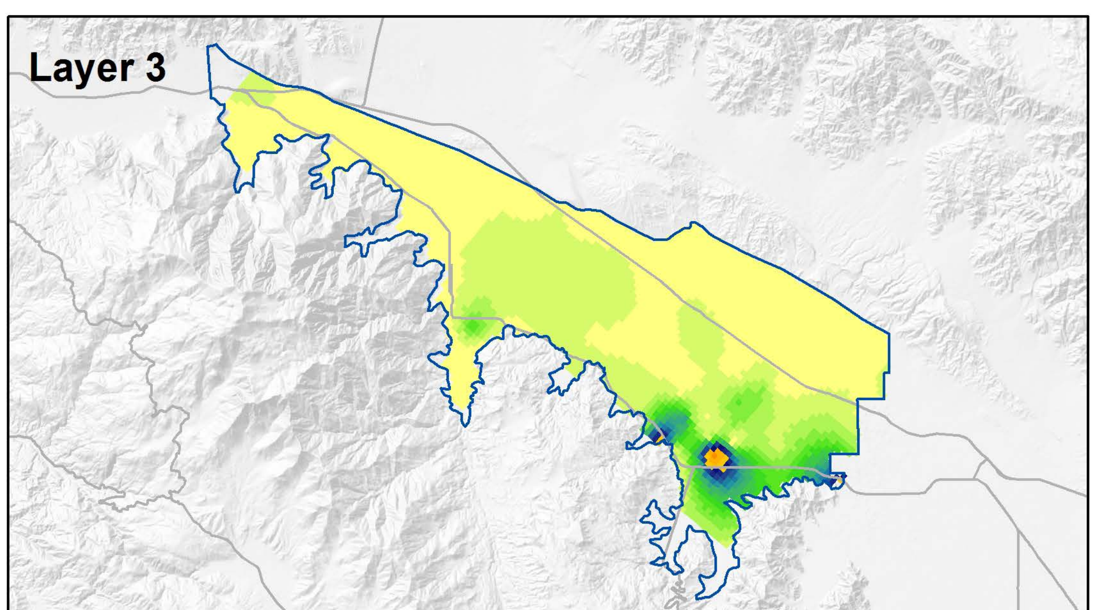
West Whitewater Volume-Weighted Ambient Water Quality for Total Dissolved Soilds (High Estimate)

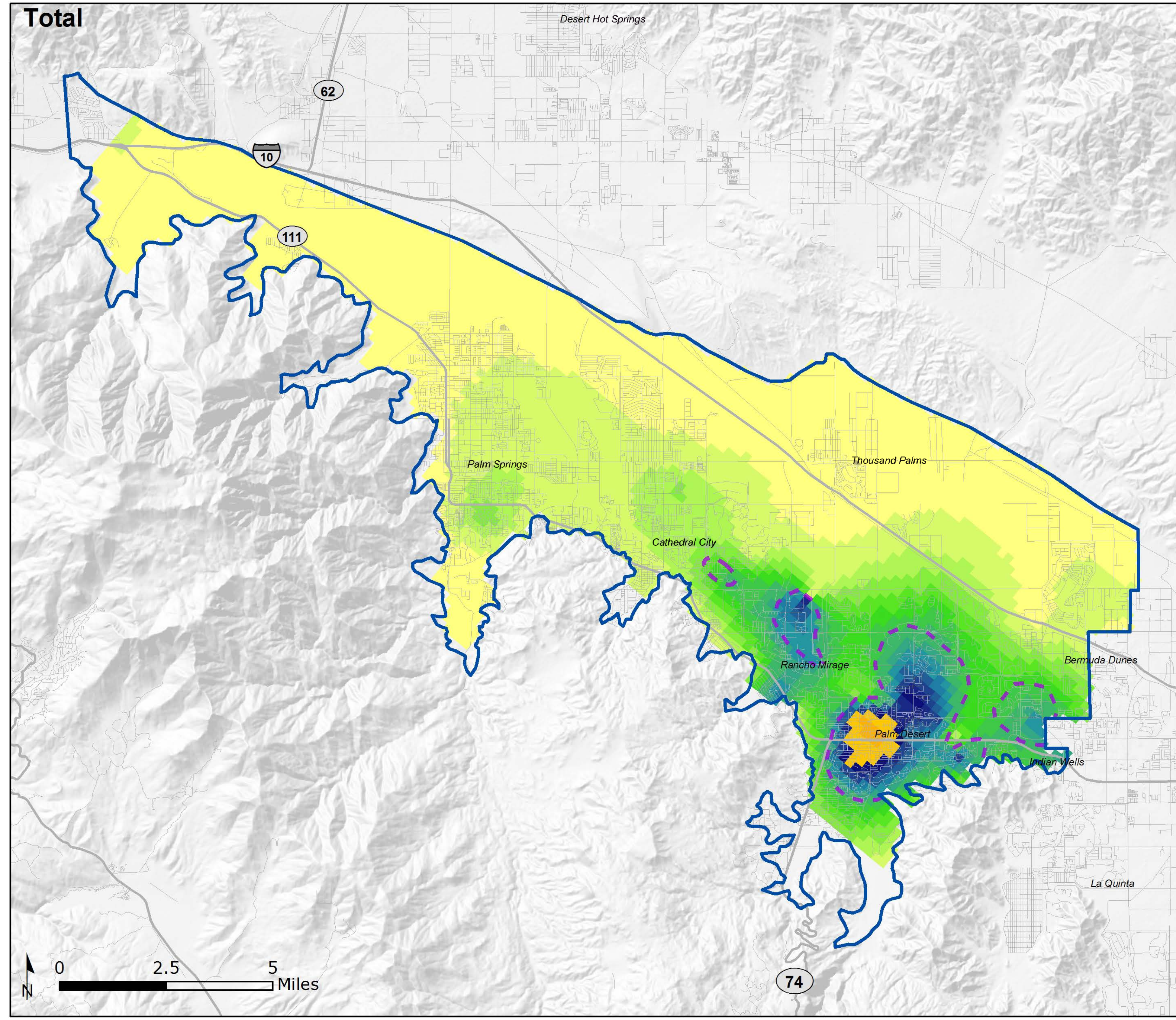
MWH

Figure 3-3b









Nitrate (as NO_3)

Non-Detect

45 mg/L

45 mg/L

230 mg/L

Estimated Ambient Water Quality Contour

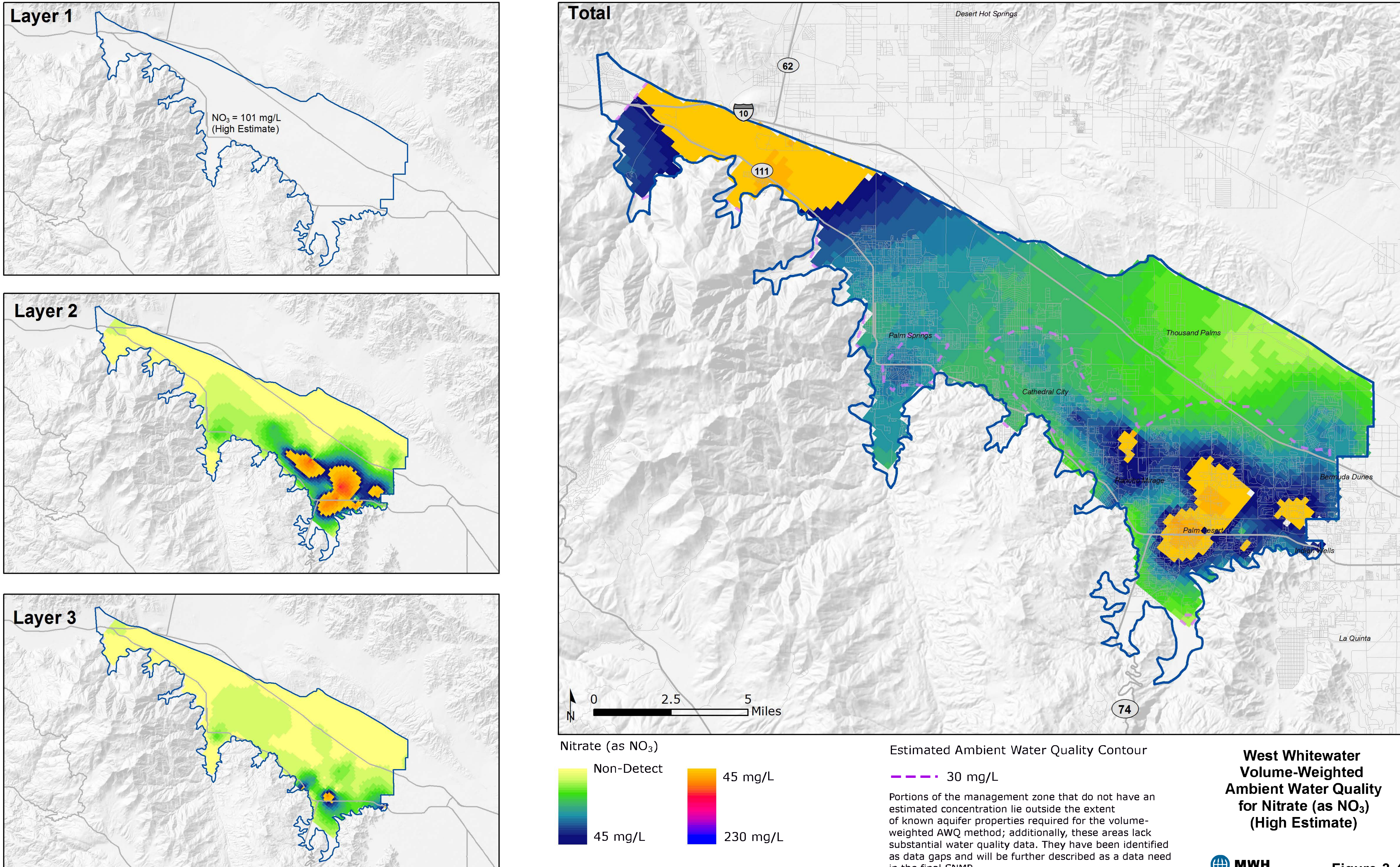
7 mg/L

Portions of the management zone that do not have an estimated concentration lie outside the extent of known aquifer properties required for the volume-weighted AWQ method; additionally, these areas lack substantial water quality data. They have been identified as data gaps and will be further described as a data need in the final SNMP.

West Whitewater Volume-Weighted Ambient Water Quality for Nitrate (as NO_3) (Low Estimate)

MWH

Figure 3-4a



West Whitewater Volume-Weighted Ambient Water Quality for Nitrate (as NO_3) (High Estimate)

Figure 3-4b

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3.2 EAST WHITEWATER RIVER MANAGEMENT ZONE

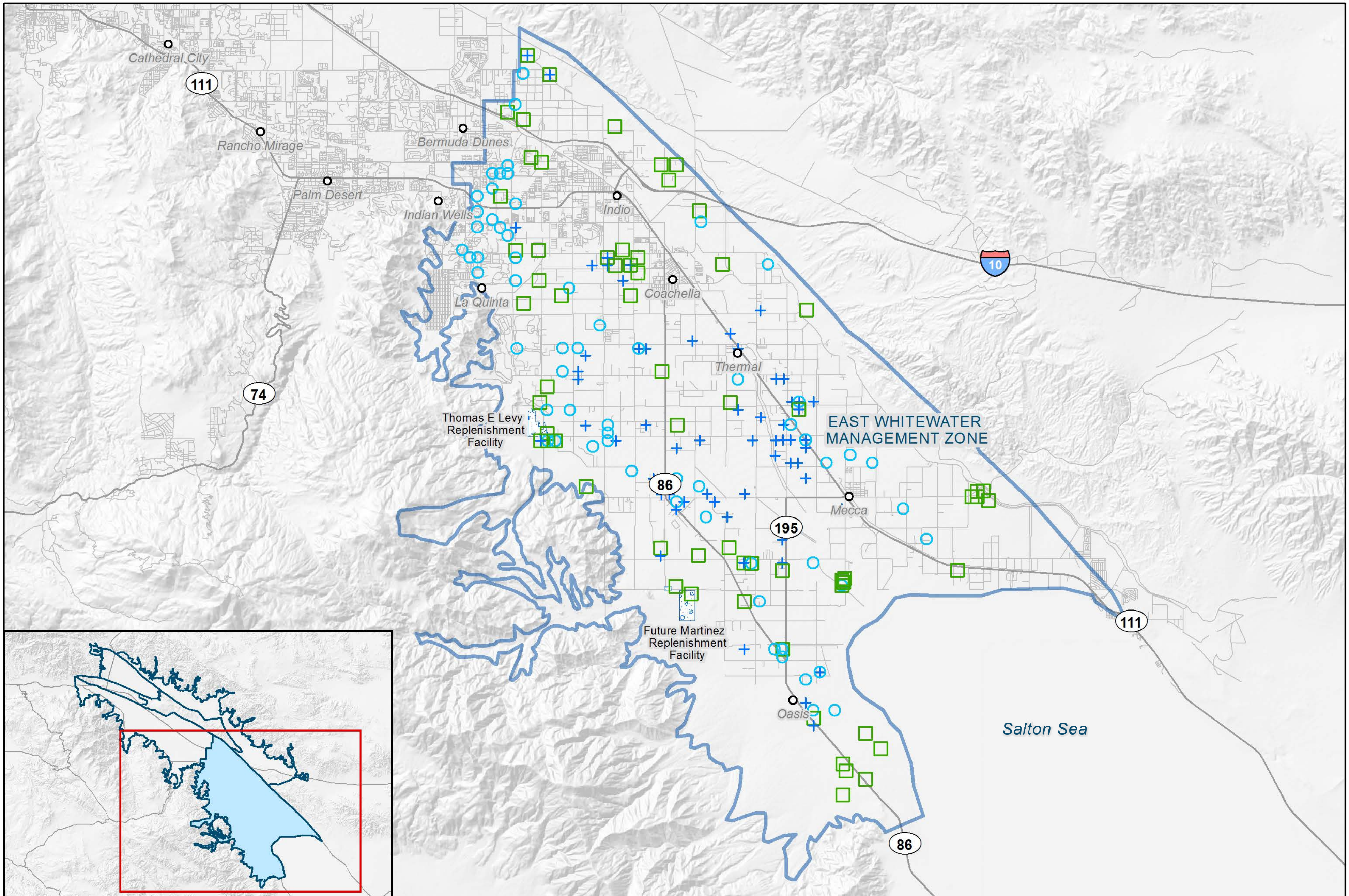
The East Whitewater River Management Zone is comprised primarily of the southern portion of the Thermal Subarea, the Oasis Subarea, and a small portion of the Thousand Palms Subarea of the Whitewater River Subbasin. This management zone is west of the San Andreas Fault zone, east of the San Jacinto Mountains and southeast of the West Whitewater River Management Zone. Groundwater travels southeastward through the interbedded sands, silts, and clays underlying the central portion of the East Whitewater River. The division between the West Whitewater River Management Zone and East Whitewater River Management Zone extends from Point Happy near the Indian Wells-La Quinta boundary and Highway 111 northeasterly to the Indio Hills at the northern extension of Jefferson Street.

Two aquifers separated by a zone of fine-grained materials were identified from well logs (DWR, 1964). An aquitard separates upper and lower aquifer zones in the management zone. In much of the management zone, the upper aquifer is capped at the ground surface with clays and silts with minor amounts of sand. Semi-perched groundwater occurs in this capping zone, which is up to 100 feet thick. No recent water quality data exists for the semi-perched aquifer as it is not used beneficially. Subsurface tile drainage systems were installed in the 1950s to control the high water table conditions, to allow reclamation of saline soils, and to intercept poor quality return flows. All agricultural drains empty into the Salton Sea, or into the Coachella Valley Stormwater Channel, which also flows into the Salton Sea. Each of the four water-bearing zones, from shallowest to deepest, is described earlier in TM-1.

All results are summarized by the layers used in the volume-weighted method. East Whitewater River Management Zone is separated into three layers. The upper aquifer, approximately less than 400 feet below ground surface, is grouped into Layer 1; a top portion of the confined aquifer, approximately 400 to 600 feet below ground surface, into Layer 2; and the bottom of the confined aquifer, depths greater than approximately 600 feet below ground surface, is Layer 3. Layer 1 also includes any data from the perched aquifer.

3.2.1 Summary of Unfiltered Data

The unfiltered dataset for the East Whitewater River Management Zone consists of 3,711 water quality records during the period of 1999 to 2013. The locations of wells with water quality records used in the AWQ determination are illustrated on **Figure 3-5**. It should be noted that groundwater quality data in the semi perched aquifer is a known data gap and will be identified in the monitoring portion of the final SNMP. The unfiltered dataset for East Whitewater River Management Zone contains 1,765 TDS records and 1,946 nitrate records. Nitrate is more frequently monitored in wells than TDS because nitrate levels in groundwater can exhibit greater variability over shorter time periods. The statistical summary of unfiltered data for the East Whitewater River Management Zone is presented on **Table 3-4**.



Key to Features

Management Zone

City

Highway

Local Roads

Groundwater Well Location
Type of Aquifer Penetrated

Layer 1

Layer 2

Layer 3

0 2.5 5 Miles

N

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Date: 2/27/2015

East Whitewater
Wells with Water Quality
Records in 1999-2013

MWH

Figure 3-5

Table 3-4
Descriptive Statistics of Unfiltered Data for East Whitewater River (1999-2013)

	Layer 1		Layer 2		Layer 3	
Statistic	**Total Dissolved Solids**	**Nitrate as NO_3**	**Total Dissolved Solids**	**Nitrate as NO_3**	**Total Dissolved Solids**	**Nitrate as NO_3**
Count	1,017	992	201	201	547	753
Mean (mg/L)	1,497	23.7	621	4.7	2,191	3.5
Median (mg/L)	864	7.2	287	1.1	272	0.3
Mode (mg/L)	1,600	ND	980	ND	150	ND
Std. Dev. (mg/L)	2,986	32.3	587	7.8	3,644	10.7
Range (mg/L)	135 to 29,000	ND to 260	104 to 2,000	ND to 33	120 to 15,910	ND to 221
95% Confidence Interval (mg/L)	1,313 to 1,681	21.7 to 25.8	539 to 702	3.6 to 5.8	1,885 to 2,497	2.8 to 4.3

ND = non-detect

3.2.2 Statistical Description of Ambient Water Quality

The filtered dataset for East Whitewater River Management Zone consists of 132 TDS values and 131 nitrate values. The statistical summary of filtered data for the East Whitewater River Management Zone is presented on **Table 3-5**.

A particular deep nested monitoring well is included in this dataset that is located near the Salton Sea that is sampled much more frequently than other wells. High salinity is found in the lower two intervals, 1,220 to 1,260 feet and 1,430 to 1,470 below ground surface. These readings have a significant effect on the summary statistics of the unfiltered dataset. The filtered dataset minimizes the bias induced by the more frequent sampling at these wells.

Higher TDS readings appear in some lower aquifer wells between La Quinta and Coachella, as well as in Oasis Subarea, and west of the Salton Sea. High TDS also appears in the lower aquifer in areas between Thermal and Mecca, south of La Quinta, and in a deep monitoring well near the Salton Sea. Higher TDS reading are also found in the upper aquifer within the Thousand Palms Subarea, to the north of the management zone. Very high TDS measurements were found in shallow groundwater monitoring wells at the Mecca Landfill site.

Nitrate is generally low within East Whitewater River Management Zone except for high nitrate in the Oasis area and the upper aquifer west of Desert Hot Springs Management Zone. In general, nitrate decreases from the upper to the lower aquifer of East Whitewater River.

Table 3-5
Descriptive Statistics of Filtered Data for East Whitewater River (1999-2013)

	Layer 1		Layer 2		Layer 3	
Statistic	**Total Dissolved Solids**	**Nitrate as NO_3**	**Total Dissolved Solids**	**Nitrate as NO_3**	**Total Dissolved Solids**	**Nitrate as NO_3**
Count	41	41	43	43	48	47
Mean (mg/L)	1,509	24.7	362	3.9	355	6.5
Median (mg/L)	698	3.6	202	0.8	180	2.2
Mode (mg/L)	665	ND	162	ND	160	ND
Std. Dev. (mg/L)	3,081	45.4	360	6.5	510	18.3
Range (mg/L)	152 to 19,100	ND to 230	104 to 1,750	ND to 28	123 to 3,270	ND to 111
95% Confidence Interval (mg/L)	537 to 2,482	10.4 to 39	251 to 472	1.9 to 5.9	207 to 503	1.1 to 11.8

ND = non-detect

The mean TDS of the filtered dataset falls within the interval of 537 to 2,482 mg/L, 251 to 472 mg/L, 207 to 503 mg/L for Layer 1, Layer 2, and Layer 3, respectively, with a 90 percent probability; for nitrate (as NO_3), this interval is from 10.4 to 39 mg/L, 1.9 to 5.9 mg/L, and 1.1 to 11.8 mg/L for Layer 1, Layer 2, and Layer 3, respectively. The filtered dataset provides a substantially different view of TDS in the statistical summary because the contribution of the frequently sampled nested monitoring well with high TDS is normalized to that of other wells in the East Whitewater River. As expected, **Table 3-5** strongly suggests that TDS concentrations are generally lower in the lower aquifer compared to the upper aquifer.

3.2.3 Volume-weighted Ambient Water Quality

For the determination of volume-weighted ambient water quality, the East Whitewater River Management Zone is separated into three layers. The upper aquifer (generally less than 400 feet below ground surface), inclusive of any perched aquifer data, is evaluated as one contoured layer. The top portion of the lower aquifer (extending from 400 to 600 feet below ground surface) is the next contoured layer. The bottom of the lower aquifer (generally greater than 600 feet below ground surface) is the final contoured layer. Note that these depths vary with location according to the model grid described in TM-1 to take advantage of known aquifer geometry.

Table 3-6 summarizes the results of the volume-weighted AWQ determination for East Whitewater River Management Zone. Water quality concentration is contoured in three layers: the upper, unconfined system and two subdivisions of the lower, confined aquifer due to its thickness. Concentrations are assigned to each cell in each layer. Layers are then aggregated using the volume-weighted method to generate the total volume-weighted AWQ. **Figure 3-6** and

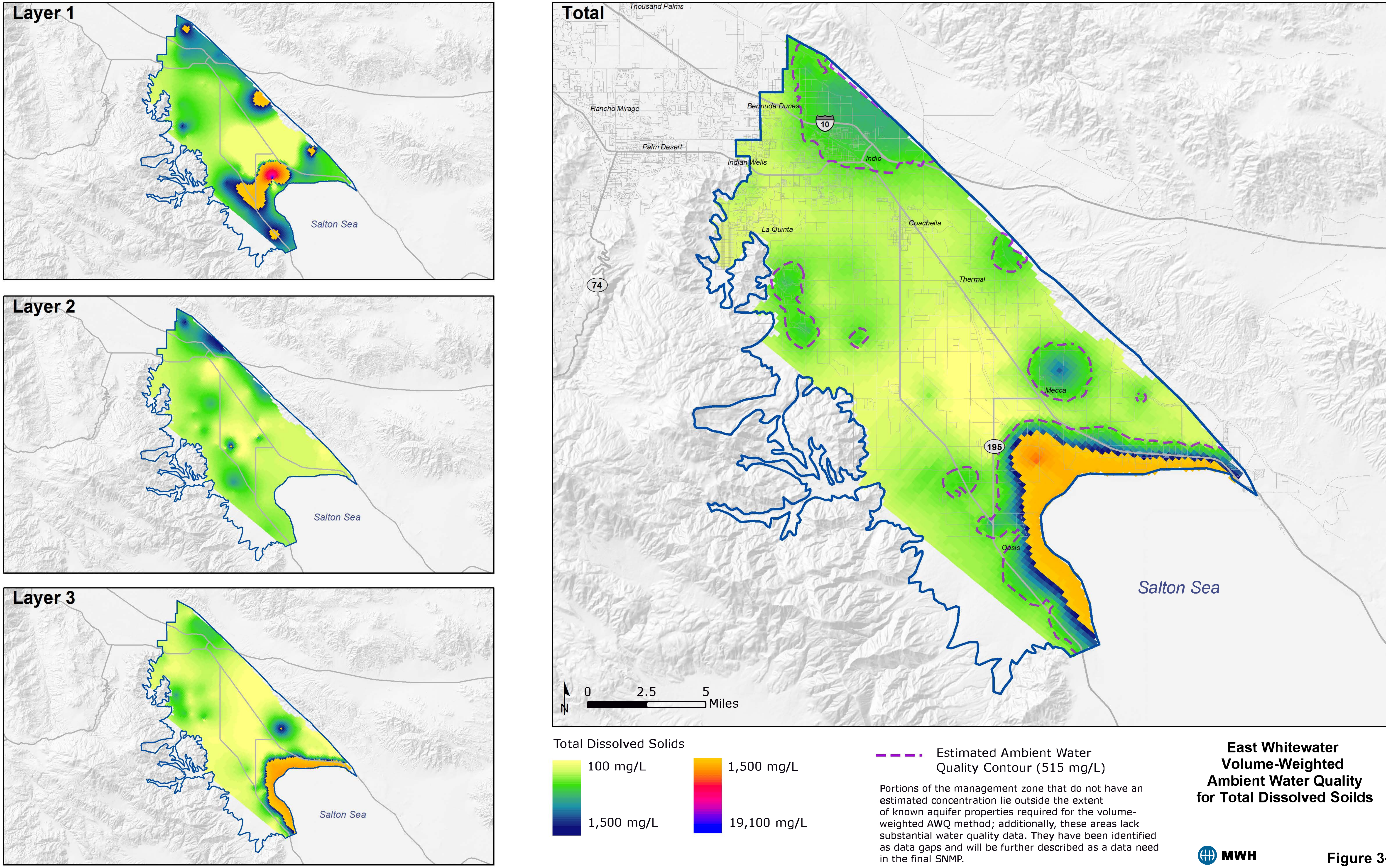
Figure 3-7 illustrate the relative TDS and nitrate concentrations, respectively, for each layer and the total management zone (an aggregate of all three layers, or the two aquifer systems) of East Whitewater River Management Zone.

Table 3-6
Volume-weighted Ambient Water Quality for East Whitewater River Management Zone

Aquifer Zone	Total Dissolved Solids (mg/L)	Nitrate as NO_3 (mg/L)
Layer 1	789	10.1
Layer 2	366	8.6
Layer 3	470	5.8
Total	**515**	**7.0**

The volume-weighted AWQ for TDS in East Whitewater River Management Zone is 515 mg/L. The lower aquifer generally has lower TDS than the upper aquifer; there are some locations in the lower aquifer near Salton Sea where high TDS concentrations have been observed with nested wells (e.g., nested well 07S09E30R01S screened at 1,430 to 1,470 feet below ground surface). It is not known if TDS concentration increases in very deep sediments farther from the Sea as there are no monitoring wells installed in this zone away from the Sea. Areas with TDS concentrations higher than the volume-weighted AWQ include: (1) areas near the Thousand Palms Subarea, (2) isolated zones southwest of Indio, (3) areas near Desert Hot Springs Management Zone, and (4) the east end of the Oasis Subarea.

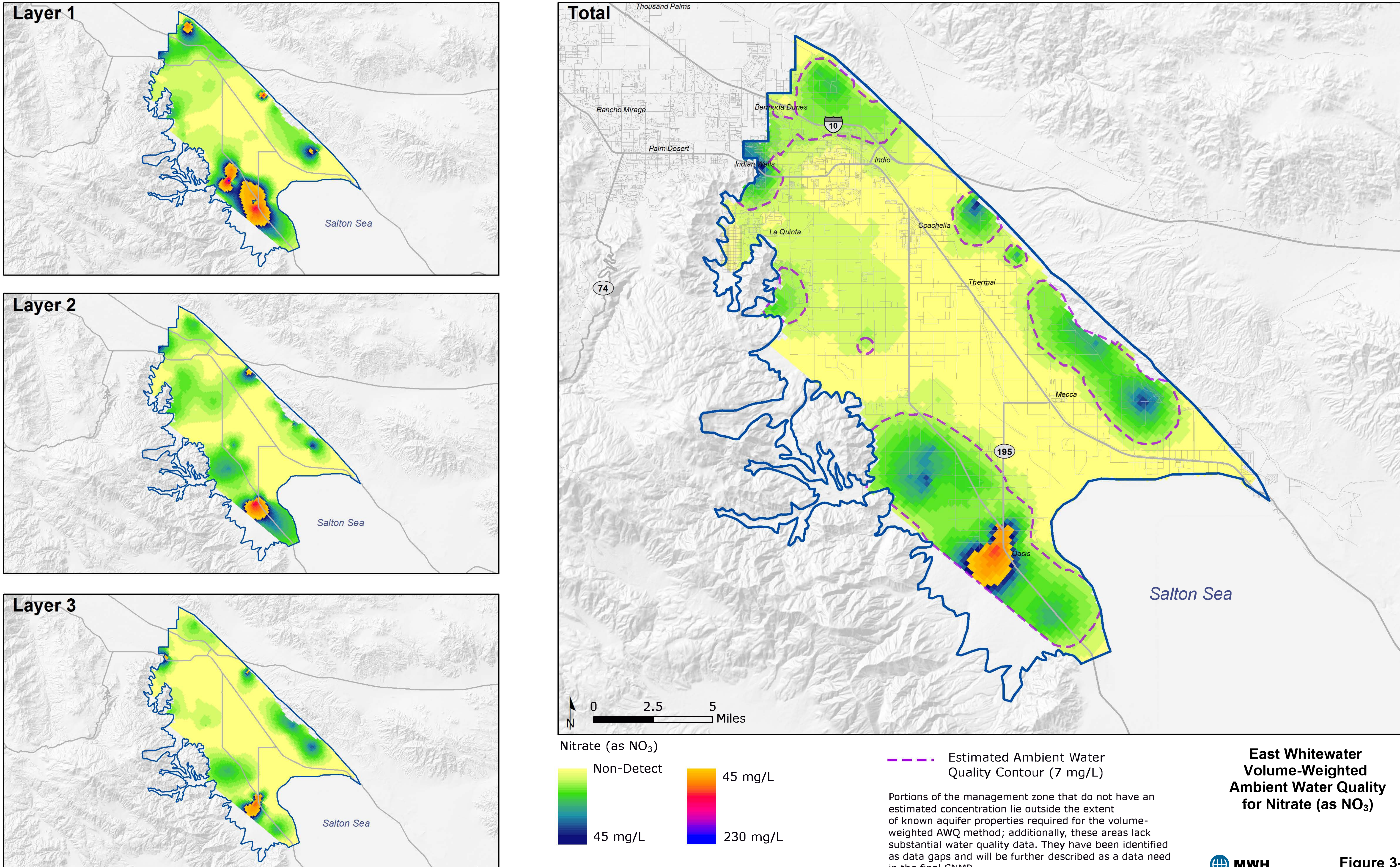
The volume-weighted AWQ for nitrate (as NO_3) in East Whitewater River Management Zone is 7.0 mg/L. The lower aquifer has marginally less nitrate content than the upper aquifer, in general. Along the center of East Whitewater River, nitrate is generally below the volume-weighted AWQ with a large amount of undetected concentrations. Nitrate concentrations higher than the volume-weighted AWQ occur in: (1) the southern boundary of East Whitewater River at the border of West Whitewater River Management Zone extending to the southeast, (2) the southern parts of Thousand Palms Subarea, (3) the southern boundary with Desert Hot Springs Management Zone extending southeast to the Salton Sea, and (4) much of Oasis Subarea.



East Whitewater Volume-Weighted Ambient Water Quality for Total Dissolved Soilds

MWH

Figure 3-6



Portions of the management zone that do not have an estimated concentration lie outside the extent of known aquifer properties required for the volume-weighted AWQ method; additionally, these areas lack substantial water quality data. They have been identified as data gaps and will be further described as a data need in the final SNMP.

East Whitewater Volume-Weighted Ambient Water Quality for Nitrate (as NO_3)

MWH

Figure 3-7

3.3 MISSION CREEK MANAGEMENT ZONE

The Mission Creek Management Zone is located in the northwestern Coachella Valley, north of the Garnet Hill Management Zone and west of the Desert Hot Springs Management Zone. The Mission Creek Fault and the Banning Fault form the northern and southern boundaries, respectively. Both faults act to limit groundwater movement as evidenced by groundwater level differences across the faults. The main water bearing units of the Mission Creek Management Zone are unconsolidated Holocene and late Pleistocene alluvial deposits forming a single unconfined aquifer with a saturated thickness of approximately 1,200 feet. An attempt was made to separate the aquifer into layers, but continuous well perforations limited the number of data points exclusive to a single layer; therefore, separation of aquifer layers could not be completed.

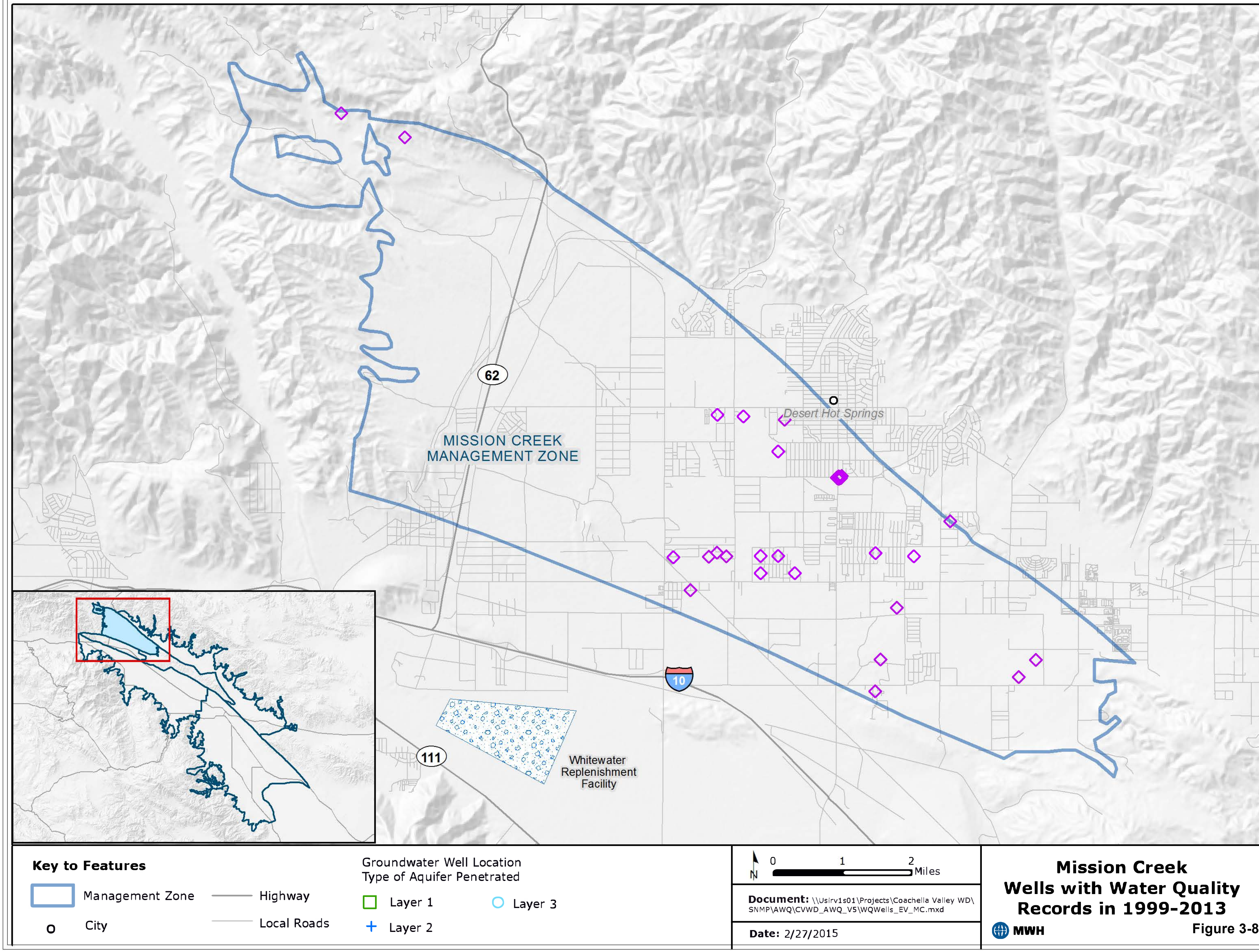
3.3.1 Summary of Unfiltered Data

The unfiltered dataset for the Mission Creek Management Zone consists of 391 water quality records during the baseline period of 1999 to 2013. The locations of wells with water quality records used in the AWQ determination are illustrated on **Figure 3-8**. It should be noted that there is a lack of data on the western portion of the management zone. This is a known data gap and will be identified in the monitoring portion of the final SNMP. The unfiltered dataset for Mission Creek Management Zone contains 77 TDS records and 314 nitrate records. Nitrate is more frequently monitored in wells than TDS because groundwater is typically more likely to see short term changes in nitrate levels. One shallow well with high nitrate was sampled approximately once a month over a period of nine years. The statistical summary of unfiltered data for the Mission Creek Management Zone is presented on **Table 3-7**.

Table 3-7
Descriptive Statistics of Unfiltered Data for Mission Creek (1999-2013)

Statistic	Total Dissolved Solids	Nitrate as NO_3
Count	77	314
Mean (mg/L)	516	27.5
Median (mg/L)	465	5.6
Mode (mg/L)	430	71
Std. Dev. (mg/L)	204	31.1
Range (mg/L)	270 to 1,100	ND to 86
95% Confidence Interval (mg/L)	470 to 563	24 to 30.9

ND = non-detect



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Date: 2/27/2015

Mission Creek Wells with Water Quality Records in 1999-2013

MWH

Figure 3-8

3.3.2 Statistical Description of Ambient Water Quality

The filtered dataset for Mission Creek Management Zone consists of 22 TDS values and 25 nitrate values. The statistical summary of filtered data for the Mission Creek Management Zone is presented on **Table 3-8**. The filtered dataset minimizes the effects of many of the biases discussed in Section 2.2, such as the abundance of high nitrate values from a single shallow well.

Influence from high salinity groundwater from Desert Hot Springs may contribute to the upper end of the range. TDS concentrations generally decrease from the Desert Hot Springs to the Garnet Hill management zones. Very few data exist in the northwest of the management zone.

High nitrate values in a shallow well sampled more frequently than others in this dataset are a cause for the large difference between the average and median nitrate.

Table 3-8
Descriptive Statistics of Filtered Data for Mission Creek (1999-2013)

Statistic	Total Dissolved Solids	Nitrate as NO_3
Count	22	25
Mean (mg/L)	606	5.8
Median (mg/L)	499	3.8
Mode (mg/L)	N/A	3.6
Std. Dev. (mg/L)	242	8.1
Range (mg/L)	300 to 1,096	0.3 to 42.8
95% Confidence Interval (mg/L)	499 to 713	2.4 to 9.1

ND = non-detect

The mean TDS of the filtered dataset falls within the interval of 499 to 713 mg/L with a 95 percent confidence; for nitrate (as NO_3), this interval is between 2.4 and 9.1 mg/L.

3.3.3 Volume-weighted Ambient Water Quality

For the determination of volume-weighted AWQ, Mission Creek is contoured over a single layer using the filtered dataset for TDS and nitrate. It is determined after several iterations that insufficient data are available to contour multiple layers in Mission Creek Management Zone. Further, due to a lack of available data on the west end of the management zone, areas in excess of halfway between the west border of the management zone and the west-most filtered data points were not included in the AWQ calculation; this area is clearly shown on **Figure 3-9** and **Figure 3-10**.

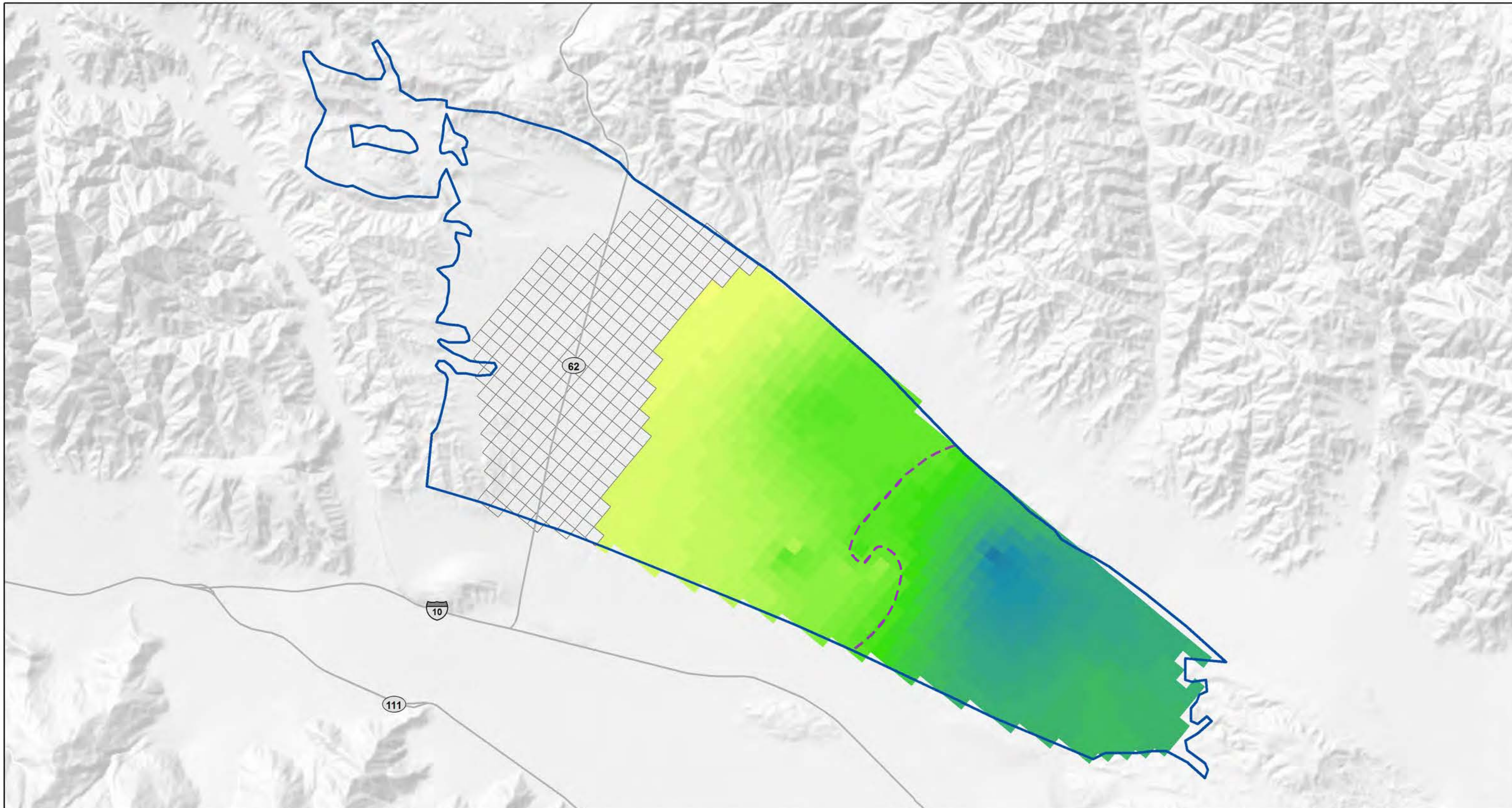
Table 3-9 summarizes the results of the volume-weighted AWQ determination for Mission Creek Management Zone. Water quality is contoured and TDS/nitrate concentrations are assigned to each cell. The layer cells are aggregated using the volume-weighted method to generate the volume-weighted AWQ. **Figure 3-9** and **Figure 3-10** illustrate the relative TDS and nitrate concentrations, respectively, in the Mission Creek Management Zone.

Table 3-9
Volume-weighted Ambient Water Quality for Mission Creek Management Zone (1994-2013)

Total Dissolved Solids (mg/L)	Nitrate as NO_3 (mg/L)
510	3.6

The volume-weighted AWQ for TDS in the Mission Creek Management Zone is 510 mg/L. TDS is above the volume-weighted AWQ towards the southeast of Mission Creek and where it borders Desert Hot Springs Management Zone. TDS decreases to the northwest end of Mission Creek Management Zone and near the Garnet Hill Management Zone. Few data are available in the western portion of Mission Creek Management Zone. Consequently, this area was excluded from the AWQ computation. Without data, it is uncertain how this exclusion impacts the AWQ.

The volume-weighted AWQ for nitrate (as NO_3) in the Mission Creek Management Zone is 3.6 mg/L. Nitrate is generally low throughout Mission Creek. The area above the volume-weighted AWQ is south of the Desert Hot Springs Management Zone extending to the Garnet Hill Subbasin, with the exception of the far southeast end of the Mission Creek Management Zone.



Total Dissolved Solids

100 mg/L

1,500 mg/L

1,500 mg/L

19,100 mg/L

Estimated Ambient Water Quality Contour (510 mg/L)

Area not included in AWQ determination

Portions of the management zone that do not have an estimated concentration lie outside the extent of known aquifer properties required for the volume-weighted AWQ method; additionally, these areas lack substantial water quality data. They have been identified as data gaps and will be further described as a data need in the final SNMP.

Area not included in AWQ determination indicated by grey cells have aquifer properties but lack nearby data to contour.

0 1 2 Miles

N

Mission Creek Volume-Weighted Ambient Water Quality for Total Dissolved Soilds

MWH

Figure 3-9

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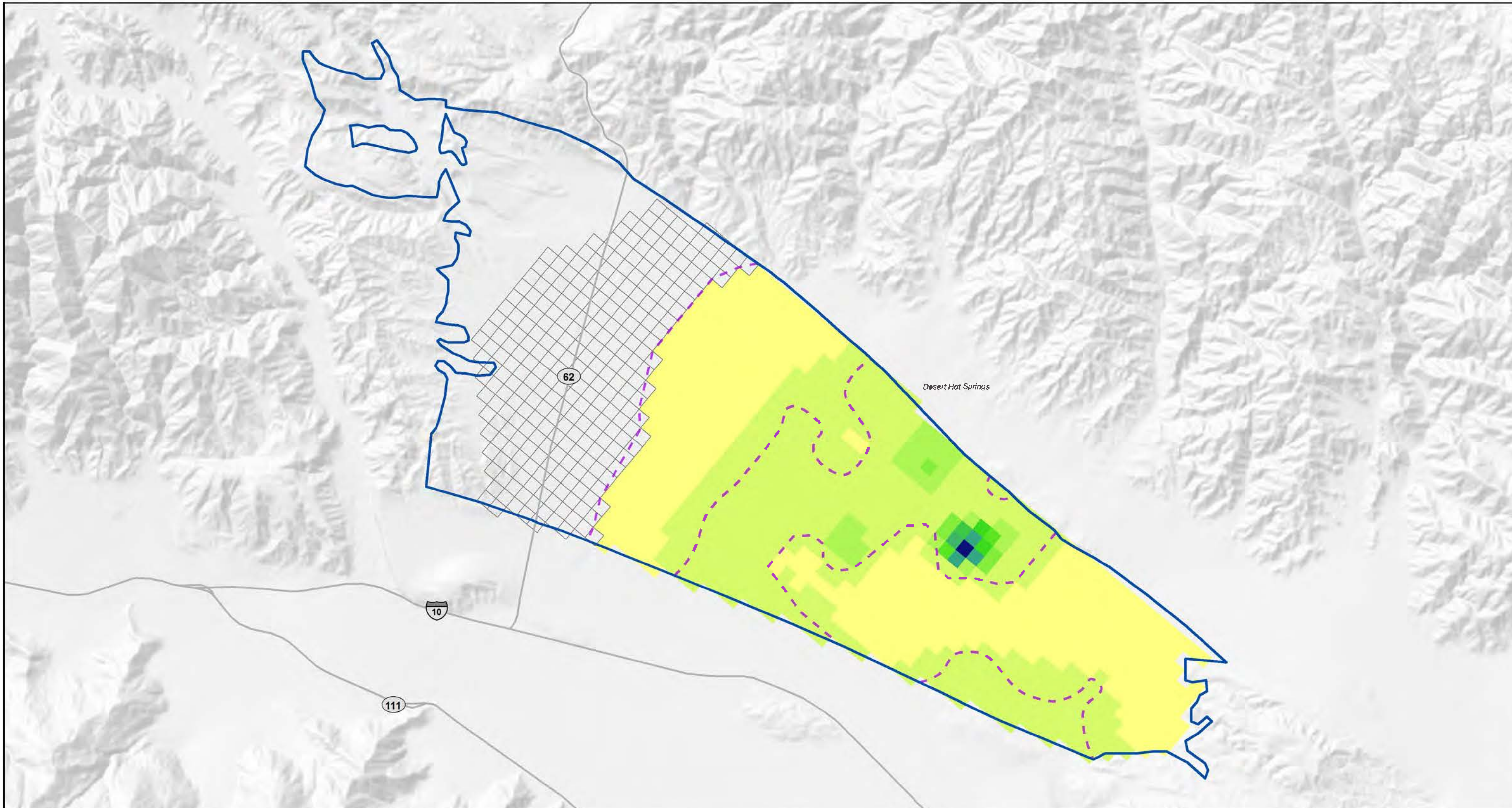


Portions of the management zone that do not have an estimated concentration lie outside the extent of known aquifer properties required for the volume-weighted AWQ method; additionally, these areas lack substantial water quality data. They have been identified as data gaps and will be further described as a data need in the final SNMP.

Area not included in AWQ determination indicated by grey cells have aquifer properties but lack nearby data to contour.

Mission Creek Volume-Weighted Ambient Water Quality for Nitrate (as NO_3)

MWH

Figure 3-10

3.4 GARNET HILL MANAGEMENT ZONE

The area between the Garnet Hill Fault and the Banning Fault, named the Garnet Hill Subarea by DWR (DWR, 1964), was considered a distinct subbasin by the United States Geological Survey (USGS) because of the effectiveness of the Banning and Garnet Hill Faults as barriers to groundwater movement (Tyley, 1974). This subbasin is considered part of the Whitewater River (Indio) Subbasin in DWR Bulletin 118 (2003); however, CVWD and DWA consider it a separate subbasin based on USGS findings and water level observations. In 1964, when the initial DWR evaluation was completed, it was observed that limited data existed to characterize the hydrogeology of this subbasin (DWR, 1964). The Garnet Hill Subbasin is considered an unconfined aquifer with a saturated thickness of 1,000 feet or more based on well depths and has an estimated total storage capacity on the order of 1.0 million acre-feet.

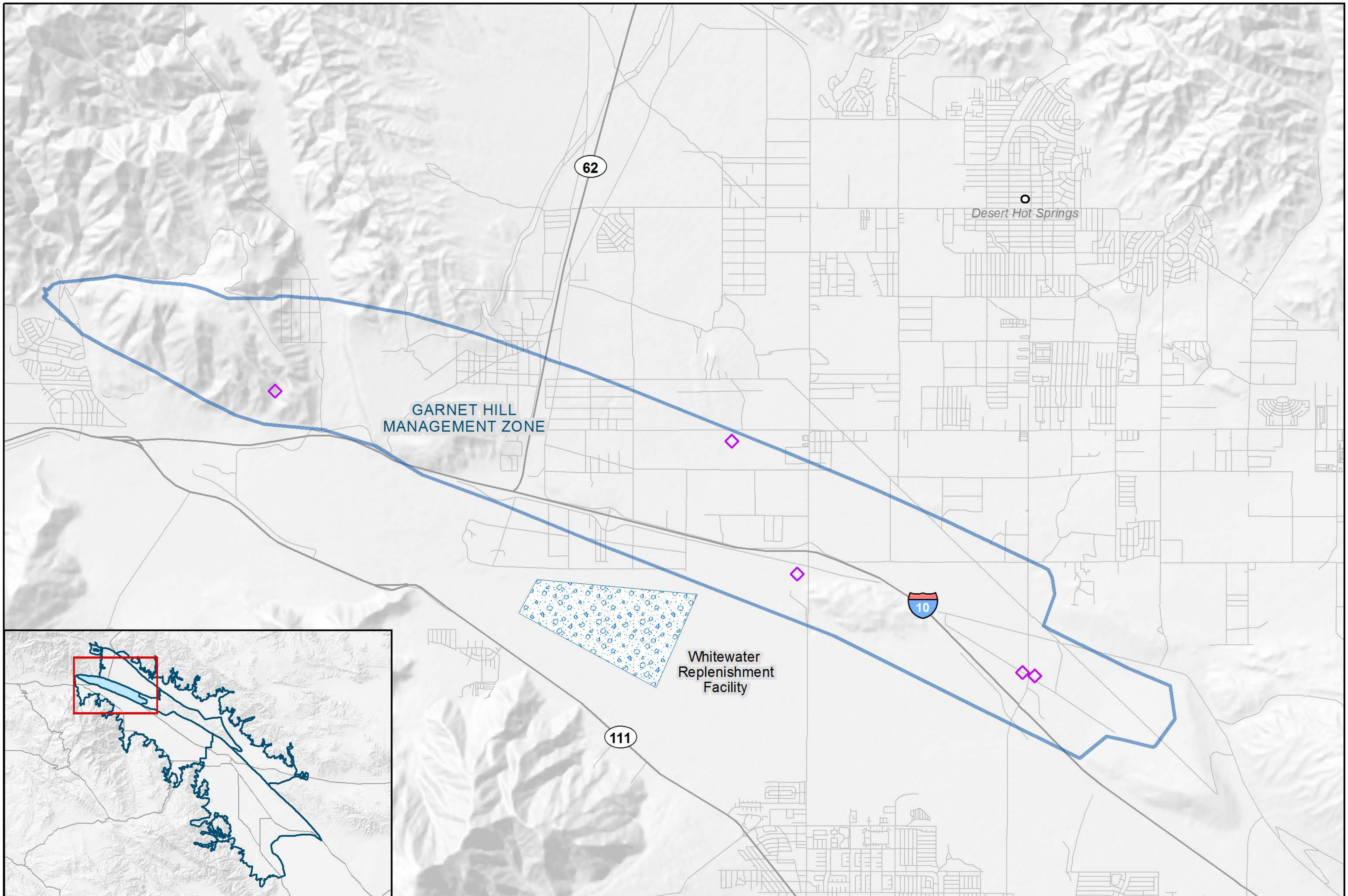
3.4.1 Summary of Unfiltered Data

The unfiltered dataset for the Garnet Hill Management Zone consists of 32 records during the baseline period of 1999 to 2013. Too few data points are available to compute the volume-weighted AWQ for Garnet Hill. The locations of wells with water quality records used in the AWQ determination are illustrated on **Figure 3-11**.The unfiltered dataset for Garnet Hill Management Zone contains 16 TDS records and 16 nitrate records. The statistical summary of unfiltered data for the Garnet Hill Management Zone is presented on **Table 3-10**.

Table 3-10
Descriptive Statistics of Unfiltered Data for Garnet Hill (1999-2013)

Statistic	Total Dissolved Solids	Nitrate as NO_3
Count	16	16
Mean (mg/L)	269	3.5
Median (mg/L)	273	2.4
Mode (mg/L)	N/A	1.8
Std. Dev. (mg/L)	56	3.4
Range (mg/L)	156 to 376	ND to 14.3
95% Confidence Interval (mg/L)	239 to 299	1.7 to 5.4

ND = non-detect



Key to Features

Management Zone
City
Highway
Local Roads

Groundwater Well Location
Type of Aquifer Penetrated

Layer 1
Layer 2
Layer 3

0 1 2 Miles

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Garnet Hill
Wells with Water Quality
Records in 1999-2013

MWH

Figure 3-11

3.4.2 Statistical Description of Ambient Water Quality

The filtered dataset for Garnet Hill Management Zone consists of 4 TDS values and 4 nitrate values. The statistical summary of filtered data for the Garnet Hill Management Zone is presented on **Table 3-11**.

TDS concentrations within Garnet Hill Management Zone are very low compared to other management zones. Very few data are available for characterizing the spatial distribution of groundwater quality within Garnet Hill Management Zone. However, available data indicate that water quality is generally excellent.

Table 3-11
Descriptive Statistics of Filtered Data for Garnet Hill (1999-2013)

Statistic	Total Dissolved Solids	Nitrate as NO_3
Count	4	4
Mean (mg/L)	217	2.2
Median (mg/L)	212	1.8
Mode (mg/L)	N/A	N/A
Std. Dev. (mg/L)	58	1.6
Range (mg/L)	156 to 288	0.6 to 4.5
95% Confidence Interval (mg/L)	124 to 309	ND to 4.8

ND = non-detect

There are too few data points to draw meaningful conclusions within the Garnet Hill Management Zone. This is a known data gap and will be identified in the monitoring portion of the final SNMP.

3.5 DESERT HOT SPRINGS MANAGEMENT ZONE

The Desert Hot Springs Subbasin is located adjacent to the Mission Creek and Whitewater River Subbasins and runs northwest to southeast along the foothills of the Little San Bernardino Mountains. The Desert Hot Springs Subbasin is bounded to the north by the Little San Bernardino Mountains and to the southwest by Mission Creek Fault, the San Andreas Fault, and the semipermeable rocks of the Indio Hills. These faults act as groundwater barriers and direct the groundwater in a southeast direction. The subbasin has been divided into three subareas: Miracle Hill, Sky Valley, and Fargo Canyon. Based on limited groundwater data for this area, flow is generally to the southeast.

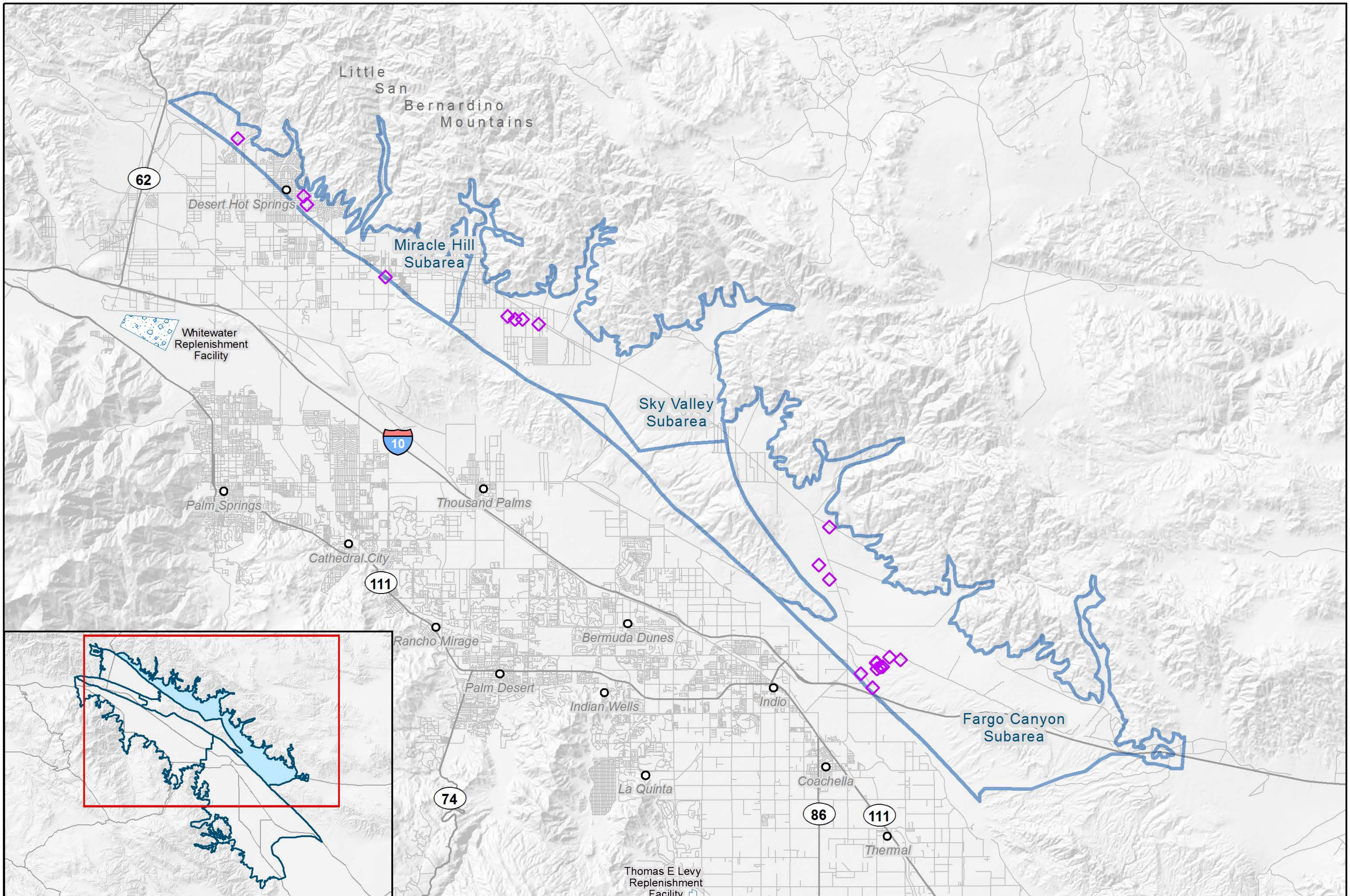
3.5.1 Summary of Unfiltered Data

The locations of wells with water quality records used in the AWQ determination are illustrated on **Figure 3-12**. The unfiltered dataset for the Desert Hot Springs Management Zone consists of 1,394 water quality records during the baseline period of 1999 to 2013 – 674 TDS records and 720 nitrate records. Most of these data points exist in the Fargo Canyon Subarea. Too few data points relative to the size of Desert Hot Springs are available to compute the volume-weighted AWQ. The statistical summaries of unfiltered data for the Desert Hot Springs Management Zone are presented on **Table 3-12**.

Table 3-12
Descriptive Statistics of Unfiltered Data for Desert Hot Springs (1999-2013)

Subarea	Statistic	Total Dissolved Solids	Nitrate as NO_3
Miracle Hill	Count	7	50
	Mean (mg/L)	471	10.5
	Median (mg/L)	440	9.4
	Mode (mg/L)	N/A	11
	Std. Dev. (mg/L)	185	8.1
	Range (mg/L)	240 to 845	0.5 to 44
	95% Confidence Interval (mg/L)	300 to 642	8.2 to 12.8
Sky Valley	Count	5	5
	Mean (mg/L)	1,294	20
	Median (mg/L)	1,300	20
	Mode (mg/L)	N/A	N/A
	Std. Dev. (mg/L)	168	15.7
	Range (mg/L)	1,070 to 1,500	0.4 to 40
	95% Confidence Interval (mg/L)	1,086 to 1,502	0.5 to 39.6
Fargo Canyon	Count	662	665
	Mean (mg/L)	1,384	18.7
	Median (mg/L)	1,400	13.3
	Mode (mg/L)	1,700	5.3
	Std. Dev. (mg/L)	445	16.7
	Range (mg/L)	256 to 2,570	ND to 101
	95% Confidence Interval (mg/L)	1,350 to 1,418	17.5 to 20

ND = non-detect



Key to Features

Management Zone
City
Highway
Local Roads

Groundwater Well Location
Type of Aquifer Penetrated

Layer 1
Layer 2
Layer 3

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Date: 2/27/2015

Desert Hot Springs Wells with Water Quality Records in 1999-2013

MWH

Figure 3-12

3.5.2 Statistical Description of Ambient Water Quality

High TDS groundwater comprises much of the Desert Hot Springs Management Zone. Areas of the Fargo Canyon Subarea near the East Whitewater River Management Zone have the highest TDS values and values over 1,000 mg/L exist in the Sky Valley Subarea. The Miracle Hill Subarea has some of the lowest TDS in Desert Hot Springs. In general, nitrate is lower in the Miracle Hill Subarea while groundwater in the Sky Valley and Fargo Canyon subareas show higher nitrate concentrations.

The filtered dataset for Desert Hot Springs Management Zone consists of 20 TDS values and 21 nitrate values. The statistical summary of filtered data for the Desert Hot Springs Management Zone is presented on **Table 3-13**.

Table 3-13
Descriptive Statistics of Filtered Data for Desert Hot Springs (1999-2013)

Subarea	Statistic	Total Dissolved Solids	Nitrate as NO_3
Miracle Hill	Count	3	4
	Mean (mg/L)	558	4.8
	Median (mg/L)	440	4.2
	Mode (mg/L)	N/A	N/A
	Std. Dev. (mg/L)	250	4.1
	Range (mg/L)	390 to 845	0.5 to 10.2
	95% Confidence Interval (mg/L)	<100 to 1,178	ND to 11.2
Sky Valley	Count	4	4
	Mean (mg/L)	1,280	18.8
	Median (mg/L)	1,275	17.4
	Mode (mg/L)	N/A	N/A
	Std. Dev. (mg/L)	186	17.4
	Range (mg/L)	1,070 to 1,500	0.4 to 40
	95% Confidence Interval (mg/L)	984 to 1,576	ND to 46.5
Fargo Canyon	Count	13	13
	Mean (mg/L)	1,351	22.9
	Median (mg/L)	1,325	17.9
	Mode (mg/L)	1,800	24.8
	Std. Dev. (mg/L)	491	27
	Range (mg/L)	688 to 2,020	0.1 to 101
	95% Confidence Interval (mg/L)	1,054 to 1,648	6.6 to 39.3

ND = non-detect

There are too few data points to draw meaningful conclusions within the Desert Hot Springs Management Zone. This is a known data gap and will be identified in the monitoring portion of the final SNMP.

4 References

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Attachment A – Determination of Data Adequacy for Ambient Water Quality Calculation

ATTACHMENT A

Attachment A – Determination of Data Adequacy for Ambient Water Quality Calculation

1 Introduction

This attachment describes the methods applied and results obtained to evaluate the data adequacy of contouring water quality constituents for management zones and aquifer layers.

The volume-weighted method for determination of ambient water quality (AWQ) is used when an adequate amount of data exist for a particular management zone or aquifer layer. This method computes the average water quality based on the amount of mass of a particular constituent in storage. The mass of the constituent is determined by multiplying the water quality concentration by the amount of water in storage at a point of discrete "cell". The concentration of a discrete cell is based on either the actual data or an interpolation based on surrounding data using a water quality contour map. The contour maps are typically prepared with oversight from a professional geologist or engineer and completed in an iterative fashion using numerical and hand contouring methods.

During the stakeholder review process for Draft TM-2, the following comments were submitted:

- What is considered "sufficient" data for the volume weighted method of Ambient Water Quality determination? (Pages 9, 34, 39).
- S 2.2.3: The spatial filter is described as calculating a cell-layer average based upon the baseline well concentrations. This method does not account for water quality data that shows a trend in concentration.
- Section 2, Ambient Water Quality Methods: In response to "single concentration value that is representative of water quality within a management zone for a particular constituent and time period", MSWD does not agree. The management zones are essentially the sub basins which can have inherently different characteristics within different areas. More refinement is necessary to identify subareas within the management zones. Also more attention should be given to the production areas. The spatial and temporal approach does not accurately reflect actual conditions. It should be focused on pumping areas. In addition, averaging the data set over the past 20 years isn't appropriate. The present ambient levels are more relevant data sets.
- The use of water quality data collected from 1994 to 2013 for the calculation of AWQ is unacceptable particularly in the case of Coachella Valley because it blurs the effect of recent discharge/recharge activities.

Determination of data adequacy for contouring the water quality of an aquifer layer within a particular management zone is not a well-defined undertaking, but it is essential for applying the volume-weighted method. A determination of data adequacy through strictly quantitative methods has not been made within any other SNMPs within the state; typically, it is based on professional judgment. This attachment describes the methods applied to determine how management zones and aquifer layers ambient water quality will be represented, specifically, if there is sufficient data to contour water quality. The determination of adequacy is based on the following key factors:

- Spatial distribution of data points – the physical location of data points within a management zone or aquifer layer has a marked effect on the ability to approximate values with certainty
- Spatial autocorrelation – the assumption that one value is more related to nearby points and less related to distant points.
- Supporting statistics – the underlying summary statistics must support high or low autocorrelation and can assist in the decision to develop a contoured surface.

This attachment provides an evaluation of these factors for management zones and aquifer layers over different periods of time. At the conclusion of this attachment are recommendations for the most appropriate method of AWQ calculation—volume-weighted method or statistical summary—based on the available data.

2 Evaluation Methods

The following subsections provide a description of the evaluation methods applied to determine the suitability of data for contouring to calculate the ambient water quality. No single method can determine the suitability of data for contouring. When spatial distribution of data points is considered with autocorrelation and standard statistics, insight can be gained regarding whether it is reasonable to contour a data period for a particular management zone or aquifer layer.

2.1.1 Spatial Distribution

Unlike population or topographic data, which are usually obtainable in whatever quantity is needed to construct accurate contour maps; data from the subsurface is uncommon and not obtained without some cost. Therefore, any map of subsurface characteristics, including water quality in this case, is subject to individual interpretation. The two-dimensional areal extent of the data (spatial distribution of the data) used to prepare the map reduces uncertainty and drives the method of contouring (Tearpock and Bischke, 2003).

Spatial distribution is an important consideration when determining ambient water quality. Spatial distribution is the two-dimensional arrangement of data points within the desired area of analysis; this area may be a management zone or a particular aquifer layer within a management zone. A graphical display of spatial distribution summarizes the locations of data. Ideally, when approximating water quality concentration, data collected should be well-disturbed across the area of analysis. If the data is not well distributed spatially, ambient water quality determined from the data may be skewed, favoring the water quality of the particular area where data is available. Patterns of data points can be categorized into three classes, regular, random, and aggregated, as shown in **Figure 1**. The distribution patterns range from regular, the most uniform pattern where every point is equidistant, to an aggregated pattern where there probability of another point varies in some inverse manner with the distances of pre-existing points (Davis, 2002). To evaluate the spatial distribution, maps of data points for varying time periods and water quality constituents are plotted, evaluated and described as one of these patterns.

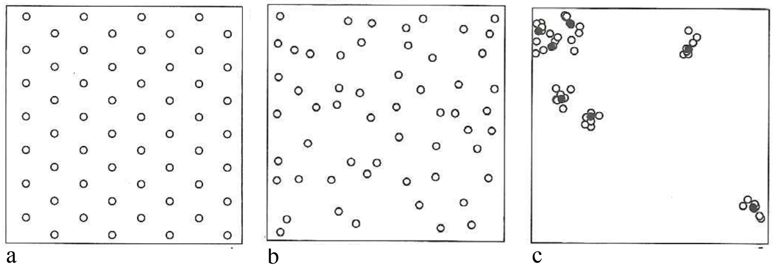


Figure 1
Spatial Distribution of Points, a) Regular, b) Random, and c) Aggregated
(After Davis, 2002)

2.1.2 Spatial Autocorrelation

Spatial autocorrelation is a measure of dependency among data points with respect to geographic location. A common definition of spatial autocorrelation states that pairs of subjects that are close to each other are more likely to have values that are more similar, and pairs of subjects far apart from each other are more likely to have values that are less similar (Griffith, 1987). The spatial structure of the data refers to any patterns that may exist. Gradients or clusters are examples of spatial structures that are positively correlated, whereas negative correlation may be exhibited in a checkerboard pattern where subjects appear to be dispersed relative to each other. If no pattern is apparent, correlation lies between these two extremes and the data appears random. When a dataset has significant positive spatial autocorrelation, it suggests higher confidence in predicting the value at one location based on the value sampled from a nearby location when using data interpolation methods. Thus, a statistically significant positive autocorrelation supports the decision to contour. Note that data within a specific management zone that has very small variance will have a low spatial autocorrelation, but this does not necessarily imply that contouring is not appropriate.

ArcGIS, a geographic information system (GIS) for working with maps and geographic information, includes tools to evaluate spatial autocorrelation within a dataset. These tools evaluate the Global Moran's I statistic for a particular dataset and test the significance of the resulting statistic. This statistic measures spatial autocorrelation within a single quantitative variable. The Global Moran's I statistic takes the form of a correlation coefficient using the difference between each sample value and the mean of a variable at some distance threshold. The distance threshold is the distance been points being evaluated. The Moran's I for spatial autocorrelation is given as (ESRI, 2015):

$$I = \frac{n}{S_0} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j} z_i z_j}{\sum_{i=1}^{n} z_i^2}$$

Z_i is the deviation of an attribute (concentration in this case) for feature point *i* from its mean (x_i – X), $w_{i,j}$ is the spatial weight between features *i* and *j*, n is equal to the total number of features, so S_0 is the aggregate of all the spatial weights.

$$S_0 = \sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j}$$

The z_I score for the statistic is computed as:

$$z_I = \frac{I - \mathrm{E}[I]}{\sqrt{\mathrm{V}[I]}}$$

Where,

$$\begin{aligned} \mathrm{E}[I] &= -1/(n-1) \\ \mathrm{V}[I] &= \mathrm{E}[I^2] - \mathrm{E}[I]^2 \end{aligned}$$

This results in coefficients ranging from (-1) to (+1), where values between (0) and (+1) indicate a positive association between variables, values between (0) and (-1) indicate a negative association, and (0) indicates there is no correlation (random) between variables. For statistical hypothesis testing, the Global Moran's I statistic can be transformed to z-scores in which values greater than 1.96 or smaller than -1.96 indicate spatial autocorrelation that is significant at the 5 percent significance level, or 95% confidence level (ESRI, 2015). Similarly, z-scores corresponding to values greater than 1.65 or smaller than -1.65 indicate spatial autocorrelation that is significant at the 10 percent significance level, or 90% confidence level. **Figure 2** illustrates spatial autocorrelation for an example dataset and the significance regions for the Global Moran's I statistic. In the evaluation of data for determination of AWQ, the resulting significance test on the positive Global Moran's I statistic is of greatest importance in determining evidence of spatial autocorrelation within the data.

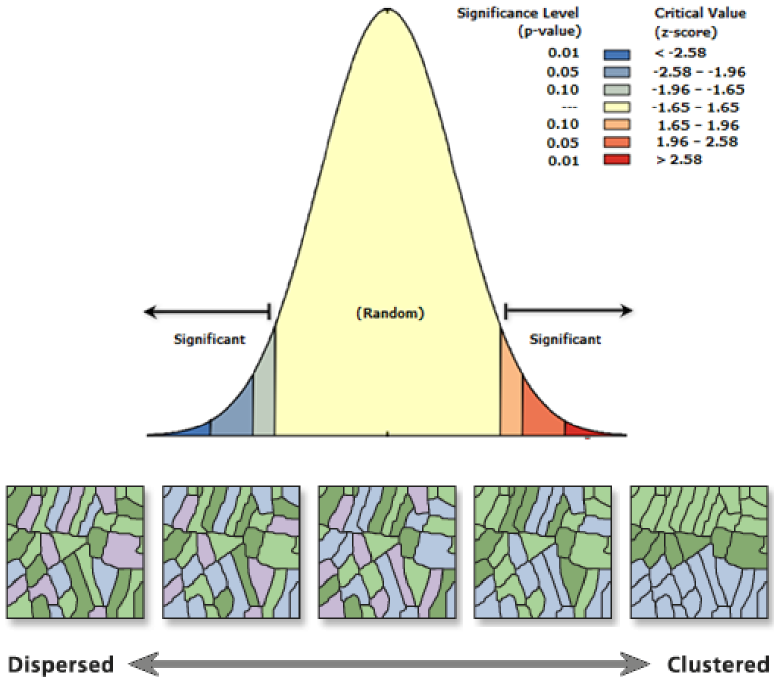


Figure 2
Spatial Autocorrelation Report Example (ESRI, 2015)

2.1.3 Descriptive Statistics

Statistical analyses of water quality data are performed and summarized for each management zone. The statistics computed in this evaluation are summarized in **Table 1**.

The statistical descriptions provide a summary of the filtered dataset, as described in Section 2.2 of TM-2, for a particular management zone, layer, and baseline period. These summaries are important for evaluating the results of the spatial autocorrelation tests and provide a general understanding of the data. Note that although statistical summaries can provide insight into the data at a macroscopic level, spatial relationships in the data are not considered.

3 Evaluation

The methods to evaluate data adequacy were presented in the previous section. These methods include evaluations of spatial distribution (two dimensional coverage of the area), spatial autocorrelation (relationship of data points that can be used for mapping/contouring given location and concentration), and descriptive statistics of each dataset. The following subsections summarize the results of these methods for each management zone and aquifer layer (when applicable) at the 5-Year, 10-Year, 15-Year, and 20-Year baseline periods.

Table 1
Summary of Statistical Values Determined for the Evaluation of Descriptive Statistics

Statistic	Description	Notes
Count	The number of data points in a given dataset	
Mean	The arithmetic mean, or average, of the dataset	Sum of the values divided by the number of values
Median	The numerical value separating the higher half of a dataset from the lower half	If there is an even number of observations, then there is no single middle value; the median is then defined to be the mean of the two middle values
Mode	The value that appears most often in a dataset	If the mode is not applicable (N/A), this indicates no value appeared more than once in a given dataset
Standard Deviation (Std. Dev.)	The standard deviation is a measure that is used to quantify the amount of variation or dispersion of a dataset	Standard deviation is the square root of the average of the squared differences of the values from their average value
Range	The minimum and maximum values of a dataset	
95% Confidence Interval (95% CI)	Two-tailed confidence interval on the mean using the t-distribution at a 0.05 significance level: uses t-distribution as the true population mean and standard deviation is unknown.	Interpreted as a 95% chance that the confidence interval contains the true population mean

It is the intent of this study to describe ambient water quality by aquifer layer when the data permits and aggregate each aquifer layer with a management zone. As described in TM-1 (MWH, 2014), two groundwater models were obtained for as the primary basis for quantifying the vertical and horizontal extent of the groundwater systems. These models cover the Whitewater, Garnet Hill, and Mission Springs subbasins. CVWD (Fogg *et al.*, 2002) developed a groundwater model of the Whitewater and Garnet Hill Subbasins as part the 2002 Water Management Plan (MWH, 2002). The geometry (cell size, layering, and orientation) for this model was used as the base for the recently completed Mission Creek and Garnet Hill Subbasins groundwater model (Psomas, 2013). The layering of these groundwater models was based on a best estimate of basin lithologic characteristics. The layering is used to categorize areas of the aquifer, e.g., perched aquifer, deep aquifer. When evaluating groundwater quality, well screen intervals were used to categorize a well into a particular model layer. This allows for a general quantification of measurements and quality with depth. Based on the available well construction information and water quality data, the West Whitewater and East Whitewater were separated into three layers. The Mission Creek management zone was evaluated as a two layer and single aquifer system to determine what the level of evaluation the data would allow. Results of the evaluation are listed by aquifer layer for the West and East Whitewater Management Zones as well as the Mission Creek Management Zone.

3.1 SPATIAL DISTRIBUTION OF DATA POINTS

Figure 3 through **Figure 7** provide the spatial data distribution of filtered data points, as described in Section 2.2, for TDS and nitrate (as NO_3) for management zones and aquifer layers at the 5-Year, 10-Year, 15-Year, and 20-Year baseline periods. The objective is to provide graphical representation of the spatial distribution for visual inspection.

For general reference, **Table 2** provides a listing of the data density, the square miles associated with each data point by management zone, aquifer layer (if applicable), and baseline period.

Listed below in **Table 3** through **Table 9** are descriptions of the spatial data distribution prepared following visual inspection of **Figure 3** through **Figure 7**. These tables present a qualitative summary of the spatial data distribution, as well as any specific observations. This qualitative summary is subjective and was prepared by a Professional Geologist. The description of the spatial data points is as follows:

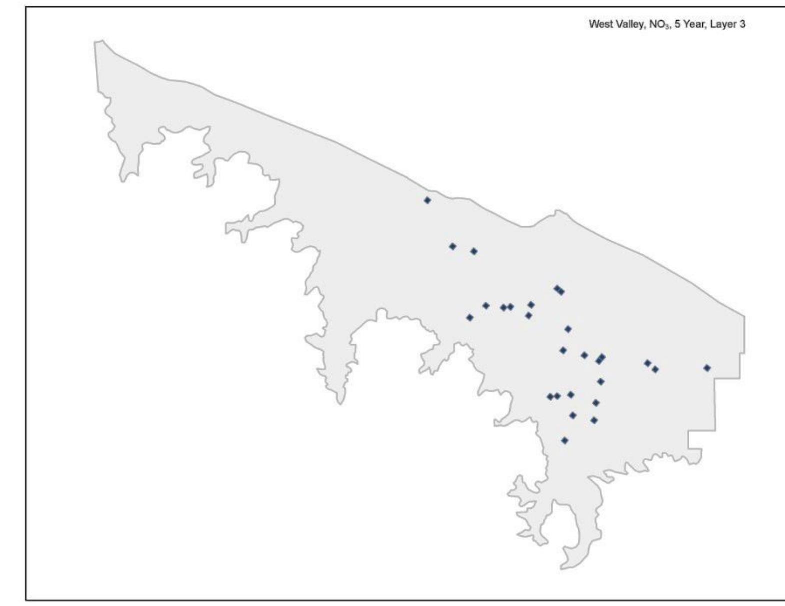
- Poor: Lack of data points or aggregated data points that would not lend themselves to approximating concentration across a management zone or aquifer layer.
- Fair: Data points are somewhat random or distributed in spatial distribution, areas lacking data are present.
- Good: Data points are random or distributed in spatial distribution

Table 2
Summary of Data Density (Square Miles per Data Point)

Management Zone	Baseline Period	5-Year Baseline					
		Layer 1		Layer 2		Layer 3	
		TDS	Nitrate	TDS	Nitrate	TDS	Nitrate
West Whitewater	5-Year Baseline	21	21	30	25	5	5
East Whitewater		15	15	24	24	10	10
Mission Creek[1]		48	48	24	24	7	5
Garnet Hill		-	-	N/A	N/A	N/A	N/A
Miracle Hill		16	8	N/A	N/A	N/A	N/A
Sky Valley		11	11	N/A	N/A	N/A	N/A
Fargo Canyon		6	6	N/A	N/A	N/A	N/A
West Whitewater	10-Year Baseline	19	19	17	15	5	5
East Whitewater		9	9	11	11	8	8
Mission Creek1		8	8	24	24	3	2
Garnet Hill		7	7	N/A	N/A	N/A	N/A
Miracle Hill		16	8	N/A	N/A	N/A	N/A
Sky Valley		9	9	N/A	N/A	N/A	N/A
Fargo Canyon		5	5	N/A	N/A	N/A	N/A
West Whitewater	15-Year Baseline	11	11	5	5	4	4
East Whitewater		6	6	6	6	6	6
Mission Creek1		8	8	12	12	2	2
Garnet Hill		5	5	N/A	N/A	N/A	N/A
Miracle Hill		5	4	N/A	N/A	N/A	N/A
Sky Valley		9	9	N/A	N/A	N/A	N/A
Fargo Canyon		5	5	N/A	N/A	N/A	N/A
West Whitewater	20-Year Baseline	9	9	4	4	4	4
East Whitewater		4	4	4	4	4	4
Mission Creek1		8	8	12	12	2	2
Garnet Hill		5	5	N/A	N/A	N/A	N/A
Miracle Hill		5	4	N/A	N/A	N/A	N/A
Sky Valley		9	9	N/A	N/A	N/A	N/A
Fargo Canyon		5	5	N/A	N/A	N/A	N/A

1. Layer 3 represents the aggregated "No Layer" option for Mission Creek Management Zone

Figure 3
West Whitewater River Data Point Spatial Distribution for Different Baseline Periods
(Three Aquifer Layers)

<table>
<tr><th>Baseline Period</th><th>Constituent</th><th>Layer 1</th><th>Layer 2</th><th>Layer 3</th></tr>
<tr><td rowspan="2">5-Year</td><td>Nitrate Data Points</td><td>
</td><td>
</td><td>
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<tr><td>TDS Dtata Points</td><td>
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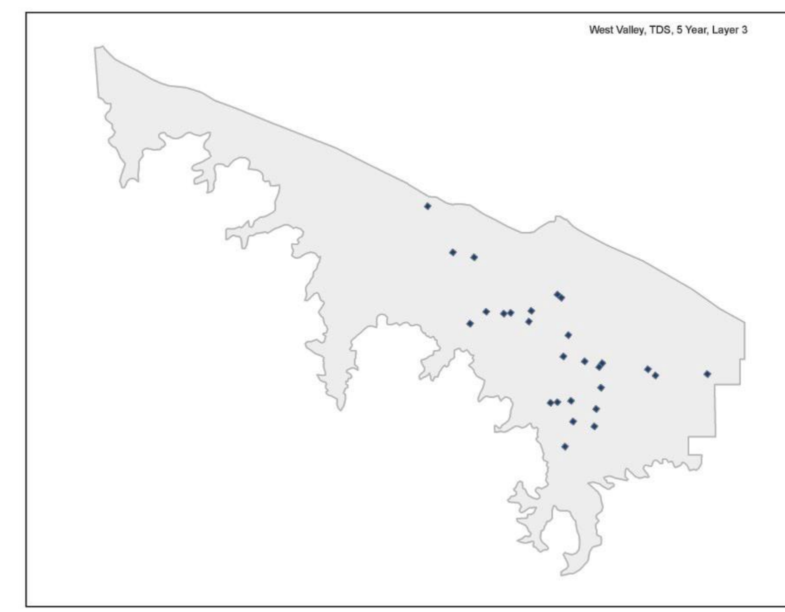
</td><td>
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Figure 3 (CONTINUED)
West Whitewater River Data Point Spatial Distribution for Different Baseline Periods
(Three Aquifer Layers)

<table>
<tr><th>Baseline Period</th><th>Constituent</th><th>Layer 1</th><th>Layer 2</th><th>Layer 3</th></tr>
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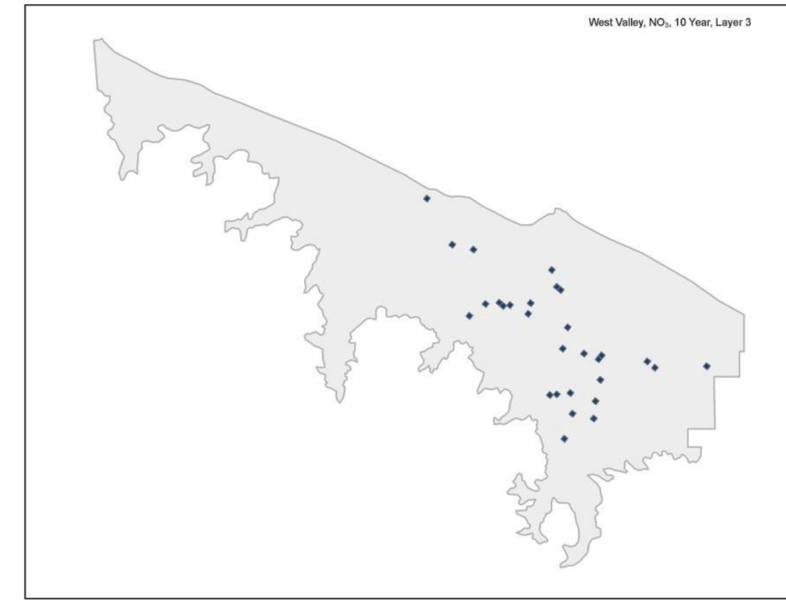
</td><td>
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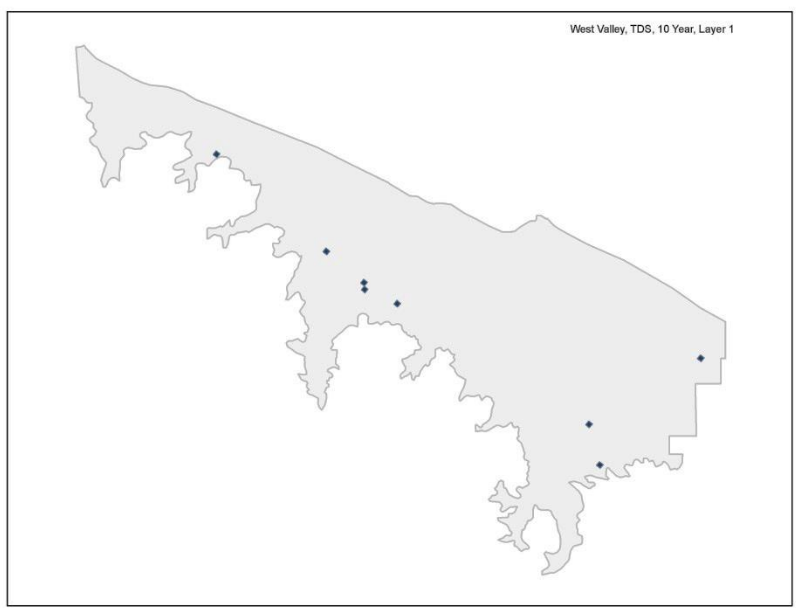
<tr><td>TDS Dtata Points</td><td>
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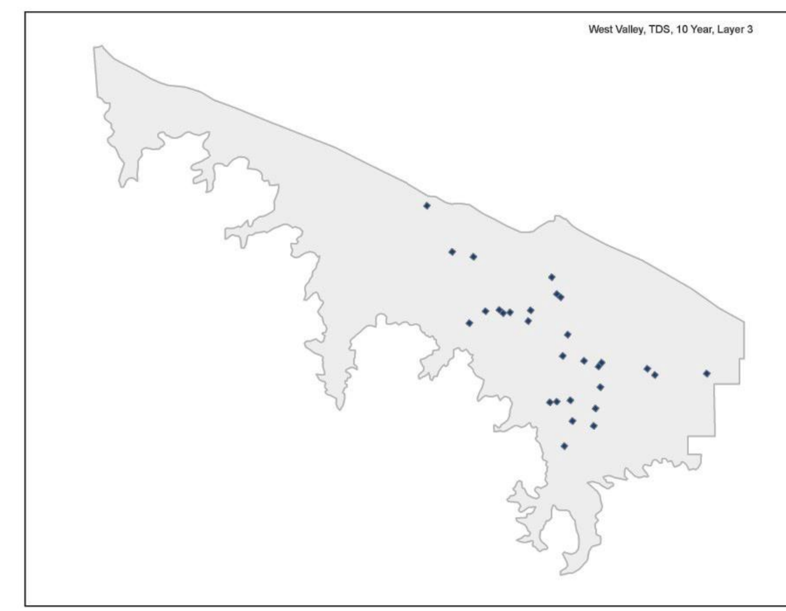
</td><td>
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Figure 3 (CONTINUED)
West Whitewater River Data Point Spatial Distribution for Different Baseline Periods
(Three Aquifer Layers)

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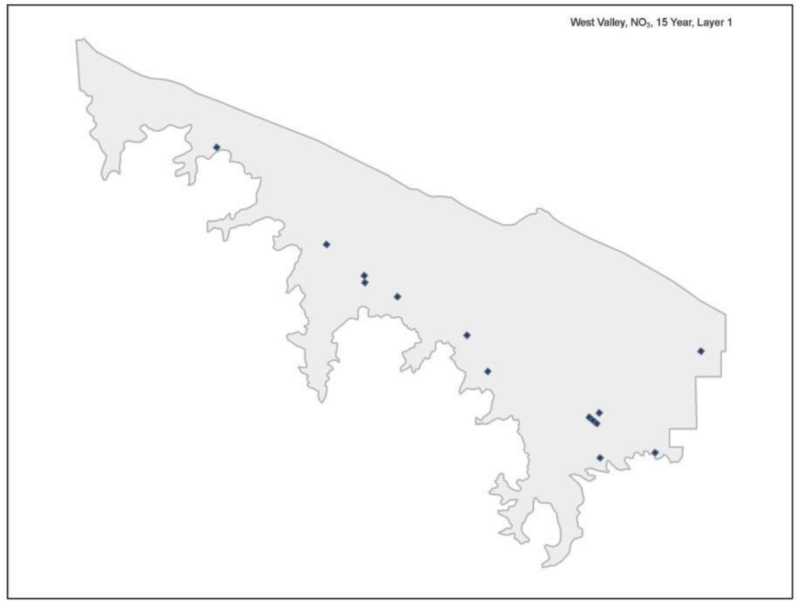
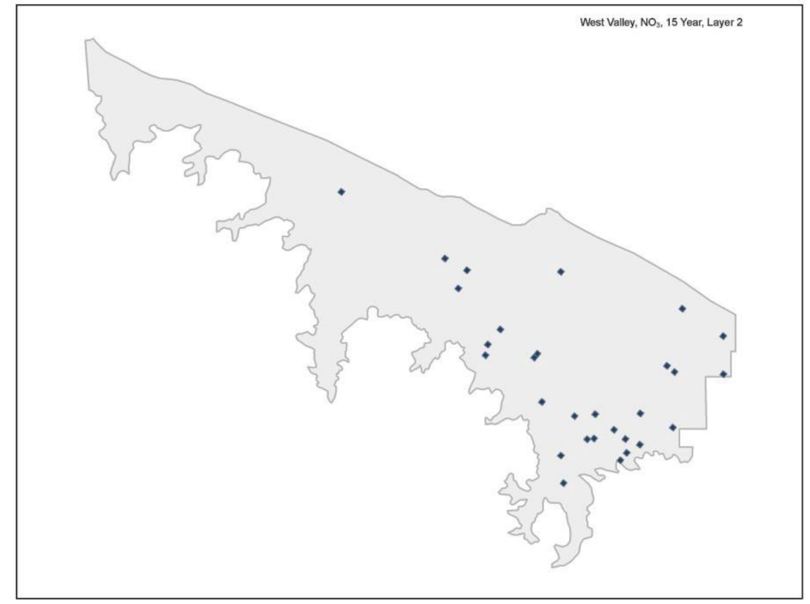
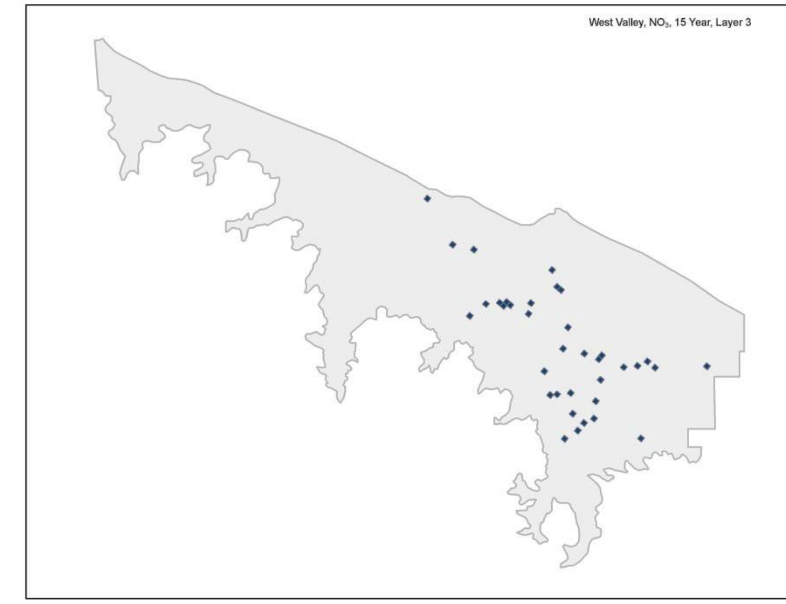
<tr><td rowspan="2">15-Year</td><td>Nitrate Data Points</td><td>
</td><td>
</td><td>
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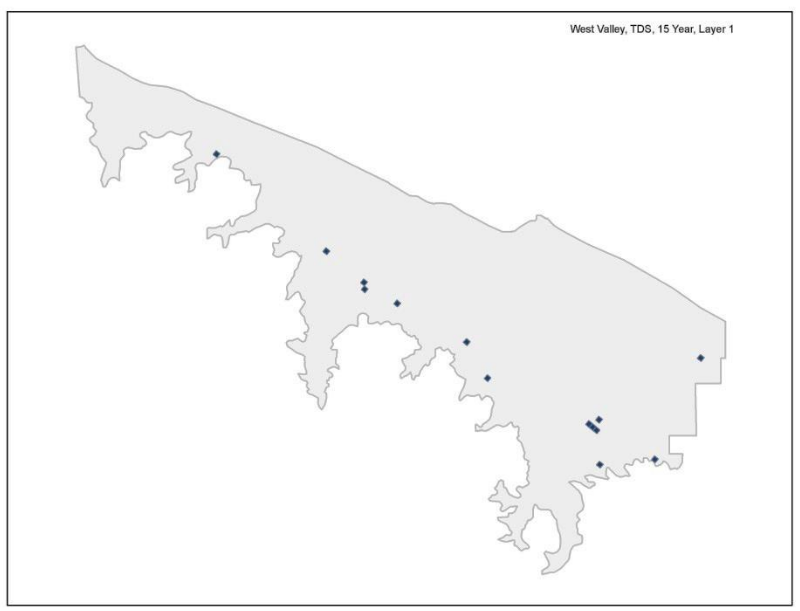
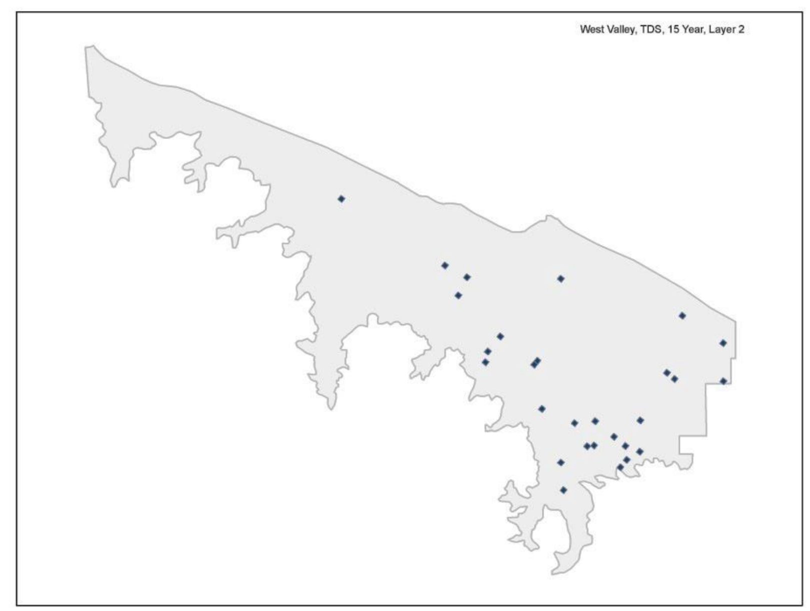
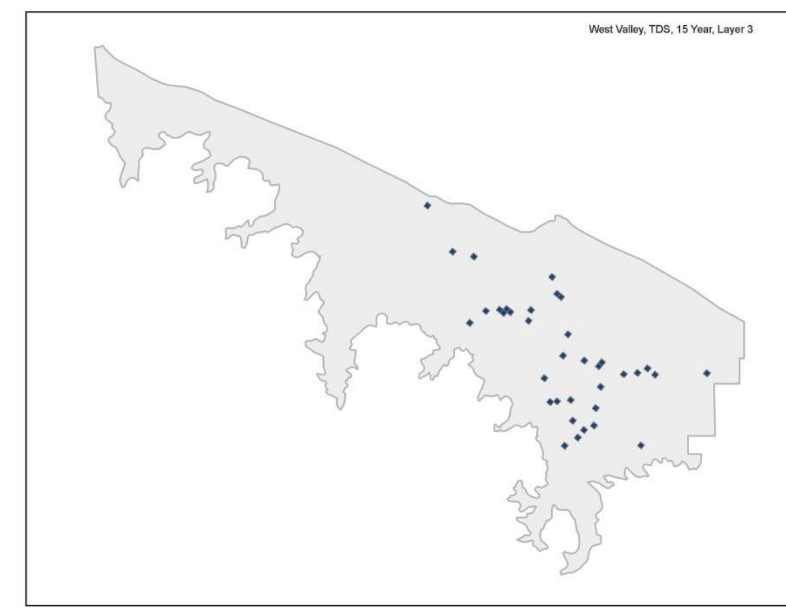
<tr><td>TDS Dtata Points</td><td>
</td><td>
</td><td>
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Figure 3 (CONTINUED)
West Whitewater River Data Point Spatial Distribution for Different Baseline Periods
(Three Aquifer Layers)

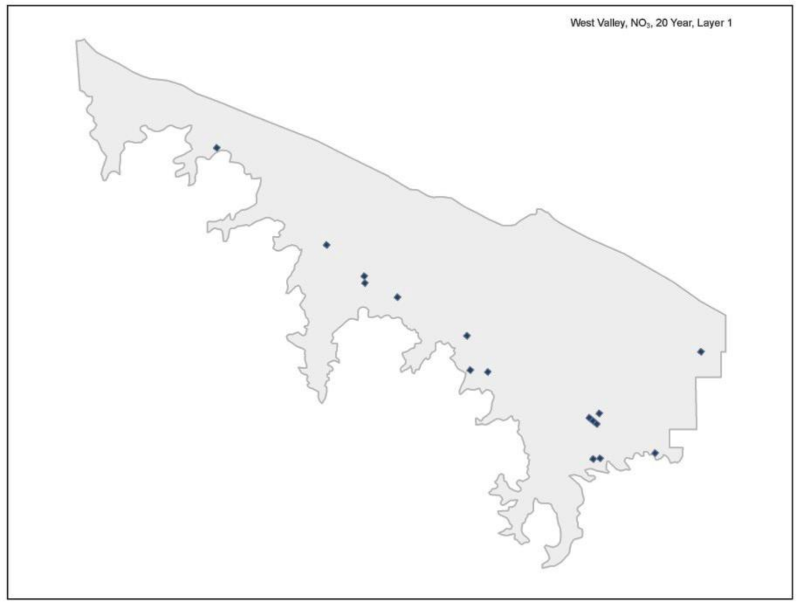
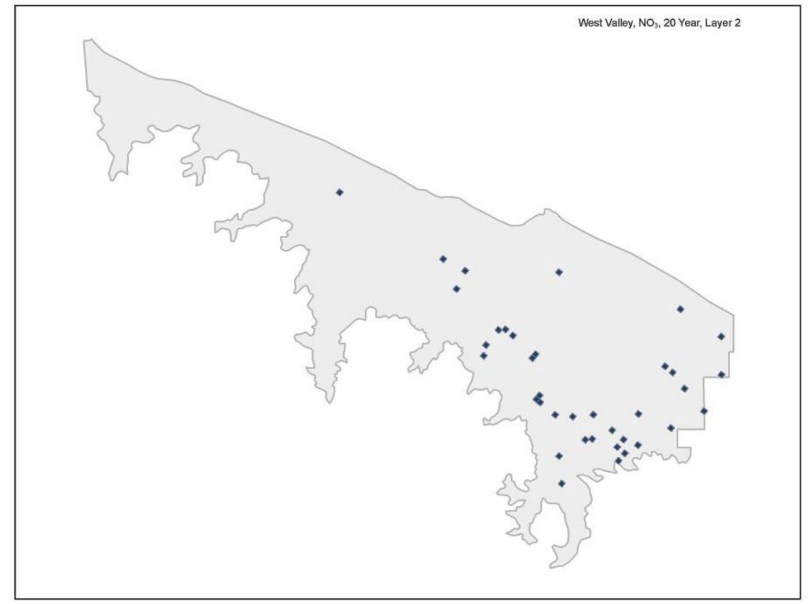
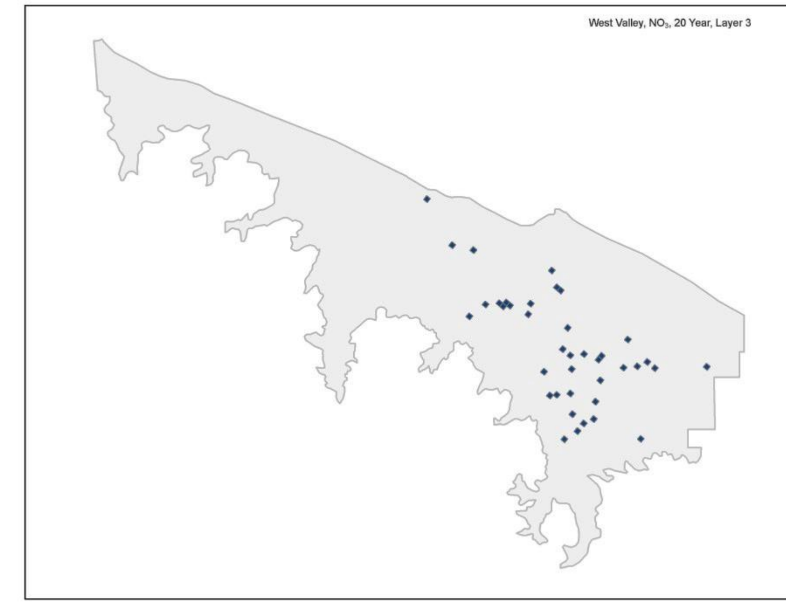
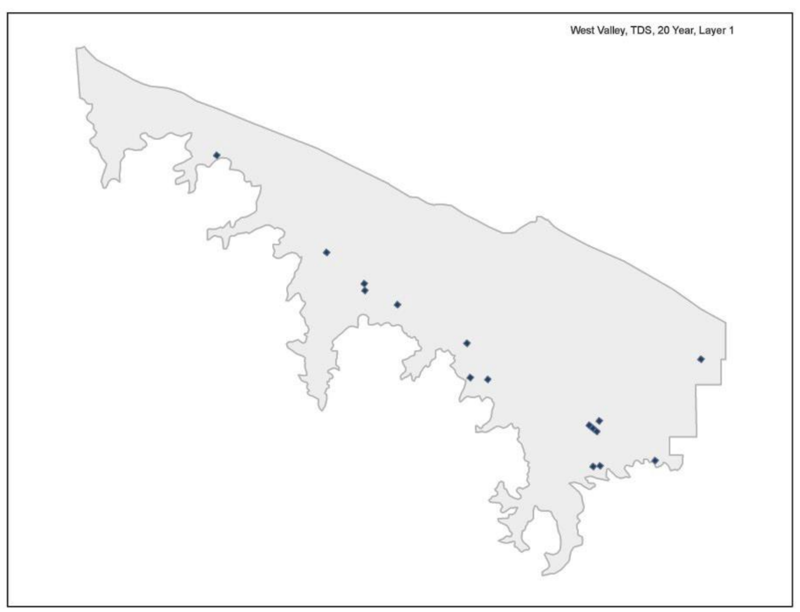
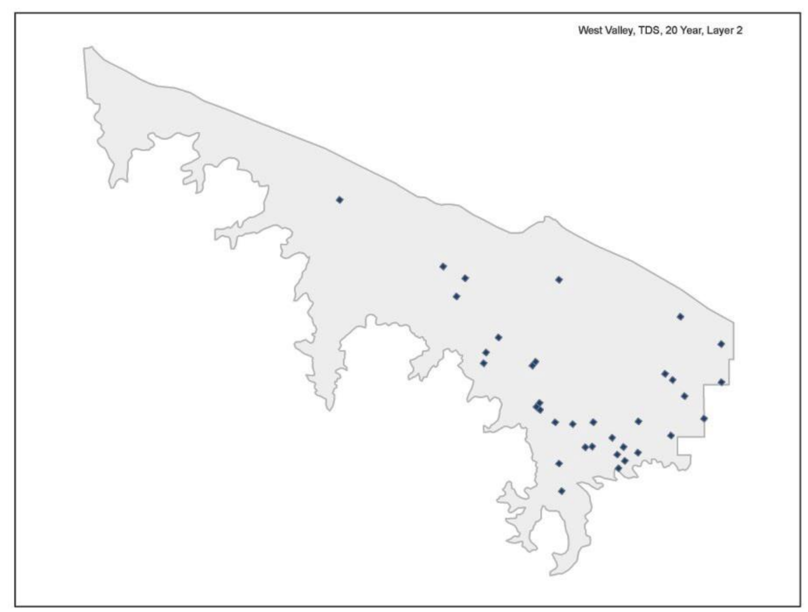
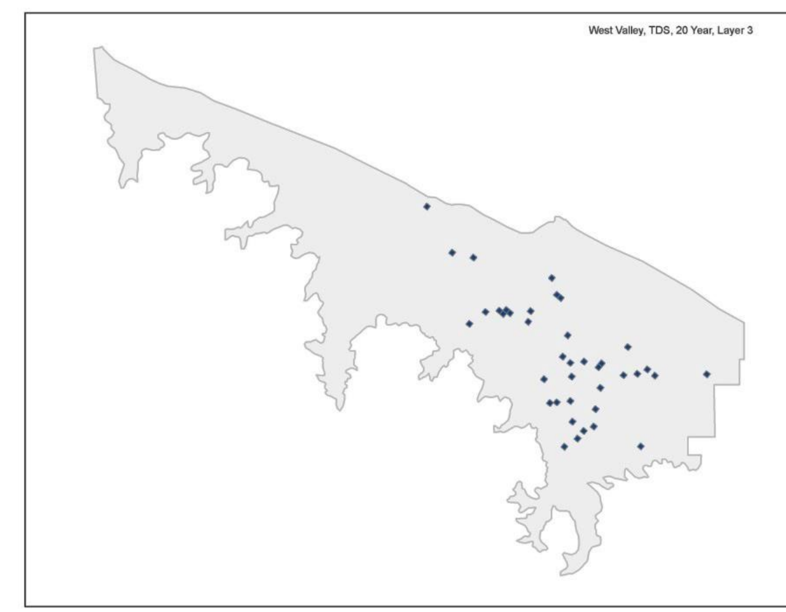
Baseline Period	Constituent	Layer 1	Layer 2	Layer 3
20-Year	Nitrate Data Points			
	TDS Dtata Points			

Figure 4
East Whitewater River Data Point Spatial Distribution for Different Baseline Periods
(Three Aquifer Layers)

Baseline Period	Constituent	Layer 1	Layer 2	Layer 3
5-Year	Nitrate Data Points			
	TDS Dtata Points			

Figure 4 (CONTINUED)
East Whitewater River Data Point Spatial Distribution for Different Baseline Periods
(Three Aquifer Layers)

(Three Aquifer Layers)

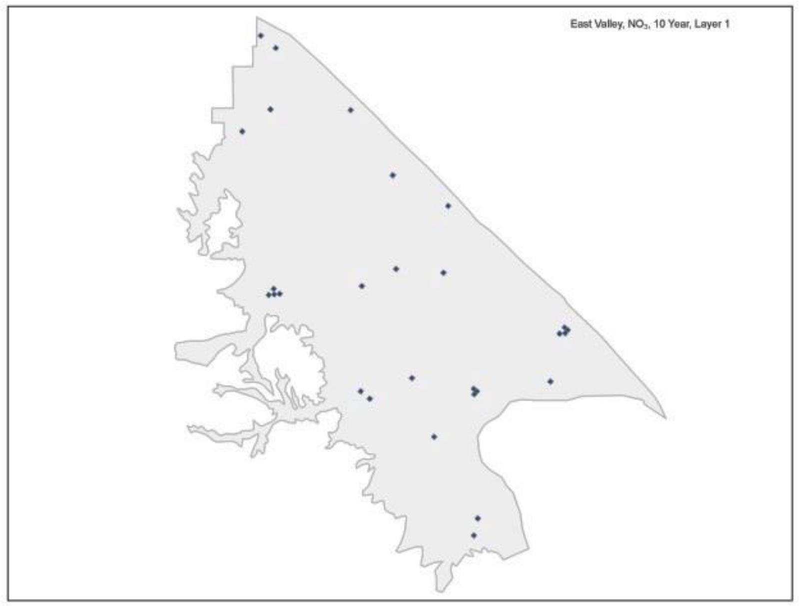
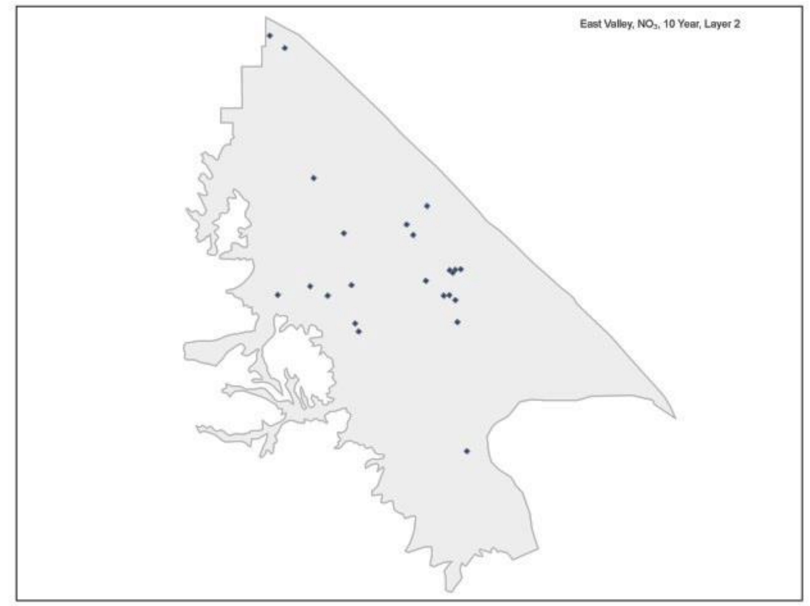
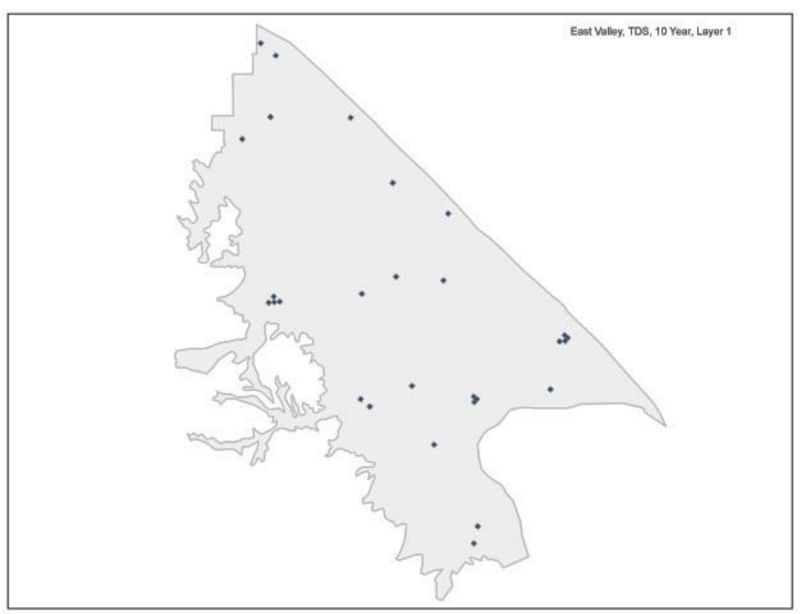
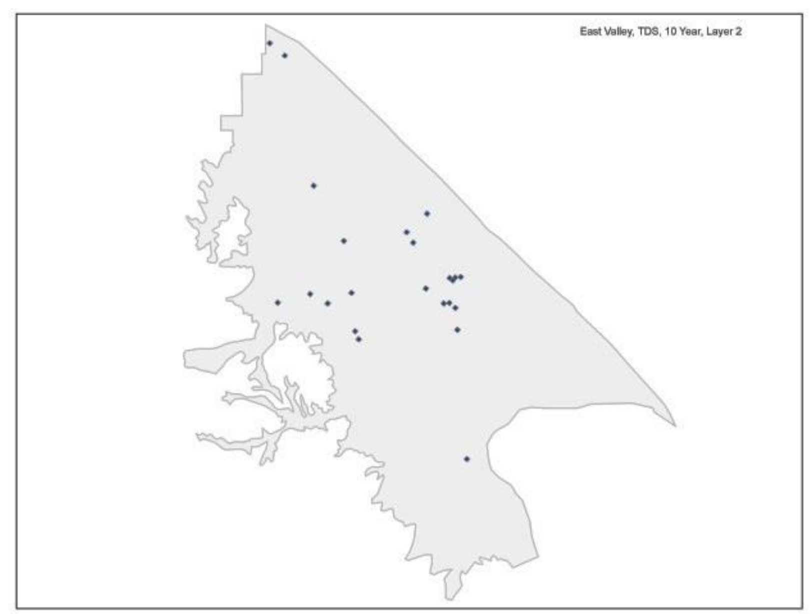
Baseline Period	Constituent	Layer 1	Layer 2	Layer 3
10-Year	Nitrate Data Points			
	TDS Dtata Points			

Figure 4 (CONTINUED)
East Whitewater River Data Spatial Point Distribution for Different Baseline Periods
(Three Aquifer Layers)

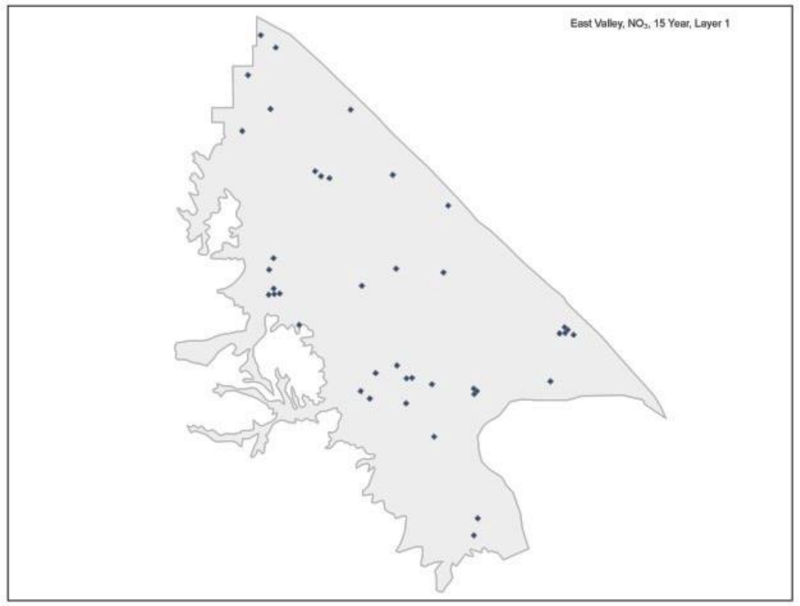
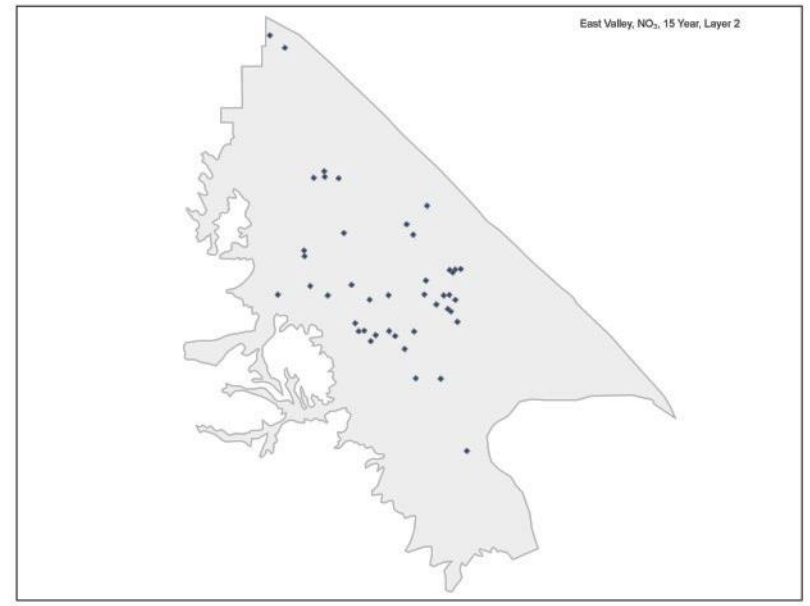
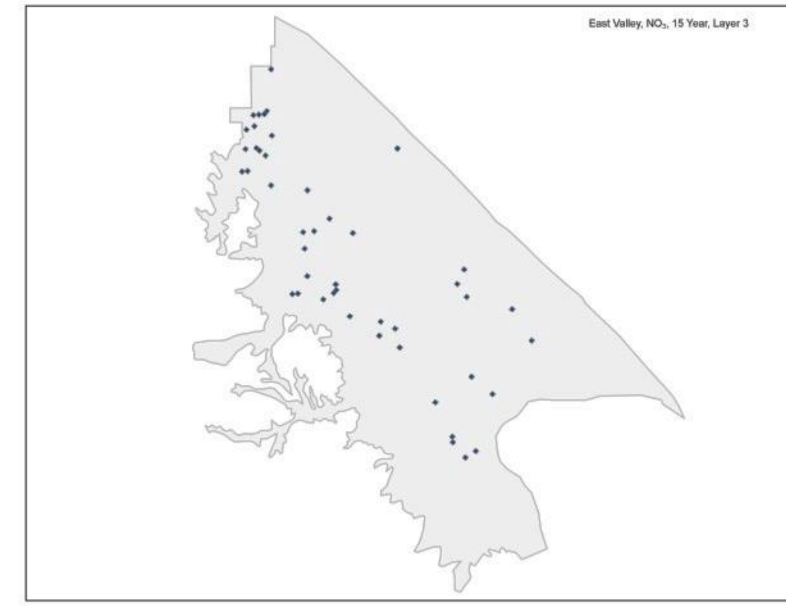
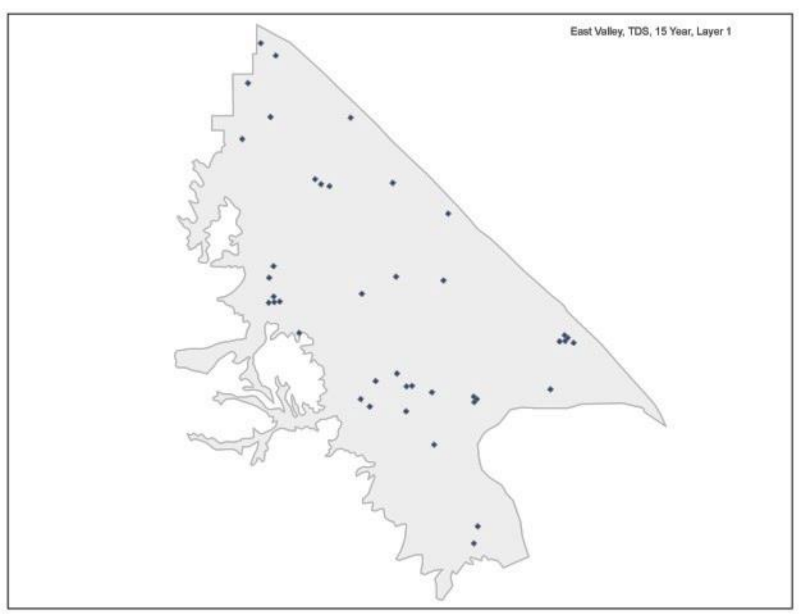
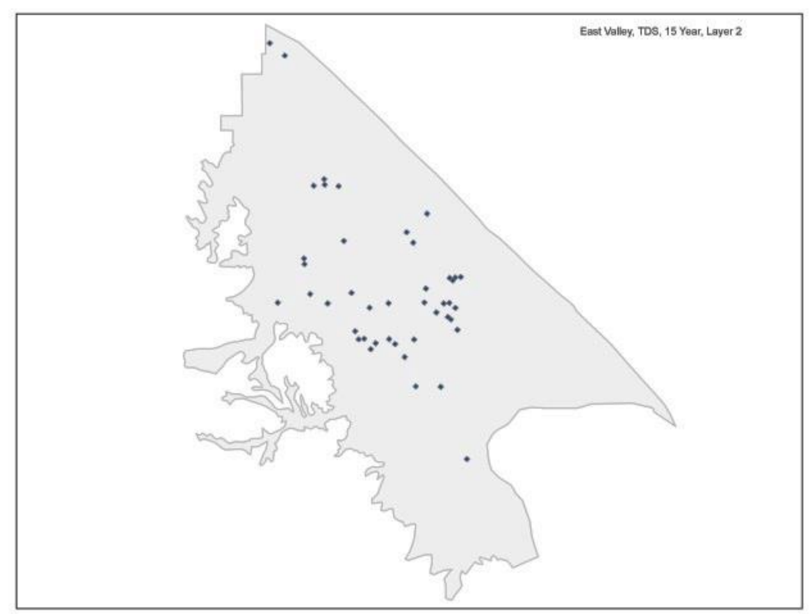
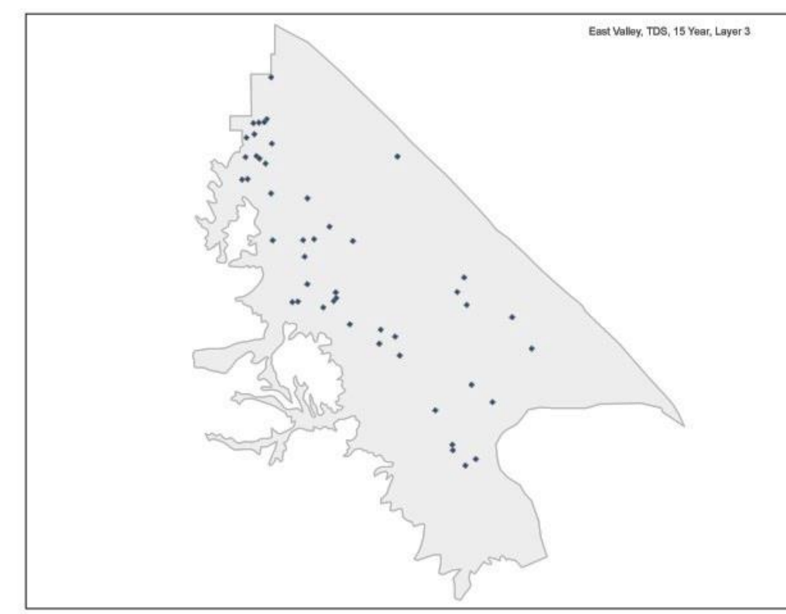
Baseline Period	Constituent	Layer 1	Layer 2	Layer 3
15-Year	Nitrate Data Points			
	TDS Dtata Points			

Figure 4 (CONTINUED)
East Whitewater River Data Point Spatial Distribution for Different Baseline Periods
(Three Aquifer Layers)

<table>
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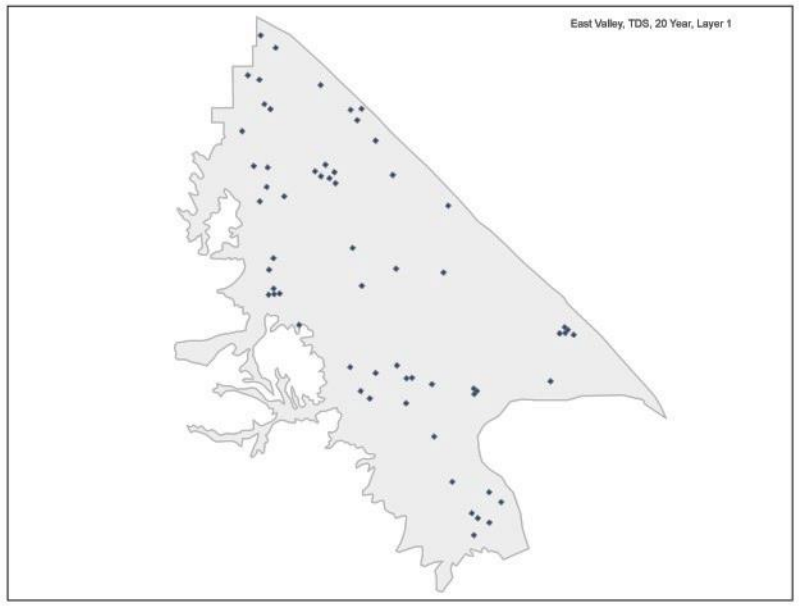
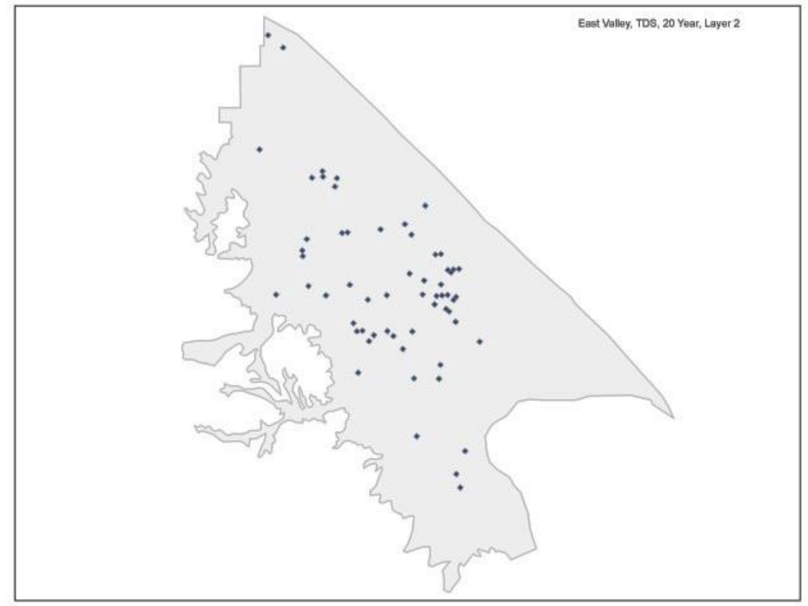
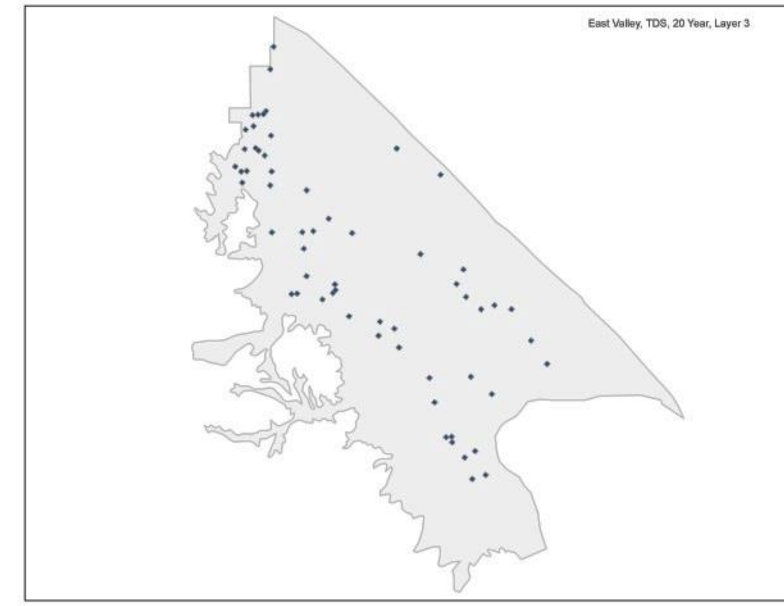
<tr><td rowspan="2">20-Year</td><td>Nitrate Data Points</td><td>
</td><td>
</td><td>
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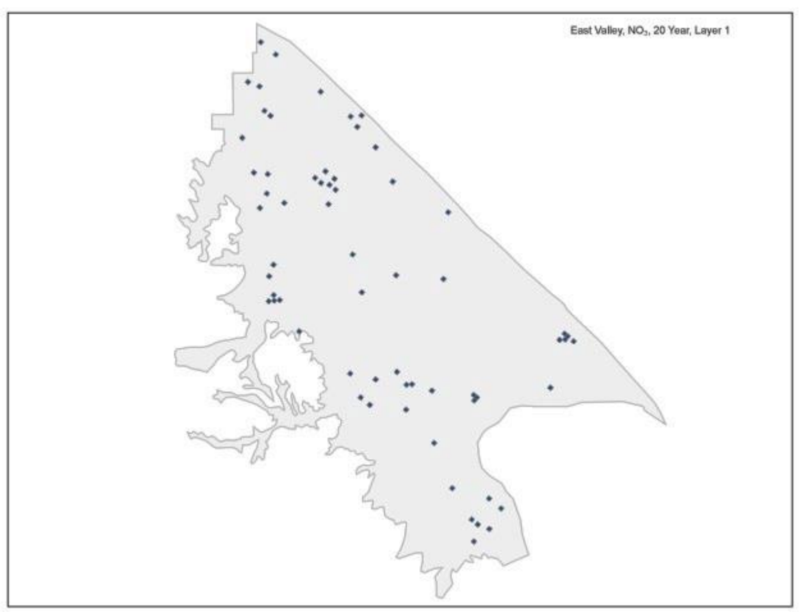
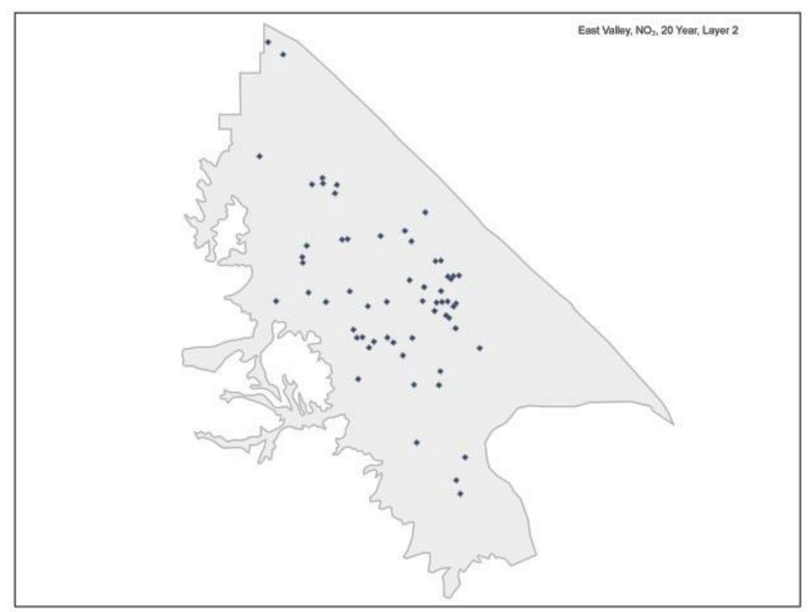
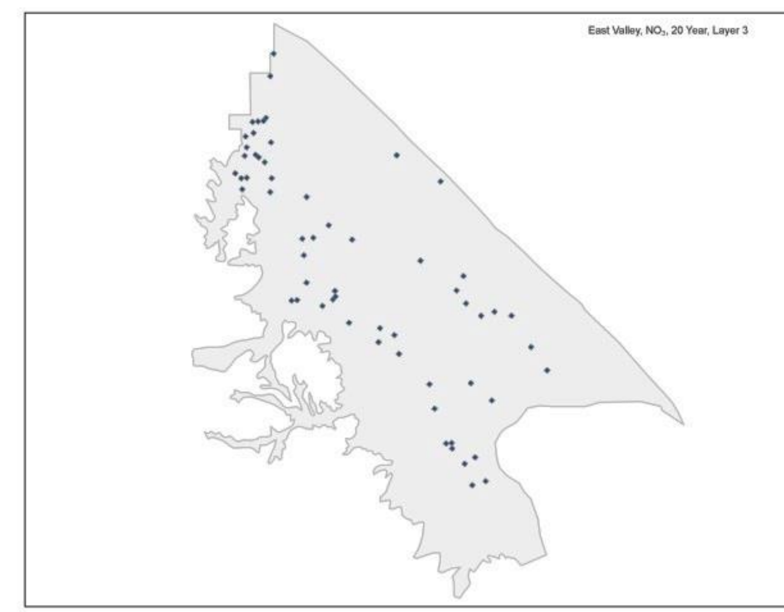
<tr><td>TDS Dtata Points</td><td>
</td><td>
</td><td>
</td></tr>
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Figure 5
Mission Creek Data Point Spatial Distribution for Different Baseline Periods
(No Aquifer Layering)

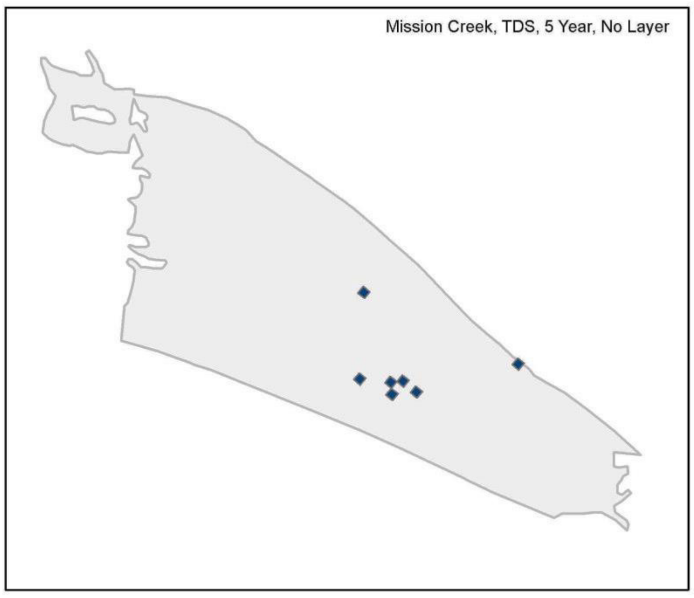
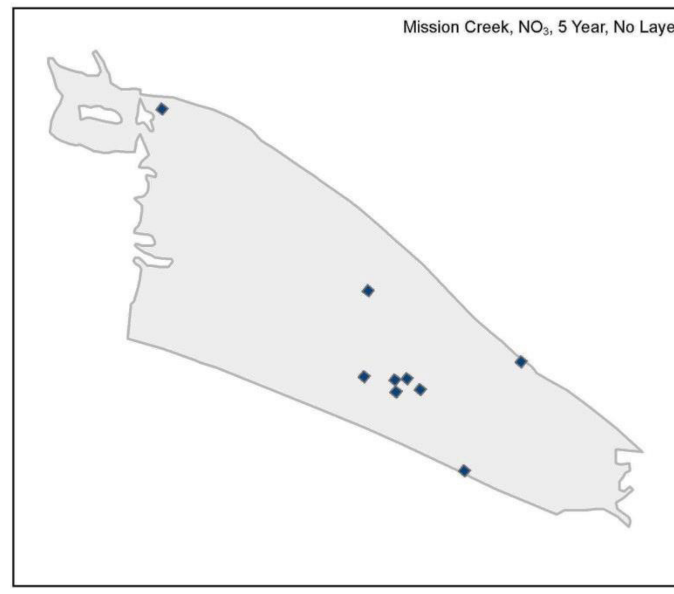
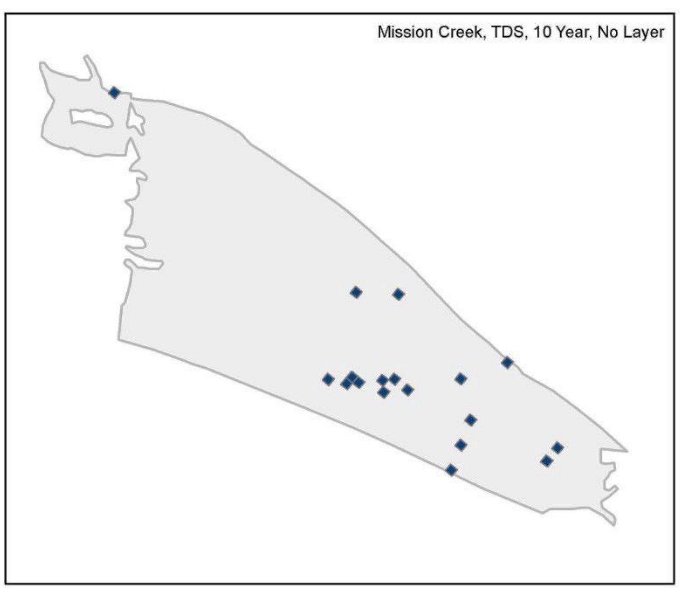
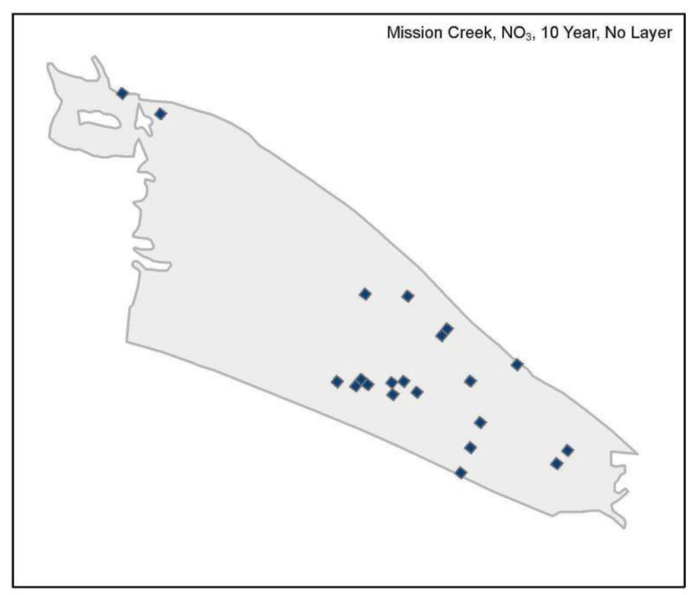
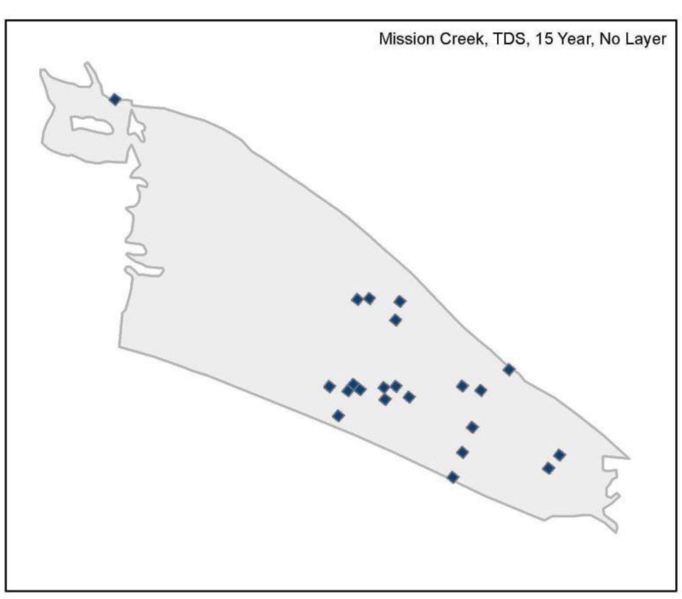
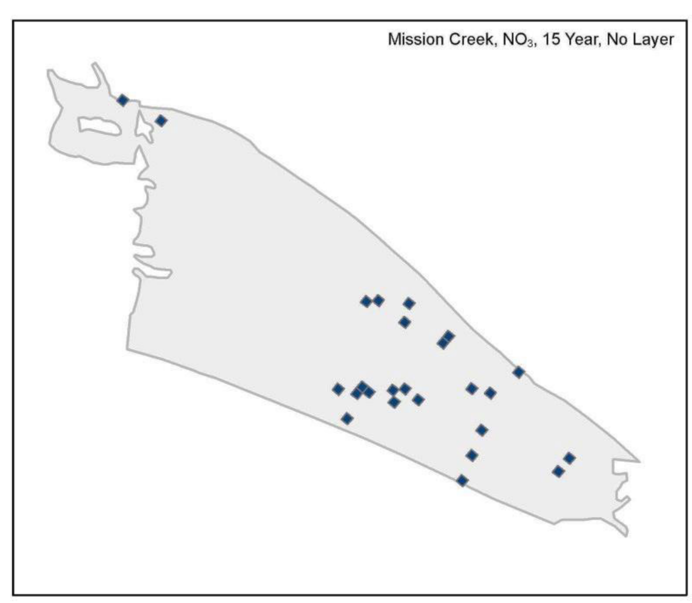
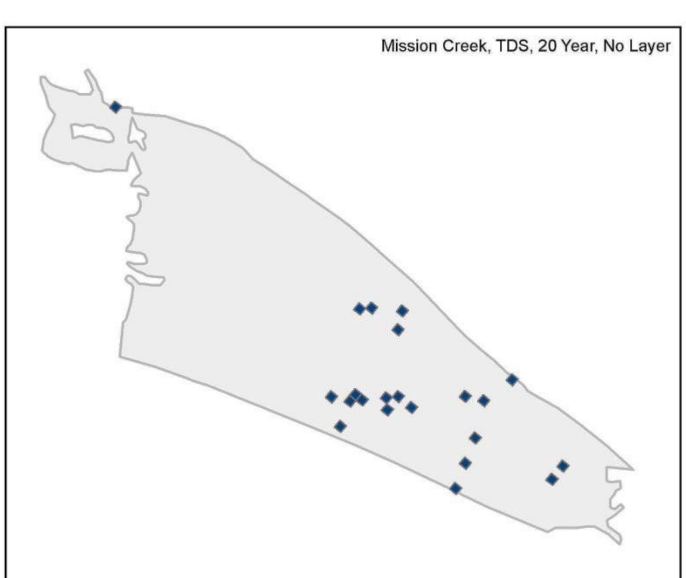
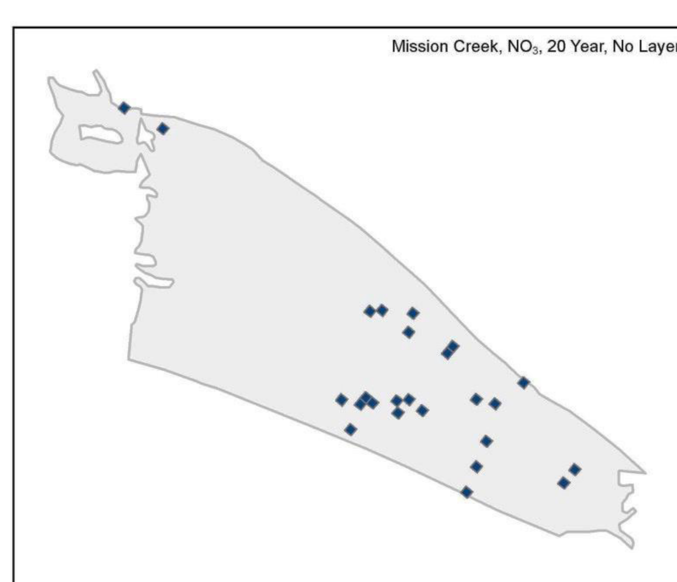
Baseline Period	TDS Data Point	Nitrate Data Points
5-Year		
10-Year		
15-Year		
20-Year		

Figure 6
Garnet Hill Data Point Spatial Distribution for Different Baseline Periods
(No Aquifer Layering)

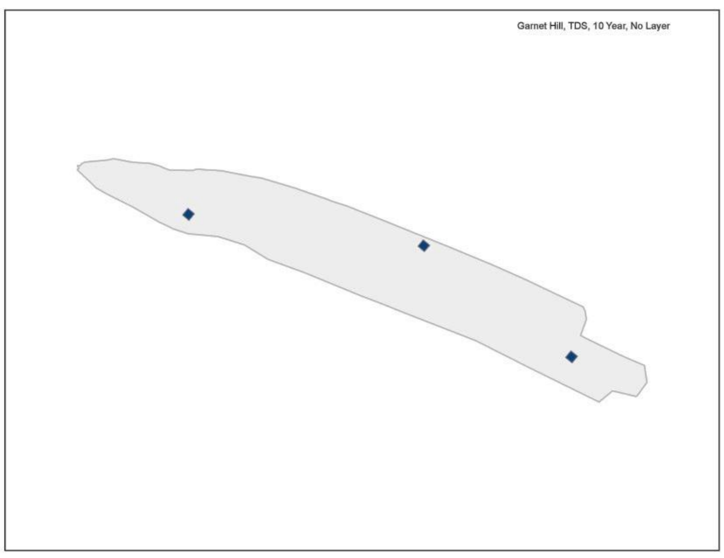
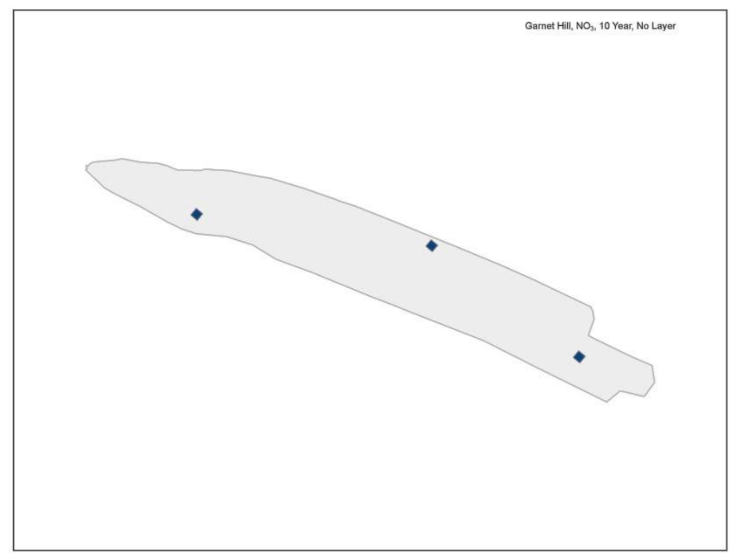
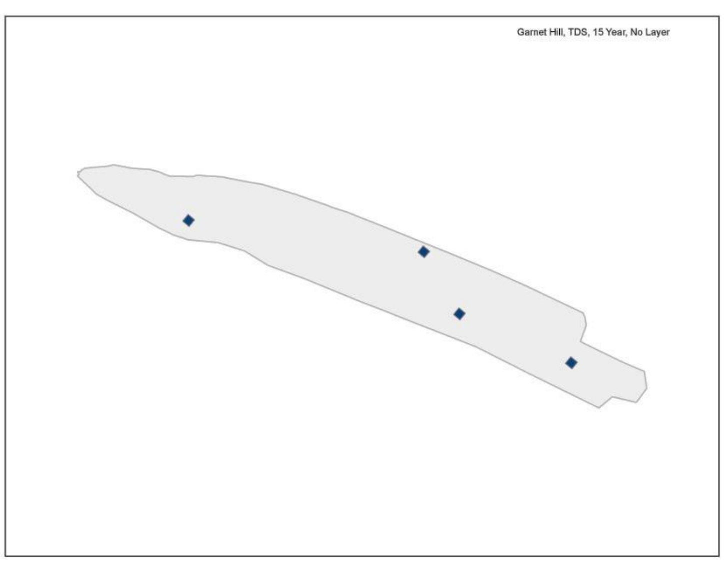
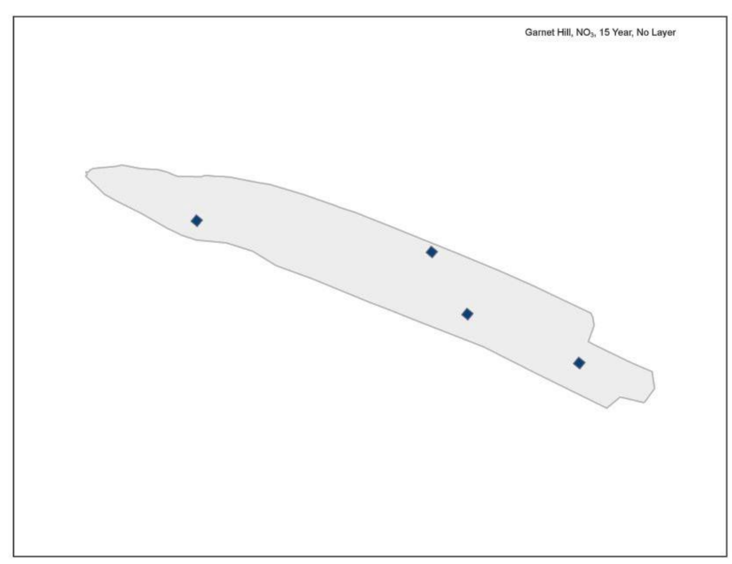
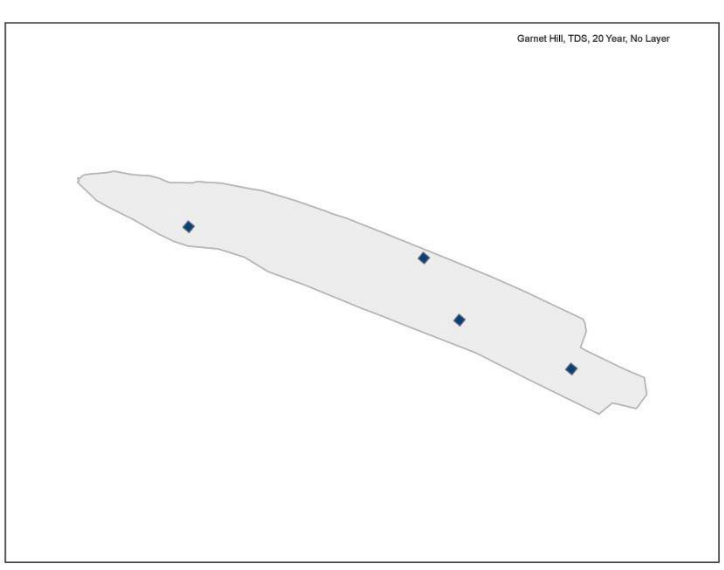
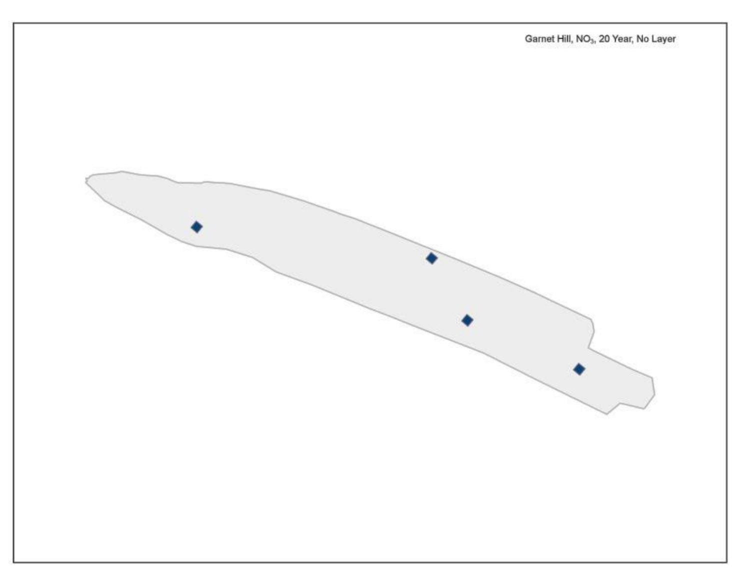
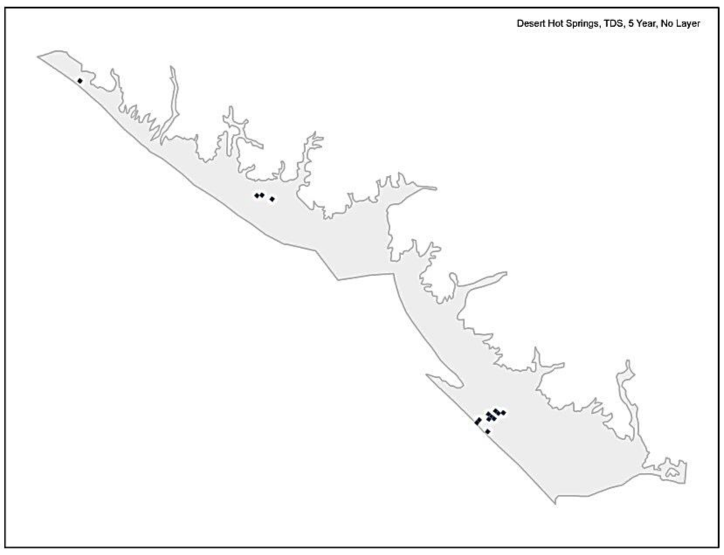
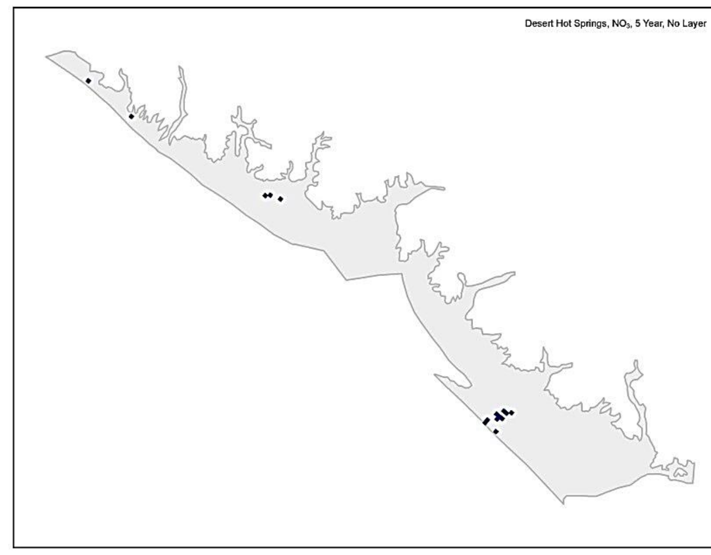
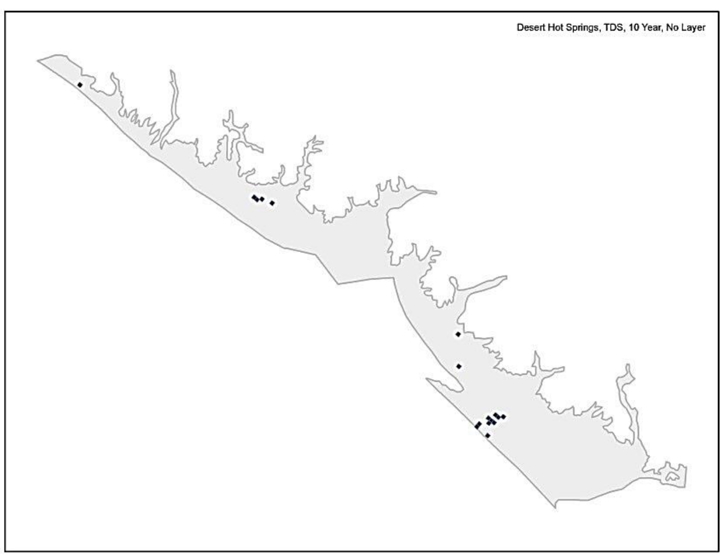
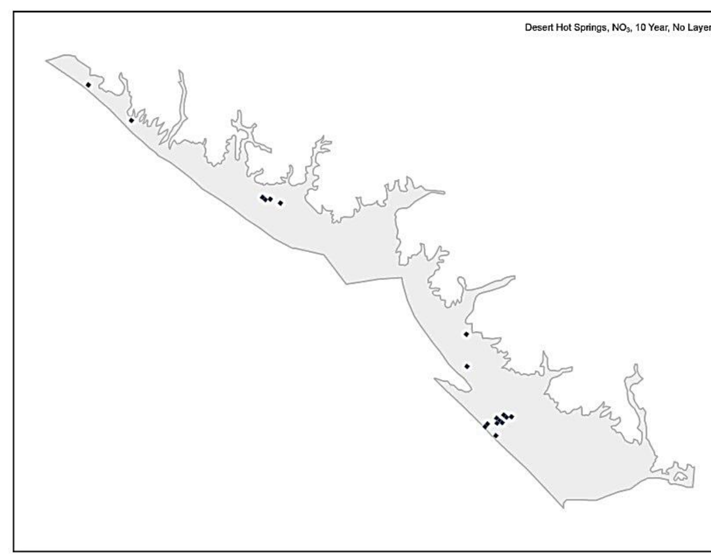
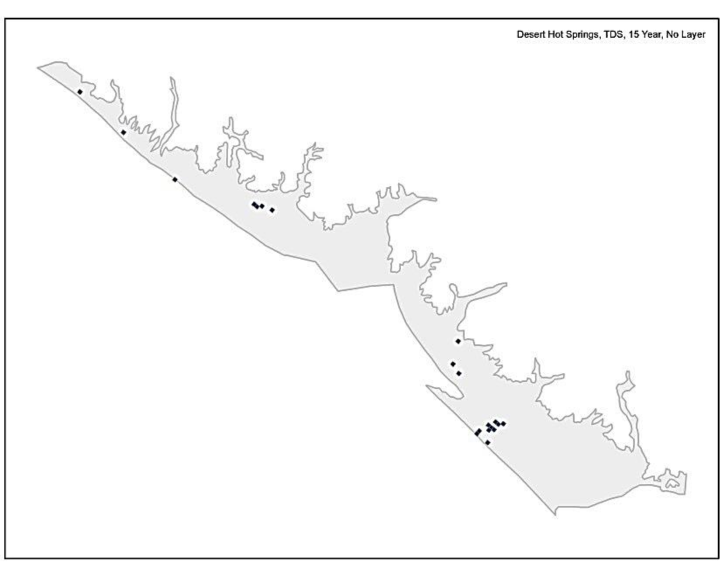
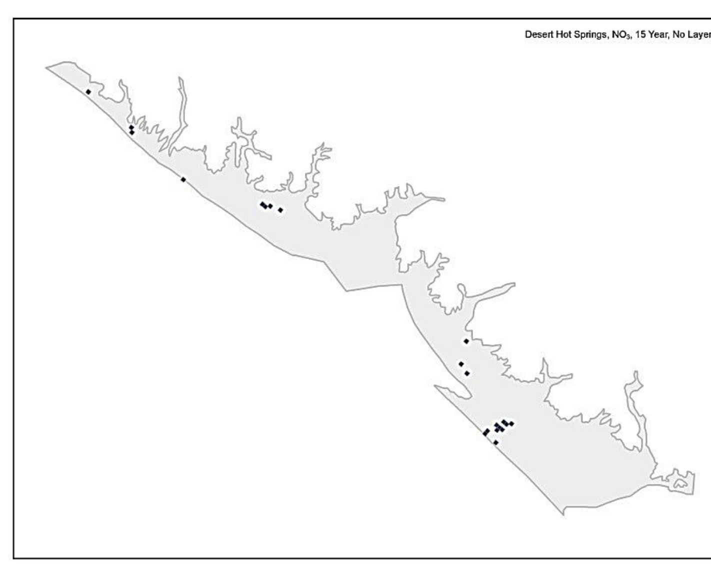
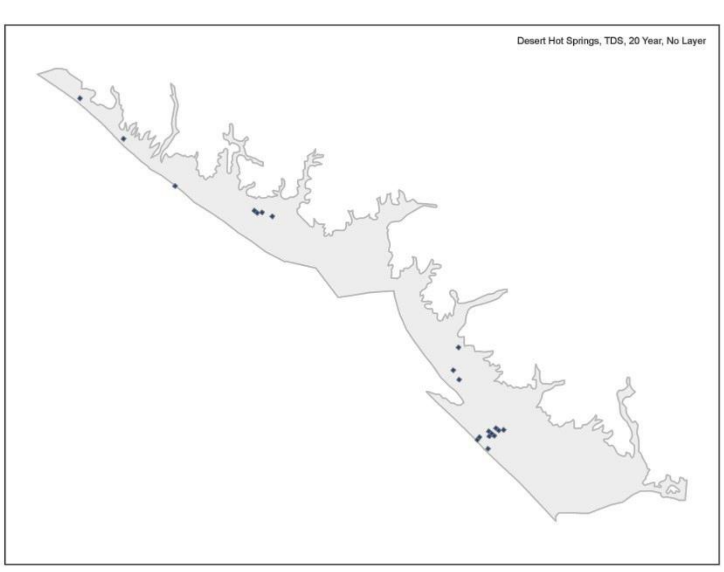
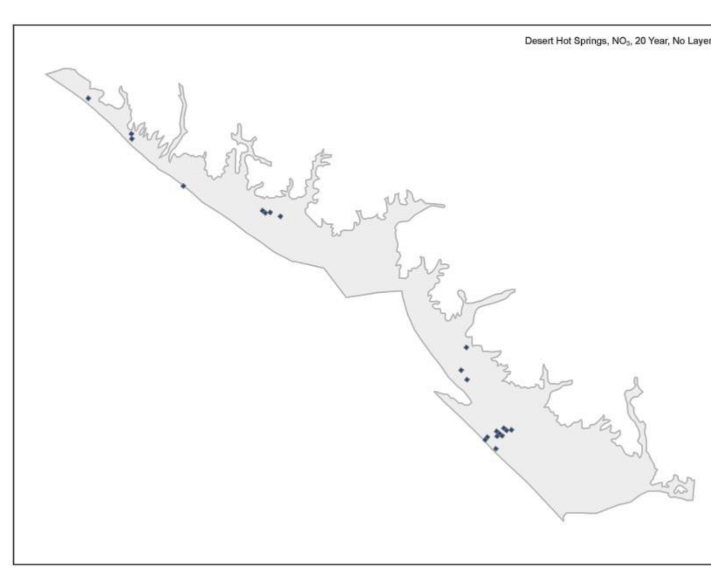
Baseline Period	TDS Data Point	Nitrate Data Points
5-Year	**NO DATA POINTS**	**NO DATA POINTS**
10-Year		
15-Year		
20-Year		

Figure 7
Desert Hot Springs Data Point Spatial Distribution for Different Baseline Periods
(No Aquifer Layering)

Baseline Period	TDS Data Point	Nitrate Data Points
5-Year		
10-Year		
15-Year		
20-Year		

3.1.1 West Whitewater Management Zone

Table 3 presents a description of the data distribution summary prepared from visual inspection of **Figure 3**. Listed below is a discussion of the spatial distribution of data points by aquifer layer.

- Layer 1: This layer lacks sufficient spatial distribution for contouring under any baseline. In particular, there are few data points in the northern portion of the management zone.
- Layer 2: This layer lacks sufficient spatial distribution for contouring until approximately the 15-Year baseline. The density of points is low, but the distribution is random in the eastern two thirds of the management zone.
- Layer 3: This layer has good density of data points, but is very limited in spatial distribution in the western portion of the management zone. The eastern portion could be contoured for the 10-Year baseline.

Table 3
West Whitewater Management Zone Baseline Period Data Spatial Distribution Summary

Baseline Period	Spatial Distribution of Data Points			Notes
	Layer 1	Layer 2	Layer 3	
5-Year	Poor	Poor	Fair	Layers 1 and 2 lack data points, Layer 3 lacks data points in western portion of management zone
10-Year	Poor	Poor	Fair	Layer 2 lacks many points, Layer 3 lacks data points in western portion of management zone
15-Year	Poor	Fair	Fair	Layer 2 lacks many points, Layer 3 lacks data points in western portion of management zone
20-Year	Poor	Fair	Fair	Layer 2 lacks many points, Layer 3 lacks data points in western portion of management zone

3.1.2 East Whitewater Management Zone

Table 4 presents a description of the data distribution summary prepared from visual inspection of **Figure 4**. Listed below is a discussion of the spatial distribution of data points by aquifer layer.

- Layer 1: This layer lacks sufficient spatial distribution for contouring until the 10-Year or 15-Year baseline. The spatial distribution appears random.
- Layer 2: This layer lacks spatial distribution for the full extent of the aquifer limits. Data is concentrated in the center of the aquifer. The majority of the layer could be contoured at the 15-Year baseline.
- Layer 3: This layer lacks sufficient spatial distribution for contouring until the 10-Year or 15-Year baseline. The spatial distribution appears random, although data gaps exist along the northern boundary of the aquifer layer.

Table 4
East Whitewater Management Zone Baseline Period Data Spatial Distribution Summary

Baseline Period	Spatial Distribution of Data Points			Notes
	Layer 1	Layer 2	Layer 3	
5-Year	Poor	Poor	Poor	
10-Year	Fair	Poor	Fair	Layer 2 lacks data outside the center of the management zone, layer 3 lacks data along its northern boundary
15-Year	Fair	Fair	Fair	Layer 2 lacks data outside the center of the management zone, layer 3 lacks data along its northern boundary
20-Year	Good	Fair	Fair	Layer 2 lacks data outside the center of the management zone, layer 3 lacks data along its northern boundary

3.1.3 Mission Creek Management Zone

Table 5 presents a description of the data distribution summary prepared from visual inspection of **Figure 5**. Listed below is a discussion of the spatial distribution of data points by aquifer layer and a combined single aquifer system.

- Layer 1: This layer lacks sufficient spatial distribution for contouring under any baseline.
- Layer 2: This layer lacks sufficient spatial distribution for contouring under any baseline.
- Combined/no layering: The data distribution is random in the eastern portion of the management zone. After the 5-Year baseline, this portion could be contoured; the western portion could be contoured only with significant uncertainty.

Table 5
Mission Creek Management Zone Baseline Period Data Spatial Distribution Summary

Baseline Period	Spatial Distribution of Data Points			Notes
	Layer 1	Layer 2	No Layering	
5-Year	Poor	Poor	Poor	
10-Year	Poor	Poor	Fair	Lacking western portion data
15-Year	Poor	Poor	Fair	Lacking western portion data
20-Year	Poor	Poor	Fair	Lacking western portion data

3.1.4 Garnet Hill Management Zone

Table 6 presents a description of the data distribution summary prepared from visual inspection of **Figure 6**. Listed below is a discussion of the spatial distribution of data points within the management zone

- Combined/no layering: The data distribution is random, although there are very few data points. There is no data in the 5-Year baseline. Due to limited data points, this management zone lacks data for contouring under baseline period.

Table 6
Garnet Hill Management Zone Baseline Period Data Spatial Distribution Summary

Baseline Period	Spatial Distribution of Data Points	Notes
5-Year	N/A	No data
10-Year	Poor	Good distribution, although few data points
15-Year	Fair	Good distribution, although few data points
20-Year	Fair	Good distribution, although few data points

3.1.5 Desert Hot Springs Management Zone

Table 7 presents a description of the data distribution summary prepared from visual inspection of **Figure 7**. Listed below is a discussion of the spatial distribution of data points within the Miracle Hill area of the Desert Hot Springs Management Zone.

- Combined/no layering: The data distribution is random, although there are very few data points. Due to limited data points, this management zone lacks data for contouring under baseline period.

Table 7
Miracle Hill Area – Desert Hot Springs Management Zone
Baseline Period Data Spatial Distribution Summary

Baseline Period	Spatial Distribution of Data Points	Notes
5-Year	Poor	Single data point
10-Year	Poor	Good distribution, although few data points
15-Year	Fair	Good distribution, although few data points
20-Year	Fair	Good distribution, although few data points

Table 8 presents a description of the data distribution summary prepared from visual inspection of **Figure 7**. Listed below is a discussion of the spatial distribution of data points within the Sky Valley area of the Desert Hot Springs Management Zone.

- Combined/no layering: The data distribution is random, although there are very few data points. Due to limited data points, this management zone lacks data for contouring under baseline period.

Table 8
Sky Valley Area – Desert Hot Springs Management Zone
Baseline Period Data Spatial Distribution Summary

Baseline Period	Data Distribution	Notes
5-Year	Poor	Cluster of data points – poor spatial distribution
10-Year	Poor	Cluster of data points – poor spatial distribution
15-Year	Poor	Cluster of data points – poor spatial distribution
20-Year	Poor	Cluster of data points – poor spatial distribution

Table 9 presents a description of the data distribution summary prepared from visual inspection of **Figure 7**. Listed below is a discussion of the spatial distribution of data points within the Fargo Canyon area of the Desert Hot Springs Management Zone.

- Combined/no layering: The data distribution is not random and there are very few data points. Due to limited data points, this management zone lacks data for contouring under baseline period.

Table 9
Fargo Canyon Area – Desert Hot Springs Management Zone
Baseline Period Data Distribution Summary

Baseline Period	Spatial Distribution of Data Points	Notes
5-Year	Poor	Poor spatial distribution, lacking data in southern/eastern portion
10-Year	Poor	Poor spatial distribution, lacking data in southern/eastern portion
15-Year	Poor	Poor spatial distribution, lacking data in southern/eastern portion
20-Year	Poor	Poor spatial distribution, lacking data in southern/eastern portion

3.2 SPATIAL AUTOCORRELATION OF DATA POINTS

As mentioned in Section 2.1.2, a positive spatial autocorrelation suggests higher confidence in predicting the value at one location based on the value sampled from a nearby location when using data interpolation methods. A negative autocorrelation describes patterns in which neighboring patters are unlike and not related. **Table 10** though **Table 13** summarize the confidence levels associated with positive spatial autocorrelation by management zone.

3.2.1 West Whitewater Management Zone

Table 10 presents the autocorrelation results summary. The following bullets describe what the results mean relative to each aquifer layer and baseline period within the management zone.

- Layer 1: Positive spatial correlation is not observed for either TDS or nitrate. Spatial autocorrelation for the 5- and 10-Year baseline periods could not be evaluated due to the lack of data.
- Layer 2: The 15- and 20-Year baseline periods show strong positive autocorrelation for both TDS and nitrate; this indicates that the water quality data varies predictably. Similar to Layer 1, spatial autocorrelation could not be evaluated for the 5- and 10-Year baseline periods.
- Layer 3: High positive spatial correlation is observed for nitrate in all baseline periods and TDS in the 15- and 20-Year baseline periods, suggesting predictability in space.

Table 10
West Whitewater Management Zone Positive Spatial Autocorrelation Confidence Levels by Layer and Baseline Period

Baseline Period	Layer 1		Layer 2		Layer 3	
	TDS	Nitrate	TDS	Nitrate	TDS	Nitrate
5-Year	-	-	-	-	< 90%	**95%**
10-Year	-	-	-	-	< 90%	**95%**
15-Year	< 90%	< 90%	**95%**	**95%**	**95%**	**95%**
20-Year	< 90%	< 90%	**95%**	**95%**	**95%**	**95%**

Notes: no value (-) indicates that the spatial autocorrelation test failed due to lack of data.

3.2.2 East Whitewater Management Zone

Table 11 presents the autocorrelation results summary. The following bullets describe what the results mean relative to each aquifer layer and baseline period within the management zone.

- Layer 1: TDS data shows positive spatial autocorrelation for all baseline periods and confidence increasing from the 5- to the 10-Year baseline period. Positive spatial autocorrelation is observed in the nitrate data for the 15- and 20-Year baseline periods.
- Layer 2: Spatial autocorrelation could not be evaluated for the 5-Year baseline period. Positive spatial autocorrelation is observed for TDS and nitrate in all other baseline periods except for TDS in the 15-Year baseline period; this may be due to increased random variability with the additional data gained between the 10- and 15-Year baseline periods, but strong positive spatial autocorrelation is again observed in the 20-Year baseline period.
- Layer 3: Positive spatial autocorrelation is observed in the TDS data except for the 5-Year baseline period where it cannot be evaluated. Nitrate is observed to have strong positive spatial autocorrelation in the 5-Year baseline period, but not for all other baseline periods; this together with the increased variance observed in the data suggests the nitrate data varies with less predictability in Layer 3.

Table 11
East Whitewater Management Zone Positive Spatial Autocorrelation Confidence Levels by Layer and Baseline Period

Baseline Period	Layer 1		Layer 2		Layer 3	
	TDS	Nitrate	TDS	Nitrate	TDS	Nitrate
5-Year	90%	< 90%	-	-	-	**95%**
10-Year	95%	< 90%	**95%**	**95%**	**90%**	< 90%
15-Year	**95%**	**90%**	< 90%	**95%**	**95%**	< 90%
20-Year	**95%**	**90%**	**95%**	**95%**	**90%**	< 90%

Notes: no value (-) indicates that the spatial autocorrelation test failed due to lack of data.

3.2.3 Mission Creek Management Zone

Table 12 presents the autocorrelation results summary. The following bullets describe what the results mean relative to each aquifer layer and baseline period within the management zone.

- Layers 1 and 2: Spatial autocorrelation could not be evaluated for all baseline periods for Mission Creek Management Zone when separated into layers due to the lack of data.
- No Layering: If no layering is considered, strong positive spatial autocorrelation is observed for TDS and nitrate in all baseline periods except for the 5-Year baseline period for which spatial autocorrelation could not be evaluated.

Table 12
Mission Creek Management Zone Positive Spatial Autocorrelation Confidence Levels by Layer and Baseline Period

Baseline Period	Layer 1		Layer 2		No Layering	
	TDS	Nitrate	TDS	Nitrate	TDS	Nitrate
5-Year	-	-	-	-	-	-
10-Year	-	-	-	-	**95%**	**95%**
15-Year	-	-	-	-	**95%**	**90%**
20-Year	-	-	-	-	**95%**	**90%**

Notes: no value (-) indicates that the spatial autocorrelation test failed due to lack of data.

3.2.4 Garnet Hill Management Zone

No spatial autocorrelation could be evaluated for any baseline period within Garnet Hill Management Zone due to a lack of data.

3.2.5 Desert Hot Springs Management Zone

No spatial autocorrelation could be evaluated for the Miracle Hill or Sky Valley Subareas within Desert Hot Springs Management Zone due to a lack of data.

Fargo Canyon (see **Table 13**): Strong positive spatial autocorrelation is observed for TDS in all baseline periods except for the 10-Year baseline period. Nitrate shows strong positive spatial autocorrelation in the 5-Year baseline period, but not in other baseline periods. Note that the spatial autocorrelation for the 10-Year baseline period could not be evaluated, but data in this period is very similar to the 5-Year baseline period with the addition of two filtered data points a small distance from the cluster that comprises the entire 5-Year baseline period.

Table 13
Fargo Canyon Subarea of the Desert Hot Springs Management Zone
Positive Spatial Autocorrelation Confidence Levels by Baseline Period

Baseline Period	TDS	Nitrate
5-Year	**95%**	**95%**
10-Year	-	-
15-Year	**95%**	< 90%
20-Year	**95%**	< 90%

Notes: no value (-) indicates that the spatial autocorrelation test failed due to lack of data.

3.3 SUMMARY STATISTICS

Table 14 through **Table 20** list summary statistics for the filtered data set, as described in Section 2.2 of TM-2, within each baseline period for each management zone and each aquifer layer, if applicable. These tables are provided for general reference and can be reviewed with the results in the previous two subsections. Basic statistical methods are described in the following: USGS, 2010. Statistical Methods in Water Resources, Techniques of Water-Resources Investigations of the United States Geological Survey, Book 4, Hydrologic Analysis and Interpretation.

Table 14
West Whitewater Management Zone Summary Statistics by Layer and Baseline Period

		Layer 1		Layer 2		Layer 3	
Baseline Period	**Statistic**	**TDS**	**Nitrate**	**TDS**	**Nitrate**	**TDS**	**Nitrate**
5-Year	Count	7	7	5	6	29	29
	Mean	640	25.2	368	28.6	198	5.6
	Median	610	7.9	450	21.5	190	3.3
	Mode	N/A	N/A	450	N/A	210	3
	Std. Dev.	199	33.8	130	28.9	34	6.3
	Range	450 to 1060	3 to 88.9	190 to 480	2.7 to 62.1	160 to 330	2.2 to 27
	95% CI	456 to 825	ND to 56.5	207 to 529	ND to 59	185 to 211	3.2 to 8
10-Year	Count	8	8	9	10	31	31
	Mean	606	22.2	359	32.2	198	5.4
	Median	590	6.4	303	21.2	191	3.2
	Mode	N/A	N/A	450	N/A	210	3
	Std. Dev.	208	32.4	121	36.6	33	6.1
	Range	367 to 1,060	1.2 to 88.9	190 to 536	1.59 to 109.0	160 to 330	1.9 to 27
	95% CI	432 to 780	ND to 49.3	266 to 452	6 to 58.4	186 to 210	3.1 to 7.6
15-Year	Count	14	14	28	29	38	38
	Mean	544	31.8	414	36.9	204	8.2
	Median	520	10.4	375	28.5	195	3.2
	Mode	N/A	N/A	302	2.7	210	3
	Std. Dev.	194	36.2	201	37	49	14
	Range	201 to 1,060	1.2 to 101	169 to 842	1.6 to 120	160 to 420	1.9 to 76
	95% CI	432 to 656	10.9 to 52.7	336 to 492	22.8 to 51	188 to 220	3.6 to 12.8
20-Year	Count	16	16	35	37	41	41
	Mean	590	41.2	379	31.8	202	7.8
	Median	548	17.9	302	15	190	3
	Mode	N/A	N/A	190	2.7	210	3
	Std. Dev.	224	44.6	196	34.8	47	13.6
	Range	201 to 1,060	1.2 to 145	169 to 842	1.6 to 120	160 to 420	1.6 to 76
	95% CI	470 to 709	17.4 to 65	312 to 447	20.2 to 43.5	187 to 217	3.5 to 12.1

Table 15
East Whitewater Management Zone Summary Statistics by Layer and Baseline Period

		Layer 1		Layer 2		Layer 3	
Baseline Period	**Statistic**	**TDS**	**Nitrate**	**TDS**	**Nitrate**	**TDS**	**Nitrate**
5-Year	Count	18	18	11	11	26	26
	Mean	2,553	32.2	494	3.5	343	3.4
	Median	1,400	14.6	260	0.7	175	2.6
	Mode	1,400	ND	N/A	ND	160	ND
	Std. Dev.	4,444	55.1	446	5.8	610	5
	Range	170 to 19,100	ND to 230	129 to 1,500	ND to 16	142 to 3,270	ND to 24.5
	95% CI	343 to 4,762	4.8 to 59.6	195 to 794	ND to 7.4	96 to 589	1.3 to 5.4
10-Year	Count	28	28	23	23	34	34
	Mean	1,938	29.6	363	2.5	354	7.8
	Median	979	8.5	202	0.6	180	2.6
	Mode	2,200	ND	N/A	ND	160	ND
	Std. Dev.	3,654	51.3	335	4.5	554	21.4
	Range	153 to 19,100	ND to 230	129 to 1,500	ND to 16	139 to 3,270	ND to 111
	95% CI	521 to 3,355	9.7 to 49.4	218 to 508	0.5 to 4.4	161 to 548	0.4 to 15.3
15-Year	Count	41	41	43	43	48	47
	Mean	1,509	24.7	362	3.9	355	6.5
	Median	698	3.6	202	0.8	180	2.2
	Mode	665	ND	162	ND	160	ND
	Std. Dev.	3,081	45.4	360	6.5	510	18.3
	Range	152 to 19,100	ND to 230	104 to 1,750	ND to 28	123 to 3,270	ND to 111
	95% CI	537 to 2,482	10.4 to 39	251 to 472	1.9 to 5.9	207 to 503	1.1 to 11.8
20-Year	Count	62	63	60	60	61	61
	Mean	1,233	19.1	360	4.8	356	7.2
	Median	665	4.4	201	1.2	190	2
	Mode	665	ND	162	ND	160	ND
	Std. Dev.	2,538	37.7	343	9.2	463	17.1
	Range	132 to 19,100	ND to 230	104 to 1,750	ND to 57.5	123 to 3,270	ND to 111
	95% CI	589 to 1,878	9.7 to 28.6	271 to 449	2.4 to 7.2	238 to 475	2.8 to 11.6

Table 16
Mission Creek Management Zone Summary Statistics by Layer and Baseline Period

		Layer 1		Layer 2		No Layering	
Baseline Period	Statistic	TDS	Nitrate	TDS	Nitrate	TDS	Nitrate
5-Year	Count	1	1	2	2	7	9
	Mean	820	4.2	350	1.9	473	4.6
	Median	820	4.2	350	1.9	420	4.1
	Mode	N/A	N/A	N/A	N/A	N/A	3.7
	Std. Dev.	N/A	N/A	28	2.6	172	1.7
	Range	N/A	N/A	330 to 370	ND to 3.7	300 to 820	2.9 to 8.2
	95% CI	N/A	N/A	96 to 604	ND to 25.3	314 to 632	3.2 to 5.9
10-Year	Count	6	6	2	2	18	21
	Mean	724	2.5	350	1.9	614	6.3
	Median	802	2.5	350	1.9	514	3.8
	Mode	N/A	N/A	N/A	N/A	N/A	3.7
	Std. Dev.	214	1.5	28	2.6	234	10.7
	Range	446 to 956	0.9 to 4.2	330 to 370	ND to 3.7	300 to 956	0.3 to 52
	95% CI	500 to 949	1 to 4.1	96 to 604	ND to 25.3	498 to 730	1.4 to 11.2
15-Year	Count	6	6	4	4	22	25
	Mean	724	2.5	421	2.4	606	5.8
	Median	802	2.5	423	3	499	3.8
	Mode	N/A	N/A	N/A	N/A	N/A	3.6
	Std. Dev.	214	1.5	85	1.7	242	8.1
	Range	446 to 956	0.9 to 4.2	330 to 509	ND to 3.7	300 to 1,096	0.3 to 42.8[1]
	95% CI	500 to 949	1 to 4.1	286 to 556	ND to 5.2	499 to 713	2.4 to 9.1
20-Year	Count	6	6	4	4	22	25
	Mean	724	2.5	421	2.4	606	5.5
	Median	802	2.5	423	3	499	3.8
	Mode	N/A	N/A	N/A	N/A	N/A	3.6
	Std. Dev.	214	1.5	85	1.7	242	7
	Range	446 to 956	0.9 to 4.2	330 to 509	ND to 3.7	300 to 1,096	0.25 to 37[1]
	95% CI	500 to 949	1 to 4.1	286 to 556	ND to 5.2	499 to 713	2.7 to 8.4

[1] The range decreases from the 10-Year to the 15-Year baseline period and again from the 15-Year to the 20-Year baseline period. This is due to wells being added to the database because their records only exist for earlier years, bringing the maximum filtered data point lower as they exist in the same grid cell and layer used in spatial filtering.

Table 17
Garnet Hill Management Zone Summary Statistics by Baseline Period

Baseline Period	Statistic	TDS	Nitrate
5-Year	Count	-	-
	Mean	-	-
	Median	-	-
	Mode	-	-
	Std. Dev.	-	-
	Range	-	-
	95% CI	-	-
10-Year	Count	3	3
	Mean	237	2.3
	Median	237	1.8
	Mode	N/A	N/A
	Std. Dev.	51	2
	Range	186 to 288	0.6 to 4.5
	95% CI	111 to 363	ND to 7.3
15-Year	Count	4	4
	Mean	217	2.2
	Median	212	1.8
	Mode	N/A	N/A
	Std. Dev.	58	1.6
	Range	156 to 288	0.6 to 4.5
	95% CI	124 to 309	ND to 4.8
20-Year	Count	4	4
	Mean	217	2.2
	Median	212	1.8
	Mode	N/A	N/A
	Std. Dev.	58	1.6
	Range	156 to 288	0.6 to 4.5
	95% CI	124 to 309	ND to 4.8

Table 18
Miracle Hill Subarea of Desert Hot Springs Management Zone
Summary Statistics by Baseline Period

Baseline Period	Statistic	TDS	Nitrate
5-Year	Count	1	2
	Mean	390	7.7
	Median	390	7.7
	Mode	N/A	N/A
	Std. Dev.	N/A	3.5
	Range	N/A	5.2 to 10.2
	95% CI	N/A	ND to 39.1
10-Year	Count	1	2
	Mean	390	7.7
	Median	390	7.7
	Mode	N/A	N/A
	Std. Dev.	N/A	3.5
	Range	N/A	5.2 to 10.2
	95% CI	N/A	ND to 39.1
15-Year	Count	3	4
	Mean	558	4.8
	Median	440	4.2
	Mode	N/A	N/A
	Std. Dev.	250	4.1
	Range	390 to 845	0.5 to 10.2
	95% CI	< 100 to 1,178	ND to 11.2
20-Year	Count	3	4
	Mean	558	4.8
	Median	440	4.2
	Mode	N/A	N/A
	Std. Dev.	250	4.1
	Range	390 to 845	0.5 to 10.2
	95% CI	< 100 to 1,178	ND to 11.2

Table 19
Sky Valley Subarea of Desert Hot Springs Management Zone
Summary Statistics by Baseline Period

Baseline Period	Statistic	TDS	Nitrate
5-Year	Count	3	3
	Mean	1,350	24.9
	Median	1,350	25
	Mode	N/A	N/A
	Std. Dev.	150	15.2
	Range	1,200 to 1,500	9.7 to 40
	95% CI	977 to 1,723	ND to 62.5
10-Year	Count	4	4
	Mean	1,280	18.8
	Median	1,275	17.4
	Mode	N/A	N/A
	Std. Dev.	186	17.4
	Range	1,070 to 1,500	0.4 to 40
	95% CI	984 to 1,576	ND to 46.5
15-Year	Count	4	4
	Mean	1,280	18.8
	Median	1,275	17.4
	Mode	N/A	N/A
	Std. Dev.	186	17.4
	Range	1,070 to 1,500	0.4 to 40
	95% CI	984 to 1,576	ND to 46.5
20-Year	Count	4	4
	Mean	1,280	18.8
	Median	1,275	17.4
	Mode	N/A	N/A
	Std. Dev.	186	17.4
	Range	1,070 to 1,500	0.4 to 40
	95% CI	984 to 1,576	ND to 46.5

Table 20
Fargo Canyon Subarea of Desert Hot Springs Management Zone
Summary Statistics by Baseline Period

Baseline Period	Statistic	TDS	Nitrate
5-Year	Count	10	10
	Mean	1,486	17.9
	Median	1,650	17.4
	Mode	1,800	24.8
	Std. Dev.	469	14.5
	Range	780 to 2,020	0.1 to 40.85
	95% CI	1,150 to 1,821	7.5 to 28.2
10-Year	Count	12	12
	Mean	1,406	24.8
	Median	1,463	19.1
	Mode	1,800	24.8
	Std. Dev.	469	27.3
	Range	780 to 2,020	0.1 to 101
	95% CI	1,108 to 1,704	7.4 to 42.2
15-Year	Count	13	13
	Mean	1,351	22.9
	Median	1,325	17.9
	Mode	1,800	24.8
	Std. Dev.	491	27
	Range	688 to 2,020	0.1 to 101
	95% CI	1,054 to 1,648	6.6 to 39.3
20-Year	Count	13	13
	Mean	1,351	22.9
	Median	1,325	17.9
	Mode	1,800	24.8
	Std. Dev.	491	27
	Range	688 to 2,020	0.1 to 101
	95% CI	1,054 to 1,648	6.6 to 39.3

4 Summary and Recommendations

During the stakeholder process and review of the Draft TM-2, comments were received regarding the determination of when contouring of water quality constituents should be applied. The preparation of a contour map is integral to the application of the volume-weighted method for determination of AWQ, and therefore can determine which AWQ method is applied. Key concerns included (1) whether there was enough data to contour and represent the physical system, and (2) what is the earliest baseline period that can be used to ensure the most recent data is represented in the AWQ calculation. Although what baseline to use depends on when there is enough data to use, the ultimate question is how much is enough?

Determining what is an adequate amount of data to prepare contour maps is not a simple question to answer. As noted earlier, no other SNMP in the state has made such a quantification. The decision to contour is typically based on professional judgment. The basis of this determination is based primarily on the spatial distribution of data points and autocorrelation. Spatial distribution of data points evaluates the arrangement of the data points, are they randomly distributed and do the data points cover the extent of the management zone. Spatial autocorrelation is used to evaluate whether known nearby data points can be used to approximate unknown points.

This section provides a summary of the analytical results and recommendations for the method AWQ calculation based on data availability to represent the physical system. Based on review of the analyses, the following general recommendations can be made with specific recommendations described in each management zone subsection:

- Using the 5-Year baseline period alone is not feasible in any management zone or aquifer layer for a volume weighted AWQ calculation. Data is typically scarce with poor spatial distribution in the 5-Year baseline period while only four cases show statistically significant positive spatial autocorrelation.
- If contouring cannot be completed, provide summary statistics only.

4.1.1 West Whitewater Management Zone Recommendations

Layer 1 lacks sufficient spatial distribution for contouring under any baseline; this is consistent with the autocorrelation analysis. Layer 2 lacks sufficient spatial distribution for contouring until approximately the 15-Year baseline. The spatial autocorrelation results found the 15- and 20-Year baseline periods have a strong positive autocorrelation for both TDS and nitrate, meaning data points have relationships and estimation between points (contours) is reasonable. The density of points is low, but the distribution is random in the eastern two thirds of the management zone. For Layer 3, data points are randomly distributed, but there is very limited data in the western portion of the management zone. The eastern portion could be contoured at the 10-Year baseline. This layer has a high positive spatial correlation for nitrate in all baseline periods and TDS in the 15- and 20-Year baseline periods, suggesting predictability in space.

Recommendation: For Layer 2 and Layer 3, use the most current data in any cell. Check the most current data point to determine if it is an outlier or consistent with older records or continuing a trend. Use older records to 15 years or 20 only if needed to fill areas of poor spatial distribution. Provide a summary that communicates the number of points used within each baseline period.

Regarding Layer 1, all baseline periods failed to provide enough data for contouring. Given the lack of available data, it is recommended that in place of contouring a range of constants value be assumed for Layer 1 to calculate the volume weighted AWQ. Use of the minimum and maximum for the 15-Year baseline is proposed. Using these single values for Layer 1 will provide a range of AWQ for the aggregated West Whitewater Management Zone AWQ value.

4.1.2 East Whitewater Management Zone Recommendations

Within Layer 1, the spatial distribution is random, but lacks sufficient quantity for contouring until the 10- or 15-Year baseline. TDS data shows positive spatial autocorrelation for all baseline periods and confidence level of the positive spatial autocorrelation increasing from the 5- to the 10-Year baseline period. Positive spatial autocorrelation is observed in the nitrate data for the 15- and 20-Year baseline periods.

Layer 2 lacks spatial distribution for the full extent of the aquifer in any period. Data is concentrated in the center of the aquifer. The majority of the layer could be contoured with the most recent data limited by the 15-Year baseline. Spatial autocorrelation could not be evaluated for the 5-Year baseline period. Positive spatial autocorrelation is observed for TDS and nitrate in all other baseline periods except for TDS in the 15-Year baseline period.

Similar to Layer 2, Layer 3 lacks sufficient spatial distribution for contouring until the 10- or 15-Year baseline. The spatial distribution appears random, although data gaps exist along the northern boundary of the aquifer layer. Positive spatial autocorrelation is observed in the TDS data except for the 5-Year baseline period where insufficient data prevents evaluation. Nitrate is observed to have strong positive spatial autocorrelation in the 5-Year baseline period, but not for all other baseline periods. This is likely due to increased range in values with minimal spatial distribution.

Recommendation: For Layers 1 through 3, use the most current data in any cell. Check the most current data point to determine if it is an outlier or consistent with older records or continuing a trend. Use older records to 15 years or 20 only if needed to fill areas of poor spatial distribution. Provide a summary that communicates the number of points used within each baseline period.

4.1.3 Mission Creek Management Zone Summary and Recommendations

When the management zone was divided into two vertical layers, the spatial autocorrelation could not be evaluated for all baseline periods. Similarly, the spatial distribution was poor for all baseline periods when the layers are subdivided. Without layering, assuming a single aquifer, strong positive spatial autocorrelation is observed for TDS and nitrate in all baseline periods except for the 5-Year baseline period for which spatial autocorrelation could not be evaluated. Similarly, after the 5-Year baseline, the eastern portion on the management zone has random spatial distribution and could be contoured. The primary issue in this management zone is the lack of data in the western third of the management zone.

Recommendation: Limit the contouring and AWQ calculation to the eastern portion of the management zone. To limit the area, use half the distance between a boundary and the nearest well with water quality data. For this portion, use the most current data in any cell. Check the most current data point to determine if it is an outlier or constant with older records or continuing a trend. Use older records to 15 years or 20 years only if needed to fill areas of poor spatial distribution – likely not necessary. Provide a summary that communicates the number of points used within each baseline period.

4.1.4 Garnet Hill Management Zone Summary and Recommendations

No spatial autocorrelation could be evaluated for any baseline period within Garnet Hill Management Zone due to a lack of data.

Recommendation: Provide a statistical summary and range for AWQ.

4.1.5 Desert Hot Springs Management Zone Summary and Recommendations

Spatial autocorrelation could not be evaluated for the Miracle Hill or Sky Valley Subareas within Desert Hot Springs Management Zone due to a lack of data. Similarly, spatial distribution in these areas is limited by data availability.

Within Fargo Canyon, a strong positive spatial autocorrelation is observed for TDS in all baseline periods. Nitrate shows strong positive spatial autocorrelation in the 5-Year baseline period. Spatial distribution in these areas is poor due to limited data availability.

Recommendation: Provide a statistical summary and range of AWQ.

5 References

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Attachment B – Effective Porosity Approximation for the Volume Weighted Average Calculation

ATTACHMENT B

Attachment B - Effective Porosity Approximation for the Volume Weighted Average Calculation

1 Introduction

The volume-weighted method for determination of the ambient water quality (AWQ) uses the volume of water in storage to assign weights to water quality concentration within the basin. For estimation of the volume of water in a management zone the management zone is discretized into cells. For each cell, the water level surface, aquifer thickness, and effective porosity are needed. A grid is used to delineate cells for calculations. The volume being approximated is not the total volume in storage (based on porosity) or the total volume that can be pumped (based on specific yield), but the amount available for mixing (based on effective porosity). In this case, the effective porosity is the portion of the interconnected void space of a porous material that is capable of transmitting (and mixing) a fluid.

This document summarizes the definition for effective porosity used to determine the AWQ, published effective porosity values for similar hydrogeologic conditions, and results of an approximation of effective porosity for the Coachella Valley.

2 Definition

Total porosity is defined as the ratio of void space to the total volume of a geologic formation. The effective porosity is the portion of the void space of a porous material that is capable of transmitting (and thereby mixing) a fluid and excludes clay-bound water (water that is electrochemically attached to clay particles that does not contribute to flow). Effective porosity occurs because a fluid in a saturated porous media will not flow through all voids, but only through the voids which are interconnected. Effective porosity is typically higher than specific yield (the volume of water that can be drained by gravity).

3 Representative Effective Porosity Values

A literature search has been conducted to determine effective porosity values for similar hydrogeologic conditions. This section provides a summary of the results of the literature search.

The USGS conducted a modeling study in an area of alluvial and fluvial sand and gravel aquifers to evaluate groundwater vulnerability. As part of their study, they estimated effective porosity. The three-dimensional distribution of effective porosity for the model was estimated by using an empirical relationship between hydraulic conductivity and effective porosity developed by Ahuja, et al. (1989) and modified using information from Morris and Johnson (1967). The application of these methods was completed by Hinkle (1997). A summary of the effective porosities used are presented in **Table 1**.

Table 1
Effective porosities of hydrogeological units in Clark County, Washington
(Snyder et al., 1989)

Material	Minimum	Maximum	Mean
Unconsolidated sedimentary aquifer	0.19	0.31	0.31
Troutdale gravel aquifer	0.18	0.31	0.28
Confining unit 1	0.13	0.3	0.19
Troutdale sandstone aquifer	0.18	0.31	0.29
Confining unit 2	0.13	0.3	0.2
Sand and gravel aquifer upper coarse-grained subunit	0.22	0.31	0.28
Sand and gravel aquifer lower fine-grained subunit	0.2	0.24	0.24
Undifferentiated fine-grained sediments	0.13	0.31	0.23

McWorter and Sunada (1977) prepared a summary of values in their text for sedimentary materials. **Table 2** summarizes total porosity and effective porosity values for various sedimentary materials.

Table 2
Representative porosity values
(McWorter and Sunada, 1977)

Material	Total Porosity, n		Effective Porosity, n_e	
	Range	Arithmetic Mean	Range	Arithmetic Mean
Sandstone (fine)			0.02 - 0.40	0.21
Sandstone (medium)	0.14 - 0.49	0.34	0.12 - 0.41	0.27
Siltstone	0.21 - 0.41	0.35	0.01 - 0.33	0.12
Sand (fine)	0.25 - 0.53	0.43	0.01 - 0.46	0.33
Sand (medium)			0.16 - 0.46	0.32
Sand (coarse)	0.31 - 0.46	0.39	0.18 - 0.43	0.3
Gravel (fine)	0.25 - 0.38	0.34	0.13 - 0.40	0.28
Gravel (medium)			0.17 - 0.44	0.24
Gravel (coarse)	0.24 - 0.36	0.28	0.13 - 0.25	0.21
Silt	0.34 - 0.51	0.45	0.01 - 0.39	0.2
Clay	0.34 - 0.57	0.42	0.01 - 0.18	0.06

Urumovic, et al. (2014) researched effective porosity based on geometric mean grain size and measured hydraulic conductivity. This paper suggested procedures for calculating referential grain size and determining effective (flow) porosity result with parameters that reliably determine specific surface area and permeability. The work was based on data from sandy and gravely aquifers to clayey-silty deposits. Representative values for different materials are summarized in **Table 3**.

Table 3
Calculated effective porosity based on geometric mean grain size
(Urumovic et al., 2014)

Material	Grain Size (mm)	Effective Porosity
Gravel	> 2	0.16 - 0.31
Sand	0.1 - 2	0.24 - 0.36
Silt	0.01 - 0.1	0.06 - 0.24
Clay	< 0.01	< 0.06

4 Method for Estimating Effective Porosity

There is little published information of the effective porosity in the Coachella Valley. Two groundwater models were obtained for quantifying the vertical and horizontal extent of the groundwater systems. These models cover the Whitewater, Garnet Hill, and Mission Springs subbasins. CVWD (Fogg *et al.*, 2002) developed a groundwater model of the Whitewater and Garnet Hill Subbasins as part of the 2002 Water Management Plan (MWH, 2002). The geometry (cell size, layering, and orientation) for this model was used as the base for the recently completed Mission Creek and Garnet Hill Subbasins groundwater model. Significant effort went into characterizing hydrostratigraphy and areas of similar hydraulic properties. The layering of these groundwater models was based on a best estimate of basin lithologic characteristics. The calibrated hydraulic conductivity from these models was used to estimate the effective porosity.

Referencing the empirical method developed by Ahuja, et al. (1989), Hinkle and Snyder (1997) estimated effective porosity values for different hydrogeologic units. Ahuja, et al. (1989) analyzed 473 samples and related effective porosity to hydraulic conductivity values. Though the linear regression ranges over five orders of magnitude of the hydraulic conductivity value, the calculated effective porosity value deviates from measured data for large hydraulic conductivity values. Therefore, Hinkle and Snyder (1997) set a maximum effective porosity value of 0.31 for any hydraulic conductivity values that are greater than or equal to 15 feet per day.

The linear relation derived by Ahuja, et al (1989) is:

$$K_S = 764.5 \times n_e^{3.29} \quad (1)$$

Where K_S is saturated hydraulic conductivity, in centimeters per hour, n_e is effective porosity. Equation (1) can be rewritten as:

$$n_e = 10^{(log K_S - 2.88)/3.29} \quad (2)$$

Using the hydraulic conductivity for each model cell, the effective porosity is estimated for the Coachella Valley lithology using equation (2).

4.1 Results

Calibrated groundwater model hydraulic conductivity values are exported from the groundwater models. These conductivity values for each individual cell are inserted into equation (2) for each cell. Similar to Snyder et al. (1998), the maximum effective porosity value is set to 0.31, when hydraulic conductivity value is greater or equal to 15 feet per day. Only calibrated hydraulic conductivity is used; therefore, any decrease in effective porosity with depth due to compaction is not necessary. Zones of like material type are aggregated for summary and comparison to published values of the same material type.

Table 4
Estimated Effective Porosity Value Range for Model Calibrated Hydraulic Conductivity Compared to Literature Data

Material	K	n_e (-)	
	(ft/day)	Estimated	Literature
Clay, Silty Clay	0.005 - 1	0.027-0.133	0.01-0.18
Silt	1 - 11	0.133 - 0.275	0.01-0.39
Sand	11-187	0.275-0.31	0.19-0.31
Gravel	107 - 602	0.31	0.21-0.31

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Attachment C – Response to Comments on the Draft Technical Memorandum No.2

Coachella Valley SNMP - TM-2, Response to Comments

General Notes:	**Based on comments from stakeholders, revisions were made to Technical Memorandum No.2 (TM-2). Two key comments were fundamental to process, these include the use of a 20-year baseline period and the adequacy of data for contouring water quality. As such, general comments are provided herein to address these key issues independent of specific stakeholder comments.**
Adequacy of Data	An attachment to TM-2 was prepare that describes the methods applied and results obtained to evaluate the data adequacy of contouring water quality constituents for management zones and aquifer layers. The volume-weighted method for determination of ambient water quality (AWQ) is used when an adequate amount of data exist for a particular management zone or aquifer layer. This method computes the average water quality based on the amount of mass of a particular constituent in storage. The mass of the constituent is determined by multiplying the water quality concentration by the amount of water in storage at a point of discrete "cell". The concentration of a discrete cell is based on either the actual data or an interpolation based on surrounding data using a water quality contour map. The contour maps are typically prepared with oversight from a professional geologist or engineer and completed in an iterative fashion using numerical and hand contouring methods. Determination of data adequacy for contouring the water quality of an aquifer layer within a particular management zone is not a well-defined undertaking, but it is important for applying the volume-weighted method. The determination of adequacy is based on the following key factors, spatial distribution of data points – the physical location of data points within a management zone or aquifer layer has a marked effect on the ability to approximate values with certainty; spatial autocorrelation – the assumption that one value is more related to nearby points and less related to distant points; and supporting statistics. The attachment provides an evaluation of these factors for management zones and aquifer layers over different periods of time. At the conclusion of the attachment are recommendations for the most appropriate method of AWQ calculation—volume-weighted method or statistical summary—based on the available data.
Baseline Period	When considering the time period for the AWQ calculation, the quantity of data points gained from using older records must be balanced with the desire characterize current water quality (less data). To evaluate the potential impact of older data a trend analysis was completed. Water quality trends were reviewed in TM-1 that considered historical and vertical records throughout the Valley. In addition, a Mann-Kendall analysis was completed within TM-2. A Mann-Kendall trend analysis tests for statistically significant trending in water quality records. A Mann-Kendall test is a widely used method for evaluating trends that compares samples for a particular well and tests for a positive (increasing) or negative (decreasing) trend result for a particular level of statistical significance; see Data Quality Assessment: Statistical Methods for Practitioner (EPA, 2006). Only records with a prescribed number of well records could be considered - not all wells could be evaluated. The results of the Mann-Kendall trend analyses for TDS and nitrate indicate an increasing trend in concentration with time. Based on this consistent result, using older records, generally speaking, decreasing the accuracy of an AWQ calculation or statistical summary if the objective is to represent current water quality. Although due to the size of the Valley, using "current" or even records for all wells within the last 5 years in not feasible due the effort and cost associated with sampling. Based on this consistent result, using older records may underestimate the AWQ if the objective is to represent current water quality. To obtain the most representative AWQ, the most recent measurements are used for each well. The use of the most recent measurements is a change in approach from the first draft of TM-2. . The most recent data point is considered the yearly median if there are multiple data points for a well in a single year. Based on the results of data adequacy (Attachment A), no records will be used that are older than 15 years.

Stakeholder	No.	Comment	General Topic	Response
BIA	1	The baseline TDS and Nitrate concentrations used for establishing the Assimilative Water Quality numbers should be included as well as a citation from the document from which they were sourced.	General	The data, and their sources, are being provided on the SNMP website.
BIA	2	The basins are being described by the data blocks of one thousand square feet. The total numbe of blocks as well as a conversion to square miles (or kilometers) within each basin description would be informative information.	Filtering	Commented noted. Text was modified to reflect the comment by adding spatial statistics for each management zone.
VSD	3	The TM is thorough and well prepared.	General	Comment noted.
VSD	4	The non-detect sample results explanation on page 6 is thorough and acceptable. As stated, this treatment will cause a computed "average" value of the data set to be less than or equal to the actual average value. In actuality, it will always be less than the actual value. The only concern that remains is what impact this will have on assimilative capacity and permit levels.	Data	For datasets with significantly more non-detect results, the skewing effect of this substitution is magnified. However, substitution with zero is consistent with recommended standard practices found in EPA's Data Quality Assessment based on the number of non-detects in the SNMP dataset; this suggests that the effects of this substitution for the determination of AWQ is minimal. To minimize this risk, substitution with half of the most common (mode) nitrate detection limit is used. Because a majority of the records are not accompanied with a method detection limit, using half the detection limit (the other recommended method by EPA) is not possible for all records. Instead, half of the mode of the listed detection limits for all records was used. One half of the mode detection limit (0.02 mg/L) is 0.01 mg/L.
VSD	5	What is considered "sufficient" data for the volume weighted method of Ambient Water Quality determination? (Pages 9, 34, 39).	Data	An attachment has been included that provides an evaluation of data adequacy or data "sufficiency" within the study area for use in the ambient water quality calculation.
VSD	6	All of the information regarding unfiltered data sets, filtered data sets, and volume weighted calculations (where available) are presented in a thorough and deliberate way to present the process of filtering the data and illustrate how the filtering affects the AWQ result. However, a summary table at the end of each section that compares the mean or median and range for each of the data review methods would be beneficial.	General	A summary table was prepared for the volume weighted method (when applicable) and the filtered data within the TM (including mean, median, range, count, mode, standard deviation, and 95 percer confidence interval). The unfiltered data is presented within the text for the purpose of transparency. These data should not be used for conclusion purposes as the results can be misleading (skewed by location, skewed by data frequency etc.) as described in section 2 of the TM.

Stakeholder	No.	Comment	General Topic	Response
VSD	7	On page 15, Section 3.1 , last sentence: the word "Recent" should not be capitalized.	Editorial	In this context, "Recent" is used as a proper noun describing the current geologic time period, the last 11,700 years of the Earth's history — the time since the end of the last major glacial epoch, or "ice age." The term is modified to "Holocene (Recent)" to avoid confusion with the adjective use of the word.
VSD	8	On page 23, Section 3.2.2, second paragraph, last sentence should read: "Higher TDS readings ..... "	Editorial	Commented noted. Text is modified to reflect the comment.
VSD	9	On page 25, Section 3.2.3, first full paragraph, third sentence: replace "further" with "farther."	Editorial	Commented noted. Text is modified to reflect the comment.
VSD	10	On page 28, Section 3.3, last sentence: the third word "is" should be replaced with "was".	Editorial	Commented noted. Text is modified to reflect the comment.
VSD	11	On page 28, Section 3.3.1, fourth sentence: the phrase "data gap" is repeated.	Editorial	Commented noted. Text is modified to reflect the comment.
VSD	12	On page 39, Section 3.5.2, the word "values" should be added between "TDS" and "and".	Editorial	Commented noted. Text is modified to reflect the comment.
VSD	13	Attachment A, Section 3, second paragraph, last sentence: the word "are" should be added between "used" and "presented".	Editorial	Commented noted. Text is modified to reflect the comment.
VSD	14	Attachment A, Section 4, first paragraph, fourth sentence: the word "of" should be added between "part" and "the".	Editorial	Commented noted. Text is modified to reflect the comment.
ACBCI	15	S 2. 1; P 6: The referenced USEPA guidelines for addressing ND in analysis of water quality data provides a more conservative method using half of the detection limit. What effect would this have on the resulting AWQ calculation? Would this be more appropriate method to safeguard the aquifer? The EPA document entitled: Data Quality Assessment: Statistical Methods for Practitioners EPA QA/G-9S, EPA/240/8-06/003 notes on page 131: "If a small proportion of the observations are non-detects, then these may be replaced with a small number, usually DU/2, and the usual analysis performed. Alternative substitution values are 0 (see Aitchison's Method below) or the detection limit"	Data	See response to VSD's comment (No. 4). Based on comments, the half of the mode of the listed detection limits was applied for all non-detects to be conservative. This is consistent with your proposed conservative approach.
ACBCI	16	S 2.2.2: Temporal filter 2 calculates a baseline well concentration using a median (frequency statistic) versus an average (volume statistic). Does this method provide a less conservative value for the AWQ? The temporal filters do not account for wells with clear trends in water quality such as the Palm Springs area wells (04S05E04N01 S and 04S05E09N03S) with TDS, or the Palm Desert wells with nitrate. Should the AWQ at these wells be the most recent data for a baseline determination of ambient water quality?	Filtering	The median does not necessarily favor lower values for AWQ. The reason this statistic is chosen for the filter is that it arguably provides some protection against outliers for a particular dataset.
ACBCI	17	S 2.2.3: The spatial filter is described as calculating a cell-layer average based upon the baseline well concentrations. This method does not account for water quality data that shows a trend in concentration.	Filtering	Commented noted. AWQ is intended to quantify ambient conditions. Water quality trends were evaluated using a Mann-Kendall trend analysis which indicates which wells have increasing, decreasing or no statistical trends. Several increasing trends were observed. As such, the AWQ calculation method was revised to take the most recent yearly median for each well. Using the most recent data should improve the representation of current water quality.
ACBCI	18	Figure 3-1: This figure shows the 20-year unfiltered data statistics for each Management Zone. Please add the average statistics to these graphs. The median value plots closer to the 25-percentile than the mid-point between the 25- and 75-percentiles. Does the median statistic introduce a bias towards a lower AWQ?	Editorial	By definition, the upper and lower limits of the central box are defined using quartiles. Quartiles are the 25th, 50th and 75th percentiles of a data set. The observation that the median plots closer to the 25th percentile indicates that the dataset is not normally distributed; instead it is skewed toward the lower end of the range. The box plot is simply a way to summarize the data. The mean is added to the figure for convenience.
ACBCI	19	Table 3-3: Please provide the volume-weighted AWQ by layer.	AWQ	Comment noted. Managing or regulating at the aquifer level is not consistent with the Recycled Water Policy. The mass of constituents is calculated for separate zones and then aggregated together. This is consistent with the Recycled Water Policy that states salts and nutrients from all sources be managed on a basin-wide or watershed-wide basis. However, it is still useful to understand how water quality varies with depth. Therefore the volume-weighted AWQ by layer has been incorporated into the TM.

Stakeholder	No.	Comment	General Topic	Response
MSWD	20	Section 1, Introduction: The first paragraph indicates "TM-2 summarizes the results…based on the methodology described in TM-1" must also recognize that if MSWD disagrees with the methodology in TM-1 then, of course, MSWD disagrees with the summary of results. In addition, based on paragraph 2, a majority of the SNMP scope of services is still to be completed. Yet, during the October workshop, it was indicated that only one workshop remains. MSWD requests that workshops continue until the plan is complete. Also, the second paragraph refers to tasks to be completed but does not identify needed projects to manage salt and nutrients.	General	A significant portion of the SNMP scope of work is still being completed, this scope of work includes identification of projects and strategies to manage salt and nutrients. This task will be documented in the final SNMP. An Additional workshop has been added to the project schedule to address this. Six stakeholders meetings have been planned for the project, as well as a workshop with the Regional Water Quality Control Board. Stakeholder meetings will continue until the plan is completed.
MSWD	21	Section 1.1, Background: The paragraph states "One objective of the Policy is that salts and nutrients from all sources be managed on a basin-wide or watershed-wide basis that ensures meeting water quality objectives and protection of beneficial uses." First, water quality objectives and beneficial uses are two distinctly different outcomes. Secondly, to date, the neither technical memorandum discusses "all sources". Third, prior to completing the SNMP, RWQCB position on these issues must be incorporated. Is it the intent of MWH to advise the RWQCB what their direction is, instead of asking them what their direction is?	General	Yes, meeting water quality objectives and protecting beneficial uses can be considered different goals. The project technical team continues to work with stakeholders and the RWQCB to get their feedback on this issue. The development of an SNMP is a stakeholder driven process.
MSWD	22	Section 1.2, Salt and Nutrient Management Planning Area: A portion of MSWD's service area overlies SGPWA jurisdictional boundaries.	General	Commented noted.
MSWD	23	Section 1.3, Salt and Nutrient Management Plan Development: The title of this section is misleading. The discussion is describing the contents of TM 2, not the SNMP.	Editorial	Commented noted. Text is modified to reflect the comment.
MSWD	24	Section 2, Ambient Water Quality Methods: In response to "single concentration value that is representative of water quality within a management zone for a particular constituent and time period", MSWD does not agree. The management zones are essentially the sub basins which can have inherently different characteristics within different areas. More refinement is necessary to identify subareas within the management zones. Also more attention should be given to the production areas. The spatial and temporal approach does not accurately reflect actual conditions. It should be focused on pumping areas. In addition, averaging the data set over the past 20 years isn't appropriate. The present ambient levels are more relevant data sets.	AWQ	For each management zone, the AWQ by cell is shown in graphical form, as well as areas above and below the AWQ. The areas where more data is needed will be linked to the Recycled Water Policy-required monitoring plan. Assimilative capacity is a single number per management zone and provides one method of assessing recycled water projects and other discharges at the basin/subbasin level. This approach is consistent with approaches used in at least five other regions around the state. Basin Plan Amendments have been prepared relying on this approach. The RWQCB still maintains the flexibilit to evaluate projects having unique site-specific conditions in the permitting process consistent with Items 2c and 2d of the Recycled Water Policy. Many of the suggested methods in the Coachella Valley SNMP, from volume-weighted averaging, contouring, layering, etc., are also applied in other SNMPs throughout California. In some areas of the Valley, a 20-year period may be appropriate while in others it may not. Therefore, the approach was revised. The approach now conducts an annual temporal filter, uses the most recent annual data point for each well, then filters spatially by grid cell for contouring and AWQ calculation.
MSWD	25	Section 2.2, Filtering: The temporal and spatial discussions are certainly informative but application of unfiltered and filtered datasets is not fully explained as they were at the stakeholde meeting. This is clear as to how the calculations are done but the reasoning seems to be short. Clustered wells may skew the results but the argument can be made that these clusters represer a management area important to the pumpers.	Filtering	Commented noted. Text is modified to reflect the comment. The Mission Creek Management Zone was reduced to reflect the area where data is present and the area most important for municipal supply. The reduced Mission Creek MZ for volume-weighted AWQ in Section 3.3.3.
MSWD	26	Section 2.2.1, Temporal Filter 1 – Frequency Bias: The section discusses nitrate concentrations indicating that between 1994 and 2009, levels do not exceed the MCL; however, after 2009, samples do exceed the MCL. It is inappropriate to apply a 20-year average when levels already exceed the MCL.	AWQ	Comment noted. The hypothetical case presented was intended as an example to illustrate the effects of filtering. This example was removed to avoid confusion.
MSWD	27	Section 3.3.2, Statistical Description of Ambient Water Quality, and Section 3.3.3, Volume Weighted Ambient Water Quality: Provide the methods used for data filtering together with explanations for methods used. For example, TDS (90% Confidence Interval for the Mean) in the Mission Creek Subbasin/Management Zone ranges from 466 to 547 mg/l for unfiltered while the filtered data ranges from 493 to 706 mg/l. The range of 270-1100 seems to be high and the standard deviation of 240 seems incorrect.	Statistical	The filtering methods are described in TM-1 and TM-2 (section 2.2, pages 7 and 8). Statistical methods, such as standard deviation are standard and not modified. Statistical results will be checked. Basic statistical methods are descried in the following: USGS, 2010. Statistical Methods in Water Resources, Techniques of Water-Resources Investigations of the United States Geological Survey, Book 4, Hydrologic Analysis and Interpretation.

Stakeholder	No.	Comment	General Topic	Response
RWQCB	28	While we agree with the concept of separating the Basin into management zones (MZ) due to variations in water quality and/or geologic conditions, we do not agree with the number of proposed MZs or the methodology for determining AWQ conditions within each MZ. The resulting single concentration value to represent the water quality within an entire MZ for a particular constituent is of little value.	Management Zone	The Recycled Water Policy states that the plan is to be completed at a "basin/subbasin" level. The Implementation Strategies section of the SNMP will highlight areas of a management zones contributing the most to available assimilative capacity for future project consideration. The Regional Board still maintains the flexibility to evaluate projects having unique site-specific conditions in the permitting process consistent with Items 2c and 2d of the Recycled Water Policy. See also the response to comment no. 24.
RWQCB	29	We strongly believe that a more complex numeric modeling approach should be applied to each MZ that generates data driven concentration contours illustrating both horizontal and vertical variability for any given constituent, at any given location/time. This approach will allow the Distric to identify areas (subzones) within MZs that possess or lack assimilative capacity as it provides more accurate approximation of mean constituent concentrations.	Numerical Model	Comment noted. Numerical modeling would allow for incorporation of a comprehensive data history, although at significant cost and impact to project schedule. The Integrated Regional Water Resources Planning Group, for which the RWQCB was a part of, evaluated this issue and determined it was not feasible. For determination of the ambient water quality, a numerical model is used to leverage information on aquifer layer and hydraulic properties. A numerical model for planning would need calibration; this would pose more significant data adequacy problems than currently exist. Dynamic or long-term project evaluation with a numerical model would be useful, although not required. Non numerical modeling/methods have been used successfully for SNMPs throughout the state. Using a model for the ambient water quality will provide the same result as the volume weighted method. The spreadsheet model being developed for planning purposes is conservative and has been useful throughout the state. It is also important to note that this plan is likely a living document. As models are updated and calibrated they can be incorporated.
RWQCB	30	In short, the application of statistics to homogenize a heterogeneous groundwater basin is not appropriate. This is exemplified in TM-2, Table 3-5, which provides descriptive statistics used to determine the volume-weighted TDS AWQ for the East Valley MZ.	AWQ	Table 3-5 lists the filtered dataset for East Valley Management Zone. Statistics are provided for summary reference. Note that the mass of constituents is calculated for three separate vertical layers and then aggregated together. Using the groundwater flow model layering, well construction information, hydraulic properties from the groundwater flow model, and the filtered database, the aquifer heterogeneity is considered at the 1,000 by 1,000-foot horizontal scale and up to three vertical layers. The results of individual cells are then aggregated first by layer and then by management zone. This is consistent with the Recycled Water Policy that states salts and nutrients from all sources be managed on a basin-wide or watershed wide basis.
RWQCB	31	For the sake of transparency, please provide all data used for scientific interpretations (i.e., summaries of raw data, sampling locations, MZ and subzone delineation, sampling date, map, etc.) in an acceptable and usable format (digital or otherwise) in all future submittals, including th final versions of TM-1 and TM-2.	General	All data has been provided in electronic format to the RWQCB, these data have also been reviewed on two occasions with RWQCB staff and MWH staff at RWQCB offices. All data is presented in TM-2 as filtered and unfiltered for transparency. Please note the response to comment No. 1.
RWQCB	32	The use of water quality data collected from 1994 to 2013 for the calculation of AWQ is unacceptable particularly in the case of Coachella Valley because it blurs the effect of recent discharge/recharge activities.	Period	Based on feedback from stakeholders, the AWQ calculation method was revised. The current method determines the annual median for each well. Within each cell the yearly cell mean is calculated based on yearly well medians within the cell. This determines a value for each cell for each year. The most recent annual value for each cell is used, all values are less than 15 years old. Shortening this period of data used will reduce the data available for the AWQ calculation. An attachment has been included to provide an investigation of data adequacy or data "sufficiency" within the study area that includes an evaluation of different baseline periods and the effect on data adequacy. As noted, the filtering method has been modified to use the most recent yearly median available for each well, as opposed to the median of all data points over a chosen baseline period.

Stakeholder	No.	Comment	General Topic	Response
RWQCB	33	The District's consultant (MWH) states there is insufficient recent data for statistical analysis if a 20-year data span is not utilized. If the District feels recent data (i.e., data collected in the last five years) is insufficient to develop a SNMP for the Coachella Valley Basin, then the District needs to collect more data.	Data	Please note response to comment No. 32. The reference to the approved 5-Year baseline period is in Policy under section 9.c.1, this subsection refers to groundwater recharge with recycled water, as opposed to irrigation that occurs in this region. The "5-year or approved" baseline is not applicable in this case, regardless, the stakeholders have and will continue to work with RWQCB staff to determine an applicable period. The revised AWQ is an example. The Policy makes reference to data needs and monitoring to improve available data for analysis in the form of a monitoring plan. The basin wide monitoring plan is to include an appropriate network of monitoring locations. The scale of the plan is dependent upon the site-specific conditions and "shall be adequate to provide a reasonable, cost-effective means of determining whether the concentrations of salt, nutrients, and other constituents of concern as identified in the salt and nutrient plans are consistent with applicable water quality objectives." Note the Policy does not accept a perfect data history for calculations. At this time, it would not be reasonable or cost-effective to install a monitoring network. A monitoring plan will be a part of the final SNMP with monitoring and implementation recommendations.
RWQCB	34	As a final note, while it is commendable the District has taken the initiative to develop a SNMP for the Coachella Valley Basin, We are concerned with the absence or limited participation by other major stakeholders in the Technical Advisory Group. The Recycled Water Policy views this endeavor as locally driven and encourages the participation of all stakeholders.	Stakeholder	The Technical Advisory Group (CVWD, DWA, and IWA), that funds the plan and manages the consultant, has made it a primary emphasis to encourage stakeholders to participate. Four stakeholder meetings have been conducted, two more are planned, and others can be added if needed. All recycled water permittees, all wastewater agencies, all tribes, all water purveyors, and all golf courses have been invited. A website has been set up to publicly post deliverables, comments, and meeting information. Fifteen meetings have been conducted with RWQCB. It has been the intent of the Technical Advisory Group to manage a locally-driven SNMP. A list of stakeholders will be included in the SNMP.