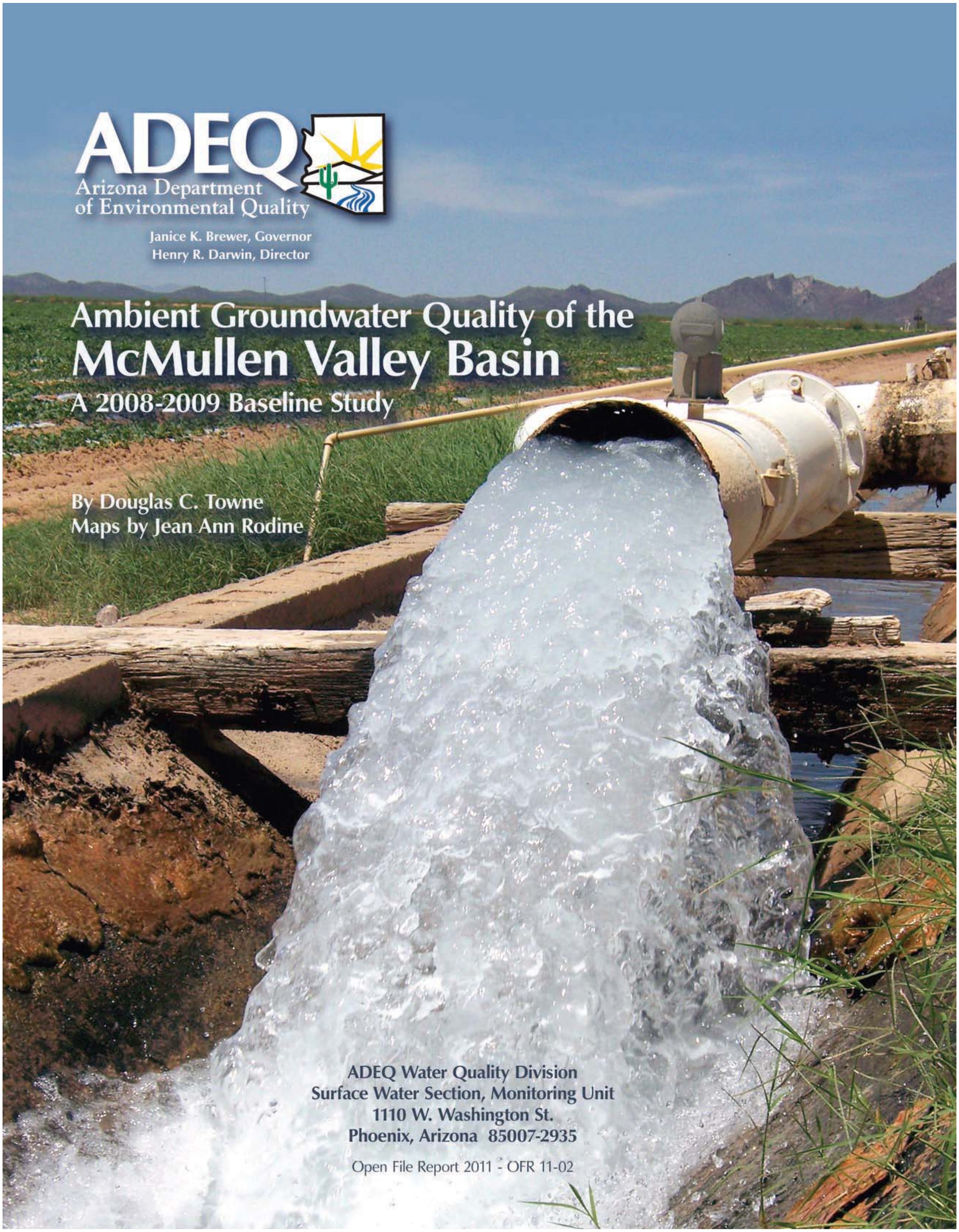

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Arizona Department of Environmental Quality

Janice K. Brewer, Governor
Henry R. Darwin, Director

Ambient Groundwater Quality of the McMullen Valley Basin

A 2008-2009 Baseline Study

By Douglas C. Towne
Maps by Jean Ann Rodine

ADEQ Water Quality Division
Surface Water Section, Monitoring Unit
1110 W. Washington St.
Phoenix, Arizona 85007-2935

Open File Report 2011 - OFR 11-02

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Surface Water Section
Monitoring Unit
1110 West Washington St.
Phoenix, Arizona 85007-2935

Thanks:

Field Assistance:	Jason Jones, Brent Mitchell, David Pinol and Dennis Turner. Special recognition is extended to the many well owners who were kind enough to give permission to collect groundwater data on their property.
Photo Credits:	Douglas Towne
Report Cover:	Well #23 pumps a prodigious amount of groundwater for use on the nearby irrigated fields of cantaloupe near the town of Aguila. Like many wells in the Eastern Regional aquifer, samples from the well exceeded aesthetics-based standards for fluoride.

Other Publications of the ADEQ Ambient Groundwater Monitoring Program

ADEQ Ambient Groundwater Quality Open-File Reports (OFR):

Gila Valley Sub-basin	OFR 09-12, November 2009, 99 p.
Agua Fria Basin	OFR 08-02, July 2008, 60 p.
Pinal Active Management Area	OFR 08-01, June 2007, 97 p.
Hualapai Valley Basin	OFR 07-05, March 2007, 53 p.
Big Sandy Basin	OFR 06-09, October 2006, 66 p.
Lake Mohave Basin	OFR 05-08, October 2005, 66 p.
Meadview Basin	OFR 05-01, January 2005, 29 p.
San Simon Sub-Basin	OFR 04-02, October 2004, 78 p.
Detrital Valley Basin	OFR 03-03, November 2003, 65 p.
San Rafael Basin	OFR 03-01, February 2003, 42 p.
Lower San Pedro Basin	OFR 02-01, July 2002, 74 p.
Willcox Basin	OFR 01-09, November 2001, 55 p.
Sacramento Valley Basin	OFR 01-04, June 2001, 77 p.
Upper Santa Cruz Basin	OFR 00-06, Sept. 2000, 55 p. (With the U.S. Geological Survey)
Prescott Active Management Area	OFR 00-01, May 2000, 77 p.
Upper San Pedro Basin	OFR 99-12, July 1999, 50 p. (With the U.S. Geological Survey)
Douglas Basin	OFR 99-11, June 1999, 155 p.
Virgin River Basin	OFR 99-04, March 1999, 98 p.
Yuma Basin	OFR 98-07, September, 1997, 121 p.

ADEQ Ambient Groundwater Quality Fact sheets (FS):

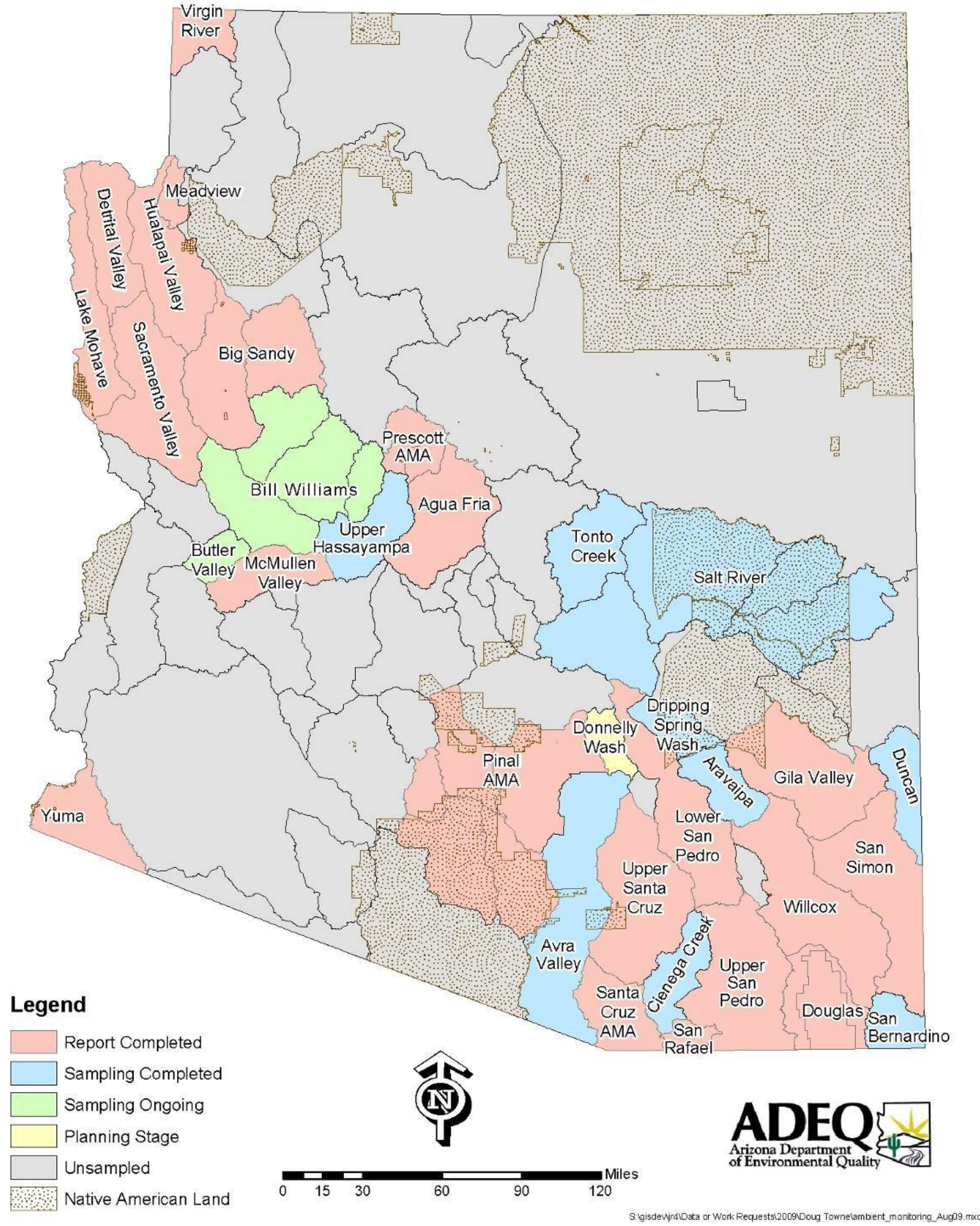
McMullen Valley Basin	FS 11-03, 2010, 6 p.
Gila Valley Sub-basin	FS 09-28, November 2009, 7 p.
Agua Fria Basin	FS 08-15, July 2008, 4 p.
Pinal Active Management Area	FS 07-27, June 2007, 7 p.
Hualapai Valley Basin	FS 07-10, March 2007, 4 p.
Big Sandy Basin	FS 06-24, October, 2006, 4 p.
Lake Mohave Basin	FS 05-21, October 2005, 4 p.
Meadview Basin	FS 05-01, January 2005, 4 p.
San Simon Sub-basin	FS 04-06, October 2004, 4 p.
Detrital Valley Basin	FS 03-07, November 2003, 4 p.
San Rafael Basin	FS 03-03, February 2003, 4 p.
Lower San Pedro Basin	FS 02-09, August 2002, 4 p.
Willcox Basin	FS 01-13, October 2001, 4 p.
Sacramento Valley Basin	FS 01-10, June 2001, 4 p.
Yuma Basin	FS 01-03, April 2001, 4 p.
Virgin River Basin	FS 01-02, March 2001 4 p.
Prescott Active Management Area	FS 00-13, December 2000, 4 p.
Douglas Basin	FS 00-08, September 2000, 4 p.
Upper San Pedro Basin	FS 97-08, August 1997, 2 p. (With the U.S. Geological Survey)

These publications are available on-line.
Visit the ADEQ Ambient Groundwater Monitoring Program at:

www.azdeq.gov/environ/water/assessment/ambient.html

ADEQ Ambient Groundwater Monitoring Program Studies

February 2010



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Abbreviations

amsl	above mean sea level
ac-ft	acre-feet
AGF/yr	acre-feet per year
ADEQ	Arizona Department of Environmental Quality
ADHS	Arizona Department of Health Services
ADWR	Arizona Department of Water Resources
ARRA	Arizona Radiation Regulatory Agency
AZGS	Arizona Geological Survey
As	arsenic
bls	below land surface
BLM	U.S. Department of the Interior Bureau of Land Management
^{o}C	degrees Celsius
$CI_{0.95}$	95 percent Confidence Interval
Cl	chloride
EPA	U.S. Environmental Protection Agency
F	fluoride
Fe	iron
gpm	gallons per minute
hard-cal	hardness concentration calculated from calcium and magnesium concentrations
HUC	Hydrologic Unit Code
LLD	Lower Limit of Detection
MMU	McMullen Valley Groundwater Basin
Mn	manganese
MCL	Maximum Contaminant Level
ml	milliliter
msl	mean sea level
ug/L	micrograms per liter
um	micron
uS/cm	microsiemens per centimeter at 25° Celsius
mg/L	milligrams per liter
MRL	Minimum Reporting Level
MTBE	Methyl tertiary-Butyl Ether
ns	not significant
ntu	nephelometric turbidity unit
pCi/L	picocuries per liter
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
SAR	Sodium Adsorption Ratio
SDW	Safe Drinking Water
SC	Specific Conductivity
su	standard pH units
SO_4	sulfate
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
USGS	U.S. Geological Survey
VOC	Volatile Organic Compound
*	significant at $p \leq 0.05$ or 95% confidence level
**	significant at $p \leq 0.01$ or 99% confidence level

Ambient Groundwater Quality of the McMullen Valley Basin: A 2008-2009 Baseline Study

Abstract - In 2008-2009, the Arizona Department of Environmental Quality (ADEQ) conducted a baseline groundwater quality study of the McMullen Valley basin located in west-central Arizona. The basin consists of the drainage of the ephemeral Centennial Wash within McMullen Valley and the surrounding mountains.[6] Groundwater is predominantly used for irrigation near the communities of Aguila, Wenden and Salome.[7] The City of Phoenix has purchased farms near Salome to obtain the water rights for potential transfer to Maricopa County for municipal use.[7] The main source of groundwater in the basin is the Regional aquifer. [24] Heavy pumping near Aguila and Salome has produced a groundwater divide near the La Paz-Maricopa County line creating Eastern and Western Regional aquifers.[25] In terms of spatial extent and groundwater storage these are the largest aquifers in the basin. [25] Low hills east of Aguila that minimize groundwater movement divide the Eastern Regional aquifer from the Forepaugh aquifer.[43] A subsurface extension of the Harquahala Mountains that limits groundwater movement separates the Western Regional aquifer from the Southern Regional aquifer located in Harrisburg Valley.[25] Another subsurface geologic feature separates the Harcuvar aquifer from the Southern and Western Regional aquifers lying to the east. [24] Groundwater movement between the Western Regional aquifer and the overlaying Perched aquifer is restricted by the Lake-bed Unit, a layer of fine-grained sediments. [24] These deposits, however, are absent in an area one mile northeast of Salome where groundwater flowing from the Perched aquifer into the Western Regional aquifer is termed the Mixed aquifer. [24]

To characterize regional groundwater quality, samples were collected from 124 wells. The wells supply water for irrigation, domestic, municipal and stock uses throughout the basin. Inorganic constituents and oxygen and deuterium isotopes were collected from all wells. At selected wells, radon (79 sites), radiochemistry (50 sites) and pesticide (2 sites) samples were also collected. In addition to the 124 wells, 12 additional wells were sampled for field parameters and nitrate.

Primary maximum contaminant levels (MCLs) for inorganic constituents were exceeded at 54 of the 124 sites (44 percent). These enforceable standards define the maximum concentrations of constituents allowed in water supplied for drinking water purposes by a public water system and are based on a lifetime daily consumption of two liters. [38] Constituents exceeding Primary MCLs include arsenic (24 sites), fluoride (27 sites), nitrate (25 sites), and selenium (2 sites). Primary MCLs for radionuclides were exceeded at 9 of the 50 sites (18 percent) including gross alpha (9 sites) and uranium (4 sites). Elevated concentrations of arsenic and fluoride likely occur naturally. Elevated nitrate concentrations appear to be caused by nitrogen-laden recharge resulting from irrigation applications and wastewater from septic systems. Gross alpha and uranium exceedances are likely naturally occurring though may be impacted by anthropomorphic activities.[42] Secondary MCLs were exceeded at 87 of 124 sites (70 percent). These are unenforceable aesthetics guidelines that define the maximum constituent concentration that can be present in drinking water without an unpleasant taste, color, or odor.[38] Constituents above Secondary MCLs include chloride (13 sites), fluoride (69 sites), manganese (2 sites), pH (19 sites), sulfate (8 sites), and TDS (31 sites).

The basin's most important groundwater quality issue is the absence of the Lake-bed Unit northeast of Salome. [24] Nearby wells commonly exceed water quality standards and guidelines; nitrate concentrations were elevated up to seven times the 10 mg/L health-based water quality standard. This is the result of percolating irrigation water containing salts and nitrate recharging the Perched aquifer. With a higher static water level than the Regional aquifer, groundwater drains downward from the Perched aquifer into the Western Regional aquifer. This impacted area is referred to in this report as the Mixed aquifer. [24] TDS, sodium, chloride, sulfate, and nitrate were significantly higher in the Perched and Mixed aquifers than in all the other aquifers (Kruskal-Wallis with Tukey test, $p \leq 0.05$).

Both the Eastern and Western Regional aquifers had water quality issues. In the Eastern Regional aquifer, southeast of Aguila, some sample sites exceeded standards for fluoride and, to a lesser degree, arsenic. Similarly, in the Western Regional aquifer near Wenden, sample sites also exceeded standards for fluoride and, to a lesser degree, arsenic. The Eastern Regional aquifer exhibited significantly lower concentrations of TDS, sodium, and boron than in the Western Regional aquifer; the opposite pattern occurs with well depth and groundwater depth. (Kruskal-Wallis with Tukey test, $p \leq 0.05$) These differences may result from poor quality irrigation recharge minimally impacting the Eastern Regional aquifer because of the great depths needed to percolate to groundwater. Almost all the sites sampled in the Forepaugh aquifer exceeded water quality standards for fluoride and arsenic. Fluoride concentrations commonly were up to three times the health-based standard. Few water quality standards were exceeded in the Southern Regional and Harcuvar aquifers; both appear to consist of more recent recharge.

INTRODUCTION

Purpose and Scope

The McMullen Valley groundwater basin encompasses approximately 591 square miles in west-central Arizona.[5] The western portion of the basin is located in La Paz County, the southeastern portion is in Maricopa County and a small portion in the northeast is in Yavapai County (Map 1). The economy of McMullen Valley is predominantly based on agriculture as well as serving the needs of the area's retired population. Groundwater is the primary source for agricultural, municipal, stock and domestic water supply within the basin. [6]

The McMullen Valley basin is one of the few groundwater basins in Arizona designated for out-of-basin transport of groundwater. The City of Phoenix has purchased 14,000 acres of agricultural land to obtain the water rights for potential future transport of groundwater to the Phoenix Active Management Area for municipal uses. [7]

The Arizona Department of Environmental Quality (ADEQ) Ambient Groundwater Monitoring program was originally charged with characterizing nitrate concentrations in the town of Salome to explore the possibility of creating a Nitrogen Management Area.[3] The study was subsequently expanded to characterize the groundwater quality of the entire McMullen Valley basin.

Sampling by the ADEQ Ambient Groundwater Monitoring program is authorized by legislative mandate in the Arizona Revised Statutes §49-225, specifically: "*...ongoing monitoring of waters of the state, including...aquifers to detect the presence of new and existing pollutants, determine compliance with applicable water quality standards, determine the effectiveness of best management practices, evaluate the effects of pollutants on public health or the environment, and determine water quality trends.*" [3]

Benefits of ADEQ Study – This study, which utilizes accepted sampling techniques and quantitative analyses, is designed to provide the following benefits:

- A general characterization of regional groundwater quality conditions in the McMullen Valley basin identifying areas with water quality concerns.

- A characterization of nitrate concentrations in groundwater in areas of housing developments using septic systems for wastewater disposal in areas south of the town of Salome

- A process for evaluating potential groundwater quality impacts arising from a variety of sources including mineralization, mining, agriculture, livestock, septic tanks, and poor well construction.

- A guide for identifying future locations of public supply wells.

- A guide for determining areas where further groundwater quality research is needed.

Physical Characteristics

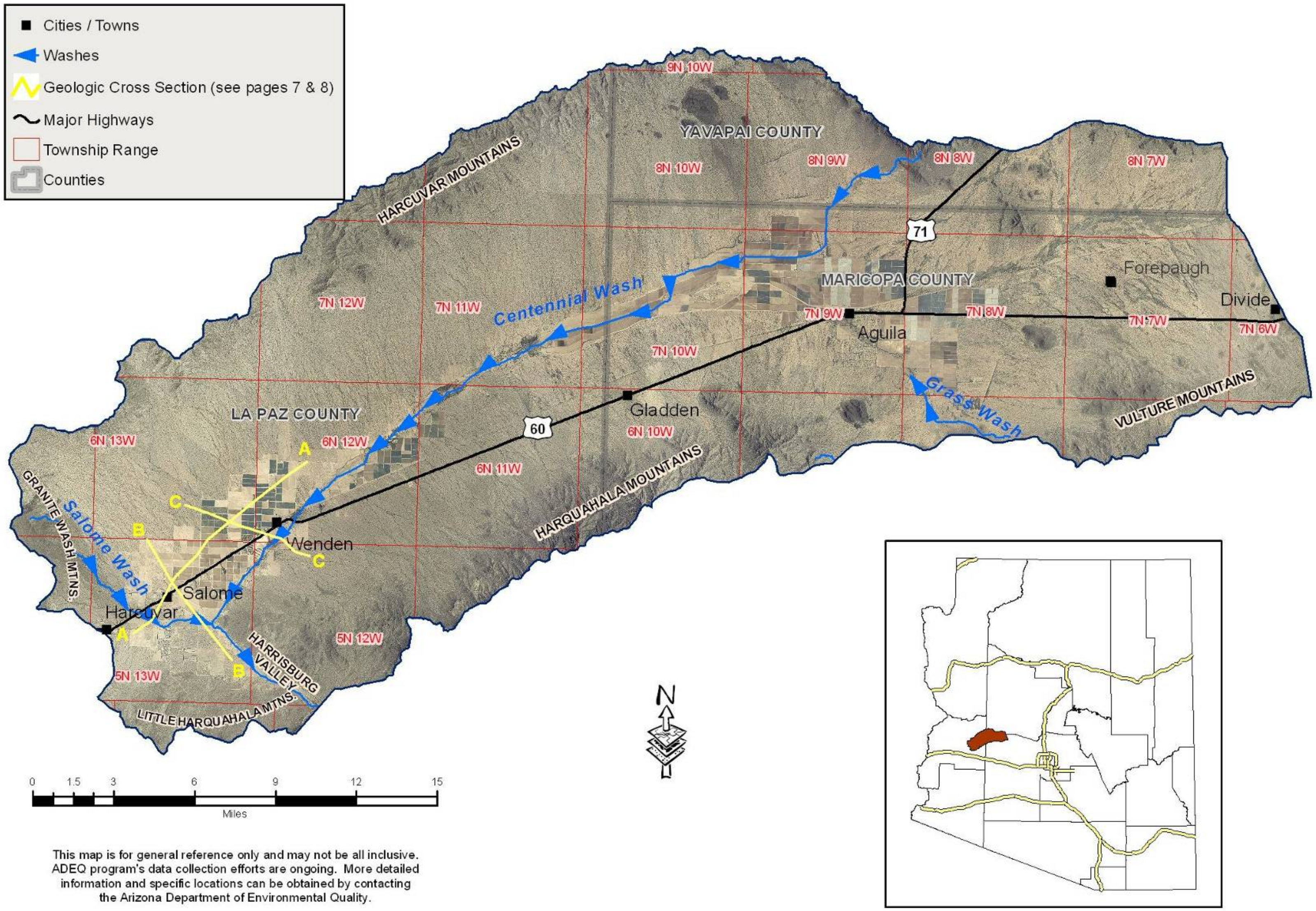
Geography – The McMullen Valley basin is located within the Basin and Range physiographic province which is characterized by broad alluvial valleys separated by mountain ranges. The kidney-shaped basin is oriented northeast-to-southwest and is about 15 miles wide and 48 miles long.

The basin is bounded on all sides, except the northeast, by mountains. The Harcuvar Mountains are to the north, the Harquahala and Vulture Mountains are to the south, and the Little Harquahala and Granite Wash Mountains are to the west. A ridge near the railroad siding of Divide marks the eastern boundary that separates it from the Upper Hassayampa basin. At the southwest end of the basin is Harrisburg Valley, oriented perpendicular to the axis of McMullen Valley.

The basin is drained by Centennial Wash, an ephemeral tributary of the Gila River that heads about 20 miles east of Aguila and discharges from the basin through "the Narrows" into the Harquahala basin.[25] Elevations in the McMullen Valley basin range from 5,720 feet above sea level atop Harquahala Peak to approximately 1,700 feet above mean sea level at "the Narrows". Elevation of the McMullen Valley floor typically ranges from 1,900 to 2,200 feet. [7]

Within McMullen Valley are the communities of Aguila, Wenden, and Salome. The latter two communities had a combined population of 2,246 permanent residents in 2000.[1] Agriculture is the main industry although the area is increasingly a destination for retirees either as permanent residents or, more often, seasonal visitors.

Map 1: McMullen Valley Basin



This map is for general reference only and may not be all inclusive. ADEQ program's data collection efforts are ongoing. More detailed information and specific locations can be obtained by contacting the Arizona Department of Environmental Quality.

Approximately 14,600 acres were farmed in 2007 of which 79 percent were flood irrigated and 21 percent drip irrigated. [7] Crops grown in 2007 included melons (60 percent), cotton (19 percent), sorghum (8 percent) and minor amounts of chilies, oats, alfalfa, corn, guayule, and pistachio. Irrigated agriculture has spatially decreased in the basin with 34,200 acres farmed as recently as 1980.[25]

There are two irrigation districts: the Aguila Irrigation District and the McMullen Valley Water Conservation District. All wells and ditches are privately owned in both districts as neither has a consolidated distribution system. Both districts were formed in order to potentially contract water and power from the Colorado River; groundwater is currently the only water supply. [7]

The City of Phoenix purchased and/or leased approximately 16,000 acres of farmland in the Salome/Wenden area in 1986 with plans to eventually pump and transport groundwater from this area to Phoenix to use as for municipal purposes. [24] Until this groundwater transfer occurs, Phoenix is managing these farm properties by leasing them to farm operators.[24] About 93 percent of private lands in the McMullen Valley Water Conservation District are owned by the City of Phoenix. [24]

Climate – The arid climate of the McMullen Valley basin is characterized by hot summers and mild winters. Precipitation occurs predominantly as rain in either late summer, localized monsoon thunderstorms or in winter as widespread, low intensity rain that sometimes includes snow especially at higher elevations. Annual precipitation averages about 7 inches. [25]

Geology - The McMullen Valley basin is characterized by two principal physiographic features:

- mountainous regions, and
- an intermontane, sediment-filled basin.

The mountains consist of relatively impermeable, granites, gneisses and variably metamorphosed-to-unmetamorphosed sedimentary and volcanic rocks. [24] The basin-fill is comprised largely of unconsolidated to consolidated sedimentary rocks that have been eroded from the surrounding mountains and deposited within the basin. [24]

Early basin sedimentation was characterized by deposition of alluvial fans by streams emanating from the bordering mountains into a subsiding basin. Over time, these alluvial fans coalesced to form a broad bajada projecting from the mountains toward the center of the basin, with sediments becoming finer towards the center of the basin. [24]

Although through-flowing drainage occurred at this time, basin stratigraphy suggests it was eventually replaced by internal drainage characteristic of a closed basin. With no external drainage, bajada deposition was joined by a lake-depositional environment, accumulating evaporite, and fine-grained sand, silt, and clay deposits as thick as 1,100 feet. Subsequently, external drainage was re-established and alluvial deposition once again became the dominant form of basin sedimentation. [24]

HYDROLOGY

Lithology

McMullen Valley's long sedimentation history has resulted in depositional sediments over 5,000 feet thick in its western portion increasing to over 6,000 feet in the eastern portion. [6] The basin-fill has been classified into three main stratigraphic units based on lithologic characteristics and depositional environments. These units are, in order of deposition:

- the Alluvial Fan/Fanglomerate Unit,
- the Lake-bed Unit, and
- the Upper Alluvial Fill Unit. [24]

Alluvial Fan/Fanglomerate Unit –These deposits are the main water bearing unit in the basin, directly overlie bedrock, and are found throughout the basin. Comprised of sediments that created the bajada during the early formation of the basin, the lithology of the unit ranges from relatively coarse, heterogeneous detritus on the flanks of the mountains to somewhat finer, better sorted material toward the center of the basin. [24]

This unit is composed primarily of poorly sorted gravel and coarse sand but may locally contain clay, silt and fine sand. Cementation, which significantly affects its hydraulic characteristics, varies greatly within this unit but appears to be more prevalent in the eastern portion of the basin. The maximum thickness of this unit is unknown but gravity data suggest it's greater than 5,000 feet thick. [24] Two cones of depression near Aguila and in the Salome/Wenden area that have been in existence since at least 1958, limit the flow of groundwater. [9, 25]

The cones of depression create a groundwater divide between Aguila and Wenden that trends northwest to southeast in the vicinity of the county line. The boundary between the coalescing cones of depression is not exactly known because of the scarcity of water level data in the middle of the basin; its location will also vary slightly with time due to pumping rates in the two subareas. [24]

Lake-Bed Unit – These deposits were created when events perhaps related to the Basin and Range structural formation closed the basin causing it to drain internally. This created a playa-lake environment which resulted in a deposition of fine-grained sediments including clay, silt, and very fine sand; with local evaporate deposits, near the center of the subsiding basin. [24] Lake-bed deposits have a relatively low permeability and form a confining layer above the Regional aquifer. This unit, however, may contain local saturated sand lenses which are sufficiently permeable to act as perched aquifers. A few wells have produced limited amounts of poor-quality water from these sand lenses. [24]

The lake-bed unit covers about 140 square miles of the western portion of the basin. It is not found to the east of the La Paz-Maricopa County line. The unit has a maximum recorded thickness of 1,100 feet approximately four miles northwest of the town of Wenden. A hydrologic cross-section extending from three miles northeast of Wenden through Salome to Harcuvar is shown in Diagram 1. [24]

Notably, this unit is absent at one location within the main body of the deposit approximately a mile northwest of the town of Salome. The lack of any lake-bed deposits at this location may be due to either the presence of a topographic high at this location at the time of sedimentation or due to post-depositional erosion and removal of the unit. [24]

Upper Alluvial Fill Unit – This unit consists largely of unconsolidated gravel, sand, silt and clay deposited by Centennial Wash and its tributaries after the re-establishment of external drainage. Where the Upper Alluvial Fill unit overlies the Lake-Bed unit, the contact is generally evident. However, in the absence of lake-bed sediments, the contact between it and the underlying Alluvial Fan/Fanglomerate Unit is less pronounced. [24]

Found throughout the basin, this unit's thickness varies from near zero near the mountain fronts to at least 560 feet near the town of Aguila and is typically 100-200 feet thick in western McMullen Valley, decreasing to less than 50 feet thick in southeastern Harrisburg Valley.[24] In the Aguila area, the Upper Alluvial Fill unit has, for the most part, been dewatered from heavy pumping for irrigation use. [25]

Groundwater

In the McMullen Valley basin, the land surface gradient is greater than the slope of the water table; thus the depth to water increases northeastward along the valley floor and laterally from the axis of the valley.[6] Recharge occurs only by rainfall and agricultural return flows; consequently groundwater withdrawals by agriculture greatly exceed recharge and cause depletion of the aquifer. [6]

Aquifers – Seven unique aquifers were identified in the McMullen Valley basin based on water quality data collected for this report in conjunction with previously published hydrologic studies.

- The main aquifer system is the Regional aquifer which can be subdivided into Eastern, Western and Southern aquifers based on water quality data, groundwater flow patterns and geologic structures.

- Two aquifers of more limited productivity were also identified: the Forepaugh aquifer located in the extreme eastern portion of the basin and the Harcuvar aquifer located in the extreme western portion of the basin.

- A Perched aquifer is located above the Western Regional aquifer separated by an aquitard composed of fine-grained lake deposits. There is a half-mile gap in the aquitard about a mile northeast of the town of Salome where the Perched and Western Regional aquifers merge to form the Mixed aquifer of limited spatial extent.

Regional Aquifer – Found throughout McMullen Valley, the aquifer consists of the Alluvial Fan/Fangolmerate Unit found underlying the Lake-bed Unit in the western portion of the basin and underlying the Upper Alluvial Fill Unit in the eastern portion of the basin.

Stratigraphic data suggest that the Regional aquifer is mainly composed of coalescing heterogeneous deposits of poorly sorted, coarse gravel and sand. Although thought to be hydrologically connected, the sediments heterogeneous nature results in highly variable hydraulic properties throughout the aquifer. Intergranular cementation also impacts the aquifer's hydraulic properties. In general, cementation increases in the basin from west to east, around the basin's margins, and in proximity to bedrock. [24] Available water quality data indicate, for the most part, that it contains good quality water suitable for drinking and irrigation uses. [24] For the purposes of this study, the Regional Aquifer is divided into three areas:

- **Eastern Regional Aquifer**: consisting of basin areas roughly lying east of the La Paz-Maricopa County line, a cone of depression caused by irrigation pumping near Aguila has essentially divided the basin near where the Lake-bed Unit peters out. [24, 25]

- **Western Regional Aquifer**: consisting of basin areas roughly lying west of the La Paz-Maricopa County line, a cone of depression caused by irrigation pumping near Aguila has essentially divided the basin near where the Lake-bed Unit begins. [24, 25]

- **Southern Regional Aquifer**: is present in basin areas lying south of the western subsurface extension of the Harquahala Mountains that partially retards the movement of groundwater from the Harrisburg Valley area to the zone of heavy pumping around Salome and Wenden (Diagram 2).[24] This subsurface structural extension becomes indistinct further west near the community of Harcuvar.

Forepaugh Aquifer – For the purposes of this report, this aquifer is considered separate from the Eastern Regional aquifer. The steep hydraulic gradient between the Forepaugh and Eastern Regional aquifers is evidence of their poor connection. [43] The aquifer is found near the community of Forepaugh in the easternmost area of the McMullen Valley basin. The aquifer is separated from the Eastern Regional aquifer by some low hills (in Townships 7 and 8 North, Range 8 West) and an unnamed ridge that extends southeastward from the northeast end of the Harcuvar Mountains. [43]

Harcuvar Aquifer – For the purposes of this report, this aquifer is considered separate from the Southern and Western Regional aquifers. The aquifer is found near the community of Harcuvar located three miles west of Salome along U.S. Highway 60. Groundwater flow is limited in the Alluvial Fan/Fanglomerate Unit from Harcuvar to areas to the east (see Diagram 1) by the thickness of the Lake-bed Unit which extends almost down to bedrock.

Perched Aquifer – Present only in the western portion of the basin, this shallow aquifer includes isolated, water-bearing sand lenses within the Lake-bed Unit and water-bearing zones within the overlying Upper Alluvial Fill Unit. The Perched aquifer system is not a significant water source and little information is known about the occurrence and movement of water within it. [24] However, since it is composed of discontinuous sand and gravel lenses, the Perched aquifer may actually be a system composed of several aquifers that may not all be hydrologically connected. [24]

Natural recharge to the perched aquifer is the result of percolation from the ephemeral Centennial Wash and its tributaries. However, most recharge comes from deep percolation of excess irrigation water as well as minor amounts of wastewater discharged from septic systems. As such, the water quality in the Perched aquifer is generally poor. [24]

Mixed Aquifer – In general, the Regional and Perched aquifers appear to act independently of one another relative to applied hydraulic stresses. This suggests that the intervening Lake-bed Unit is an effective barrier to the downward percolation of ground water, effectively isolating the two aquifers.

However, short circuiting between the two aquifers takes place within some wells that penetrate both aquifers. This occurs through perforations or breaks in the well casing within the Perched aquifer system which allows water to enter the casing and cascade down the well to the Regional aquifer. The total annual volume of this leakage between aquifers is not known but has been estimated to be as much as 40 acre-feet per leaking well. [24]

Stratigraphic data suggest that the Regional aquifer also receives natural recharge from the Perched aquifer in certain locations. These areas include along the perimeter of the Lake-bed Unit as water from the Perched aquifer spills over the edge into the Regional aquifer. [24] For the purposes of this study, the effects of water from the Perched aquifer entering the Regional aquifer through cascading wells and along the perimeter of the Lake-bed Unit was not considered separately. However another area where water from the two aquifers merges was analyzed in the study.

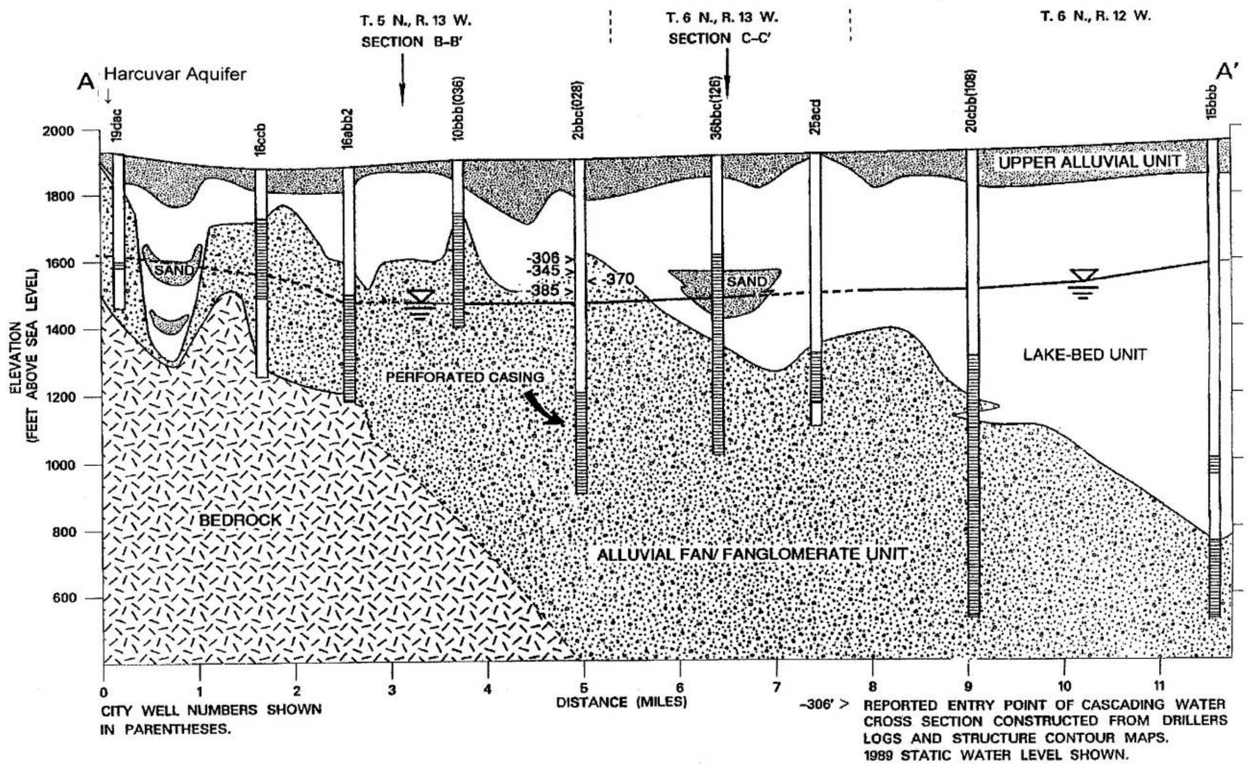


Diagram 1. Hydrologic cross section of western McMullen Valley stretching from Harcuvar (on the left) through Salome to four miles northeast of Wenden.[24]

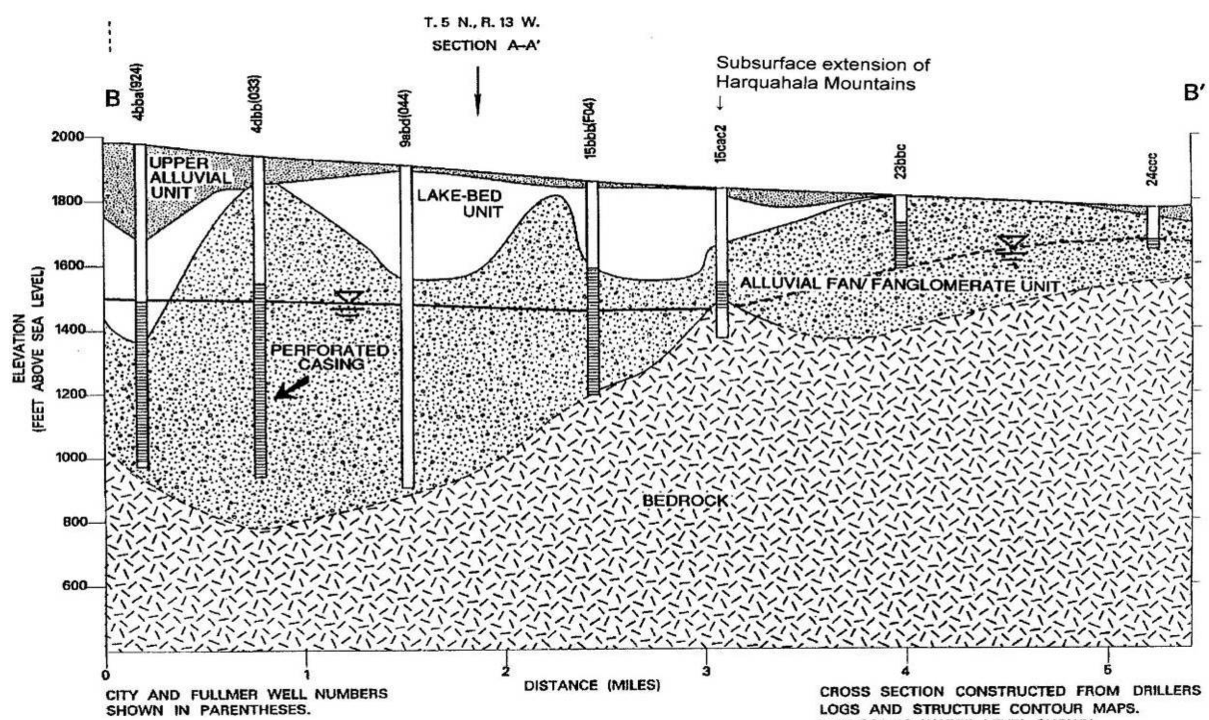


Diagram 2. Hydrologic cross section of Harrisburg Valley from two miles north of Salome (on the left) to three miles southeast of the town.[24]

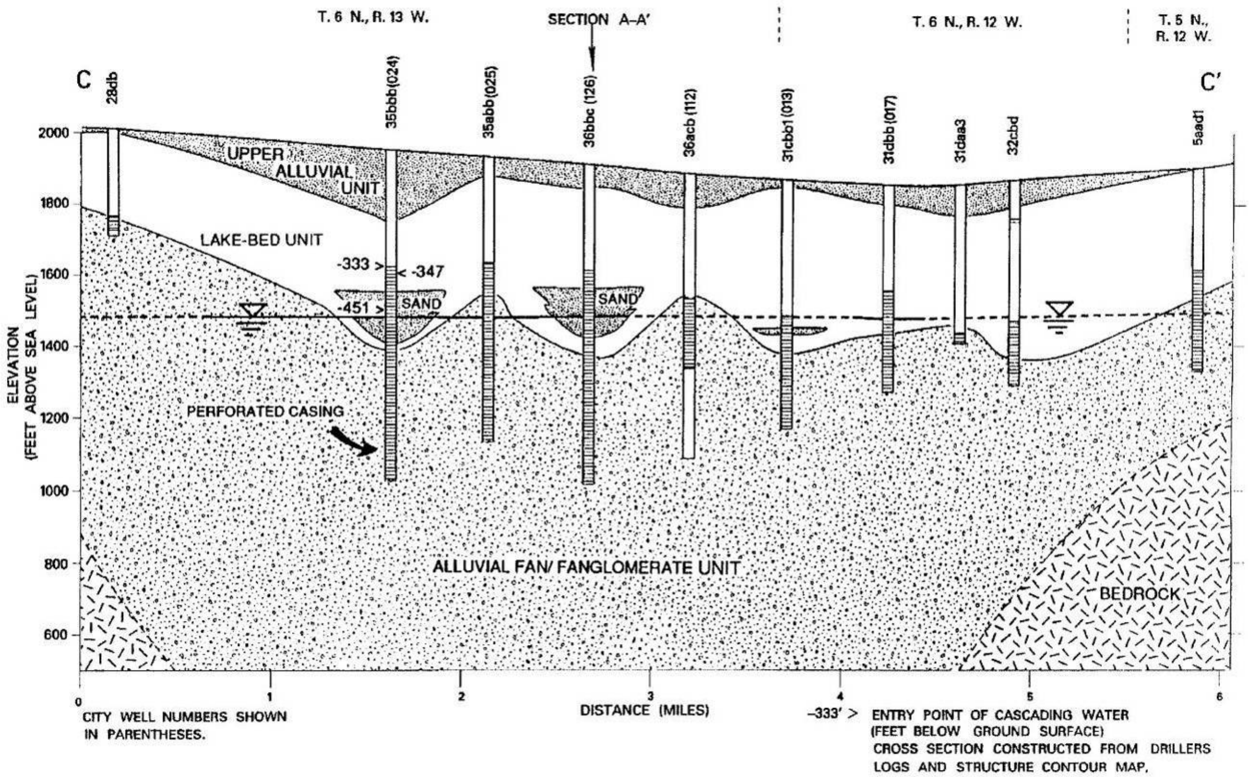


Diagram 3. Hydrologic cross section of western McMullen Valley stretching from four miles north of Salome (on the left) southeast to a point one mile southeast of Wenden.[24]

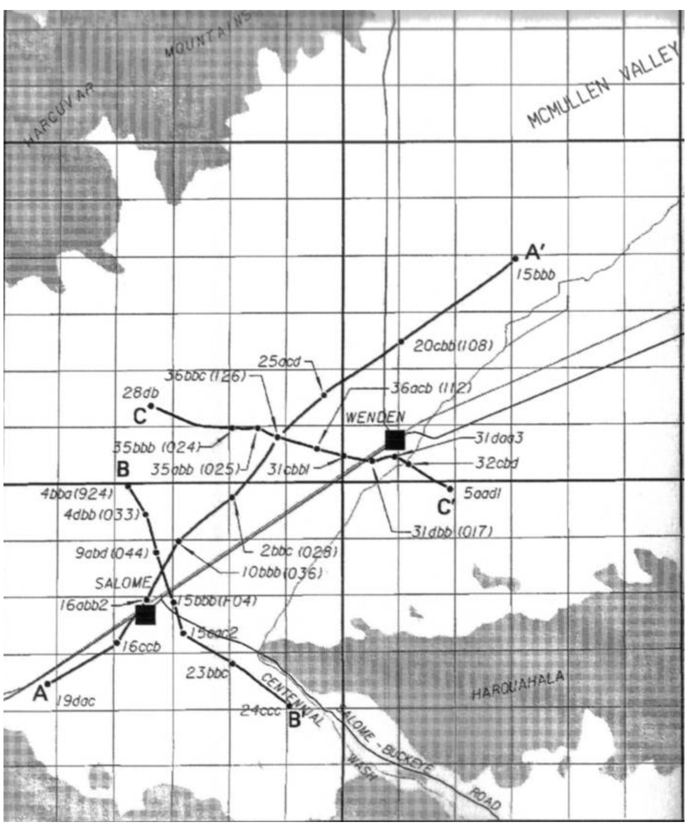


Diagram 4. Map showing the paths of three hydrologic cross sections in western McMullen Valley.[24]

The Perched and Regional aquifers appear to be in direct contact in a one-half mile gap where lake-bed sediments are absent about one mile northeast of Salome.[24] Since the Perched aquifer has a higher static water level, groundwater tends to drain downward from the Perched aquifer to the Western Regional aquifer in this area. Although the phrase, "Persistent Degraded Water Quality Zone" has been used to describe the area by previous studies, the area will be called the Mixed aquifer in this report.[24]

Wells

Groundwater development in the McMullen Valley basin began with mining, stock and domestic wells in the early 1900s. Substantial increases in groundwater pumping did not occur until the mid-1950s with the development of irrigated agriculture. Wells for irrigation increased in numbers through the 1970s until tapering off in the 1980s.[24] The majority of wells are located near the axis of McMullen Valley where agricultural activities and the communities of Aguila, Salome and Wenden are located. There are also many domestic wells throughout Harrisburg Valley. On the flanks of the basin, only a few wells for stock or domestic use, are found.

The oldest wells in the western part of the basin were shallow wells that obtained water predominantly from the Perched aquifer system. As deeper wells began to be drilled, many were perforated in both the Perched and Regional aquifers. More recently drilled wells are perforated only in the Regional aquifer.

Cross-contamination between aquifers occurs via cascading water in wells perforated in both aquifers. Other cross-contamination causes include breaks in the well casing, voids behind the casing, and by leakage through filter packs surrounding the casing in rotary-drilled wells.[24] The City of Phoenix estimates that at least 15 of its 42 wells blend water from both the Perched and Regional aquifers based on well construction data and video surveys.[24]

Irrigation wells tapping the Regional aquifer produce 150 to 3,500 gallons per minute (gpm); the wide range in production is attributed to encountering more permeable beds of sand and gravel within the aquifer and to individual well characteristics.[25]

Although groundwater withdrawals have occurred since the early 1900s, withdrawals increased greatly beginning in the 1950s. The most significant withdrawals occurred between 1971 and 1981 with an annual average of 123,000 acre-feet. Production peaked at 144,000 acre-feet in 1981.[24] Groundwater pumping in the basin averaged 89,100 acre-feet annually from 2001 to 2005.[7]

INVESTIGATION METHODS

ADEQ collected samples from 124 groundwater sites to characterize regional groundwater quality in the McMullen Valley basin (Map 2). Specifically, the following types of samples were collected:

- oxygen and deuterium isotopes at 124 sites
- inorganic suites at 124 sites
- radon at 79 sites
- radionuclide at 50 sites
- perchlorate at 24 sites
- pesticides at 2 sites

Twelve (12) additional sites were also sampled only for physical parameters and nitrate.

No bacteria sampling was conducted because microbiological contamination problems in groundwater are often transient and subject to a variety of changing environmental conditions including soil moisture content and temperature.[18]

Sampling Strategy

The study focused on regional groundwater quality conditions that are large in scale and persistent in time. It was originally designed as a targeted investigation to determine nitrate concentrations in groundwater in Salome where residences use septic systems for domestic wastewater disposal. The data collected would assist in determining if existing conditions or trends in nitrogen loading to the aquifer will cause or contribute to an exceedance of the Aquifer Water Quality Standard for nitrate. This would potentially warrant the establishment of a Nitrogen Management Area to control nitrogen loading to groundwater as described in the Arizona Administrative Code R18-9-A317(c).[3] After the nitrate data in Salome was collected, the study was expanded into an ambient baseline study of the entire McMullen Valley basin.

Wells pumping groundwater for irrigation, stock, municipal and domestic purposes were sampled for this study, provided each well met ADEQ requirements. A well was considered suitable for sampling if the owner gave permission to sample, if a sampling point existed near the wellhead, and if the well casing and surface seal appeared to be intact and undamaged.[2, 8] Other factors such as construction information were preferred but not essential. Some

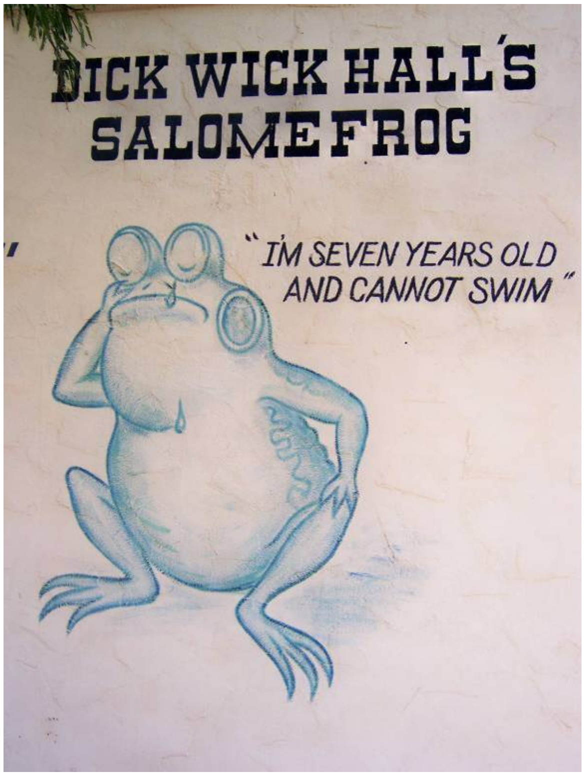


Figure 1. The largest community in McMullen Valley, Salome was founded by Dick Wick Hall in 1904. Publisher of the *Salome Sun,* his humorous columns about life in the desert were so popular they were syndicated in 28 newspapers around the country from 1925-26. The Salome Frog is one of his most famous characters, an amphibian seven years old who cannot swim because of a lack of water.

Despite McMullen Valley appearing to be a dry, desolate place, the basin has tremendous water resources. ADWR estimates that 15,100,000 acre-feet is stored in aquifers.[6] This factor led to the City of Phoenix purchasing and/or leasing almost 16,000 acres of farmland in the Salome-Wenden area in 1986.[24] Eventually, Phoenix plans to pump groundwater from the area and convey it in the Central Arizona Project to use for municipal purposes.[7]

Figure 2 – McMullen Valley occasionally has prolific surface water flows such as when Centennial Wash in the foreground flooded the nearby community of Wenden during heavy precipitation in mid-January, 2010. Flows in Centennial Wash peaked at 9,938 cubic feet per second. Farm fields and the Harcuvar Mountains lie to the north of the inundated community.

Figure 3 – ADEQ's Jason Jones samples a domestic well in the Forepaugh aquifer located east of Aguila. Many sites in the Forepaugh aquifer had health-based exceedances of fluoride and arsenic.

Figure 4 – The Harcuvar Mountains are the backdrop to an irrigation well located east of the town of Wenden in the Western Regional aquifer. Groundwater from the well is used to grow alfalfa. Samples from the 850-foot deep well revealed very soft water that exceeded health-based water quality standards for arsenic and fluoride.

Figure 5 – Like many deep wells pumping from the Eastern Regional aquifer, Well #23 located along U.S. Highway 60 east of the community of Aguila is a productive irrigation well pumping at over 1,500 gallons per minute.

Figure 6 – A 180-feet-deep well provides water for domestic uses near irrigated farmland north of Salome. The shallow well draws water from the Perched aquifer which is separated from the underlying Western Regional aquifer by a layer of fine sediments that restrict groundwater flow.[24] Samples from the well exceeded health-based water quality standards for arsenic nitrate and selenium; concentrations of chloride, fluoride, sulfate and TDS exceeded aesthetics-based water quality guidelines. The Harcuvar Mountains are in the background.

requests to sample wells were denied because of fears of how the data would be used; other wells were not sampled because they lacked proper sampling ports.

For this study, ADEQ personnel sampled 124 wells with the following types of pumps: submersible pumps (82 wells), turbine pumps (40 wells) and hand bailers (2 monitoring wells). In addition, of the 12 wells sampled only for physical parameters and nitrate, 9 wells had submersible pumps and 3 wells had turbine pumps.

Submersible pumps produce water for municipal, domestic and/or stock use, turbine pumps produce water for irrigation use and bailers were used with monitoring wells that were installed to delineate contamination plumes from underground storage tanks. Additional information on groundwater sample sites is compiled from the Arizona Department of Water Resources (ADWR) well registry in Appendix A. [7]

Sample Collection

The sample collection methods for this study conformed to the *Quality Assurance Project Plan* (QAPP) [2] and the *Field Manual For Water Quality Sampling*. [8] While these sources should be consulted as references to specific sampling questions, a brief synopsis of the procedures involved in collecting a groundwater sample is provided.

After obtaining permission from the owner to sample the well, the volume of water needed to purge the well of three bore-hole volumes was calculated from well log and on-site information. Physical parameters—temperature, pH, and specific conductivity—were monitored at least every five minutes using an YSI multi-parameter instrument.

To assure obtaining fresh water from the aquifer, after three bore volumes had been pumped and physical parameter measurements had stabilized within 10 percent, a sample representative of the aquifer was collected from a point as close to the wellhead as possible. In certain instances, it was not possible to purge three bore volumes. In these cases, at least one bore volume was evacuated and the physical parameters had stabilized within 10 percent.

Sample bottles were filled in the following order:
1. Pesticides
2. Perchlorate
3. Radon
4. Inorganic
5. Radionuclide
6. Isotope

Pesticide samples were collected in unpreserved, 1 gallon amber glass containers.

Perchlorate and isotope samples were collected in unpreserved, 500 ml polyethylene bottles.

Radon samples were collected in two unpreserved, 40-ml clear glass vials. Radon samples were carefully filled to minimize volatilization and subsequently sealed so that no headspace remained. [16]

The inorganic constituents were collected in three, 1-liter polyethylene bottles: samples to be analyzed for dissolved metals were delivered to the laboratory unfiltered and unpreserved where they were subsequently filtered into bottles using a positive pressure filtering apparatus with a 0.45 micron (µm) pore size groundwater capsule filter and preserved with 5 ml nitric acid (70 percent). Samples to be analyzed for nutrients were preserved with 2 ml sulfuric acid (95.5 percent). Samples to be analyzed for other parameters were unpreserved. [27]

Radionuclide samples were collected in two collapsible 4-liter plastic containers and preserved with 5 ml nitric acid to reduce the pH below 2.5 su. [4] All samples were kept at 4^{o}C with ice in an insulated cooler, with the exception of the isotope and radiochemistry samples. Chain of custody procedures were followed in sample handling. Samples for this study were collected during 16 field trips between April 2008 and June 2009.

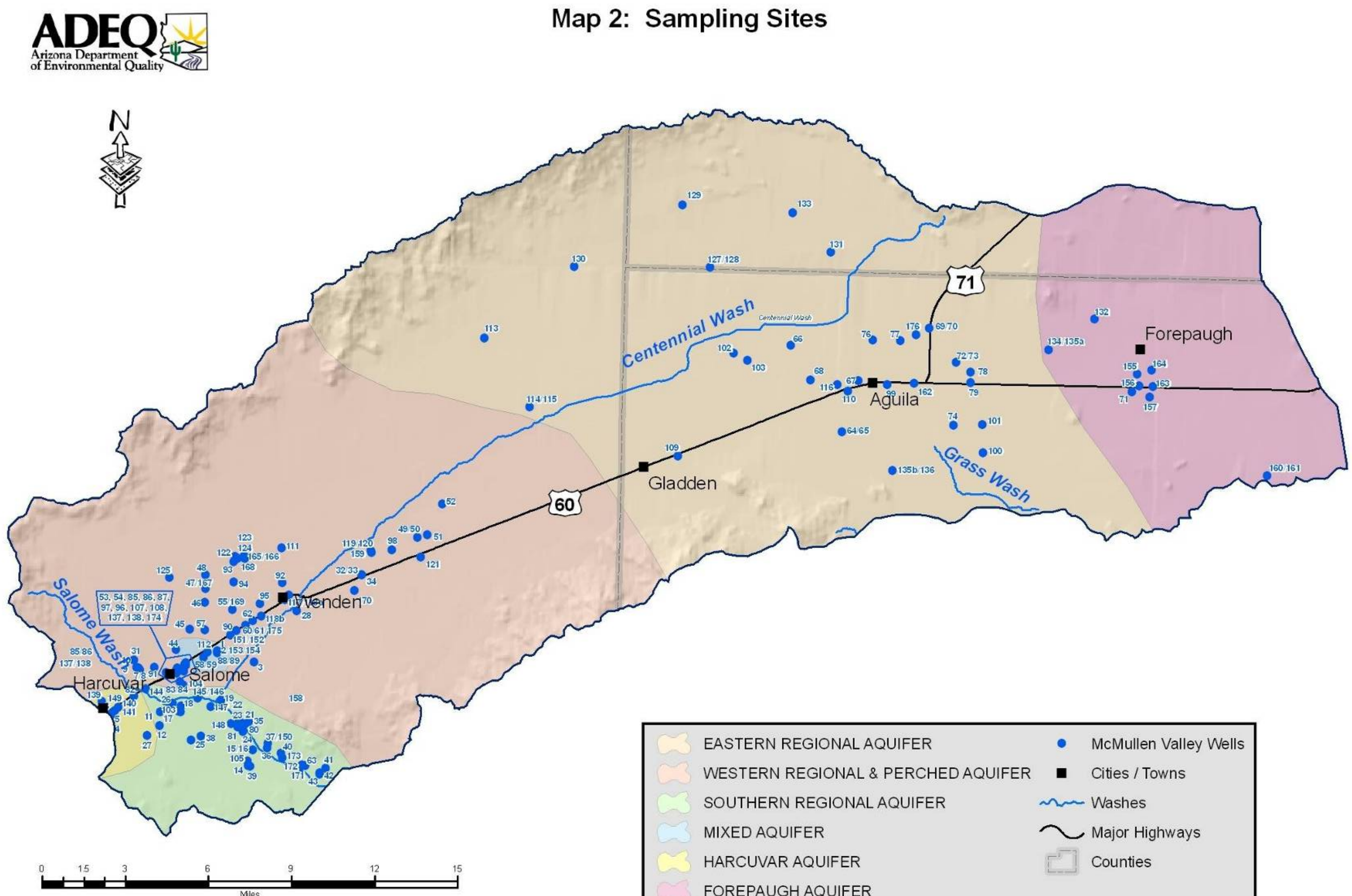
Laboratory Methods

The pesticide and inorganic analyses for this study were conducted by the Arizona Department of Health Services (ADHS) Laboratory in Phoenix, Arizona. Inorganic sample splits analyses were conducted by Test America Laboratory in Phoenix, Arizona. A complete listing of inorganic parameters, including laboratory method, EPA water method and Minimum Reporting Level (MRL) for each laboratory is provided in Table 1.

Perchlorate samples were analyzed by the Texas Tech University Environmental Services Laboratory in Lubbock, Texas.

Radon samples were analyzed by Radiation Safety Engineering, Inc. Laboratory in Chandler, Arizona.

Map 2: Sampling Sites



This map is for general reference only and may not be all inclusive. ADEQ program's data collection efforts are ongoing. More detailed information and specific locations can be obtained by contacting the Arizona Department of Environmental Quality.

Radionuclide samples were analyzed by the Arizona Radiation Agency Laboratory in Phoenix and radiochemistry splits by the Radiation Safety Engineering, Inc. Laboratory. The following EPA SDW protocols were used: Gross alpha was analyzed, and if levels exceeded 5 picocuries per liter (pCi/L), then radium-226 was measured. If radium-226 exceeded 3 pCi/L, radium-228 was measured. If gross alpha levels exceeded 15 pCi/L initially, then radium-226/228 and total uranium were measured.[4]

Isotope samples were analyzed by the Department of Geosciences, Laboratory of Isotope Geochemistry located at the University of Arizona in Tucson, Arizona.

DATA EVALUATION

Quality Assurance

Quality-assurance (QA) procedures were followed and quality-control (QC) samples were collected to quantify data bias and variability for the McMullen Valley basin study. The design of the QA/QC plan was based on recommendations included in the *Quality Assurance Project Plan* (*QAPP*) and *the Field Manual For Water Quality Sampling.*[2, 8] Types and numbers of QC samples collected for this study are as follows:

- Inorganic: (15 duplicates, 9 splits, and 10 blanks).
- Nitrate only: (2 duplicates and 1 split)
- Radionuclide: (no QA/QC samples)
- Radon: (1 duplicate)
- Isotope: (1 duplicate)
- Perchlorate (2 duplicates)

Based on the QA/QC results, sampling procedures and laboratory equipment did not significantly affect the groundwater quality samples.

Blanks - Equipment blanks for inorganic analyses were collected to ensure adequate decontamination of sampling equipment, and that the de-ionized water was not impacting the groundwater quality sampling.[8] Equipment blank samples for major ion and trace element analyses were collected by filling unpreserved bottles with de-ionized water. Equipment blank samples for nutrient analyses were collected with de-ionized water and preserved with sulfuric acid.

Systematic contamination was judged to occur if more than 50 percent of the equipment blank samples contained measurable quantities of a particular groundwater quality constituent. The equipment blanks contained specific conductivity (SC)-lab and turbidity contamination at levels expected due to impurities in the source water used for the samples. The blank results indicated systematic contamination with SC (detected in 8 equipment blanks) and turbidity (detected in 8 equipment blanks). Single detections of nitrate (0.055 mg/L) and phosphorus (0.021 mg/L) also occurred.

For SC, the eight equipment blanks had a mean (3.4 uS/cm) which was less than 1 percent of the SC mean concentration for the study. The SC detections may be explained in two ways: water passed through a de-ionizing exchange unit will normally have an SC value of at least 1 uS/cm, and carbon dioxide from the air can dissolve in de-ionized water with the resulting bicarbonate and hydrogen ions imparting the observed conductivity.[27]

For turbidity, equipment blanks had a mean level (0.0476 ntu) less than 1 percent of the turbidity median level for the study. Testing indicates turbidity is present at 0.01 ntu in the de-ionized water supplied by the ADHS laboratory, and levels increase with time due to storage in ADEQ carboys.[27]

Duplicate Samples - Duplicate samples are identical sets of samples collected from the same source at the same time and submitted to the same laboratory. Data from duplicate samples provide a measure of variability from the combined effects of field and laboratory procedures.[8] Duplicate samples were collected from sampling sites that were believed to have elevated constituent concentrations as judged by field SC values. Fifteen duplicate inorganic samples and two nitrate duplicate samples were collected in this study.

Analytical results indicate that of the 36 constituents examined, 25 had concentrations above the MRL. The maximum variation between duplicates was less than 10 percent (Table 2). The only exceptions were turbidity (60 percent), TKN (52 percent), and barium (17 percent). The median variation between duplicates was less than 2 percent except with carbonate (23 percent), chromium (11 percent), turbidity and TKN (9 percent), and total phosphorus (5 percent).

The lone isotope and radon duplicate samples showed less than a 1 percent maximum variation between duplicates as did one of the two perchlorate duplicate samples. However, the other perchlorate sample had results of 0.336 ug/L and < 0.05 ug/L.

Table 1. Laboratory Water Methods and Minimum Reporting Levels Used in the Study

Constituent	Instrumentation	ADHS / Test America Water Method	ADHS / Test America Minimum Reporting Level
Physical Parameters and General Mineral Characteristics			
Alkalinity	Electrometric Titration	SM2320B / M2320 B	2 / 6
SC (uS/cm)	Electrometric	EPA 120.1/ M2510 B	-- / 2
Hardness	Titrimetric, EDTA	SM 2340 C / SM2340B	10 / 1
Hardness	Calculation	SM 2340 B	--
pH (su)	Electrometric	SM 4500 H-B	0.1
TDS	Gravimetric	SM2540C	10 / 10
Turbidity (NTU)	Nephelometric	EPA 180.1	0.01 / 0.2
Major Ions			
Calcium	ICP-AES	EPA 200.7	1 / 2
Magnesium	ICP-AES	EPA 200.7	1 / 0.25
Sodium	ICP-AES	EPA 200.7	1 / 2
Potassium	Flame AA	EPA 200.7	0.5 / 2
Bicarbonate	Calculation	Calculation / / M2320 B	2
Carbonate	Calculation	Calculation / / M2320 B	2
Chloride	Potentiometric Titration	SM 4500 CL D / E300	5 / 2
Sulfate	Colorimetric	EPA 375.4 / E300	1 / 2
Nutrients			
Nitrate as N	Colorimetric	EPA 353.2	0.02 / 0.1
Nitrite as N	Colorimetric	EPA 353.2	0.02 / 0.1
Ammonia	Colorimetric	EPA 350.1/ EPA 350.3	0.02 / 0.5
TKN	Colorimetric	EPA 351.2 / M4500-NH3	0.05 / 1.3
Total Phosphorus	Colorimetric	EPA 365.4 / M4500-PB	0.02 / 0.1

All units are mg/L except as noted
Source [16, 27]

Table 1. Laboratory Water Methods and Minimum Reporting Levels Used in the Study--Continued

Constituent	Instrumentation	ADHS / Test America Water Method	ADHS / Test America Minimum Reporting Level
Trace Elements			
Aluminum	ICP-AES	EPA 200.7	0.5
Antimony	Graphite Furnace AA	EPA 200.8	0.005 / 0.003
Arsenic	Graphite Furnace AA	EPA 200.9 / EPA 200.8	0.005 / 0.001
Barium	ICP-AES	EPA 200.8 / EPA 200.7	0.005 to 0.1 / 0.01
Beryllium	Graphite Furnace AA	EPA 200.9 / EPA 200.8	0.0005 / 0.001
Boron	ICP-AES	EPA 200.7	0.1 / 0.2
Cadmium	Graphite Furnace AA	EPA 200.8	0.0005 / 0.001
Chromium	Graphite Furnace AA	EPA 200.8 / EPA 200.7	0.01 / 0.01
Copper	Graphite Furnace AA	EPA 200.8 / EPA 200.7	0.01 / 0.01
Fluoride	Ion Selective Electrode	SM 4500 F-C	0.1 / 0.4
Iron	ICP-AES	EPA 200.7	0.1 / 0.05
Lead	Graphite Furnace AA	EPA 200.8	0.005 / 0.001
Manganese	ICP-AES	EPA 200.7	0.05 / 0.01
Mercury	Cold Vapor AA	SM 3112 B / EPA 245.1	0.0002 / 0.0002
Nickel	ICP-AES	EPA 200.7	0.1 / 0.01
Selenium	Graphite Furnace AA	EPA 200.9 / EPA 200.8	0.005 / 0.002
Silver	Graphite Furnace AA	EPA 200.9 / EPA 200.7	0.001 / 0.01
Thallium	Graphite Furnace AA	EPA 200.9 / EPA 200.8	0.002 / 0.001
Zinc	ICP-AES	EPA 200.7	0.05
Radionuclides			
Gross alpha beta	Gas flow proportional counter	EPA 900.0	varies
Co-Precipitation	Gas flow proportional counter	EPA 00.02	varies
Radium 226	Gas flow proportional counter	EPA 903.0	varies
Radium 228	Gas flow proportional counter	EPA 904.0	varies
Uranium	Kinnetic phosporimeter	EPA Laser Phosphorimetry	varies

All units are mg/L
Source [14, 16, 27]

Table 2. Summary Results of McMullen Valley Basin Duplicate Samples from the ADHS Laboratory

Parameter	Number	Difference in Percent			Difference in Concentrations		
		Minimum	Maximum	Median	Minimum	Maximum	Median
Physical Parameters and General Mineral Characteristics							
Alk., Total	15	0 %	3 %	0 %	0	10	0
SC (uS/cm)	15	0 %	1 %	0 %	0	100	0
Hardness	15	0 %	8 %	1 %	0	20	1
pH (su)	15	0 %	1 %	0 %	0	0.1	0
TDS	15	0 %	7 %	0 %	0	100	0
Turb. (ntu) *	13	0 %	60 %	9 %	0	8	0.5
Major Ions							
Bicarbonate	15	0 %	3 %	0 %	0	20	0
Carbonate	3	0 %	23 %	7 %	0	13	0.1
Calcium	15	0 %	8 %	0 %	0	2	0
Magnesium	11	0 %	7 %	1 %	0	3	0.1
Sodium	15	0 %	5 %	0 %	0	20	0
Potassium *	14	0 %	3 %	1 %	0	0.1	0.01
Chloride	15	0 %	5 %	0 %	0	40	0
Sulfate	15	0 %	4 %	0 %	0	100	0
Nutrients							
Nitrate (as N)	15	0 %	9 %	0 %	0	4	0.1
Phosphorus *	3	5 %	9 %	5 %	0.003	0.01	0.0008
TKN *	4	3 %	52 %	9 %	0.02	0.34	0.03
Trace Elements							
Arsenic	9	0 %	4 %	1 %	0	0.001	0.0002
Barium *	12	0 %	17 %	2 %	0	0.011	0.001
Boron	14	0 %	3 %	0 %	0	0.01	0
Chromium	11	0 %	11 %	1 %	0	0.009	0.001
Fluoride	15	0 %	6 %	0 %	0	2.0	0
Selenium	5	0 %	5 %	1 %	0	0.002	0.001

All concentration units are mg/L except as noted with certain physical parameters.
* Potassium, turbidity, copper, total phosphorus, TKN, and barium each were detected near the MRL in one duplicate sample and not detected in the other duplicate sample.

Split Samples - Split samples are identical sets of samples collected from the same source at the same time that are submitted to two different laboratories to check for laboratory differences.[8] Nine inorganic split samples were collected and analytical results were evaluated by examining the variability in constituent concentrations in terms of absolute levels and as the percent difference. One additional split sample was collected and analyzed for only nitrate. Analytical results indicate that of the 36 constituents examined only 25 had concentrations above MRLs for both ADHS and Test America laboratories. The split results of the 25 constituents having concentrations above MRLs are provided in Table 3. The maximum variation between splits was less than 15 percent. The only exceptions were turbidity (69 percent), selenium (52 percent), potassium (42 percent), chloride (26 percent), nitrate (25 percent), carbonate (21 percent) and chromium (20 percent).

Split samples were also evaluated using the non-parametric Sign test to determine if there were any significant ($p \leq 0.05$) differences between ADHS laboratory and Test America laboratory analytical results.[20] Both chloride and potassium concentrations reported by the Test America laboratory were significant higher than those reported by the ADHS laboratory; sodium followed a similar trend but just missed being significantly higher (Sign test, $p \leq 0.05$).

Resample Sites – During the course of the study, five sites originally sampled for nitrate were resampled at a later date for the full suite of inorganic constituents. Nitrate concentrations were evaluated using the Wilcoxon test to determine if there were any significant ($p \leq 0.05$) differences between sample periods. No significant differences were found in nitrate concentrations between the sample periods (Wilcoxon test, $p \leq 0.05$).

Based on the results of blanks, duplicates and the split sample collected for this study, no significant QA/QC problems were apparent with the groundwater quality collected for this study.

Data Validation

The analytical work for this study was subjected to the following five QA/QC correlations. [21] The analytical work conducted for this study was considered valid based on the quality control samples and the QA/QC correlations.

Cation/Anion Balances - In theory, water samples exhibit electrical neutrality. Therefore, the sum of milliquivalents per liter (meq/L) of cations should equal the sum of meq/L of anions. However, this neutrality rarely occurs due to unavoidable variation inherent in all water quality analyses. Still, if the cation/anion balance is found to be within acceptable limits, it can be assumed there are no gross errors in concentrations reported for major ions.[21]

Overall, cation/anion meq/L balances of McMullen Valley basin samples were significantly correlated (regression analysis, $p \leq 0.01$). Of the 124 samples collected, 64 (or 52 percent) were within +/-2 percent.

Because of low cation/high anion sums, 45 samples (or 36 percent) had > 2 percent differences with 17 samples having 5 to 10 percent differences and 2 samples having a greater than 10 percent difference with 12 percent being the highest difference. The samples with low cation sums were generally collected on field trips conducted between April - May 2009. The ADHS laboratory was alerted but found no reason for the differences. [27]

Because of high cation/low anion sums, 15 samples (or 12 percent) had > 2 percent differences with 3 samples having 5 to 10 percent differences and 3 samples having a greater than 10 percent difference with 30 percent being the highest difference. The samples with high cation sums were generally collected on field trips conducted between July 2008 and January 2009. The ADHS laboratory indicated some chloride concentrations may have been reported as non-detect by the PC-Titration system when the concentration was likely greater than 10 mg/L.[27]

SC/TDS - The SC and TDS concentrations measured by contract laboratories were significantly correlated as were field-SC and TDS concentrations (regression analysis, $r = 0.99$, $p \leq 0.01$). The TDS concentration in mg/L should be from 0.55 to 0.75 times the SC in µS/cm for groundwater up to several thousand TDS mg/L.[21] Groundwater high in bicarbonate and chloride will have a multiplication factor near the lower end of this range; groundwater high in sulfate may reach or even exceed the higher factor. The relationship of TDS to SC becomes undefined for groundwater with very high or low concentrations of dissolved solids.[21]

Hardness - Concentrations of laboratory-measured and calculated values of hardness were significantly correlated (regression analysis, $r = 0.99$, $p \leq 0.01$). Hardness concentrations were calculated using the following formula: [(Calcium x 2.497) + (Magnesium x 4.118)]. [21]

Table 3. Summary Results of McMullen Valley Basin Split Samples From ADHS/Test America Labs

Constituents	Number	Difference in Percent		Difference in Levels		Significance
		Minimum	Maximum	Minimum	Maximum	
Physical Parameters and General Mineral Characteristics						
Alkalinity, total	9	0 %	5 %	0	20	ns
SC (uS/cm)	9	0 %	4 %	0	150	ns
Hardness	7	0 %	13 %	0	10	ns
pH (su)	9	0 %	13 %	0.05	1.77	ns
TDS	9	0 %	7 %	0	400	ns
Turbidity (ntu)	5	7 %	69 %	0.06	44	ns
Major Ions						
Calcium	9	0 %	9 %	0	10	ns
Magnesium	8	0 %	4 %	0	2	ns
Sodium	9	0 %	5 %	0	10	ns
Potassium	8	2 %	42 %	0.1	2.2	**
Carbonate	2	11 %	21 %	10	26	ns
Chloride	9	0 %	26 %	0	80	**
Sulfate	9	0 %	7 %	0	90	ns
Nutrients						
Nitrate as N	10	0 %	25 %	0.01	36	ns
Trace Elements						
Arsenic	5	1 %	5 %	0.0001	0.001	ns
Barium	7	2 %	11 %	0.001	0.03	ns
Boron	5	3 %	13 %	0.05	0.4	ns
Chromium	7	0 %	20 %	0	0.008	ns
Fluoride	9	0 %	8 %	0	0.8	ns
Selenium	3	16 %	52%	0.0062	.0011	ns
Zinc	1	5 %	5 %	0.007	0.007	ns

ns = No significant difference
** = Significant difference at $p \leq 0.01$ or 99 % confidence level
* = Significant difference at $p \leq 0.05$ or 95 % confidence level
All units are mg/L except as noted

SC - The SC measured in the field at the time of sampling was significantly correlated with the SC measured by contract laboratories (regression analysis, $r = 0.99$, $p \leq 0.01$).

pH - The pH value is closely related to the environment of the water and is likely to be altered by sampling and storage.[21] Still, the pH values measured in the field using a YSI meter at the time of sampling were significantly correlated with laboratory pH values (regression analysis, $r = 0.91$, $p \leq 0.01$).

Temperature / GW Depth /Well Depth – Groundwater temperature measured in the field was compared to well depth and groundwater depth. Groundwater temperature should increase with depth, approximately 3 degrees Celsius with every 100 meters or 328 feet. [9] Well depth was significantly correlated with temperature (regression analysis, $r = 0.69$, $p \leq 0.01$); so was groundwater depth (regression analysis, $r = 0.54$, $p \leq 0.01$).

Statistical Considerations

Various methods were used to complete the statistical analyses for the groundwater quality data of the study. All statistical tests were conducted on a personal computer using SYSTAT software.[40]

Data Normality: Data associated with 29 constituents were tested for non-transformed normality using the Kolmogorov-Smirnov one-sample test with the Lilliefors option.[11] Results of this test revealed that none of the 29 constituents examined were normally distributed.

Spatial Relationships: The non-parametric Kruskal-Wallis test using untransformed data was applied to investigate the hypothesis that constituent concentrations from groundwater sites having different aquifers were the same. The Kruskal-Wallis test uses the differences, but also incorporates information about the magnitude of each difference.[40] The null hypothesis of identical mean values for all data sets within each test was rejected if the probability of obtaining identical means by chance was less than or equal to 0.05.

If the null hypothesis was rejected for any of the tests conducted, the Tukey method of multiple comparisons on the ranks of data was applied. The Tukey test identified significant differences between constituent concentrations when compared to each possibility with each of the tests. [21] Both the Kruskal-Wallis and Tukey tests are not valid for data sets with greater than 50 percent of the constituent concentrations below the MRL.[20]

Correlation Between Constituents: In order to assess the strength of association between constituents, their concentrations were compared to each other using the Pearson Correlation Coefficient test.

The Pearson correlation coefficient varies between -1 and +1; with a value of +1 indicating that a variable can be predicted perfectly by a positive linear function of the other, and vice versa. A value of -1 indicates a perfect inverse or negative relationship. The results of the Pearson Correlation Coefficient test were then subjected to a probability test to determine which of the individual pair wise correlations were significant. [40]

Like Kruskal-Wallis and Tukey tests, the Pearson test is not valid for data sets with greater than 50 percent of the constituent concentrations below the MRL.[20]

Figure 7 – This 970-foot, domestic well tapping the Western Regional aquifer met all water quality standards; only water quality guidelines for pH-field and fluoride were exceeded.

Figure 8 – ADEQ's Dennis Turner samples a 512-foot deep irrigation well located in Harrisburg Valley south of Salome. Samples from the well exceeded water quality guidelines for TDS and fluoride. The radon concentration (6,894 pCi/L) exceeded the proposed health-based standards for radon (300 and 4,000 pCi/L). This was one of highest radon concentrations ever sampled in Arizona; two nearby wells had still higher levels. The nearby granite geology may influence the high radon concentrations.

Figure 9 – ADEQ's Dennis Turner samples a 470-foot deep well in Harrisburg Valley. Although most samples collected from wells in the Southern Regional aquifer met health-based water quality standards, samples from this well exceeded the 10 mg/L standard for nitrate. Water quality guidelines for chloride, fluoride, sulfate and TDS were also exceeded. A radon sample had concentrations of 10,241 piC/L the highest level ever recorded by the ADEQ ambient monitoring program.

Figure 10 – ADEQ's Dennis Turner samples irrigation Well #23 located north of Salome. Like many deep wells pumping from the northwest portion of the Western Regional aquifer, samples from this well met all water quality standards and guidelines.

Figure 11 – This 500-foot well provides water to irrigate the grounds of a trailer park just northeast of Salome. Unfortunately, due to the absence at this location of the Lake-bed Unit, the Regional aquifer merges with the poor quality water in the Perched aquifer to form the Mixed aquifer. As a result, health-based water quality standards were exceeded for arsenic and nitrate in samples from this well. In addition, water quality guidelines for chloride, sulfate and TDS were exceeded.

Figure 12 – ADEQ's Aleks Argals, Travis Barnum, and Brent Mitchell assist in sampling this 700-foot well between Salome and Wenden. Although the well's location appears to be outside the Mixed aquifer, arsenic, nitrate and fluoride exceeded water quality standards; pH-field, chloride, sulfate and TDS exceeded water quality guidelines. Water cascading from the Perched aquifer down the well may be impacting the sample's water quality.

Figure 13 – This stock well located several miles east of Wenden just south of U.S Highway 60 had the highest fluoride concentrations found in the basin at 22 mg/L. Other wells in the Wenden area, especially those east of town exceeded the health-based water quality standard for fluoride (4.0 mg/L) with those closest to Harquahala Mountains having the most elevated concentrations. Samples from these wells were depleted in calcium allowing large concentrations of fluoride to occur if a source for fluoride ions is available for dissolution. [28]

Figure 14 – The Harcuvar aquifer is created by the Lake-bed Unit which extends almost down to bedrock and effectively limits groundwater flow in the Alluvial Fan/Fanglomerate Unit to areas to the east the vicinity of the community.[24] Groundwater in the aquifer has significantly different isotope values than other sample sites in the basin. Six samples collected from wells in this area each had this unique isotope value range. Aside from oxygen and deuterium isotope values, constituent concentrations in the Harcuvar aquifer were not significantly different from those in the three Regional and Forepaugh aquifers (Kruskal-Wallis with Tukey test, $p \leq 0.05$).

GROUNDWATER SAMPLING RESULTS

Water Quality Standards/Guidelines

The ADEQ ambient groundwater program characterizes regional groundwater quality. An important determination ADEQ makes concerning the collected samples is how the analytical results compare to various drinking water quality standards.

ADEQ used three sets of drinking water standards that reflect the best current scientific and technical judgment available to evaluate the suitability of groundwater in the basin for drinking water use:

- Federal Safe Drinking Water (SDW) Primary Maximum Contaminant Levels (MCLs). These enforceable health-based standards establish the maximum concentration of a constituent allowed in water supplied by public systems.[38]

- State of Arizona Aquifer Water Quality Standards. These apply to aquifers that are classified for drinking water protected use. All aquifers within Arizona are currently classified and protected for drinking water use. These enforceable State standards are identical to the federal Primary MCLs. [3]

- Federal SDW Secondary MCLs. These non-enforceable aesthetics-based guidelines define the maximum concentration of a constituent that can be present without imparting unpleasant taste, color, odor, or other aesthetic effects on the water.[38]

Health-based drinking water quality standards (such as Primary MCLs) are based on the lifetime consumption (70 years) of two liters of water per day and, as such, are chronic not acute standards.[38] Exceedances of specific constituents for each groundwater site is found in Appendix B.

Inorganic Constituent Results - Of the 124 sites sampled for the full suite of inorganic constituents in the McMullen Valley study, 33 (27 percent) met all SDW Primary and Secondary MCLs.

Health-based Primary MCL water quality standards and State aquifer water quality standards for inorganic constituents were exceeded at 54 of the 124 sites (44 percent; Map 3; Table 4).

Constituents exceeding Primary MCLs include arsenic (24 sites) (Map 4), fluoride (27 sites) (Map 5), nitrate (25 sites) (Map 6), and selenium (2). Potential health effects of these chronic Primary MCL exceedances are provided in Table 4. [3, 38]

Aesthetics-based Secondary MCL water quality guidelines were exceeded at 87 of 124 sites (70 percent; Map 3; Table 5).

Constituents above Secondary MCLs include chloride (13 sites), fluoride (69 sites), manganese (2 sites), field-pH (19 sites), sulfate (8 sites), and TDS (31 sites) (Map 7). Potential impacts of these Secondary MCL exceedances are provided in Table 5.[38]

In addition, of the 12 sites sampled for only nitrate, 11 (92 percent) met nitrate Primary MCL standards and 10 (83 percent) met pH Secondary MCL standards.

Radiochemical Constituent Results - Health based Primary MCL water quality standards and State aquifer water quality standards were exceeded at 9 of the 50 sites (18 percent; Map 8; Table 4) at which a radionuclide sample was collected.

Of the 50 sites sampled for radionuclides, 9 sites (18 percent) exceeded gross alpha Primary MCL standards and 4 (8 percent) exceeded uranium Primary MCL standards.

Radon is a naturally occurring, intermediate breakdown product from the radioactive decay of uranium-238 to lead-206.[38]

Of the 79 sites sampled for radon, 3 exceeded the proposed 4,000 picocuries per liter (pCi/L) standard that would apply if Arizona establishes an enhanced multimedia program to address the health risks from radon in indoor air.

Sixty-eight (68) sites exceeded the proposed 300 pCi/L standard for states that would apply if Arizona doesn't develop a multimedia program (Map 9). [38]

Organic Constituent Results There were no positive detections of any of the 20 organochlorine compounds analyzed in the 2 pesticides samples collected from shallow wells near irrigated fields.

Map 3: Water Quality Standards

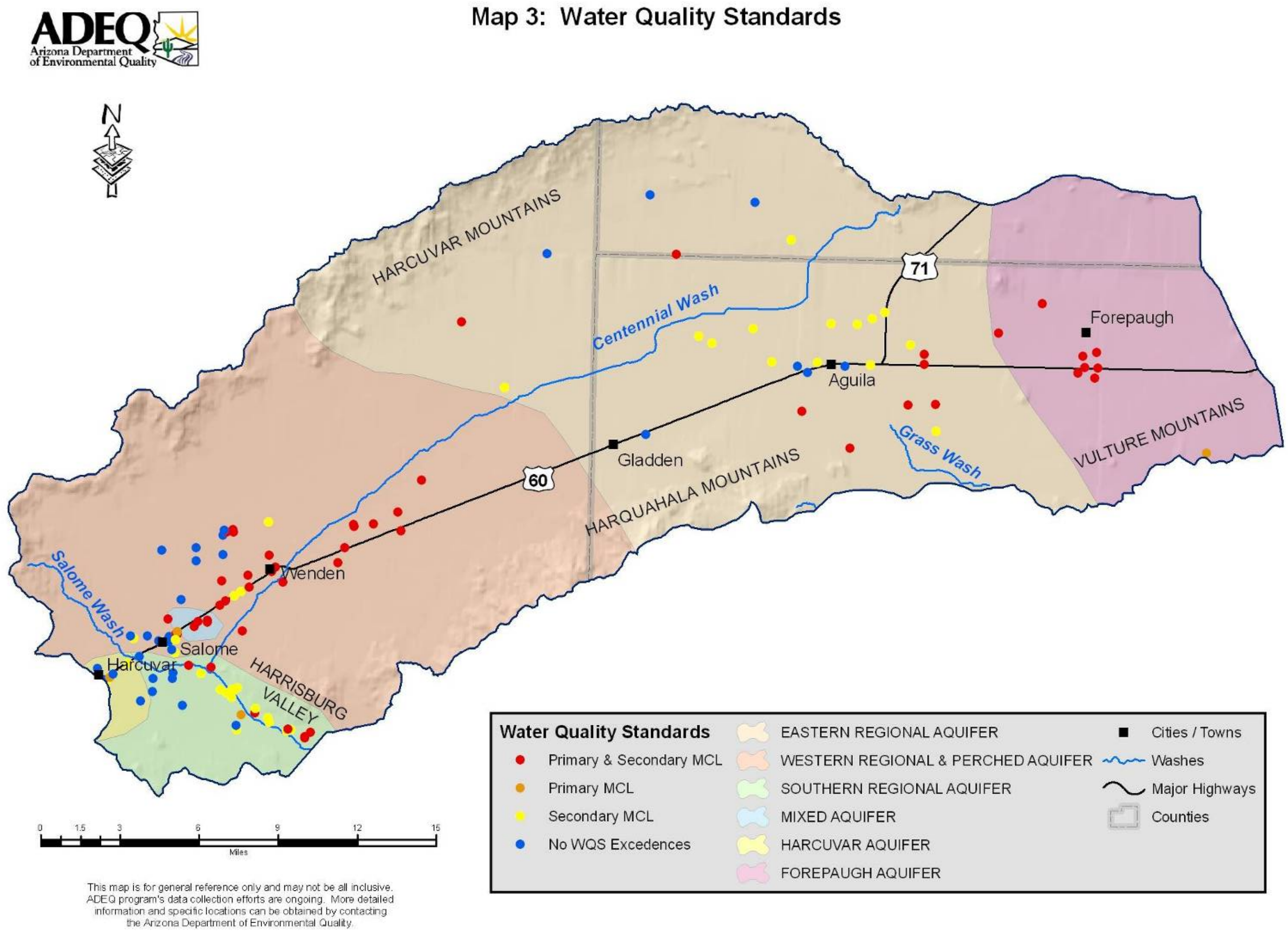


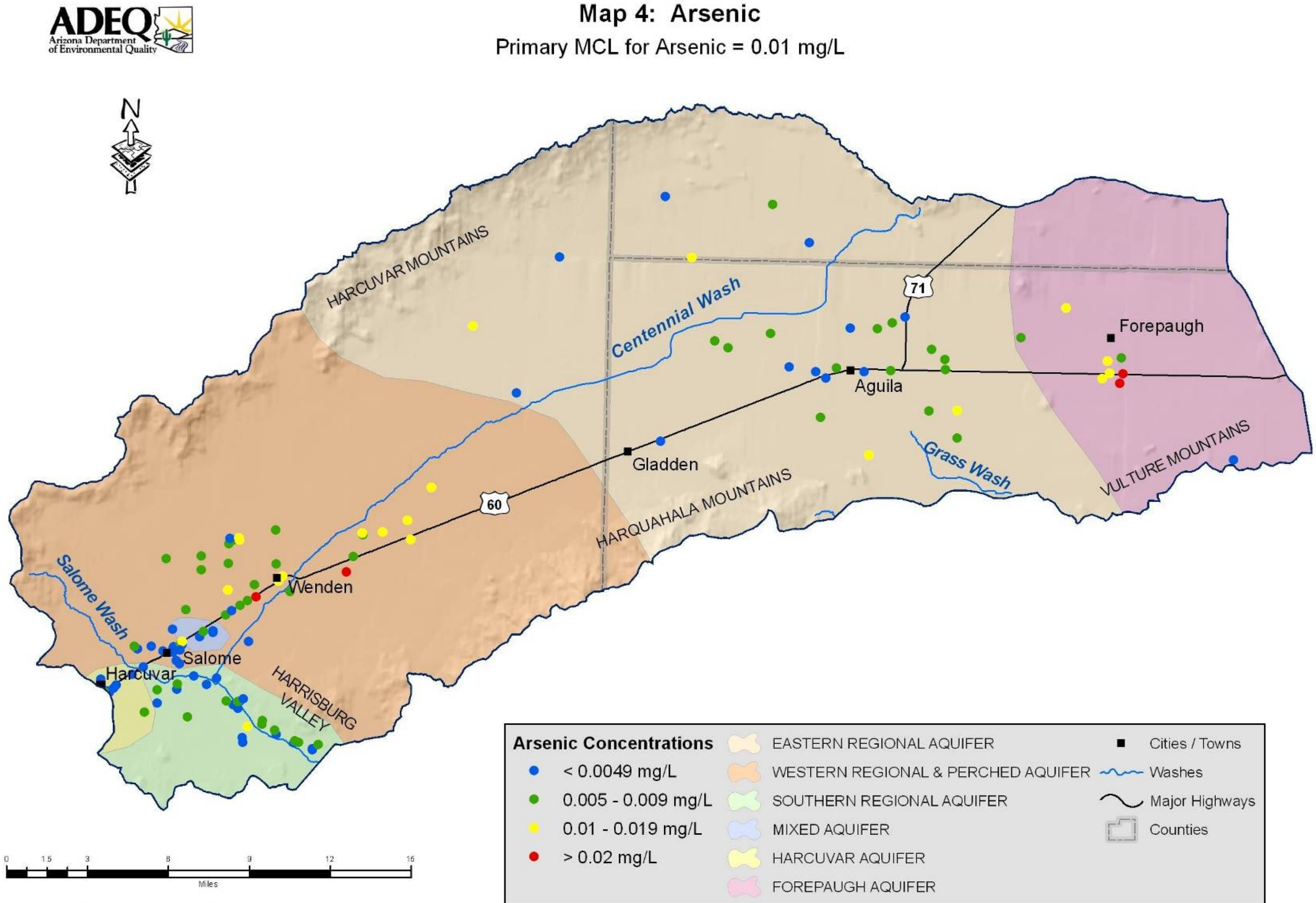
Table 4. McMullen Valley Basin Sites Exceeding Health-Based (Primary MCL) Water Quality Standards

Constituent	Primary MCL	Number of Sites Exceeding Primary MCL	Highest Concentration	Potential Health Effects of MCL Exceedances *
		Nutrients		
Nitrite (NO_2-N)	1.0	0	-	-
Nitrate (NO_3-N)	10.0	**25**	122	Methemoglobinemia
		Trace Elements		
Antimony (Sb)	0.006	0	-	-
Arsenic (As)	0.01	**24**	0.110	Dermal and nervous system toxicity
Barium (Ba)	2.0	0	-	-
Beryllium (Be)	0.004	0	-	-
Cadmium (Cd)	0.005	0	-	-
Chromium (Cr)	0.1	0	-	-
Copper (Cu)	1.3	0	-	-
Fluoride (F)	4.0	**27**	22	Skeletal damage
Lead (Pb)	0.015	0	-	-
Mercury (Hg)	0.002	0	-	-
Nickel (Ni)	0.1	0	-	-
Selenium (Se)	0.05	**2**	0.0755	Circulatory problems
Thallium (Tl)	0.002	0	-	-
		Radiochemistry Constituents		
Gross Alpha	15	**9**	130	Cancer
Ra-226+Ra-228	5	0	-	-
Radon **	300	**68**	10,241	Cancer
Radon **	4,000	**3**	10,241	Cancer
Uranium	30	**4**	120	Cancer and kidney toxicity

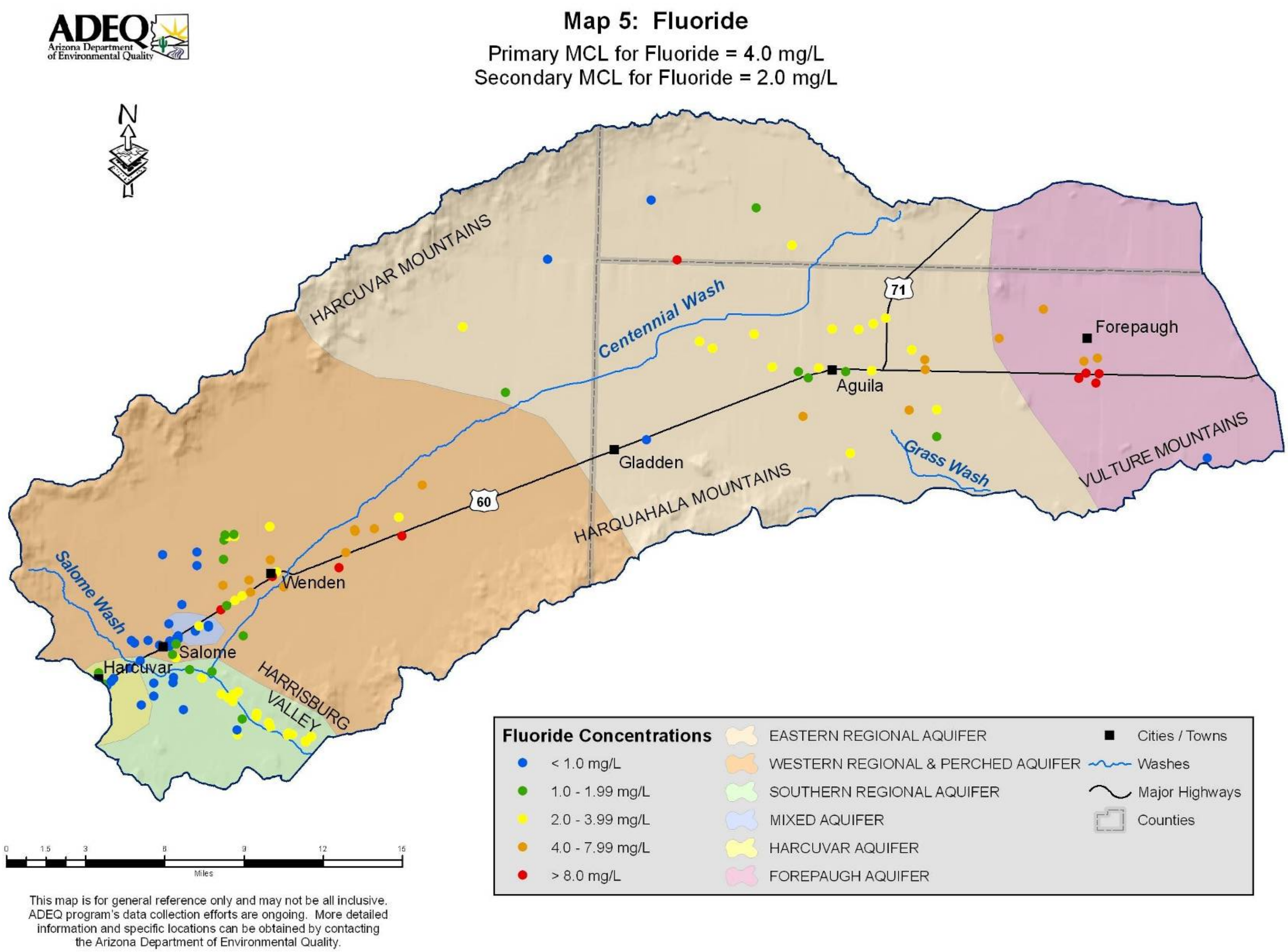
All units are mg/L except gross alpha, radium-226+228 and radon (pCi/L), and uranium (ug/L).
* Health-based drinking water quality standards are based on a lifetime consumption of two liters of water per day over a 70-year life span.[39]
** Proposed EPA Safe Drinking Water Act standards for radon in drinking water.

Map 4: Arsenic

Primary MCL for Arsenic = 0.01 mg/L



This map is for general reference only and may not be all inclusive. ADEQ program's data collection efforts are ongoing. More detailed information and specific locations can be obtained by contacting the Arizona Department of Environmental Quality.


ADEQ
Arizona Department of Environmental Quality
Map 5: Fluoride
Primary MCL for Fluoride = 4.0 mg/L
Secondary MCL for Fluoride = 2.0 mg/L
N
HARCUVAR MOUNTAINS
Centennial Wash
71
Forepaugh
Aguila
Gladden
Grass Wash
VULTURE MOUNTAINS
HARQUAHALA MOUNTAINS
60
Salome Wash
Wenden
Salome
Harcuvar
HARRISBURG VALLEY
Fluoride Concentrations
< 1.0 mg/L
1.0 - 1.99 mg/L
2.0 - 3.99 mg/L
4.0 - 7.99 mg/L
> 8.0 mg/L
EASTERN REGIONAL AQUIFER
WESTERN REGIONAL & PERCHED AQUIFER
SOUTHERN REGIONAL AQUIFER
MIXED AQUIFER
HARCUVAR AQUIFER
FOREPAUGH AQUIFER
Cities / Towns
Washes
Major Highways
Counties
0 1.5 3 6 9 12 15
Miles
This map is for general reference only and may not be all inclusive. ADEQ program's data collection efforts are ongoing. More detailed information and specific locations can be obtained by contacting the Arizona Department of Environmental Quality.

Map 6: Nitrate (as Nitrogen)

Primary MCL for Nitrate (as N) = 10 mg/L

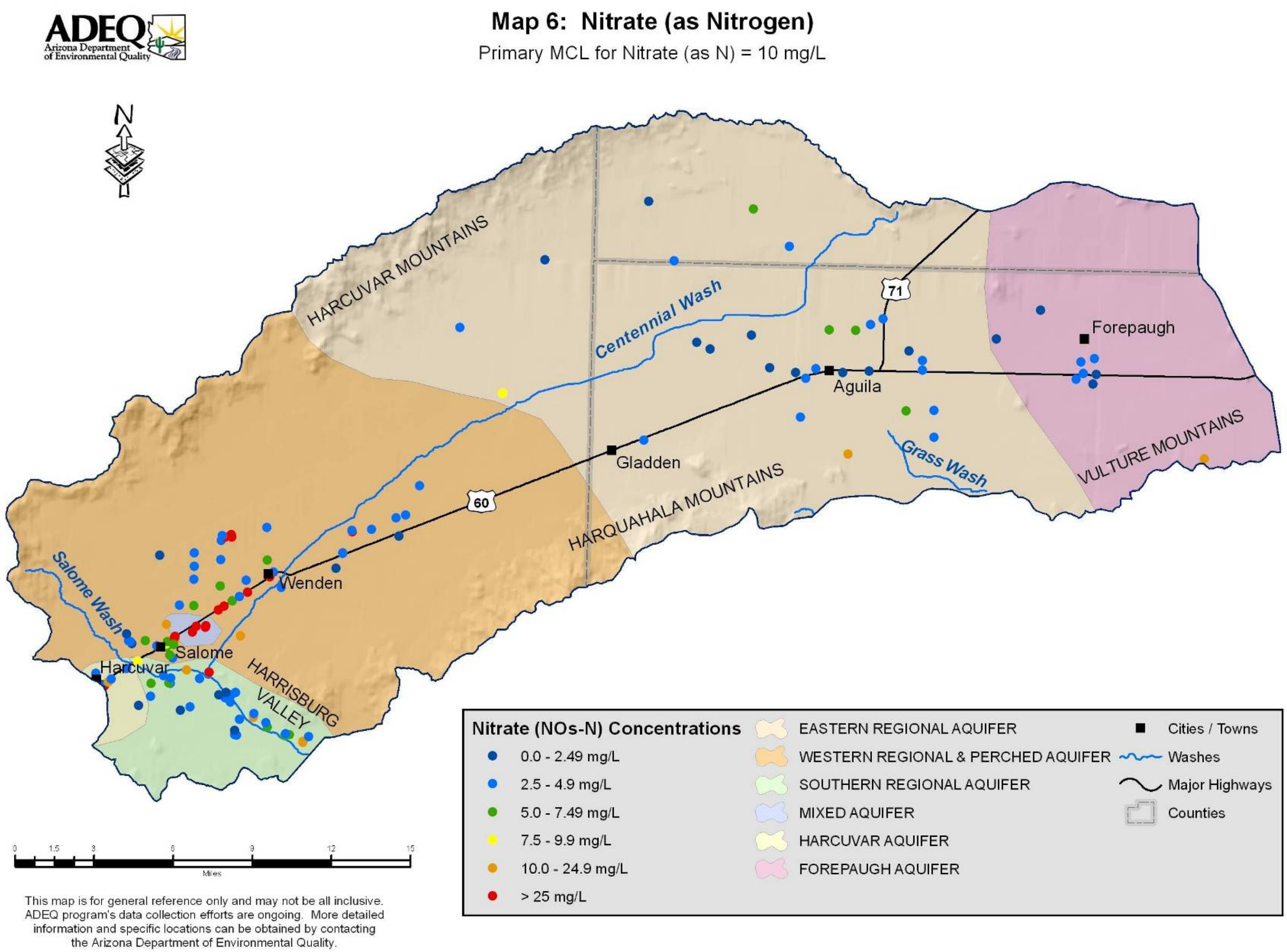


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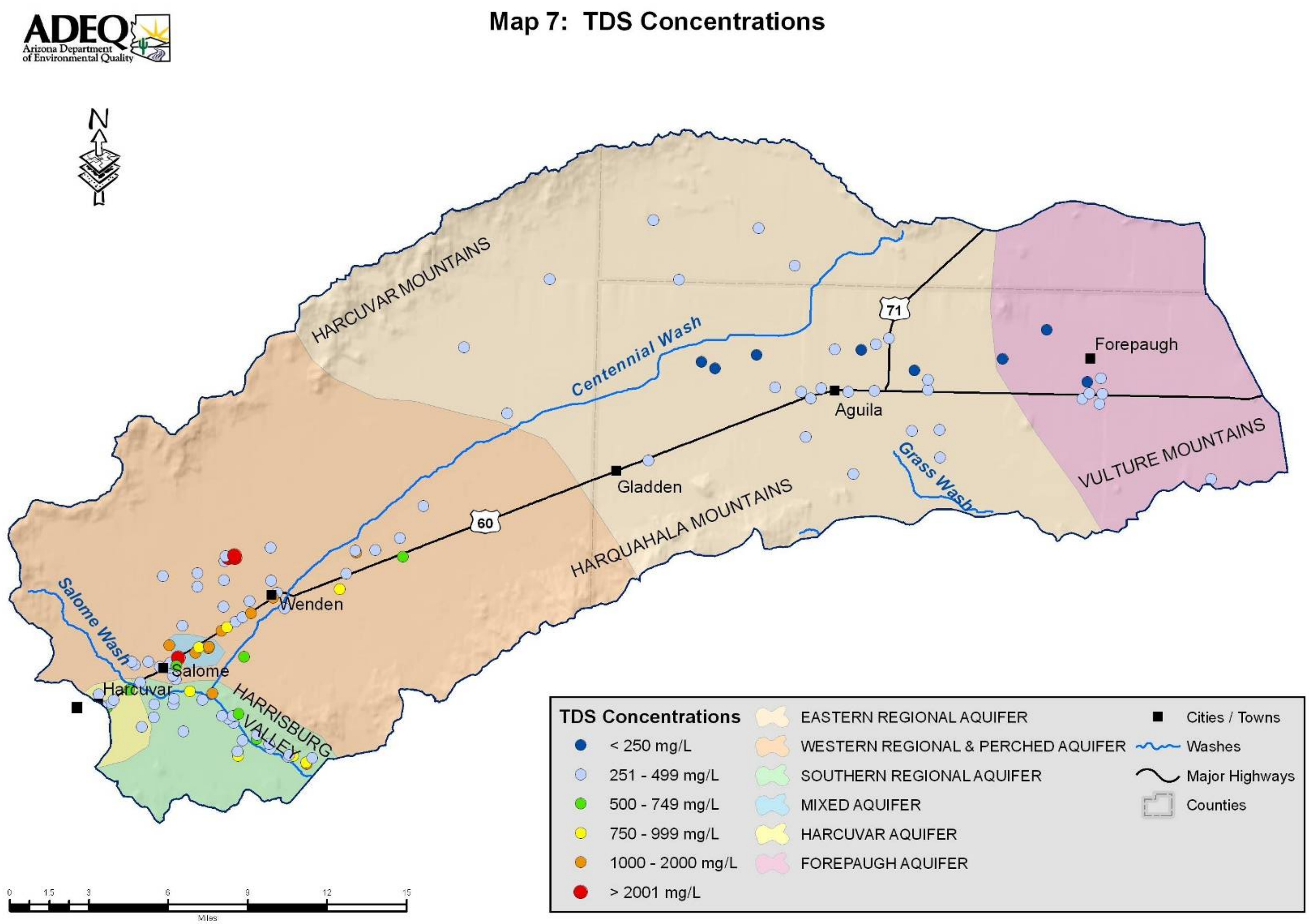
Table 5. McMullen Valley Basin Sites Exceeding Aesthetics-Based (Secondary MCL) Water Quality Standards

Constituents	Secondary MCL	Number of Sites Exceeding Secondary MCLs	Concentration Range of Exceedances	Aesthetic Effects of MCL Exceedances
		Physical Parameters		
pH - field	<6.5 ; >8.5	**19**	9.68	slippery feel; soda taste; deposits
		General Mineral Characteristics		
TDS	500	**31**	4,400	hardness; deposits; colored water; staining; salty taste
		Major Ions		
Chloride (Cl)	250	**13**	930	Salty taste
Sulfate (SO_4)	250	**8**	1,350	Rotten-egg odor, unpleasant taste and laxative effect
		Trace Elements		
Fluoride (F)	2.0	**69**	22	Mottling of teeth enamel
Iron (Fe)	0.3	0	-	-
Manganese (Mn)	0.05	**2**	0.089	black to brown color; black staining; bitter metallic taste
Silver (Ag)	0.1	0	-	-
Zinc (Zn)	5.0	0	-	-

All units mg/L except pH is in standard units (su). Source: [38]

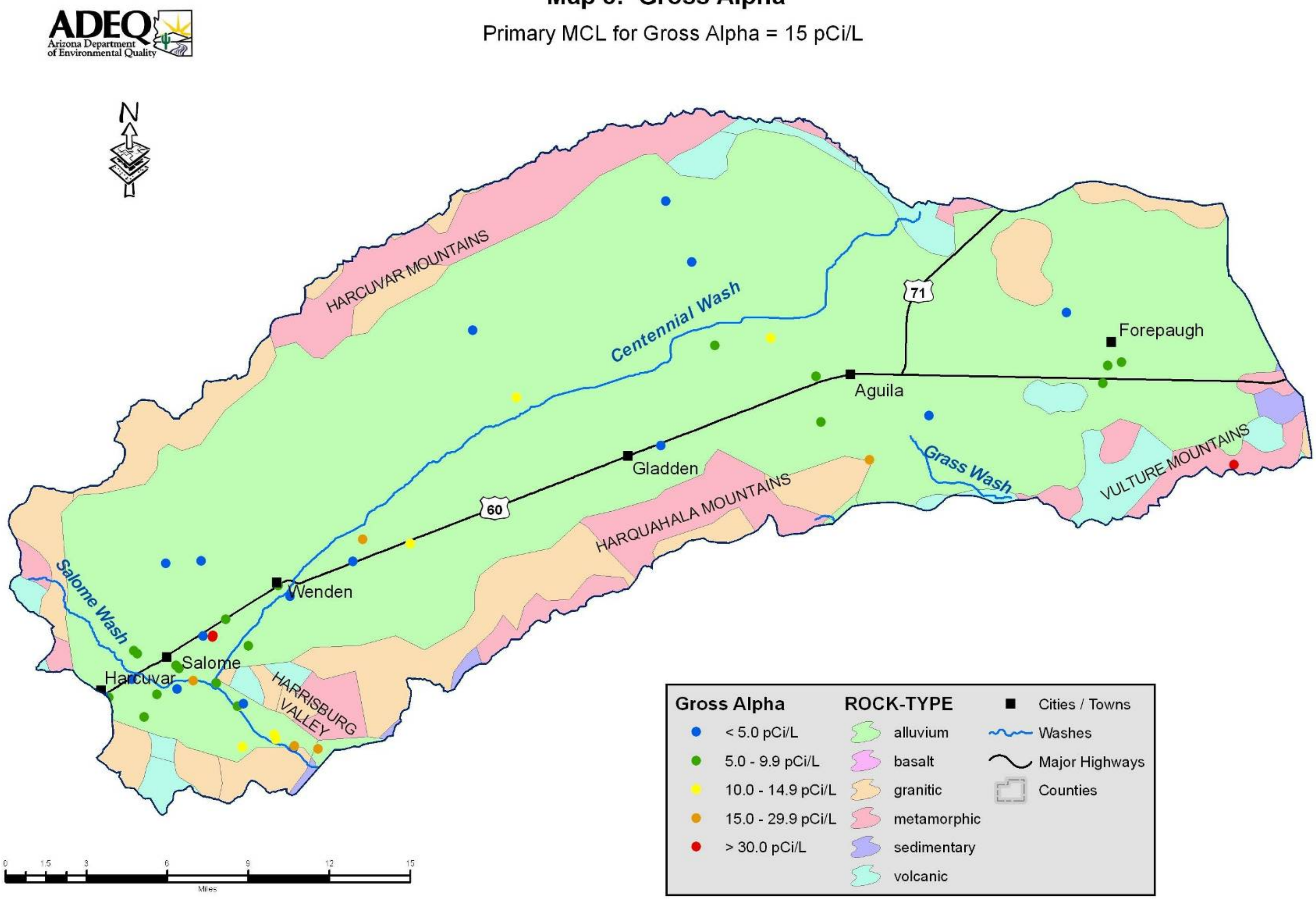
Map 7: TDS Concentrations



This map is for general reference only and may not be all inclusive. ADEQ program's data collection efforts are ongoing. More detailed information and specific locations can be obtained by contacting the Arizona Department of Environmental Quality.

Map 8: Gross Alpha

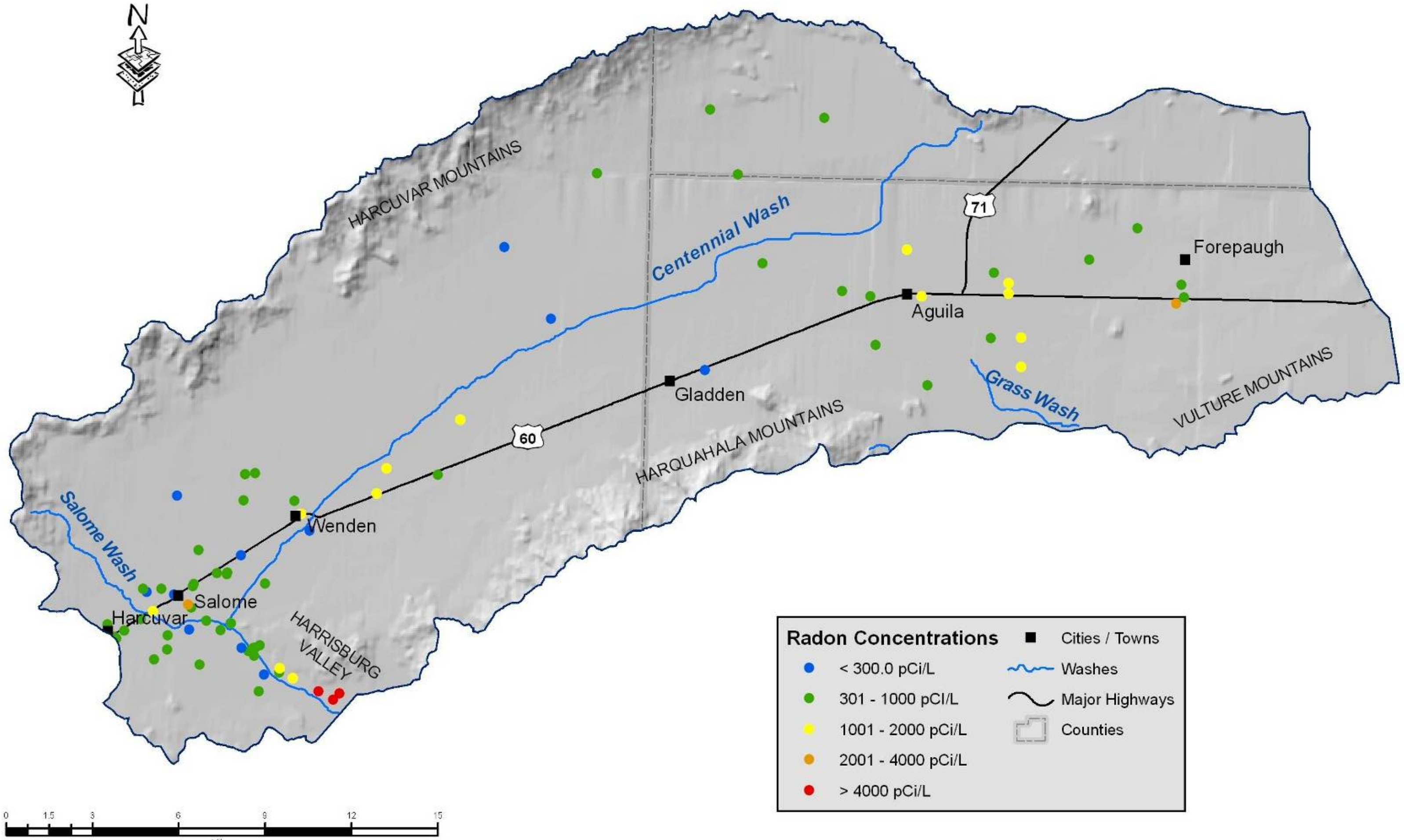
Primary MCL for Gross Alpha = 15 pCi/L



This map is for general reference only and may not be all inclusive. ADEQ program's data collection efforts are ongoing. More detailed information and specific locations can be obtained by contacting the Arizona Department of Environmental Quality.

Map 9: Radon

Proposed Primary MCL for Radon = 300 pCi/L for states w/o multimedia programs, 4000 pCi/L for states with multimedia programs



This map is for general reference only and may not be all inclusive. ADEQ program's data collection efforts are ongoing. More detailed information and specific locations can be obtained by contacting the Arizona Department of Environmental Quality.

Suitability for Irrigation

The groundwater at each sample site was assessed as to its suitability for irrigation use based on salinity and sodium hazards. Excessive levels of sodium are known to cause physical deterioration of the soil and vegetation. [39] Irrigation water may be classified using specific conductivity (Diagram 5) and the Sodium Adsorption Ratio (Diagram 6) in conjunction with one another. [39]

Groundwater sites in the McMullen Valley basin display a wide range of irrigation water classifications. The 124 sample sites are divided into the following salinity hazards: low or C1 (0), medium or C2 (85), high or C3 (31), and very high or C4 (8). The 124 sample sites are divided into the following sodium or alkali hazards: low or S1 (79), medium or S2 (23), high or S3 (11), and very high or S4 (11).

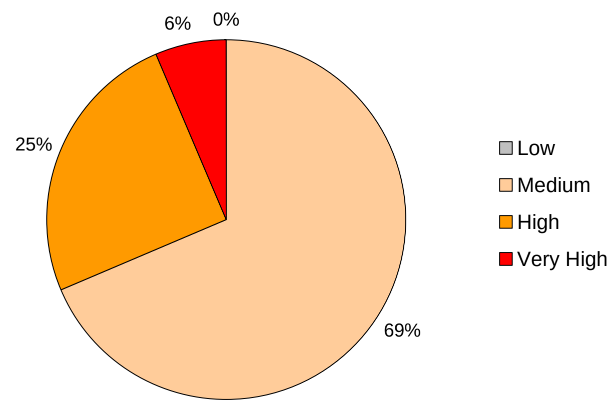


Diagram 5. Salinity Hazard of McMullen Valley Wells

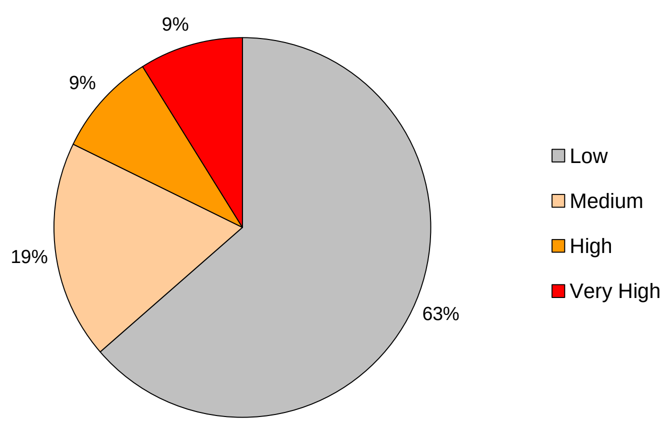


Diagram 6. Sodium Hazard of McMullen Valley Wells

Analytical Results

Analytical inorganic and radiochemistry results of the McMullen Valley basin sample sites are summarized (Table 6) using the following indices: minimum reporting levels (MRLs), number of sample sites over the MRL, upper and lower 95 percent confidence intervals ($CI_{95\%}$), median, and mean. Confidence intervals are a statistical tool which indicates that 95 percent of a constituent's population lies within the stated confidence interval.[40] Specific constituent information for each groundwater site is found in Appendix B.

Table 6. Summary Statistics for McMullen Valley Basin Groundwater Quality Data

Constituent	Minimum Reporting Limit (MRL)	# of Samples / Samples Over MRL	Median	Lower 95% Confidence Interval	Mean	Upper 95% Confidence Interval
Physical Parameters						
Temperature (C)	0.1	134 / 134	28.6	28.3	28.9	29.5
pH-field (su)	0.01	136 / 136	7.94	7.93	8.05	8.10
pH-lab (su)	0.01	124 / 124	8.20	8.22	8.20	8.33
Turbidity (ntu)	0.01	124 / 121	0.11	0.44	1.24	2.04
General Mineral Characteristics						
T. Alkalinity	2.0	124 / 124	145	153	164	176
Phenol. Alk.	2.0	124 / 27		> 50% of data below MRL		
SC-field (uS/cm)	N/A	124 / 124	662	800	945	1090
SC-lab (uS/cm)	N/A	124 / 124	638	776	931	1086
Hardness-lab	10.0	124 / 114	82	98	131	164
TDS	10.0	124 / 124	390	481	588	695
Major Ions						
Calcium	5.0	124 / 124	19	26	35	45
Magnesium	1.0	124 / 106	7.5	8.6	11.4	14.2
Sodium	5.0	124 / 124	102	116	145	175
Potassium	0.5	124 / 121	2.5	2.5	2.9	3.2
Bicarbonate	2.0	124 / 124	170	178	190	201
Carbonate	2.0	124 / 27		> 50% of data below MRL		
Chloride	1.0	124 / 123	48	77	103	130
Sulfate	10.0	124 / 124	48	68	98	128
Nutrients						
Nitrate (as N)	0.02	136 / 136	3.7	7.1	10.1	13.0
Nitrite (as N)	0.02	124 / 5		> 50% of data below MRL		
TKN	0.05	124 / 33		> 50% of data below MRL		
T. Phosphorus	0.02	124 / 23		> 50% of data below MRL		

Table 6. Summary Statistics for McMullen Valley Basin Groundwater Quality Data—Continued

Constituent	Minimum Reporting Limit (MRL)	Number of Samples Over MRL	Median	Lower 95% Confidence Interval	Mean	Upper 95% Confidence Interval
Trace Elements						
Antimony	0.005	124 / 0	> 50% of data below MRL			
Arsenic	0.01	124 / 72	0.006	0.006	0.007	0.009
Barium	0.1	124 / 89	0.037	0.049	0.059	0.070
Beryllium	0.0005	124 / 0	> 50% of data below MRL			
Boron	0.1	124 / 116	0.22	0.28	0.37	0.45
Cadmium	0.001	124 / 0	> 50% of data below MRL			
Chromium	0.01	124 / 82	0.018	0.019	0.023	0.026
Copper	0.01	124 / 16	> 50% of data below MRL			
Fluoride	0.20	124 / 124	2.4	2.5	3.2	3.9
Iron	0.1	124 / 0	> 50% of data below MRL			
Lead	0.005	124 / 0	> 50% of data below MRL			
Manganese	0.05	124 / 2	> 50% of data below MRL			
Mercury	0.0005	124 / 0	> 50% of data below MRL			
Nickel	0.1	124 / 0	> 50% of data below MRL			
Selenium	0.005	124 / 20	>50% of data below MRL			
Silver	0.001	124 / 0	> 50% of data below MRL			
Thallium	0.002	124 / 0	> 50% of data below MRL			
Zinc	0.05	124 / 15	> 50% of data below MRL			
Radiochemical Constituents						
Radon*	Varies	79 / 79	602	651	1,031	1,411
Gross Alpha*	Varies	50 / 50	6.9	7.0	12.9	18.8
Gross Beta*	Varies	50 / 50	5.7	5.1	9.9	14.6
Ra-226+228*	Varies	50 / 3	> 50% of data below MRL			
Uranium**	Varies	50 / 9	> 50% of data below MRL			
Isotopes						
Oxygen-18	Varies	124 / 124	- 10.1	- 10.0	- 9.8	- 9.7
Deuterium	Varies	124 / 124	- 74.0	- 71.9	- 70.5	- 69.2

All units mg/L except where noted or * = pCi/L, ** = ug/L, and *** = 0/00

GROUNDWATER COMPOSITION

General Summary

Groundwater in the McMullen Valley basin was predominantly of sodium-chloride or sodium-mixed chemistry (Map 10) (Diagram 7 and 8). The water chemistry at the 124 sample sites, in decreasing frequency, includes sodium-mixed (58 sites), sodium-bicarbonate (43 sites), mixed-bicarbonate (11 sites), mixed-mixed (5 sites), sodium-chloride (3 sites), mixed-chloride (2 sites) and calcium-chloride and calcium-bicarbonate (1 site apiece) (Diagram 8 – middle diagram).

Of the 124 sample sites in the McMullen Valley basin, the dominant cation was sodium at 104 sites and calcium at 2 sites; at 18 sites, the composition was mixed as there was no dominant cation (Diagram 8 – left diagram).

The dominant anion was bicarbonate at 55 sites and chloride at 6 sites; at 63 sites the composition was mixed as there was no dominant anion (Diagram 8 – right diagram).

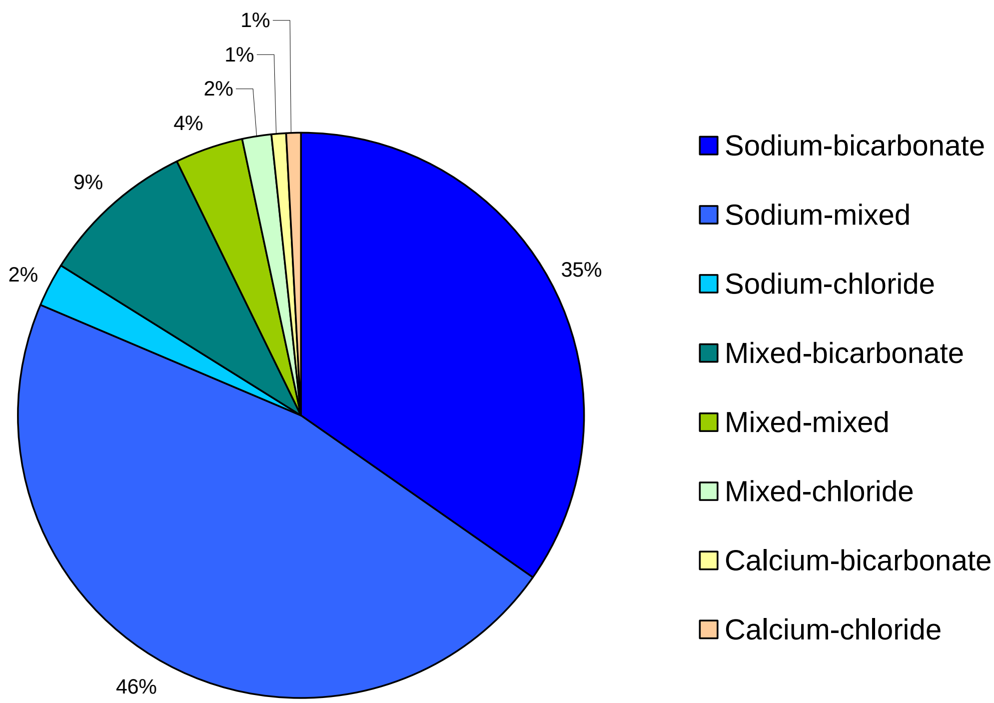


Diagram 7. Water Chemistry of McMullen Valley Wells

Diagram 7 – Of the 124 inorganic sample sites in the McMullen Valley basin, the majority consist of either sodium-mixed or sodium-bicarbonate water chemistry types. Cations, or those major ions that are positively charged, are predominantly (83 percent) sodium. The others are of a mixed composition except for 2 percent of samples that are predominantly calcium. Anions, of those major ions that are negatively charged, are almost equally divided among mixed (50 percent) and bicarbonate (45 percent); the remainder consist of chloride (5 percent).

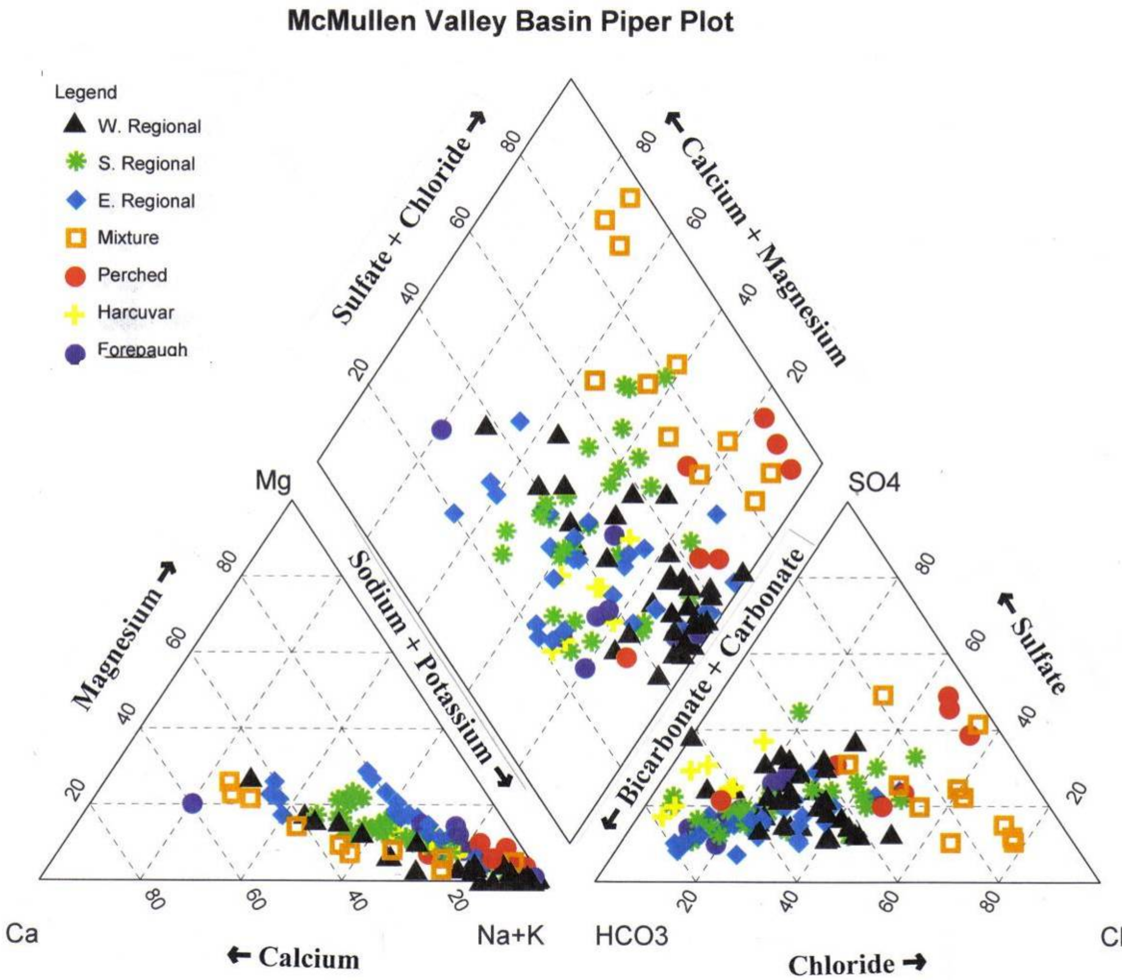
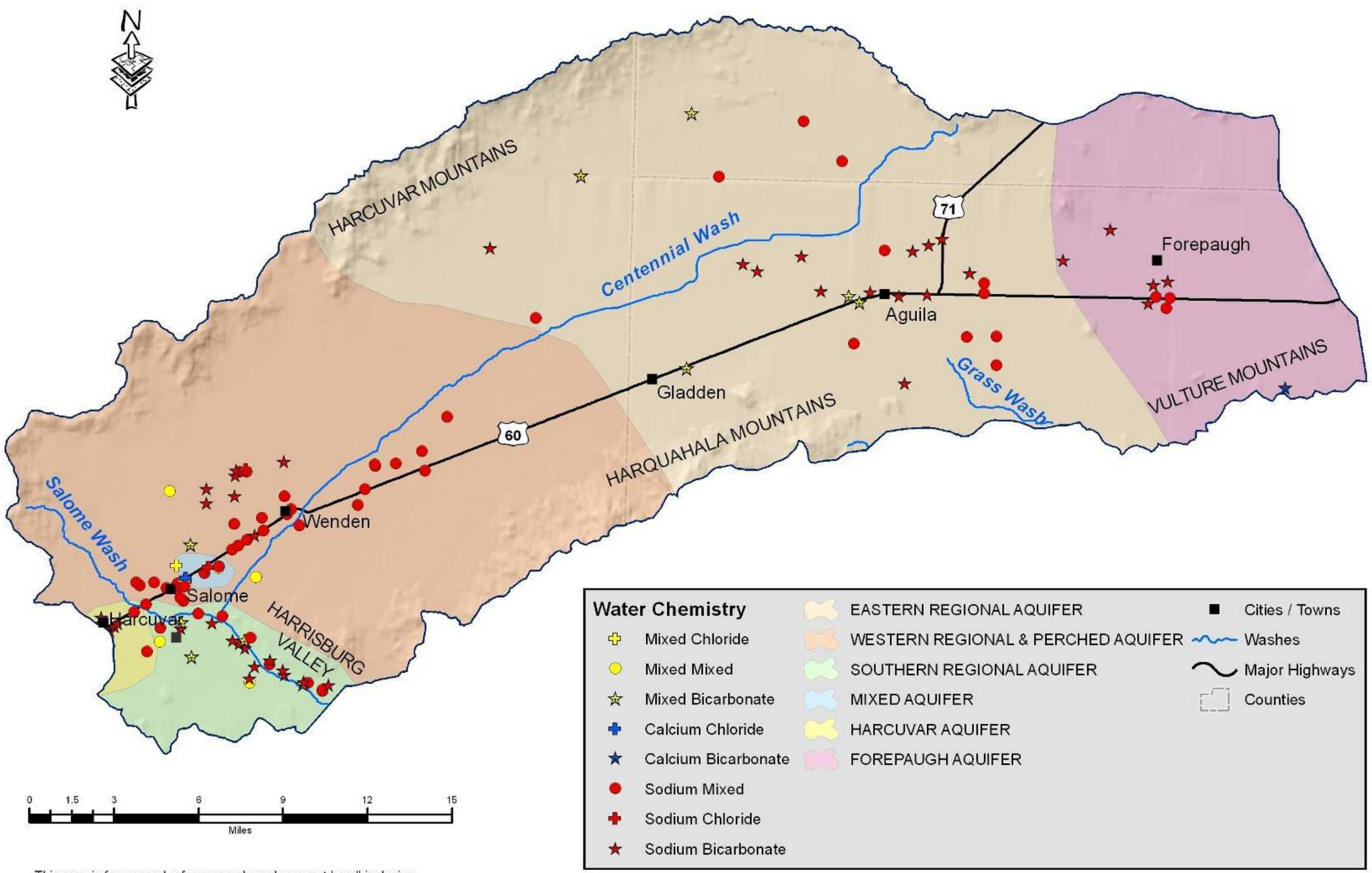


Diagram 8 – The Piper trilinear diagram shows that all the sodium-bicarbonate samples consist of sites situated in the Harcuvar, Forepaugh, the Eastern, Southern or Western Regional aquifers. The other samples from these aquifers are also chemically similar to the sodium-bicarbonate water chemistry. In contrast, the samples collected from sites in the Mixed or Perched aquifers tend to be distinct because chloride and sulfate ions make up a high percentage of their anion sums.

Map 10: Water Chemistry



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At 136 wells (124 sampled wells plus 12 wells at which only field parameters and nitrate samples were collected) levels of pH-field were *slightly alkaline* (above 7 su) at 135 sites and *slightly acidic* (below 7 su) at 1 site.[19] Of the 135 sites above 7 su, 63 sites had pH-field levels over 8 su and 6 sites had pH-field levels over 9 su.

TDS concentrations were considered *fresh* (below 1,000 mg/L) at 108 sites, *slightly saline* (1,000 to 3,000 mg/L) at 14 sites and *moderately saline* (3,000 to 10,000 mg/L) at 2 sites (Map 7).[19]

Hardness concentrations were *soft* (below 75 mg/L) at 57 sites, *moderately hard* (75 – 150 mg/L) at 38 sites, *hard* (150 – 300 mg/L) at 19 sites, and *very hard* (above 300 mg/L) at 10 sites (Diagram 9 and Map 11).[15]

Nitrate (as nitrogen) concentrations at most sites may have been influenced by human activities (Map 6). Nitrate concentrations were divided into natural background (0 sites at <0.2 mg/L), may or may not indicate human influence (53 sites at 0.2 – 3.0 mg/L), may result from human activities (56 sites at 3.0 – 10 mg/L), and probably result from human activities (17 sites >10mg/L).[23]

Most trace elements such as antimony, beryllium, cadmium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, thallium and zinc were rarely–if ever—detected. Only arsenic, barium, boron, chromium and fluoride were detected at more than 20 percent of the sites.

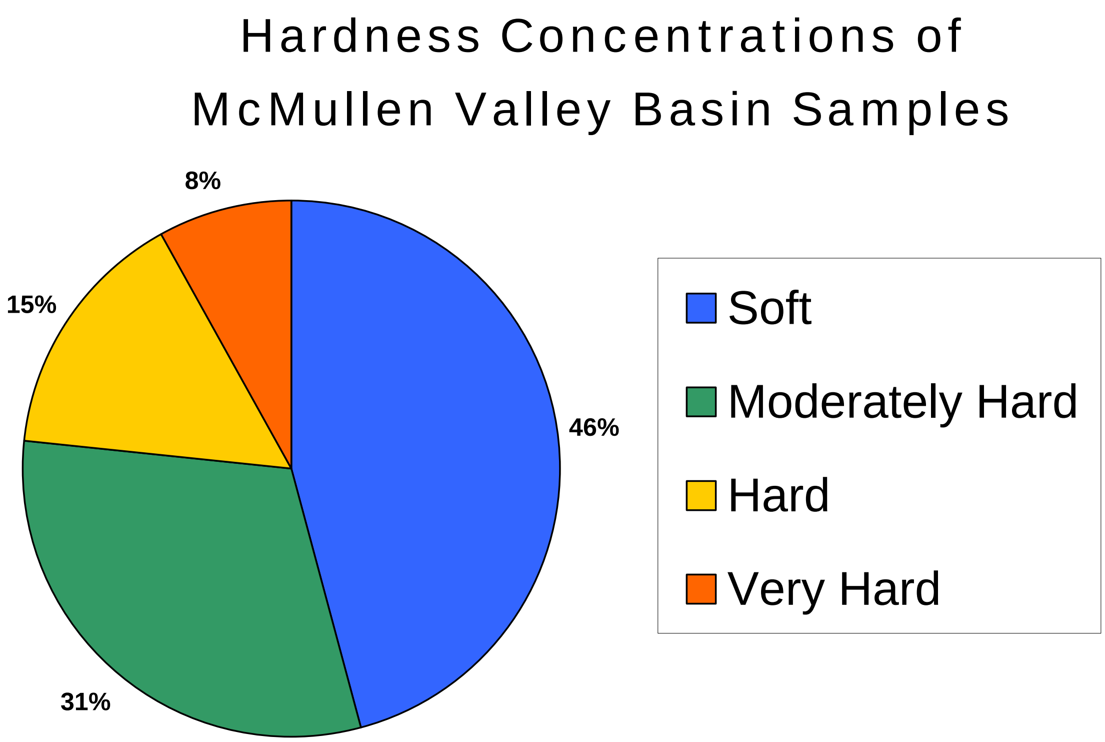
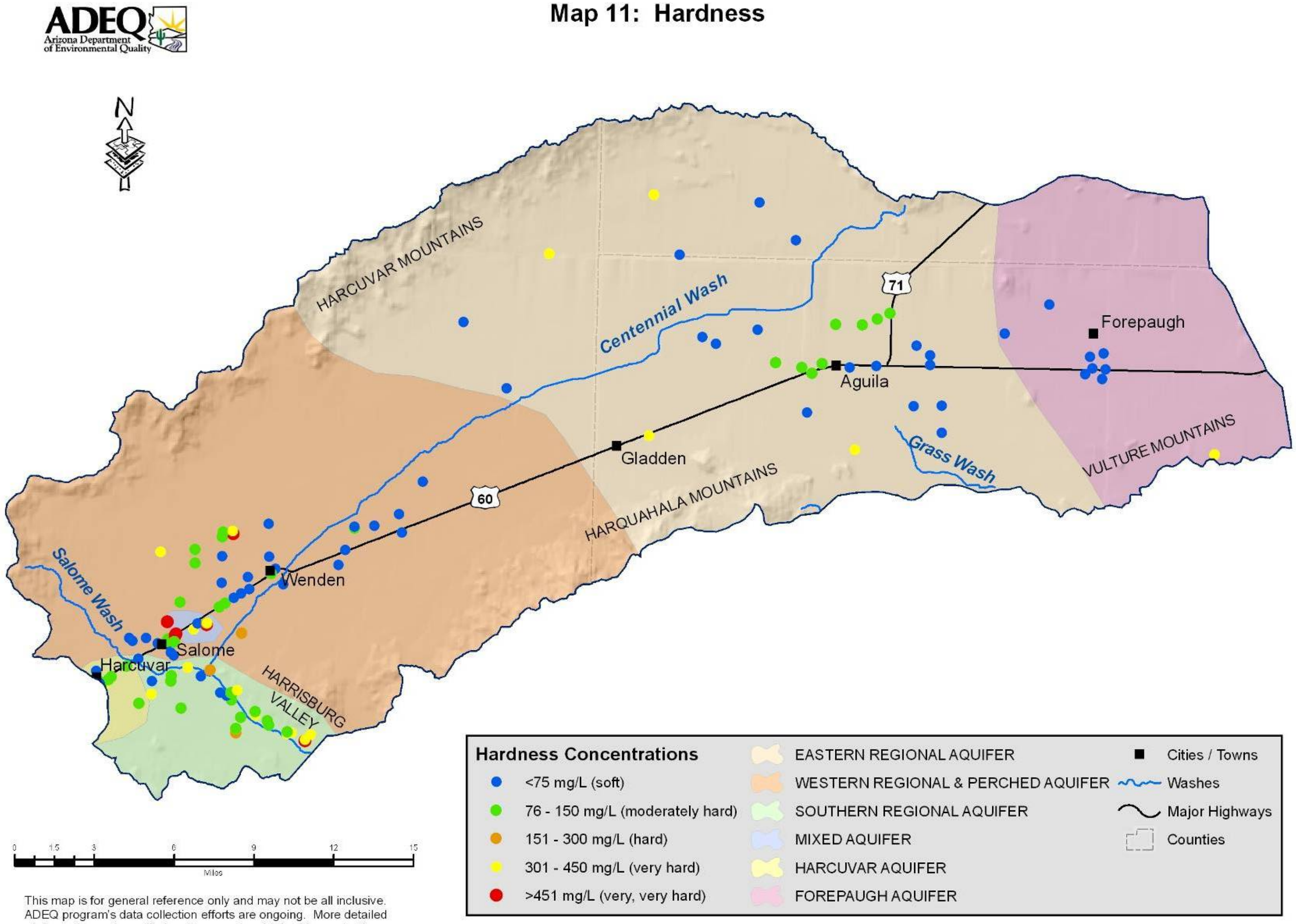


Diagram 9 – This pie chart illustrates that almost half of the sample sites in the McMullen Valley basin were characterized by having soft water. Soft water was especially prevalent in samples collected from the Eastern and Western Regional aquifers; 10 such samples had no detection of hardness at the 10 mg/L minimum reporting level. The highest hardness concentrations tended to be at sites located in the Perched or Mixed aquifers or in the Southern Regional aquifer at the southern most sites in the Harrisburg Valley.

Map 11: Hardness



This map is for general reference only and may not be all inclusive. ADEQ program's data collection efforts are ongoing. More detailed information and specific locations can be obtained by contacting the Arizona Department of Environmental Quality.

Constituent Co-Variation

The co-variation of constituent concentrations was determined to examine the strength of the association. The results of each combination of constituents were examined for statistically-significant positive or negative correlations. A ***positive correlation*** occurs when, as the level of a constituent increases or decreases, the concentration of another constituent also correspondingly increases or decreases. A ***negative correlation*** occurs when, as the concentration of a constituent increases, the concentration of another constituent decreases, and vice-versa. A positive correlation indicates a direct relationship between constituent concentrations; a negative correlation indicates an inverse relationship.[40]

Several significant correlations occurred among the 124 sample sites (Table 7, Pearson Correlation Coefficient test, $p \leq 0.05$). Several important correlations were identified:

- Positive correlations occurred among arsenic, boron and fluoride.

- Positive correlations occurred among nitrate, TDS and all major ions except for bicarbonate.

TDS concentrations are best predicted among major ions by sodium concentrations (standard coefficient = 0.66), among cations by sodium concentrations (standard coefficient = 0.81) (Diagram 10) and among anions, chloride (standard coefficient = 0.58) (multiple regression analysis, $p \leq 0.01$).

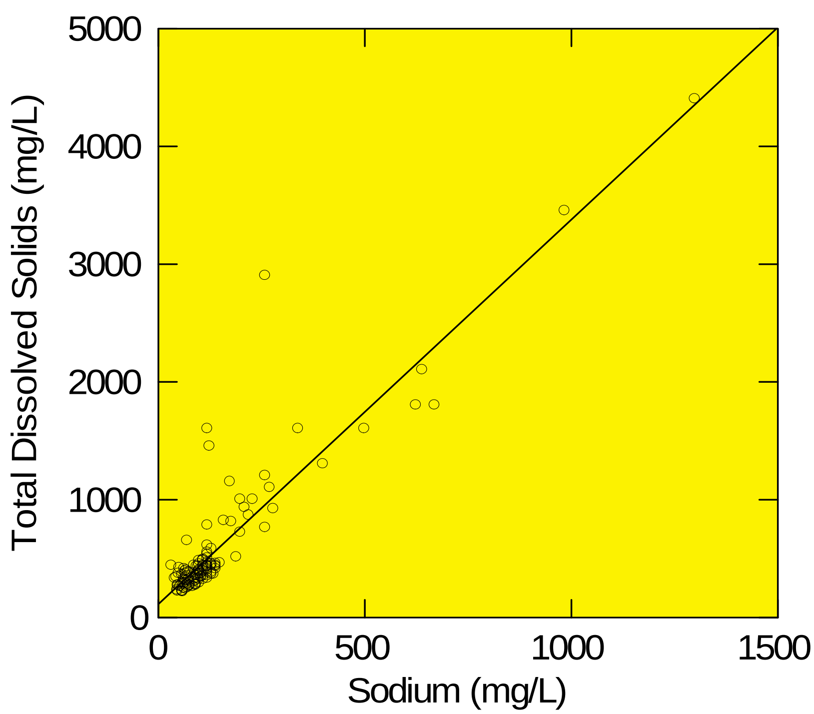


Diagram 10 – The graph illustrates a strong positive correlation between two constituents; as TDS concentrations increase so do sodium concentrations. The regression equation for this relationship is $y = 3.3x + 114$, $n = 124$, $r = 0.91$ (regression, $p \leq 0.01$). TDS concentrations are best predicted among cations by sodium concentrations with a standard coefficient of 0.81 (multiple regression analysis, $p \leq 0.01$).

Table 7. Correlation among McMullen Valley Basin Groundwater Quality Constituent Concentrations Using Pearson Correlation Probabilities

Constituent	Temp	pH-f	TDS	Hard	Ca	Mg	Na	K	Bic	Cl	SO_4	NO_3	As	B	Cr	F	O	D
Physical Parameters																		
Temperature		++	- -	- -	- -	- -		- -	- -		- -	-					-	-
pH-field			- -	- -	- -	- -		- -	- -	-	- -	- -	+		++	++	-	-
General Mineral Characteristics																		
TDS				++	++	++	++	++		++	++	++		+	-			
Hardness					++	++		++	++	++	++	++		+	-	-		
Major Ions																		
Calcium						++	+	++	++	++	++	++			- -			
Magnesium								++	++		++	++			-		+	+
Sodium								++		++	++	++		++				
Potassium									+	++	++	++			- -	- -	++	+
Bicarbonate															-		+	++
Chloride											++	++						
Sulfate												++		++				
Nutrients																		
Nitrate																		
Trace Elements																		
Arsenic														++		++		
Boron																++		
Chromium																	- -	- -
Fluoride																	-	-
Isotopes																		
Oxygen																		++
Deuterium																		

Blank cell = not a significant relationship between constituent concentrations
+ = Significant positive relationship at $p \leq 0.05$
++ = Significant positive relationship at $p \leq 0.01$
- = Significant negative relationship at $p \leq 0.05$
- - = Significant negative relationship at $p \leq 0.01$

Isotope Comparison

Groundwater characterizations using oxygen and hydrogen isotope data may be made with respect to the climate and/or elevation where the water originated, residence within the aquifer, and whether or not the water was exposed to extensive evaporation prior to collection.[14] This is accomplished by comparing oxygen-18 isotopes ($\delta^{18}O$) and deuterium (δD), an isotope of hydrogen, data to the Global Meteoric Water Line (GMWL).

The GMWL is described by the linear equation:

$$\delta D = 8\delta^{18}O + 10$$

where δD is deuterium in parts per thousand (per mil, $^0/_{00}$), 8 is the slope of the line, $\delta^{18}O$ is oxygen-18 $^0/_{00}$, and 10 is the y-intercept.[12]

The GMWL is the standard by which water samples are compared and represents the best fit isotopic analysis of numerous worldwide water samples.

Isotopic data from a region may be plotted to create a Local Meteoric Water Line (LMWL) which is affected by varying climatic and geographic factors. When the LMWL is compared to the GMWL, inferences may be made about the origin or history of the local water.[14]

The LMWL created by $\delta^{18}O$ and δD values for samples collected at sites in the McMullen Valley basin were compared to the GMWL. The δD and $\delta^{18}O$ data lie to the right of the GMWL. Meteoric waters exposed to evaporation characteristically plot increasingly below and to the right of the GMWL. Evaporation tends to preferentially contain a higher percentage of lighter isotopes in the vapor phase and causes the water that remains behind to be isotopically heavier.[14]

Groundwater from arid environments is typically subject to evaporation, which enriches δD and $\delta^{18}O$, resulting in a lower slope value (usually between 3 and 6) as compared to the slope of 8 associated with the GMWL.[14]

The data for the McMullen Valley sub-basin doesn't quite conform, having a slope of 7.4, with the LMWL described by the linear equation:

$$\delta D = 7.4^{18}O + 2.2$$

The LMWL for the McMullen Valley sub-basin (7.4) is lower than the Lake Mohave basin (7.8) but higher than most other basins in Arizona such as Detrital Valley (5.15), Agua Fria (5.3), Sacramento Valley (5.5), Big Sandy (6.1), Pinal Active Management Area (6.4), Gila Valley (6.4) and San Simon (6.5).[30, 31, 32, 33, 34, 35, 36, 37]

The isotopic data were plotted on two graphs. Samples from the Eastern, Southern and Western Regional aquifers and the Harcuvar aquifer are plotted in Diagram 11 while samples collected from sites in the Forepaugh, Mixed, Perched and the Harcuvar aquifers are plotted in Diagram 12.

Along the Local Meteoric Water Line (LMWL) the plots highest on the precipitation trajectory were the distinct cluster of six samples collected from wells in Harcuvar aquifer. The six samples are the most enriched or isotopically the heaviest sites and appear to have undergone considerable evaporation before being recharged and are likely produced from summer monsoon precipitation.

Below the Harcuvar aquifer samples, many Southern Regional aquifer samples plot high on the precipitation trajectory while Western and Eastern Regional aquifer samples are usually the most depleted and tend to plot lowest on the precipitation trajectory. The light signatures of these depleted samples suggest that the water was not provided by recharge from Centennial Wash or its tributaries but consists of water that was likely recharged during cooler climatic conditions roughly 8,000-12,000 years ago. The majority of samples from the Forepaugh, Mixed and the Perched also are depleted and don't appear to be the result of recent recharge.

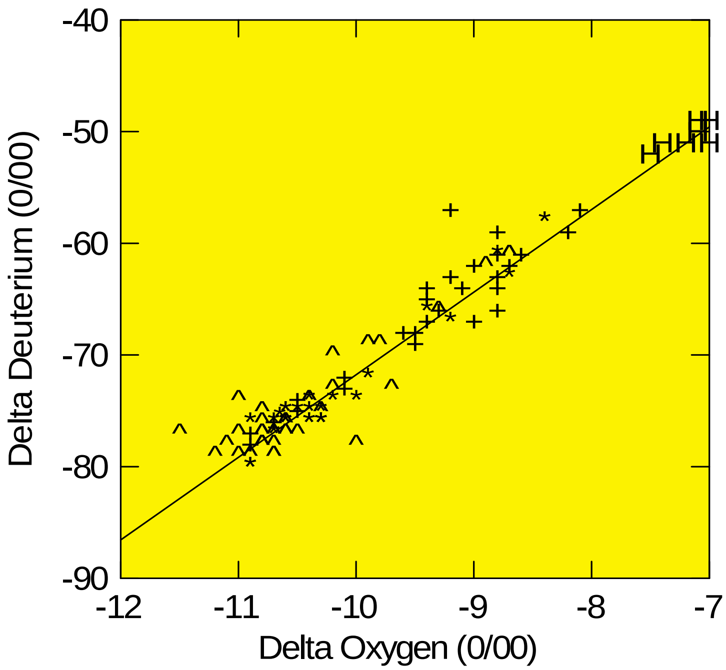


Diagram 11. The groundwater sites collected for the McMullen Valley basin study that were drawing water from the Eastern, Southern, and Western Regional aquifers and the Harcuvar aquifer were plotted according to their oxygen-18 and deuterium isotope values. Along the Local Meteoric Water Line (LMWL) starting from highest on the precipitation trajectory (upper right of graph), the following types of samples predominantly plot: Harcuvar aquifer (H), Southern Regional aquifer (+), Eastern Regional aquifer (*), and Western Regional aquifer (^). Generally the Harcuvar aquifer samples are the most enriched followed by a cluster of samples predominantly from the Southern Regional aquifer. Samples from the Eastern and Western Regional aquifer samples form a cluster at the bottom of the graph and are the most depleted in the basin.

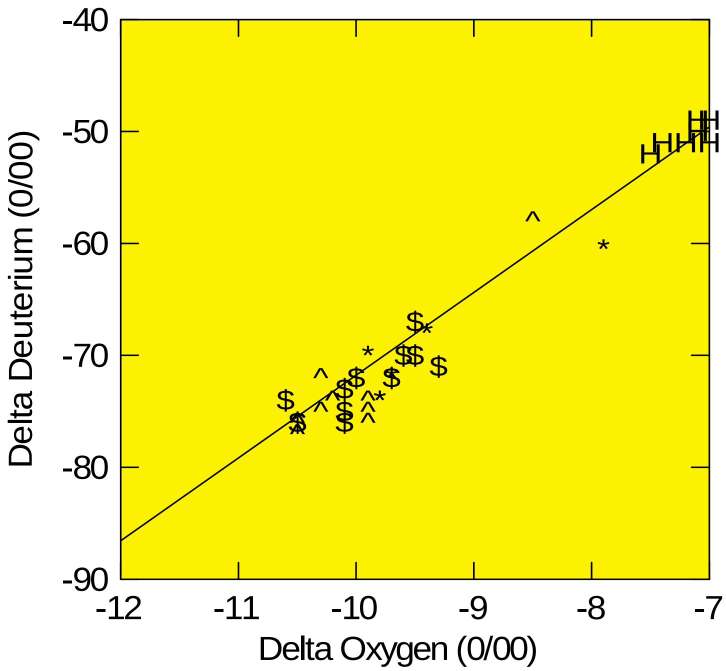


Diagram 12. The groundwater sites collected for the McMullen Valley basin study that were drawing water from the Harcuvar aquifer (H), Mixed aquifer ($), Perched aquifer (*), and Forepaugh aquifer (^) were plotted according to their oxygen-18 and deuterium isotope values. Along the Local Meteoric Water Line (LMWL) starting from highest on the precipitation trajectory (upper right of graph), the following types of samples predominantly plot: Harcuvar aquifer (H) and then a cluster of samples from the other aquifers. There are two outliers from the lower cluster of samples. The lone enriched sample from the Forepaugh aquifer was collected on the southern edge of the basin and consists of recent precipitation. The lone enriched sample from the Perched aquifer is a shallow monitoring well located in an area of irrigated farming and also appears to be recharged by recent precipitation.

Groundwater Quality Variation

Among Seven Aquifers - Twenty-eight (28) groundwater quality constituent concentrations were compared between seven aquifers: Eastern Regional (29 sites), Western Regional (34 sites), Southern Regional (29 sites), Perched (6 sites), Mixed (11 sites), Forepaugh (9 sites) and Harcuvar (6 sites). Because not all sites had the same constituents collected, site totals vary for well characteristics, field parameters, nitrate, radon and radionuclide constituents.

Significant concentration differences were found with 26 constituents (Kruskal-Wallis with Tukey test, $p \leq 0.05$). SC-field, SC-lab, TDS (Diagram 13), magnesium, sodium, chloride, sulfate, and nitrate (Diagram 14) were significantly higher in Perched and Mixed aquifers than in the three Regional, Forepaugh and Harcuvar aquifers. Hardness (Diagram 15), calcium, potassium, barium and gross beta were significantly higher in the Mixed aquifer than in the three Regional, Forepaugh and Harcuvar aquifers. Complete results are found in Table 8. Summary statistics in the form of 95% confidence intervals are provided for those constituents with significant concentration differences between aquifers in Table 9.

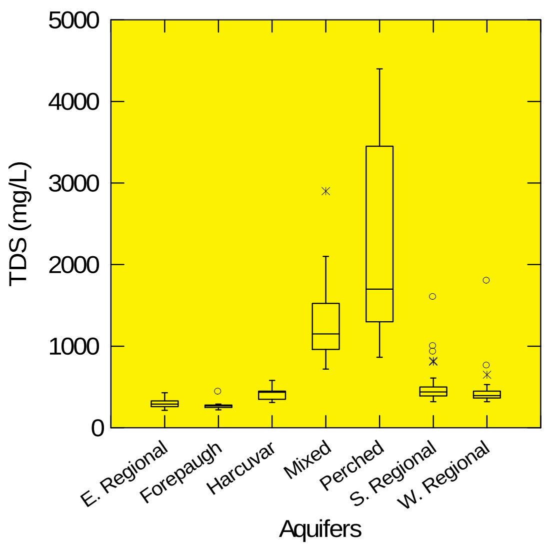


Diagram 13. Sample sites collected from the Perched and Mixed aquifers have significantly higher TDS concentrations than sample sites collected from all the other aquifers in the McMullen Valley basin; TDS concentrations in the Perched aquifer are also significantly higher than in the Mixed aquifer (Kruskal-Wallis with Tukey test, $p \leq 0.01$). The Perched and Mixed aquifers are likely impacted by highly saline recharge from irrigated fields and, to a lesser degree, poor quality recharge from septic systems. [13] Numerous sumps that catch irrigation tail water for reuse also allow large volumes of poor quality irrigation return flow water to percolate to the aquifer. [24]

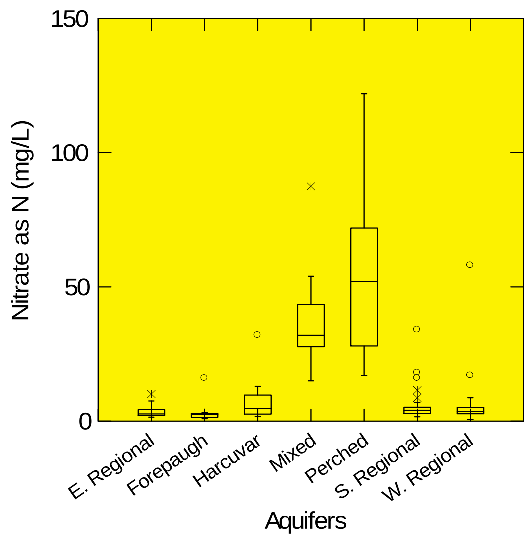


Diagram 14. Sample sites collected from the Perched and Mixed aquifers have significantly higher nitrate concentrations than sample sites collected from the Regional, Forepaugh and Harcuvar aquifers; nitrate concentrations in the Perched aquifer are also significantly higher than in the Mixed aquifer (Kruskal-Wallis with Tukey test, $p \leq 0.01$). The Perched and Mixed aquifers are likely impacted by nitrogen-laden recharge from irrigated fields and, to a minor degree, septic systems. [24] Nitrate concentrations from wells in the Perched and Mixed aquifers often exceed the 10 mg/L Primary MCL with concentrations sometimes exceeding 50 mg/L.

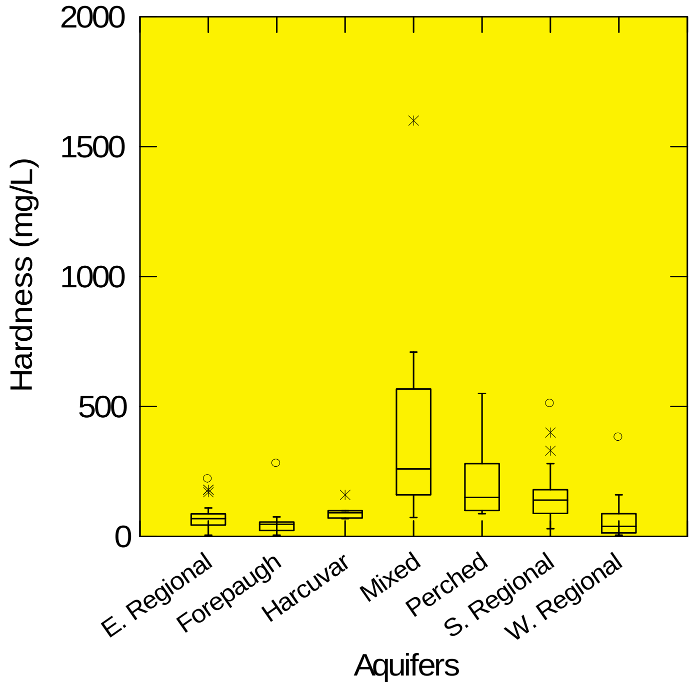


Diagram 15. Samples collected from sites in the Mixed aquifer had significantly higher hardness concentrations than samples collected from sites in the Eastern, Western and Southern Regional aquifers, the Forepaugh aquifer and Harcuvar aquifer (Kruskal-Wallis with Tukey test, $p \leq 0.05$). Calcium and magnesium followed a similar pattern to hardness.

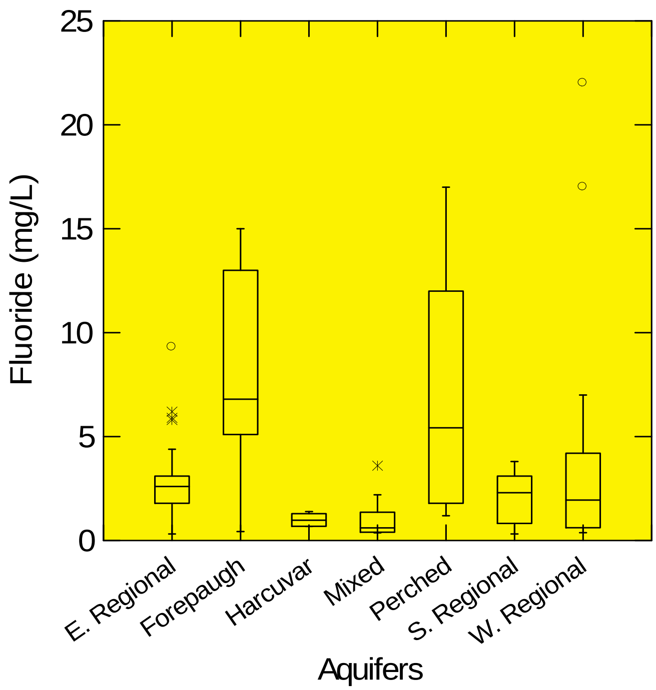


Diagram 16. Samples collected from wells in the Forepaugh aquifer have significantly higher fluoride concentrations than samples collected from all other aquifers except the Perched aquifer. The Perched aquifer has significantly higher fluoride concentrations than the Southern Regional, Mixed, and Harcuvar aquifers (Kruskal-Wallis with Tukey test, $p \leq 0.05$). The median fluoride concentration for both the Forepaugh and Perched aquifers exceeded the 4.0 mg/L health based water quality standard. Previous studies have noted that for unknown reasons the lowest fluoride concentrations tend to be north and west of the town of Salome, a conclusion that was verified by this ADEQ study.[25]

Table 8. Variation in Groundwater Quality Constituent Concentrations Among Seven Aquifers Using Kruskal-Wallis Test with the Tukey Test

Constituent	Significance	Significant Differences Among Aquifers
Well Depth	**	E. Regional > All other aquifers Forepaugh > Perched & S. Reg. W. Regional > Harcuvar, Perched and S. Regional Mixed > Perched
Groundwater Depth	**	E. Regional > All aquifers except Forepaugh Forepaugh > Mixed, Perched & S. Reg. Harcuvar, Mixed & W. Regional > Perched & S. Reg.
Temperature - field	**	Forepaugh, Mixed & W. Regional> Perched & S. Regional E. Regional > Harcuvar, Perched & S. Regional Harcuvar > Perched
pH – field	**	E. Regional, Forepaugh & W. Regional> Mixed & S. Regional
pH – lab	**	E. Regional & W. Regional. > Mixed & S. Regional. Forepaugh > Mixed
SC - field	**	Perched > All other aquifers Mixed > Forepaugh, Harcuvar, E. Regional, S. Regional & W. Regional
SC - lab	**	Perched > All other aquifers Mixed > Forepaugh, Harcuvar, E. Regional, S. Regional & W. Regional
TDS	**	Perched > All other aquifers Mixed > Forepaugh, Harcuvar, E. Regional, S. Regional & W. Regional
Turbidity	*	Perched > All other aquifers
Hardness	**	Mixed > E. Regional, Forepaugh, Harcuvar, S. Regional & W. Regional
Calcium	**	Mixed > All other aquifers
Magnesium	**	Mixed> E. Regional, Forepaugh, Harcuvar, S. Regional & W. Regional Perched > E. Regional, Forepaugh & W. Regional
Sodium	**	Perched > All other aquifers Mixed > E. Regional, S. Regional, W. Regional & Forepaugh
Potassium	**	Mixed > All other aquifers S. Regional > E. Regional & Forepaugh
Bicarbonate	**	S. Regional > E. Regional, Forepaugh & W. Regional Harcuvar > E. Regional & Forepaugh
Chloride	**	Perched & Mixed > All other aquifers
Sulfate	**	Perched > All others aquifers Mixed > Forepaugh, E. Regional, S. Regional & W. Regional
Nitrate (as N)	**	Perched > All other aquifers Mixed > Forepaugh, Harcuvar, E. Regional, S. Regional & W. Regional
Arsenic	**	-
Barium	*	Mixed > E. Regional, Forepaugh, W. Regional & Harcuvar
Boron	**	Perched > All other aquifers
Chromium	**	E. Regional > Mixed, S. Regional & Harcuvar W. Regional > S. Regional & Harcuvar
Fluoride	**	Forepaugh > All other aquifers except Perched Perched > Mixed, S. Regional & Harcuvar
Oxygen	**	Harcuvar > All other aquifers S. Regional > E. Regional & W. Regional Perched > W. Regional
Deuterium	**	Harcuvar > All other aquifers S. Regional > E. Regional, Forepaugh, Mixed & W. Regional
Gross Alpha	ns	-
Gross Beta	**	Mixed > All other aquifers
Radon	ns	-

ns = not significant * = significant at $p \leq 0.05$ or 95% confidence level ** = significant at $p \leq 0.01$ or 99% confidence level

Table 9. Summary Statistics (95% Confidence Intervals) for Groundwater Quality Constituents With Significant Concentration Differences Among Seven Aquifers

Constituent	Forepaugh	Harcuvar	Perched	Mixed	West Regional	East Regional	South Regional
Well Depth	630 to 767	496 to 534	50 to 209	512 to 724	781 to 944	993 to 1343	301 to 432
Groundwater Depth	461 to 527	334 to 371	-46 to 220	289 to 418	375 to 435	467 to 577	150 to 219
Temperature - field	25.3 to 33.4	25.0 to 26.9	22.6 to 26.8	27.0 to 32.1	30.1 to 32.1	29.4 to 31.3	25.5 to 26.4
pH – field	7.91 to 8.67	-	-	7.32 to 7.81	8.14 to 8.44	8.00 to 8.40	7.55 to 7.75
pH – lab	8.15 to 8.62	-	-	7.64 to 8.20	8.33 to 8.54	8.21 to 8.48	8.08 to 8.17
SC - field	423 to 577	540 to 1016	1336 to 5529	1507 to 2653	637 to 865	500 to 575	714 to 1017
SC - lab	393 to 549	538 to 838	1359 to 5357	1479 to 2589	605 to 868	460 to 540	696 to 1027
TDS	235 to 331	329 to 525	789 to 3683	921 to 1791	369 to 546	277 to 321	424 to 631
Turbidity	-0.14 to 1.9	0.02 to 0.09	-2.6 to 28.6	-0.6 to 2.5	-0.1 to 1.6	0.2 to 0.6	-0.4 to 1.9
Hardness	-1 to 129	62 to 132	-	148 to 737	35 to 86	56 to 97	119 to 201
Calcium	-3 to 38	16 to 35	4 to 83	47 to 213	11 to 26	13 to 24	31 to 54
Magnesium	2 to 10	5 to 12	1 to 58	7 to 55	2 to 7	6 to 10	10 to 18
Sodium	58 to 89	94 to 131	251 to 1092	146 to 341	95 to 167	62 to 78	100 to 143
Potassium	1.0 to 1.9	2.8 to 4.0	0.6 to 3.5	3.4 to 7.9	2.1 to 3.0	1.7 to 2.3	3.1 to 3.9
Bicarbonate	114 to 186	218 to 262	-	118 to 233	159 to 196	144 to 178	213 to 252
Chloride	19 to 31	6 to 32	92 to 810	238 to 455	51 to 83	33 to 50	53 to 117
Sulfate	27 to 44	47 to 92	0 to 1012	73 to 393	45 to 91	28 to 37	60 to 115
Nitrate (as N)	0 – 7.2	-1 to 19	18 to 97	24 to 51	2.7 to 8.4	2.7 to 4.2	3.7 to 8.0
Arsenic	-	-	-	-	-	-	-
Barium	0.02 to 0.05	0.02 to 0.04	-	0.06 to 0.17	0.04 to 0.07	0.04 - 0.07	-
Boron	0.14 to 0.28	0.3 to 0.5	0.6 to 2.4	0.16 to 0.82	0.22 to 0.67	0.14 to 0.18	0.20 to 0.30
Chromium	-	0.005 to 0.005	-	0.004 to 0.024	0.020 to 0.036	0.030 to 0.043	0.009 to 0.015
Fluoride	4.4 to 12.2	0.7 to 1.4	0.5 to 13.8	0.4 to 1.8	1.8 to 5.0	2.2 to 3.6	1.7 to 2.6
Oxygen	-10.5 to -9.5	-7.4 to -7.0	-10.2 to -8.6	-10.2 to -9.6	-10.7 to -10.2	-10.5 to -10.0	-9.6 to -9.0
Deuterium	-77.5 to 68.5	-51.8 to -49.6	-75.1 to -64.4	-74.2 to -70.5	-76.3 to -72.7	-75.6 to -71.5	-68.3 to -63.2
Gross Alpha	-	-	-	-	-	-	-
Gross Beta	2.3 to 7.2	-6.7 to 19.9	3.6 to 17.6	-18 to 120	3.0 to 10.5	2.4 to 4.8	5.1 to 9.6
Radon	-	-	-	-	-	-	-

All units in milligrams per liter (mg/L) unless otherwise noted

Among Five Aquifers - Twenty-eight (28) groundwater quality constituent concentrations were compared between Eastern Regional (29 sites), Western Regional (34 sites), Southern Regional (29 sites), Forepaugh (9 sites) and Harcuvar (6 sites) aquifers; sites in the Perched and Mixed aquifers were not included because their extreme values often masked more subtle differences between the other aquifers. Because not all sites had the same constituents collected, site totals vary for well characteristics, field parameters, nitrate, radon and radionuclide constituents.

Significant concentration differences were found with 24 constituents (Kruskal-Wallis with Tukey test, $p \leq 0.05$).

There were three general patterns. Well depth, groundwater depth, temperature, pH-field (Diagram 17), pH-lab and chromium were significantly higher in the Eastern and Western Regional aquifers than the Southern Regional aquifer. SC-field, SC-lab, and TDS (Diagram 18) were significantly higher in Southern and Western Regional aquifers than the Eastern Regional aquifer. Hardness, calcium, magnesium, bicarbonate (Diagram 19), oxygen and deuterium (Diagram 20) were significantly higher in the Southern Regional aquifer than in the Eastern and Western Regional aquifers. Complete results are found in Table 10.

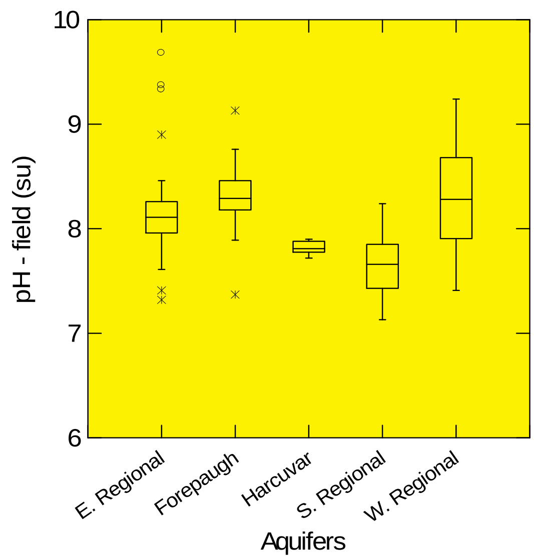


Diagram 17. Samples collected from sites in the Eastern Regional, Western Regional and Forepaugh aquifers had significantly higher pH values than samples collected from sites in the Southern Regional aquifer (Kruskal-Wallis with Tukey test, $p \leq 0.05$). Based on isotope values, the Southern Regional and Harcuvar aquifers appear to receive more recent recharge and groundwater in such areas is usually near neutral (6.9 – 7.4 su) whereas in downgradient areas, pH values in groundwater can through hydrolysis reactions increase up to 9.5 su.[28]

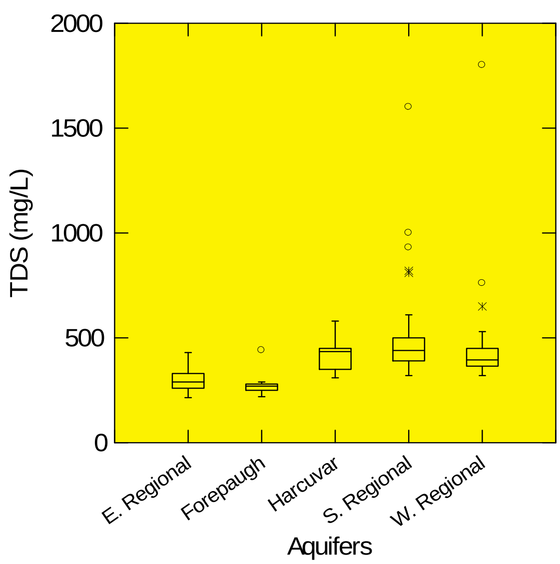


Diagram 18. Samples collected from sites in the Southern Regional aquifer had significantly higher TDS concentrations than samples collected from sites in the Eastern Regional and Forepaugh aquifers; sites in the Western Regional aquifer had significantly higher TDS concentrations than sites in the Eastern Regional aquifer (Kruskal-Wallis and Tukey test, $p \leq 0.05$). The significantly greater depth to groundwater in the Eastern Regional aquifer delays the mixing of water laden with salts from excess irrigation applications percolating to the aquifer.[13]

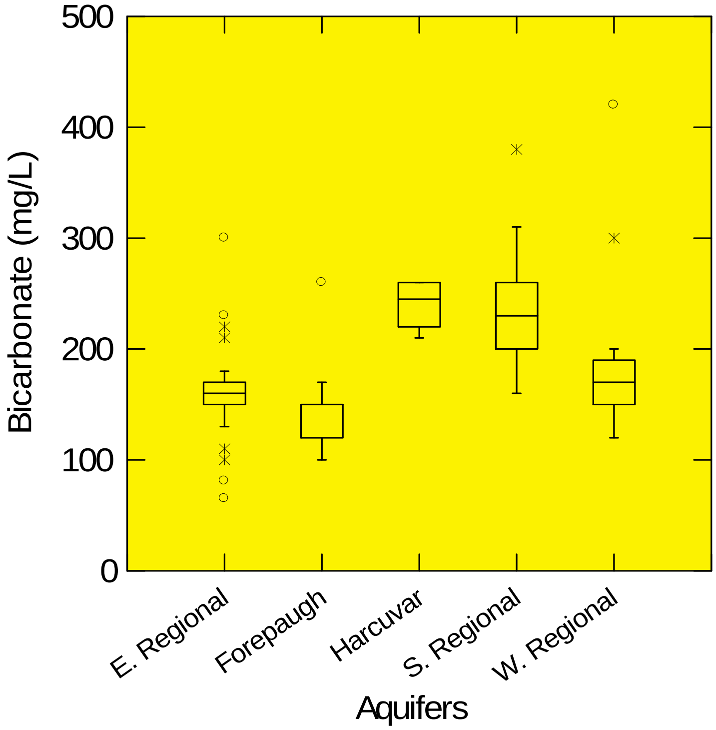


Diagram 19. Samples collected from sites in the Southern Regional and Harcuvar aquifers had significantly higher concentrations of bicarbonate than samples collected from sites in the Eastern Regional, Forepaugh and Western Regional aquifers (Kruskal-Wallis and Tukey test, $p \leq 0.05$). Elevated bicarbonate concentrations are often associated with recharge areas.[28] Since calcium, magnesium and bicarbonate are significantly greater in the Southern Regional aquifer, this is another indication that groundwater in that aquifer is of more recent origin than the Eastern and Western Regional aquifers.

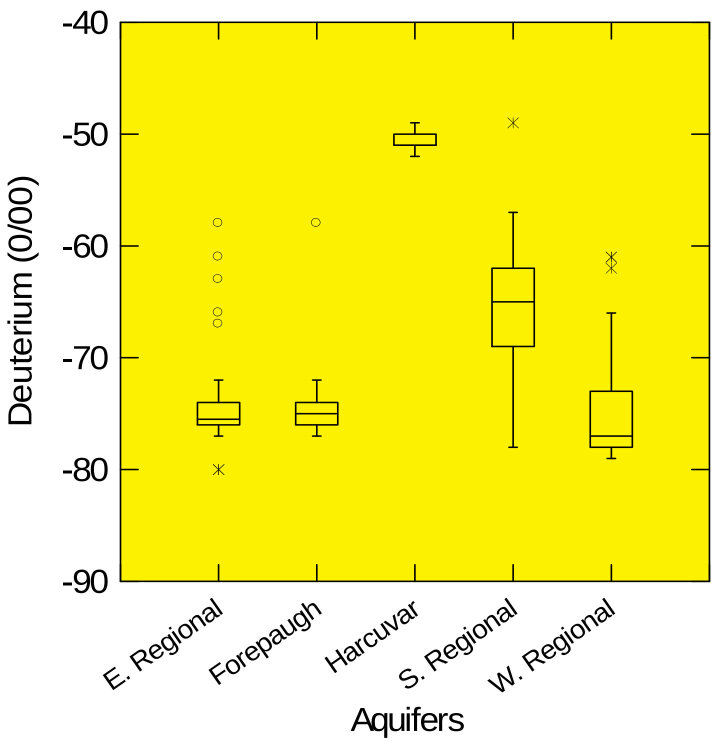


Diagram 20. Samples collected from sites in the Harcuvar aquifer had significantly higher deuterium values than samples collected from sites in the Eastern Regional, Forepaugh, Western Regional, and Southern Regional aquifers (Kruskal-Wallis with Tukey test, $p \leq 0.01$). Similarly, samples collected from sites in the Southern Regional aquifer were significant higher than those collected from the Eastern Regional, Forepaugh, Western Regional aquifers.

Samples from the Harcuvar and Southern Regional aquifers generally plotted higher on the precipitation trajectory and were isotopically heavier or more enriched than samples collected from the Eastern Regional, Forepaugh or Western Regional aquifers. This pattern is yet another indication that groundwater in that aquifer is of more recent origin than the Eastern and Western Regional aquifers.

Table 10. Variation in Groundwater Quality Constituent Concentrations Between Five Regional Aquifers Using Kruskal-Wallis with the Tukey Test

Constituent	Significance	Significant Differences Among Recharge Sources
Well Depth	**	E. Regional > All aquifers W. Regional > Harcuvar & S. Regional Forepaugh > S. Regional
Groundwater Depth	**	All aquifers > S. Regional E. Regional > W. Regional, Harcuvar & S. Regional
Temperature - field	**	E. Regional & W. Regional > Harcuvar & S. Regional Forepaugh> S. Regional
pH – field	**	E. Regional, Forepaugh & W. Regional > S. Regional
pH – lab	**	E. Regional & W. Regional > S. Regional
SC - field	**	S. Regional > E. Regional & Forepaugh W. Regional > E. Regional
SC - lab	**	S. Regional > E. Regional & Forepaugh W. Regional > E. Regional
TDS	**	S. Regional > E. Regional & Forepaugh W. Regional > E. Regional
Turbidity	ns	-
Hardness	**	S. Regional > W. Regional, E. Regional & Forepaugh
Calcium	**	S. Regional > W. Regional, E. Regional & Forepaugh
Magnesium	**	S. Regional > W. Regional, E. Regional & Forepaugh
Sodium	**	W. Regional > E. Regional & Forepaugh
Potassium	**	S. Regional & Harcuvar > Forepaugh & E. Regional W. Regional > Forepaugh S. Regional > W. Regional
Bicarbonate	**	S. Regional & Harcuvar > Forepaugh, W. Regional & E. Regional
Chloride	**	S. Regional > E. Regional, Forepaugh & Harcuvar
Sulfate	**	S. Regional> E. Regional
Nitrate (as N)	**	-
Arsenic	**	-
Barium	ns	-
Boron	**	W. Regional > E. Regional
Chromium	**	E. Regional & W. Regional > Harcuvar & S. Regional
Fluoride	**	Forepaugh > all aquifers
Oxygen	**	Harcuvar > all aquifers S. Regional > E. Regional & W. Regional
Deuterium	**	Harcuvar > all aquifers S. Regional > E. Regional, Forepaugh & W. Regional
Gross Alpha	ns	-
Gross Beta	*	-
Radon	ns	-

ns = not significant   * = significant at $p \leq 0.05$ or 95% confidence level   ** = significant at $p \leq 0.01$ or 99% confidence level
All units mg/L except temperature (degrees Celsius) and SC (uS/cm)

SUMMARY AND CONCLUSIONS

The groundwater quality of the McMullen Valley basin will be described in the following order: the Forepaugh aquifer, Eastern Regional aquifer, Western Regional aquifer, the Mixed aquifer, the Perched aquifer, Southern Regional aquifer, and the Harcuvar aquifer.

Forepaugh Aquifer – Located in the easternmost section of the McMullen Valley basin, groundwater in this aquifer is partially separated from the Eastern Regional aquifer by low hills and an unnamed ridge east of Aguila.[43] The steep hydraulic gradient between the two aquifers indicates they are poorly connected.[43]

All nine of the groundwater samples collected in the Forepaugh aquifer exceeded health-based water quality standards. At eight sites, water quality standards for fluoride were exceeded with concentrations as high as 15 mg/L, almost four times the health based water quality standard. Fluoride concentrations above 5 mg/L are controlled by calcium through precipitation or dissolution of the mineral fluorite. [28] In a chemically closed hydrologic system such as the McMullen Valley basin, calcium is removed from solution by precipitation of calcium carbonate and the formation of smectite clays. High concentrations of dissolved fluoride may occur in groundwater depleted in calcium if a source of fluoride ions is available for dissolution. [28]

Six groundwater samples collected from the Forepaugh aquifer also exceeded health-based water quality standards for arsenic; concentrations were as high as 0.022 mg/L, over twice the 0.01 mg/L standard. Arsenic concentrations may be influenced by similar reactions as fluoride, including exchange on clays or with hydroxyl ions. Other factors such as aquifer residence time, an oxidizing environment, and lithology likely effect arsenic concentrations. [28, 29]

A well located on an isolated ranch on the southern periphery of the basin, near bedrock, exceeded nitrate and gross alpha water quality standards. The nitrate exceedances may have been the result of nearby corrals that sometimes hold livestock, a source which has been thought to the cause of elevated nitrate concentrations in other isolated stock wells around Arizona. [31, 32] Fractured rock aquifers do not filter wastewater as efficiently as porous aquifers which can result in groundwater contamination.[41] The elevated gross alpha concentrations may result from the nearby granite geology, which often is correlated with high concentrations of radionuclide constituents.[23]

Eastern Regional Aquifer – In the McMullen Valley basin, groundwater formerly moved from east to west in the Regional aquifer. However, two large cones of depression caused by heavy pumping for irrigation uses near Aguila and also in the Salome/Wenden area have limited this flow creating the Eastern Regional aquifer (Diagram 21). [25] The aquifer consists of basin areas generally from the La Paz-Maricopa County line east to the Forepaugh aquifer and lacks the confining Lake-bed Unit above it. The Eastern Regional aquifer is directly connected to the Upper Alluvial Fill unit, which has largely been dewatered in the area. [25]

Although 28 percent of the 29 groundwater samples collected in the Eastern Regional aquifer exceeded health-based water quality standards, most of these sites were located south and southeast of Aguila. Fluoride and arsenic were the most common constituents exceeding health-based water quality standards. One well located on isolated ranch on the southern periphery of the basin, near bedrock, also exceeded nitrate and gross alpha water quality standards.

Most sample sites in the Eastern Regional aquifer west of Aguila met water quality standards and/or guidelines. The only exception was that many sample sites exceeded the Secondary MCL for fluoride. Overall, 69 percent of sites in the Eastern Regional aquifer exceeded the aesthetics-based, 2 mg/L guideline for fluoride. Exchange of sorption-desorption reactions are an important control for lower (< 5 mg/L) fluoride concentrations. [28] The weathering of rocks releases fluoride ions into solution. As pH levels increase down gradient, more hydroxyl ions may exchange for fluoride ions, thereby increasing the fluoride in solution. [28]

Well depth and groundwater depth in the Eastern Regional aquifer were significantly greater than for those in the Western or Southern Regional aquifers (Kruskal-Wallis with Tukey test, $p \leq 0.05$). This is likely an important factor in why the Eastern Regional aquifer exhibits significantly lower TDS, sodium and boron than the Western Regional aquifer. Excess water laden with salts from irrigation applications has further to percolate to recharge the water table that is also concurrently, moving deeper because of heavy pumping for irrigation. [13] Soil testing has indicated it would take approximately 7 to 10 years for recharge water to percolate 70 feet. [13] This allows the Eastern Regional aquifer to be, at this time, minimally impacted by poor quality irrigation recharge.

Western Regional Aquifer – The Western Regional aquifer no longer receives significant groundwater flow from areas east of the La Paz-Maricopa County line (Diagram 21) because of cones of depression caused by heavy pumping for irrigation uses near Aguila and also in the Salome/Wenden. [25]

The Western Regional aquifer also roughly correlates to the spatial expanse of the Lake-bed Unit, a layer of fine grained sediments that acts as a confining layer between the upper Perched aquifer and the lower Western Regional aquifer. [24] However, some irrigation wells in the Western Regional aquifer produce water that is a product of both the Regional and Perched aquifers. The cascading wells are caused by leaking water from the Perched aquifer that occur due to breaks that have developed in the casing, voids behind the casing, and through filter packs surrounding the casing in rotary-drilled wells.[24]

Through well logs and video examination of well casings, some irrigation wells have been identified as contributing to the cross-contamination between the Western Regional aquifer and the Perched aquifer.[24] However, not all of these connecting wells exhibited elevated constituent concentrations which could be a result of seasonal fluctuations in water quality reported by earlier studies. [24] Sampling in September during the latter stages of the growing season indicates that the improved water quality is because the plumes of poor-quality groundwater near the well had largely been removed by heavy pumping for irrigation purposes. [22]

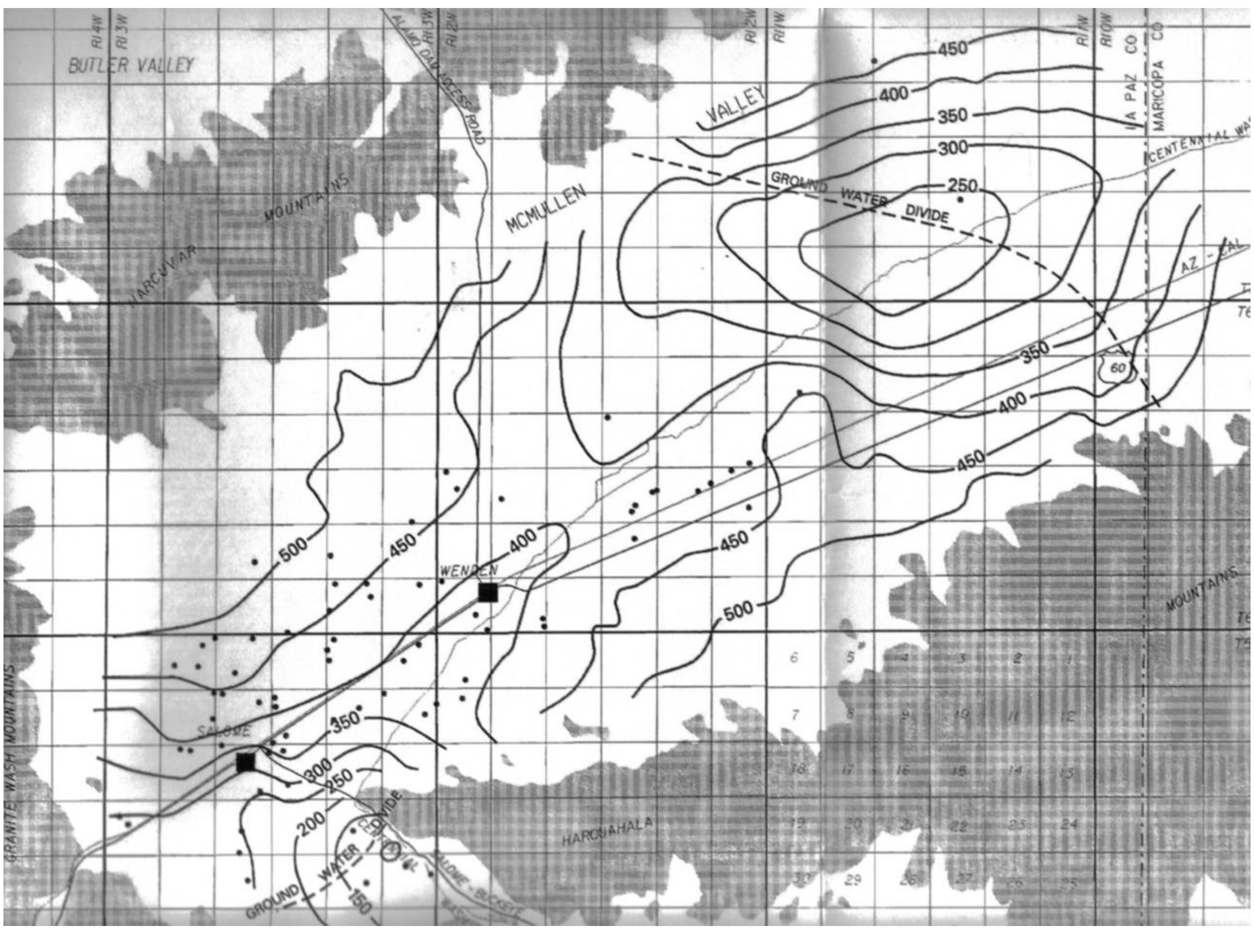


Diagram 21. Map showing depth to groundwater shows the groundwater divide in the northeast portion of the diagram that divides the Eastern and Western Regional aquifers. The divide was created by cones of depression caused by heavy pumping for irrigation use in the Eastern Regional aquifer near the town of Aguila and in the Western Regional aquifer near the towns of Wenden and Salome. The groundwater divide between the Western Regional aquifer and the Southern Regional aquifer is also shown in the southwestern portion of the diagram. [24]

Because of the difficulty in ascertaining which wells were actually producing water that was a mixture of the two sources, no additional characterization was done for the purposes of the ADEQ report. All the wells in question were designated as producing water from the Western Regional aquifer. Of the total recharge to the Western Regional aquifer, an estimated 15 percent is a result of cross-connection flow through wells. [24] Overall, cross contamination through cascading wells is thought to have a fairly small impact on the water quality of the Western Regional aquifer. [24]

The groundwater quality of the Western Regional aquifer follows a similar pattern to that found in the Eastern Regional aquifer. Although 41 percent of the 34 groundwater samples collected in the Western Regional aquifer exceeded health-based water quality standards, most of these sites were located around or east of Wenden, In contrast, most sample sites in the Western Regional aquifer west and north of Salome met water quality standards and/or guidelines.

Sample sites in the Wenden area, where elevated pH levels frequently occurred, most commonly exceeded health based water quality standards for fluoride (32 percent). Fluoride concentrations were as high as 22 mg/L, more than five times the health based water quality standard. Arsenic was exceeded at 27 percent of sample sites while nitrate was exceeded at 5 percent of sites. Fluoride and arsenic exceedances appear to be naturally occurring influenced by the same chemical processes detailed in the Eastern Regional aquifer summary. [28, 29]

The most important water quality aspect of the Western Regional aquifer—and the McMullen Valley basin—is the gap in the Lake-bed Unit northeast of Salome. The absence of the aquitard here allows poor quality groundwater in the Perched aquifer to drain downward. [24] So important is this process that, for the purposes of this report, this area is denoted as a separate aquifer and referred to as the Mixed aquifer.

Mixed Aquifer - In general, the intervening Lake-bed Unit is an effective barrier to the downward percolation of ground water, isolating the Perched and Western Regional aquifer from one another. [24] However, in a one-half mile gap where lake-bed sediments are absent one mile northeast of Salome there is no separation between the Perched and Western Regional aquifer. [24] Because the static water level of the Perched aquifer is higher than the regional water table, poor quality groundwater tends to drain downward from the Perched aquifer to the Western Regional aquifer in this area at the perimeter of the Lake-bed Unit. [24]

Wells pumping water in the vicinity of the Lake-bed Unit gap also exhibit such different water quality than that of other wells situated in the Western Regional aquifer that this area is considered a separate aquifer, the Mixed aquifer, for the purposes of this study.

Of the 11 samples collected from wells in this area, all sites exceeded water quality standards and/or guidelines for nitrate and TDS; exceedances also occurred frequently with fluoride, chloride, sulfate, arsenic, gross alpha, uranium, selenium, and manganese. In particular, nitrate concentrations were elevated up to seven times the 10 mg/L health-based water quality standard. The elevated radionuclide concentrations such as uranium may be linked to the downward movement of high alkalinity water combined with alluvial material eroded from nearby granite bedrock.[26] Other studies have shown that high alkalinity recharge liberates naturally occurring uranium that is absorbed to aquifer sediments. [42]

Although the lake bed sediment gap is not shown as extending further northeast along U.S. Highway 60, here there is another area of elevated constituent concentrations.[24] Several wells in between these two areas that don't show any impacts of recharge from the Perched aquifer. Although an earlier report shows this as a zone of permanently degraded water quality, it may be just a product of cascading wells at the northeast end.

TDS, hardness, calcium, magnesium, sodium, potassium, chloride, sulfate, nitrate, barium, boron and gross beta concentrations in the Mixed aquifer were generally significantly higher than for those found in the Western, Southern or Eastern Regional aquifers or the Forepaugh or Harcuvar aquifers (Kruskal-Wallis with Tukey test, $p \leq 0.05$).

Based on this data, the water quality of the Mixed aquifer does not appear to be able to support domestic or municipal uses without treatment.

Perched Aquifer – Present only in the western portion of the basin, this shallow aquifer composed of discontinuous sand and gravel lenses is probably a system composed of several aquifers that may not all be hydrologically connected. [24] Little information is known about the occurrence and movement of water within it. The aquifer is not a significant water source, estimated to contain around 500,000 acre-feet which is estimated to be 8 percent of the total groundwater in storage in the Western Regional aquifer above a depth of 1,200 feet. [24] However, the Perched aquifer system is important because of its impact on the water quality of other associated aquifers. [24]

Although natural recharge occurs from ephemeral flows in Centennial Wash and its tributaries, most recharge comes from deep percolation of irrigation water as well as minor amounts of wastewater discharged from septic systems. [24] As such, previous studies postulated that the water quality in the Perched aquifer system was generally poor. [24]

This finding is supported by a limited amount of samples collected from six shallow wells tapping the aquifer. All six sites exceeded water quality standards and/or guidelines for nitrate and TDS; exceedances also occurred with fluoride, chloride, sulfate, arsenic, gross alpha, selenium, and manganese. The elevated nitrate concentrations are not unexpected since previous research has indicated both irrigated farming and shallow groundwater are both strong predictors of nitrate contamination.[41] Nitrate is mobile and often is found in groundwater as the result of agricultural activities. [42]

Based on this data, the water quality of the Perched aquifer does not appear to be able to support domestic or municipal uses without treatment.

Southern Regional Aquifer – The Southern Regional aquifer is separated from the Western Regional aquifer by a subsurface bedrock extension of the Haraquahala Mountains that retards the movement of groundwater from the Harrisburg Valley area to the zone of heavy pumping in the Salome/Wenden area (Diagram 21).[25] The subsurface structural extension becomes indistinct further west near the community of Harcuvar.

The groundwater quality of the Southern Regional aquifer is generally suitable for drinking water purposes with only 18 percent of the samples sites exceeding health-based water quality standards. Of the six sites with health-based water quality standard exceedances, four sites were for nitrate and two sites were for radionuclides. Two of the sites exceeding nitrate were located in close proximity to Centennial Wash. The other four sites (two exceedances for nitrate and two exceedances for radionuclides) were located in the southern portion of Harrisburg Valley almost where Centennial Wash flows into Haraquahala basin.

In many cases, the same wells frequently also exceeded chloride and TDS water quality guidelines. The elevated nitrate concentrations probably were the result of nearby wastewater disposal through septic systems. The elevated gross alpha concentrations may result from the nearby granite geology, which often is correlated with high concentrations of radionuclide constituents.[23] Wells in the southern portion of Harrisburg Valley area also had some of the highest radon concentrations (> 10,000 piC/L) ever found in Arizona. High radon concentrations are usually associated with extensive uranium deposits.

Generally, concentrations of many water quality constituents in the Southern Regional aquifer are significantly lower than those in the Perched and Mixed aquifers (Kruskal-Wallis with Tukey test, $p \leq 0.05$). Hardness, calcium, magnesium, potassium, bicarbonate, oxygen and deuterium concentrations in the Southern Regional aquifer were generally significantly higher than for those found in the Eastern or Western Regional aquifers (Kruskal-Wallis with Tukey test, $p \leq 0.05$).

Residential areas south of Salome were investigated to determine if using septic systems for wastewater disposal was impacting nitrate concentrations in groundwater. This research was conducted to further explore the possibility of designating it a Nitrogen Management Area in an effort to control nitrogen pollutant loading to the groundwater. [3] Generally domestic and public water supply wells tested in the area had nitrate (as nitrogen) concentrations less than 5 mg/L; none exceeded the 10 mg/L water quality health-based standard.

Harcuvar Aquifer – The aquifer appears to be structurally controlled by the thickness of the Lake-bed Unit which extends almost down to bedrock, effectively limiting groundwater flow in the Alluvial Fan/Fanglomerate Unit from Harcuvar to areas to the east. The groundwater quality of the Harcuvar aquifer appears to be some of the best in the basin judging by the lack of arsenic and fluoride water quality standard exceedances and is generally suitable for drinking water purposes. Generally, aside from isotope values significantly different from all the other aquifers in the McMullen Valley basin, constituent concentrations in the Harcuvar aquifer are not significantly different from those in the adjoining Western and Southern Regional aquifers. The lone exception is that groundwater depths in the Harcuvar aquifer are significantly greater than in the Southern Regional aquifer.

RECOMENDATIONS

The most important aspect of water quality in the McMullen Valley basin is the gap found in the Lake-bed Unit northeast of Salome. Wells in the area, no matter how deep, exhibit elevated constituent concentrations with many water quality standard and/or guideline exceedances. In particular, all sites sampled in the Mixed aquifer had nitrate concentrations exceeding the Primary MCL, often several times over.

The problem will grow over time since the static water level of the Perched aquifer is higher than that of the Regional aquifer and groundwater tends to drain downward from the Perched aquifer to the Regional aquifer in this area.[24] Although the plume of degraded water in the area appears too large to be significantly reduced by pumping, wells in the area should be continued to be used for irrigation purposes to minimize the spread of the plume. Groundwater in the area would require extensive treatment to be used as a municipal or domestic source. The proposed City of Phoenix well field locations would avoid this area.[24]

Water and fertilizer applications associated with irrigated farming in McMullen Valley should be conducted to minimize the potential for groundwater contamination. In particular, this requires the proper amounts, timing and application methods for fertilizer.[24]

The application of nitrogen fertilizers is covered through a nitrogen management general permit. There is no notification requirement for this permit. This permit may be revoked in accordance with Arizona Administrative Code R18-9-404 if fertilizer is applied in such a way that it impacts groundwater.

Wells that are leaking water from the Perched aquifer to the Regional aquifer should be rehabilitated when possible especially in areas away from the Mixed aquifer. Leaking wells in the Mixed aquifer would not necessarily benefit from the rehabilitation since the natural flow from the Perched aquifer to the Regional aquifer would overwhelm any improvement in water quality.

Future groundwater quality studies should focus on exploring seasonal fluctuations in water quality. Previous studies have indicated that sampling irrigation wells in June during the early irrigation season reveals poorer quality water; late season irrigation sampling such as in September shows improved water quality.[24] Previous reports also indicated a seasonally degraded water quality zone two miles northwest of Wenden. The water quality of the zone improved during the course of the irrigation season, which may indicate a cluster of cross-connecting wells each of which develops a plume of varying size around the well as water short circuits down it from the Perched aquifer to the Regional aquifer.[24]

The season variability is shown in sampling results from a domestic well located adjacent to an irrigated field sampled for this study. Samples revealed that nitrate (as nitrogen) concentrations in April 2008 were 71 mg/L decreasing by January 2009 to 20 mg/L.

Wells located east of Aguila in the Forepaugh aquifer should also be used with caution for domestic or municipal sources. Groundwater samples collected in this area all showed concentrations of either fluoride, arsenic or both constituents exceeding health-based water quality standards. ADEQ recommends having well owners test their domestic water for these constituents.

Overall, the water quality of the Regional aquifers largely meets current irrigation needs. For potential future municipal uses, wells should be perforated only in the Regional aquifer. Well locations should also avoid areas near the Mixed aquifer. Blending of the water from many wells will help the resource meet water quality standards.

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Appendix A. Data for Sample Sites, McMullen Valley Basin, 2008-2009

Site #	Cadastral / Pump Type	Latitude - Longitude	ADWR #	ADEQ #	Site Name	Samples Collected	Well Depth	Water Depth	Perforation Interval
				1st Field Trip, April 21-22, 2008 – Towne & Turner (Equipment Blanks - MMU-13)					
MMU-1	B(5-13)11ddb Submersible	33°47'37.398" 113°35'02.652"	585905	71160	Ireland Well	Inorganic, Radiochem, Perc, Radon, Isotopes	530'	395'	450 - 530’
MMU-2/153/154 split resample	B(5-13)11ddb submersible	33°47'34.644" 113°35'02.912"	594634	71161	Carista Well	Inorganic, Radiochem, Radon, Nitrate, Perc Isotopes	518’	416’	458 - 518’
MMU 3	B(5-13)12add submersible	33°47'19.109" 113°33'35.990"	513772	48051	Cent. Park Well	Inorganic, Radiochem, Perc, Radon, Isotopes	700’	600’	417 - 700’
MMU-4	B(5-13)19bbb submersible	33°45'32.725" 113°38'59.323"	581224	71162	C. Wolfe Well	Inorganic, Radiochem, Perc, Radon, Isotopes	500’	340’	420 - 500’
MMU-5	B(5-13)19bdb submersible	33°45'33.973" 113°38'59.004"	601504	71163	R.D. Wolfe Well	Nitrate, Perchlorate	510’	330’	N/A
MMU-6	B(5-13)19bdb submersible	33°45'34.883" 113°39'11.384"	591355	71164	Dsrt Gem RV Park	Inorganic, Radiochem, Perc, Radon, Isotopes	515’	350’	456 - 496’
MMU-7/8 split	B(5-13)17aba submersible	33°46'58.509" 113°37'53.842"	603999	18516	Roach Well #1	Inorganic, Radiochem, Perc, Radon, Isotopes	700’	430’	600 - 700’
MMU-9	B(5-13)08dcd submersible	33°47'03.112" 113°38'00.058"	585977	71165	Tallerday Well #1	Nitrate, Perchlorate	550’	445’	470 - 550’
MMU-10	B(5-13)08dcc submersible	33°47'04.281" 113°38'01.462"	514804	71166	Tallerday Well #2	Inorganic, Radiochem, Perc, Radon, Isotopes	700’	435’	600 - 700’
MMU-11	B(5-13)21acc submersible	33°45'40.972" 113°37'05.298"	600082	18534	Washburn Way Well	Inorganic, Radiochem, Perc, Radon, Isotopes	800’	-	N/A
MMU-12	B(5-13)21dcc submersible	33°45'15.200" 113°37'05.505"	607057	18536	65th St. Well	Inorganic Perc, Radon, Isotopes	550’	280’	N/A
MMU-14	B(5-13)36dca submersible	33°44'03.108" 113°33'44.260"	599711	71180	Sima Well	Inorganic, Radiochem, Perc, Radon, Isotopes	309’	141’	234 - 309’
MMU-15/16 split	B(5-13)25dda submersible	33°44'34.090" 113°33'37.142"	504077	71200	Davis Well	Inorganic Perc, Radon, Isotopes	200’	85’	155 - 175’
MMU-17	B(5-13)22bcd submersible	33°45'43.157" 113°36'23.468"	585189	71226	Thornburg Well	Nitrate, Perchlorate	300’	215’	260 - 300’
MMU-18	B(5-13)22bca submersible	33°45'52.901" 113°36'21.621"	593852	71227	Chapin Well	Inorganic, Radiochem, Perc, Radon, Isotopes	375’	200’	310 - 370’
MMU-19	B(5-13)23bab submersible	33°46'05.845" 113°34'48.659"	592297	71201	Marks Well	Inorganic, Radiochem, Perc, Radon, Isotopes	298’	143’	150 - 298’
MMU-21	B(5-13)24acd submersible	33°45'22.144" 113°33'58.110"	545797	71202	Vollmer Well	Inorganic, Radiochem, Perc, Radon, Isotopes	187’	135’	127 - 187’
MMU-22/23 nitrate duplicate	B(5-13)24 submersible	33°45'26.772" 113°34'07.324"	650945	71225	Bohlen Well	Nitrate, Perchlorate	250’	50’	-
MMU-24	B(5-13)25abb submersible	33°45'08.132" 113°33'57.409"	552090	71220	Garbani Well	Inorganic Perc, Radon, Isotopes	205’	120’	120 - 205’
MMU-25	B(5-13)27bcc submersible	33°44'48.954" 113°35'54.605"	592299	71221	Dobson Well	Inorganic, Perc, Radon, Isotopes	384’	248’	344 - 384’
MMU-26	B(5-13)21aad submersible	33°45'57.147" 113°36'37.096"	600078	71222	Golf Well	Nitrate, Perchlorate	702’	205’	N/A
MMU-27	B(5-13)28bcb submersible	33°44'56.148" 113°37'33.719"	591221	71223	Rauber Well	Inorganic, Radiochem, Perc, Radon, Isotopes	460’	338’	N/A
MMU-28	B(5-13)32c submersible	33°48'57.105" 113°32'03.281"	-	71224	Wenden Well	Inorganic, Radiochem, Perc, Radon, Isotopes	-	-	-
				2nd Field Trip, May 13-14, 2008 – Towne & Turner (Equipment Blank - MMU-56)					
MMU-31	B(5-13)08dbc submersible	33°47'17.527" 113°38'07.149"	549123	71280	Roach Well #2	Nitrate	550’	462’	450 - 550’
MMU-32/33 split	B(6-12)27aba submersible	33°50'08.463" 113°29'41.658"	564394	74960	Palms RV Nw Well#2	Inorganic, Radiochem, Perc, Radon, Isotopes	600’	447’	500 – 600’
MMU-34	B(6-12)27acb submersible	33°50'09.126" 113°29'41.753"	803584	18773	Palms RV Old Well#1	Nitrate	600’	230’	-
MMU-35	B(5-13)24dc submersible	33°45'26.737" 113°33'45.136"	502709	71281	Pinol Windmill	Inorganic, Radiochem, Radon, Isotopes	213’	125’	105 - 210’

Appendix A. Data for Sample Sites, McMullen Valley Basin, 2008-2009---Continued

Site #	Cadastral / Pump Type	Latitude - Longitude	ADWR #	ADEQ #	Site Name	Samples Collected	Well Depth	Water Depth	Perforation Interval
MMU-36	B(5-12)30aac submersible	33°44'46.262" 113°33'00.396"	589698	71282	Patterson Well	Inorganic Radon, Isotopes	250'	129'	210 - 250'
MMU-37/150 resample	B(5-12)30cac submersible	33°44'38.253" 113°33'01.503"	591426	71283	Edwards Well	Inorganic, Radon, Isotopes, Nitrate	187'	110'	167 - 187'
MMU 38	B(5-13)27add submersible	33°44'56.582" 113°35'32.587"	556499	71284	Chester Well	Nitrate	305'	178'	255 - 305'
MMU-39	B(5-13)36bcc submersible	33°44'02.465" 113°33'39.529"	546952	71285	Sima Windmill	Nitrate	276'	155'	196 -276'
MMU-40	B(5-12)30ddd submersible	33°44'28.308" 113°32'31.270"	602984	18416	D. Wolfe Well	Inorganic, Radiochem, Radon, Isotopes	'	91'	
MMU-41	B(5-12)33bbb submersible	33°44'02.633" 113°30'49.331"	206491	71300	Hyatt Well	Inorganic, Radiochem, Radon, Isotopes	360'	208'	277 - 317'
MMU-42	B(5-12)33cab submersible	33°43'51.369" 113°31'02.108"	580958	18433	Cole Well	Inorganic Radon, Isotopes	470'	100'	430 - 470'
MMU-43	B(5-12)33cab submersible	33°43'53.578" 113°31'03.029"	644115	18432	Turk Well	Inorganic, Isotopes	154'	69'	-
MMU-44	B(5-13)10bcb submersible	33°47'38.740" 113°36'33.341"	609732	18470	Well #38	Inorganic, Isotopes	650'	428'	-
MMU-45	B(5-13)03caa turbine	33°48'17.574" 113°36'03.445"	609735	71320	Well #35	Inorganic, Radon, Isotopes	853'	380'	-
MMU-46	B(6-13)35cbb turbine	33°49'09.702" 113°35'30.668"	606382	18805	Well #26	Nitrate	835'	350'	-
MMU-47/167 resample	B(6-13)35bbb turbine	33°49'35.450" 113°35'30.678"	606381	18804	Well #24	Inorganic, Isotopes Nitrate	1000'	350'	-
MMU-48	B(6-13)26cbb turbine	33°50'01.820" 113°35'30.795"	606383	18800	Well #53	Inorganic, Radiochem Isotopes	1110'	390'	-
MMU-49/50 duplicate	B(6-12)13dcc turbine	33°51'21.131" 113°27'34.200"	526722	46273	Well #3	Inorganic, Isotopes	1505'	448'	800 - 1505'
MMU-51	B(6-12)13ddd turbine	33°44'28.308" 113°32'31.270"	608098	18745	Well #2	Nitrate	1195'	420'	-
MMU-52	B(6-11)07dbb turbine	33°52'25.828" 113°26'40.723"	604102	18733	Well #054-100	Inorganic Radon, Isotopes	1350'	480'	-
MMU-53/174 resample	B(5-13)15bab submersible	33°46'54.443" 113°36'33.802"	602981	18494	K Lazy B IR Well	Inorganic, Isotopes Nitrate	654'	320'	-
MMU-54	B(5-13)15bbb submersible	33°46'59.777" 113°36'35.582"	602980	18493	K Lazy B DM Well	Inorganic, Isotopes	664'	320'	-
MMU-55/169 resample	B(6-13)36cbc turbine	33°48'57.350" 113°34'27.794"	626170	18809	Well #11	Inorganic, Isotopes Nitrate	1000'	-	-
MMU-57	B(5-13)02bbc turbine	33°48'16.808" 113°35'29.301"	614472	18442	Well #29	Nitrate	1000'	325'	-
MMU-58/59 duplicate	B(5-13)11cbb turbine	33°47'25.139" 113°35'30.794"	606378	18483	Well #49-119	Inorganic, Isotopes	709'	290'	-
MMU-60/61/175 split resample	B(5-13)01bdd turbine	33°48'28.015" 113°33'58.198"	625292	18436	Well #20	Inorganic, Isotopes Nitrate	800'	350'	-
MMU-62	B(5-13)01aab turbine	33°48'37.351" 113°33'41.496"	611407	18435	Well #18	Inorganic, Isotopes	600'	346'	-
MMU-63	B(5-12)32adb submersible	33°44'05.766" 113°31'34.756"	213110	71321	K-B Road Well	Inorganic, Radon, Isotopes	512'	128'	452 - 512'
3rd Field Trip, June 10, 2008 – Towne (Equipment Blank - MMU-71)									
MMU-64/65 split	B(7-9)28ddd submersible	33°54'59.033" 113°11'40.301"	544619	71360	Toros Well	Inorganic, Radiochem, Radon, Isotopes	860'	760'	760 – 860'
MMU-66	B(7-9)08ccb turbine	33°58'17.254" 113°08'28.448"	604156	19045	Well #34	Inorganic, Radiochem, Isotopes	1430'	562'	719 – 1410'
MMU-67	B(7-9)15cdd turbine	33°56'35.227" 113°11'05.739"	604129	19063	Well P-6	Inorganic, Isotopes	1610'	460'	-
MMU-68	B(7-9)17ddc turbine	33°56'35.199" 113°12'55.333"	604134	19069	Well P-12	Inorganic Radon, Isotopes	1420'	453'	620 – 1400'

Appendix A. Data for Sample Sites, McMullen Valley Basin, 2008-2009---Continued

Site #	Cadastral / Pump Type	Latitude - Longitude	ADWR #	ADEQ #	Site Name	Samples Collected	Well Depth	Water Depth	Perforation Interval
MMU-69/70 duplicate	B(7-9)12aaa turbine	33°58'17.039" 113°08'28.090"	605007	19056	Well P-1	Inorganic, Isotopes	1123'	590'	-
4th Field Trip, July 23-24, 2008 – Towne (Equipment Blank - MMU-75)									
MMU-71	B(7-7)20bac submersible	33°56'25.28" 113°00'46.77"	516230	71480	Jarvis Well	Inorganic, Radiochem, Radon, Isotopes	580'	486'	480 – 580'
MMU-72/73 duplicate	B(7-8)17bcb turbine	33°57'14.93" 113°07'25.73"	604147	19021	Well #25	Inorganic, Radon Isotopes	2000'	571'	-
MMU-74	B(7-8)30add submersible	33°55'15.44" 113°07'29.10"	-	19033	Shaubert Well	Inorganic, Radiochem, Radon, Isotopes	-	-	-
MMU-76	B(7-9)10daa turbine	33°57'52.81" 113°10'35.84"	609737	19051	Well #36	Inorganic, Radon Isotopes	1250'	535'	-
MMU-77	B(7-9)11add turbine	33°57'53.28" 113°09'32.93"	605004	19054	Well #5	Inorganic, Isotopes	1267'	535'	-
MMU-78	B(7-8)17dbb turbine	33°56'56.48" 113°06'53.50"	604144	19022	Well #22	Inorganic, Radon Isotopes	1743'		-
MMU-79	B(7-8)17dcc turbine	33°56'36.67" 113°06'52.75"	604145	19023	Well #23	Inorganic, Radon Isotopes	1823'	595'	-
5th Field Trip, July 29-30, 2008 – Towne									
MMU-80	B(5-13)24dcb submersible	33°45'21.721" 113°33'54.505"	570672	71484	Pinol Well	Inorganic, Radiochem, Radon, Isotopes	305'	121'	245 - 305'
MMU-81	B(5-13)24ccc submersible	33°45'15.755" 113°34'09.247"	501523	18544	Porter Well	Inorganic Radon, Isotopes	200'	95'	100 – 200'
MMU 82	B(5-13)17dcc submersible	33°46'08.913" 113°38'05.195"	500727	71501	Jonson Well	Inorganic, Radiochem, Radon, Isotopes	500'	350'	400 – 500'
MMU-83/84 duplicate	B(5-13)15bcd submersible	33°46'38.120" 113°36'22.639"	545845	71500	Jones Well	Inorganic, Radiochem, Radon, Isotopes	810'	380'	400 – 810'
MMU-85/86 split	B(5-13)10cda submersible	33°47'10.947" 113°36'13.887"		71502	Store Well	Inorganic, Radiochem, Radon, Isotopes			480 – 600'
MMU-87	B(5-13)10ccc turbine	33°47'04.341" 113°36'29.932"	602979	18472	Well #1	Inorganic, Isotopes	906'	506'	-
MMU-88/89 duplicate	B(5-13)11acb turbine	33°47'37.896" 113°34'59.753"	628632	18480	Well #55	Inorganic, Radiochem Isotopes	700'	320'	-
MMU-90	B(5-13)01cba turbine	33°48'17.379" 113°34'17.583"		18437	Well #48	Inorganic, Isotopes			-
MMU-91	B(5-13)09cdd turbine	33°47'05.077" 113°37'21.826"	611556	18466	Well #45	Inorganic, Radon Isotopes	954'	400'	-
MMU-92	B(6-12)30dac turbine	33°49'50.655" 113°32'36.900"	611555	18778	Well #47	Inorganic, Radon Isotopes	1167'	450'	-
MMU-93	B(6-13)25bbb turbine	33°50'27.202" 113°34'28.208"	617127	18796	Well #8	Inorganic, Isotopes	960'	-	-
MMU-94	B(6-13)25cbb turbine	33°49'49.445" 113°34'27.483"	626172	18798	Well #10	Inorganic, Radon Isotopes	1350'	-	-
MMU-95	B(6-12)31cbb turbine	33°49'09.603" 113°33'25.892"	627990	18783	Well #13	Inorganic, Isotopes	685'	360'	-
MMU-96	B(5-13)10ccc turbine	33°46'58.746" 113°36'17.617"	-	75581	Well #3	Inorganic, Isotopes	906'	-	-
MMU-97	B(5-13)10cda turbine	33°47'09.546" 113°36'10.907"	602978	18476	Well #2	Inorganic, Isotopes	907'	360'	-
MMU-98	B(6-12)23acd turbine	33°50'56.801" 113°28'31.677"	614496	71520	Well #?	Inorganic, Isotopes	850'	360'	-
MMU-99	B(7-9)23baa submersible	33°56'29.286" 113°10'01.484"	592364	71521	Well #2	Inorganic, Radon Isotopes	900'	495'	700 - 900'
MMU-100	B(7-8)33bcc turbine	33°54'24.258" 113°06'21.722"	614522	19040	North Well	Inorganic, Radon Isotopes	1288'	615'	-
MMU-101	B(7-8)29add turbine	33°55'17.965" 113°06'23.687"	609496	19031	East Well	Inorganic, Radon Isotopes	1835'	-	-

Appendix A. Data for Sample Sites, McMullen Valley Basin, 2008-2009---Continued

Site #	Cadastral / Pump Type	Latitude - Longitude	ADWR #	ADEQ #	Site Name	Samples Collected	Well Depth	Water Depth	Perforation Interval
MMU-102	B(7-10)14aaa turbine	33°57'22.9" 113°15'50.4"	604151	19089	Well #29	Inorganic, Radiochem Radon, Isotopes	1208'	404'	-
MMU-103	B(7-10)13bda turbine	33°55'10.1" 113°15'18.4"	614532	19087	Well #30	Inorganic, Isotopes	1200'	426'	-
6th Field Trip, August 19-20, 2008 – Towne (Equipment Blank - MMU-115b) last in NAD 27									
MMU-104	B(5-13)15bd submersible	33°46'32.36" 113°36'18.23"	803706	18499	Stein Well	Inorganic, Radiochem Radon, Isotopes	705'	-	-
MMU-105	B(5-13)36ssv submersible	33°44'12.67" 113°33'48.18"	569896	71580	Coon Well	Inorganic, Isotopes	209'	123'	159 - 209'
MMU-106	B(5-13)22bca submersible	33°45'42.88" 113°36'23.26"	586335	71600	Carlson Well	Inorganic, Isotopes	400'	335'	300 - 400'
MMU-107/108 split	B(5-13)16abb turbine	33°46'55.77" 113°36'57.44"	605038	18511	Salome Water Well	Inorganic, Radon Isotopes	701'	405'	-
MMU-109	B(7-10)33ddd submersible	33°54'05.62" 113°17'54.44"	546173	51664	Gladden Water Well	Inorganic, Radiochem, Radon, Isotopes	648'	518'	543 - 648'
MMU-110	B(7-9)22b submersible	33°56'16.42" 113°11'32.31"	628258	51205	Fairhaven Well	Inorganic, Isotopes	-	-	-
MMU-111	B(6-12)19d submersible	33°50'56.00" 113°32'43.18"	617640	71601	Stephan Well	Inorganic, Isotopes	970'	170'	-
MMU-112	B(5-13)11bca submersible	33°47'36.50" 113°35'25.17"	553753	18482	Graham Well	Inorganic, Radiochem Radon, Isotopes	560'	397'	400 - 560'
MMU-113	B(7-11)8dad submersible	33°57'41.19" 113°25'16.91"	634112	19100	Happy Camp Well	Inorganic, Radiochem Radon, Isotopes	450'	280'	-
MMU 114/115a duplicate	B(7-11)27abc submersible	33°55'32.98" 113°23'30.75"	801549	19102	New Well	Inorganic, Radiochem Radon, Isotopes	340'	223'	-
MMU-116	B(7-9)21abd submersible	33°56'26.57" 113°11'55.59"	571079	71620	Hopkins Well	Inorganic, Radiochem Radon, Isotopes	920'	700'	820 - 920'
7th Field Trip, September 18, 2008 – Towne & Mitchell (Equipment Blank - MMU-121) First in NAD 83									
MMU-117/118a duplicate	B(6-12)31ada bailer	33°49'17.617" 113°32'33.799"	533515	71760	MW-1	Inorganic, Radiochem Isotopes, Pesticides	29'	16'	15 - 30'
MMU-118b	B(6-12)31c submersible	33°48'46.187" 113°33'25.167"	627992	57303	Office Well	Inorganic, Isotopes	700'	360'	-
MMU-119/120 split	B(6-12)22daa bailer	33°50'51.054" 113°29'20.090"	538770	71761	MW-1	Inorganic, Radiochem Isotopes, Pesticides	85'	41'	60 - 85'
8th Field Trip, October 29-30, 2008 – Towne (Equipment Blank - MMU-126)									
MMU-121	B(6-12)24dac submersible	33°50'44.517" 113°27'28.938"	805509	18772	Marble Well	Inorganic, Radiochem Radon, Isotopes	840'	435'	602 - 840'
MMU-122	B(6-13)24ccb submersible	33°50'37.455" 113°34'28.484"	572945	72320	Truman Well	Inorganic, Radon O & H Isotopes	608'	550'	577 - 597'
MMU-123/124 duplicate	B(6-13)24cda submersible	33°50'39.406" 113°34'07.272"	205279	72321	Thorp Well	Inorganic, Radon O & H Isotopes	150'	-	140 - 160'
MMU-125	B(6-13)28ab submersible	33°49'55.010" 113°36'55.576"	634103	18802	Buck Well	Inorganic, Radiochem Radon, Isotopes	600'	577'	-
MMU-127/128 duplicate	B(8-10)27dd submersible	34°00'03.495" 113°16'50.312"	801559	72360	Massey Well	Inorganic, Radiochem Radon, Isotopes			-
MMU-129	B(8-10)15cbb submersible	34°02'00.502" 113°17'54.969"	592683	72340	Dead Horse Well	Inorganic, Radiochem Radon, Isotopes	800'	420'	487 - 607'
MMU-130	B(8-11)36bbb submersible	33°59'59.358" 113°21'57.726"	586546	72341	Pumpjack Well	Inorganic, Radon O & H Isotopes	900'	810'	-
MMU-131	B(8-9)28bdc submersible	34°00'37.210" 113°12'18.025"	906341	72342	Langley Well	Inorganic O & H Isotopes	708'	544'	633 - 693'
MMU-132	B(7-8)1daa submersible	33°58'40.775" 113°02'17.795"	624774	19015	Forepaugh Well	Inorganic, Radiochem Radon, Isotopes	740'	418'	-

Appendix A. Data for Sample Sites, McMullen Valley Basin, 2008-2009---Continued

Site #	Cadastral / Pump Type	Latitude - Longitude	ADWR #	ADEQ #	Site Name	Samples Collected	Well Depth	Water Depth	Perforation Interval
9th Field Trip, November 6, 2008 – Towne & Jones									
MMU-133	B(8-9)18ddd submersible	34°01'49.772" 113°13'45.108"	208779	72343	Carco Well	Inorganic, Radon Isotopes	800'	460'	660-800'
MMU-134/135a duplicate	B(7-8)11caa submersible	33°57'41.763" 113°04'00.525"	539493	72346	Schweikart Well	Inorganic, Radon Isotopes	725'	545'	565 - 720'
10th Field Trip, December 18, 2008 – Towne (Equipment Blank - MMU-142)									
MMU-135b/136 duplicate	B(6-9)2aaa turbine	33°53'48.033" 113°09'48.396"	619231	18726	Eagle Eye Rnch Well	Inorganic, Radiochem, Radon, Isotopes	1000'	494'	-
MMU-137/38 split	B(5-13)10cac submersible	33°47'14.991" 113°36'13.912"	552632	72720	AZ Sunset RV Well	Isotopes Inorganic, Radon	500'	410'	400 - 500'
MMU-139	B(5-13)19bdb submersible	33°45'58.278" 113°39'20.101"	591355	72721	Christensn Well	Inorganic, Radon Isotopes	515'	350'	456 - 496'
MMU-140	B(5-13)20baa submersible	33°45'47.950" 113°38'43.445"	509107	72723	W. Salome Well	Inorganic, Radon Isotopes	500'	375'	400 - 500'
MMU-141	B(5-13)19dba submersible	33°45'36.041" 113°39'04.427"	202653	72722	Westergren Well	Inorganic, Radon Isotopes	550'	370'	485 - 550'
11th Field Trip, January 27-28, 2009 – Towne (Equipment Blank - MMU-143)									
MMU-144	B(5-13)17dad submersible	33°46'23.723" 113°37'42.074"	526673	18518	Monty Townsite	Inorganic, Radon O & H Isotopes	502'	365'	360 - 480'
MMU-145/146 duplicate	B(5-13)15ddc submersible	33°46'09.019" 113°35'44.886"	214228	72960	Magini Well	Inorganic, Radiochem Radon, Isotopes	240'	204'	200 - 240'
MMU-147	B(5-13)23bda bailer	33°45'52.932" 113°35'14.262"	205428	72961	Slawson Well	Inorganic, Radon O & H Isotopes	283'	151'	223 - 283'
MMU-148	B(5-13)24ccc submersible	33°45'21.972" 113°34'27.129"	213793	72962	Click Well	Inorganic, Radon O & H Isotopes	262'	130'	200 - 262'
MMU-149	B(5-13)19dad submersible	33°45'41.281" 113°38'49.887"		72980	Kutner Well	Inorganic O & H Isotopes	-	-	-
MMU-151/152 duplicate	B(5-13)2dad submersible	33°48'09.407" 113°34'33.629"	584380	72981	Southerlnd Well	Inorganic, Radiochem Radon, Isotopes	92'	-	57 - 92'
MMU-155	B(7-7)17caa submersible	33°56'59.378" 113°00'38.862"	087295	72982	Wood Well	Inorganic, Radiochem Radon, Isotopes	600'	500'	500 - 600'
MMU-156	B(7-7)17dcc submersible	33°56'36.541" 113°00'33.244"	647309	19012	Forepaugh Well	Inorganic, Radon O & H Isotopes	650'	540'	-
MMU-157	B(7-7)20aab submersible	33°56'16.423" 113°00'09.431"	582053	72984	Sigler Well	Inorganic Isotopes	760'	490'	660 - 760'
MMU-158	B(6-12)31bad submersible	33°49'27.147" 113°32'24.779"	631257	72985	Wenden Well #2	Inorganic O & H Isotopes	1400'	430'	1380 - 1480'
MMU-159	B(6-12)22add submersible	34°50'54.577" 113°29'21.541"	614495	18763	Alfalfa Well	Inorganic, Radon O & H Isotopes	943'	402'	-
12th Field Trip, February 26-27 , 2009 – Towne									
MMU-160/161 duplicate	B(6-6)6bab submersible	33°53'52.307" 112°55'41.355"	614490	18717	Effus Rnch Well	Inorganic, Radiochem, Isotopes	-	-	-
MMU-162	B(7-9)24baa submersible	33°56'33.078" 113°09'02.166"	604149	19079	Eagle Eye Village Wl	Inorganic, Isotopes	1562'	545'	-
13th Field Trip, March 25, 2009 – Towne									
MMU-163	B(7-7)17ddd submersible	33°56'35.791" 113°00'02.359"	900228	73240	Way Well	Inorganic Isotopes	714'	488'	614 - 714'
MMU-164	B(7-7)17add submersible	33°57'06.663" 113°00'06.879"	805136	19011	Echeverria Field Well	Inorganic, Radoiochem, Isotopes	817'	483'	600 – 817'

Appendix A. Data for Sample Sites, McMullen Valley Basin, 2008-2009---Continued

Site #	Cadastral / Pump Type	Latitude - Longitude	ADWR #	ADEQ #	Site Name	Samples Collected	Well Depth	Water Depth	Perforation Interval
				14th Field Trip, April 20-22, 2009 – Towne (Equipment Blank - BWM-110)					
MMU-165/166 duplicate	B(6-13)24cdd submersible	33°50'34.736" 113°34'05.667"	578541	73621	Patheal Well	Inorganic Isotopes	180'	87'	100 - 180'
MMU-168	B(6-13)24ccd submersible	33°50'34.269" 113°34'21.516"	575133	73622	P & C Well	Inorganic Isotopes	485'	165'	185 - 205' 445 – 485'
MMU-170	B(6-12)27cdc submersible	33°49'38.065" 113°29'56.703"	552632	73623	Wood Well	Inorganic Isotopes	606'	450'	520 - 600'
				15th Field Trip, May 13, 2009 – Towne					
MMU-171	B(5-12)32acb submersible	33°44'04.024" 113°31'49.128"	602985	18427	Nord Rnch Dm Well	Inorganic, Radiochem Isotopes	502'	365'	-
MMU-172	B(5-12)32aca turbine	33°44'08.032" 113°31'46.229"	602986	18425	Nord Rnch Ir Well	Inorganic, Radiochem Isotopes	240'	204'	-
MMU-173	B(6-12)31aaa turbine	34°44'19.780" 113°32'30.447"	602983	18417	Nord Rnch Up Ir Well	Inorganic, Radiochem Isotopes	943'	402'	-
				16th Field Trip, June 3-4 , 2009 – Towne					
MMU-176	B(7-9)12acb submersible	33°58'05.262" 113°09'00.931"	605009	19057	Well #3	Inorganic Isotopes	1280'	535'	-

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	MCL Exceedances	Temp (ºC)	pH-field (su)	pH-lab (su)	SC-field (µS/cm)	SC-lab (µS/cm)	TDS (mg/L)	Hard (mg/L)	Hard - cal (mg/L)	Turb (ntu)
MMU-1	TDS, Cl, NO_3 Gross α, U, Radon	27.7	7.34	*7.9*	1963	2000	**1200**	390	420	*0.14*
MMU-2/153/154	TDS, NO_3, Gross α, U, Radon	23.2/22.9	6.98/6.89	7.75	1859/1782	1700	**1150**	505	500	0.08
MMU 3	TDS, NO_3, Radon	28.2	7.41	*8.0*	1101	1100	**650**	380	400	0.10
MMU-4	TDS, Radon	27.2	7.89	*8.2*	861	890	**580**	160	170	0.10
MMU-5	NO_3	26.1	7.72	-	1300	-	-	-	-	-
MMU-6	Radon	26.8	7.90	*8.2*	500	480	310	69	77	0.01
MMU-7/8	pH	29.6	**9.24**	***9.16***	638	630	365	ND	ND	1.65
MMU-9	-	28.2	8.39	-	678	-	-	-	-	-
MMU-10	Radon	29.5	8.39	*8.4*	669	670	410	18	16	0.97
MMU-11	Radon	26.3	8.13	*8.3*	797	790	460	55	63	0.12
MMU-12	Radon	26.1	7.66	*8.2*	756	740	440	180	190	0.11
MMU-14	TDS, F, Radon	26.0	7.33	*8.0*	1367	1400	**820**	330	350	0.53
MMU-15/16	As	23.4	7.93	*8.175*	553	555	330	78	85	0.53
MMU-17	-	25.0	7.64	-	641	-	-	-	-	-
MMU-18	-	27.1	7.80	*8.2*	538	530	320	130	140	0.10
MMU-19	TDS, Cl, NO_3, Radon	24.1	7.18	*8.0*	1677	1700	**1000**	400	420	0.12
MMU-21	F, Radon	25.6	7.70	*8.1*	577	570	340	150	160	0.04
MMU-22/23	-	24.4	7.62	-	475	-	-	-	-	-
MMU-24	F, Radon	24.6	7.66	*8.2*	752	750	460	130	130	0.09
MMU-25	Radon	25.6	7.76	*8.2*	606	600	350	150	160	0.02
MMU-26	-	27.6	7.88	-	604	-	-	-	-	-
MMU-27	Radon	26.8	7.89	*8.2*	712	700	440	100	100	0.04
MMU-28	pH, **F**	23.4	**8.65**	*8.5*	564	560	330	28	30	2.3
MMU-31	-	28.5	7.90	-	664	-	-	-	-	-
MMU-32/33	pH, **F**, Radon	30.8	**8.70**	**8.66**	620	625	365	12	12	0.07
MMU-34	pH	32.3	**8.79**	-	858	-	-	-	-	-
MMU-35	TDS, F, Radon	26.0	7.58	*8.1*	961	970	**610**	220	210	0.33
MMU-36	F, Radon	25.4	7.85	*8.3*	619	630	390	80	75	ND

italics = constituent exceeded holding time

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	MCL Exceedances	Temp (ºC)	pH-field (su)	pH-lab (su)	SC-field (µS/cm)	SC-lab (µS/cm)	TDS (mg/L)	Hard (mg/L)	Hard - cal (mg/L)	Turb (ntu)
MMU-37/150	TDS, F, NO_3, Radon	25.4/25.0	7.61/7.7	*8.1*	1054/962	950	**550**	160	160	0.02
MMU 38	-	25.4	7.68	-	588	-	-	-	-	-
MMU-39	-	25.4	7.29	-	1820	-	-	-	-	-
MMU-40	F, Radon	26.1	7.78	*8.3*	583	580	360	89	84	0.03
MMU-41	F, Gross α, Radon	26.5	7.43	*8.1*	774	780	490	180	150	0.57
MMU-42	TDS, Cl, SO_4 NO_3, F, Radon	26.0	7.13	*8.0*	2485	2500	**1600**	510	560	0.15
MMU-43	TDS, NO_3, F	25.2	7.16	*8.0*	1441	1500	**930**	280	300	0.88
MMU-44	TDS, Cl, NO_3	28.1	7.46	*8.0*	2172	2200	**1600**	710	830	0.11
MMU-45	Radon	29.5	7.61	*8.2*	587	600	360	140	150	ND
MMU-46	-	29.2	7.62	-	626	-	-	-	-	-
MMU-47/167	-	29.55	7.55	*8.1*	659	650	380	150	150	0.01
MMU-48	-	30.3	7.72	*8.2*	620	620	380	130	130	0.01
MMU-49/50	pH, As, F	35.2	**8.91**	*8.8*	573	565	345	ND	ND	0.025
MMU-51	pH	35.4	**8.70**	-	575	-	-	-	-	-
MMU-52	pH, As, F, Radon	36.6	**8.95**	*8.9*	628	610	380	20	17	0.03
MMU-53/174	-	30.6 / 30.1	7.98 / 8.07	8.2	643 / 791	740	450	62	67	0.22
MMU-54	-	28.3	7.68	*8.1*	782	780	480	120	120	0.07
MMU-55/169	As, **F**	32.95	8.48	8.5	717	710	440	24	26	0.01
MMU-57	-	31.2	7.98	-	717	-	-	-	-	-
MMU-58/59	TDS, Cl, NO_3	30.4	7.65	*8.1*	1870	1900	**1100**	180	170	0.04
MMU-60/61/175	F	30.9/ 31.31	8.18 / 8.23	8.2	663 / 726	680	410	45	48	0.73
MMU-62	F	28.1	8.09	*8.3*	571	580	340	45	46	0.04
MMU-63	TDS, F, Radon	26.5	7.20	*8.0*	1291	1300	**810**	260	260	0.11
MMU-64/65	**F**, Radon	32.0	8.42	*8.46*	494	475	275	35	42	0.42
MMU-66	F	32.6	8.17	*8.3*	391	370	220	54	58	0.04
MMU-67	F	31.1	7.96	*8.3*	466	440	290	82	88	0.06
MMU-68	F, Radon	29.8	7.90	*8.2*	438	420	260	88	92	0.02
MMU-69/70	F	31.8	7.84	*8.2*	470	450	280	79	87.5	0.03

italics = constituent exceeded holding time

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	MCL Exceedances	Temp (ºC)	pH-field (su)	pH-lab (su)	SC-field (µS/cm)	SC-lab (µS/cm)	TDS (mg/L)	Hard (mg/L)	Hard - cal (mg/L)	Turb (ntu)
MMU-71	As, **F**, Radon	31.8	8.46	*8.4*	512	470	280	23	31	0.15
MMU-72/73	F, Radon	31.6	8.21	*8.3*	419	370	215	52.5	54.5	0.065
MMU-74	**F**, Radon	29.9	8.39	*8.4*	544	490	300	29	32	0.65
MMU-76	F, Radon	30.3	8.04	*8.2*	579	510	310	87	95	0.06
MMU-77	F	31.4	7.97	*8.2*	534	470	240	82	86	0.95
MMU-78	**F**, Radon	36.8	8.02	*8.2*	612	540	320	65	68	0.04
MMU-79	**F**, Radon	35.9	8.01	*8.2*	653	580	350	69	74	0.16
MMU-80	F, Radon	27.0	7.51	*8.1*	715	680	430	130	140	0.02
MMU-81	F, Radon	25.9	7.85	*8.2*	650	610	390	71	71	0.06
MMU 82	TDS, Radon	29.4	7.85	*8.2*	820	780	**500**	120	120	0.10
MMU-83/84	Radon	32.1	8.17	*8.3*	785	740	455	32	35	0.165
MMU-85/86	TDS, Cl, NO_3 Radon	31.3	7.30	*7.735*	2001	2025	**1450**	630	630	0.06
MMU-87	-	32.5	7.78	*8.2*	737	700	430	110	110	0.15
MMU-88/89	TDS, NO_3 Gross α, U	29.3/ 26.6	7.53 / 7.90	*8.1*	1627 / 1682	1600	**1000**	260	260	0.125
MMU-90	TDS, NO_3, Mn	37.5	7.73	*8.1*	1266	1200	**720**	130	130	7.8
MMU-91	Radon	30.6	8.34	*8.4*	736	690	440	49	52	0.06
MMU-92	**F**, pH, Radon	36.7	**8.63**	*8.6*	613	560	350	12	12	0.06
MMU-93	-	33.9	7.91	8.2	676	620	370	88	90	0.02
MMU-94	Radon	35.5	8.04	*8.3*	623	540	400	41	42	0.33
MMU-95	**F**	34.4	8.44	*8.5*	621	560	480	18	17	0.26
MMU-96	TDS	33.2	7.94	8.2	932	880	**530**	94	98	0.06
MMU-97	TDS, NO_3	32.6	7.64	*8.1*	1264	1200	**780**	250	220	0.21
MMU-98	**F**, As, pH	36.2	**8.94**	***8.9***	572	510	320	ND	ND	0.11
MMU-99	Radon	28.6	8.15	*8.3*	464	420	260	69	79	0.02
MMU-100	pH, Radon	31.2	**9.33**	*9.2*	600	550	330	ND	ND	0.49
MMU-101	pH, As, F, Radon	32.3	**9.37**	*9.2*	483	430	270	18	13	0.05
MMU-102	F, Radon	30.7	8.12	*8.3*	409	360	220	54	62	0.06
MMU-103	F	30.4	8.11	*8.3*	408	360	230	63	67	0.01

italics = constituent exceeded holding time

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	MCL Exceedances	Temp (ºC)	pH-field (su)	pH-lab (su)	SC-field (µS/cm)	SC-lab (µS/cm)	TDS (mg/L)	Hard (mg/L)	Hard - cal (mg/L)	Turb (ntu)
MMU-104	F, Radon	32.8	8.06	*8.2*	718	690	430	42	35	0.17
MMU-105	-	27.7	7.68	8.1	628	610	370	140	130	0.26
MMU-106	-	27.9	7.62	*8.1*	664	640	390	140	130	0.06
MMU-107/108	-	32.6	8.22	*8.265*	656	635	365	43	41.5	0.06
MMU-109	-	30.9	7.61	*8.1*	578	550	330	170	160	0.34
MMU-110	-	31.9	8.11	*8.2*	513	470	270	110	100	0.11
MMU-111	pH, F	31.8	**8.66**	**8.6**	635	590	390	14	11	0.22
MMU-112	TDS, Cl, NO_3, F, Radon	31.7	8.13	*8.1*	1555	1500	**920**	73	63	0.08
MMU-113	As, F	29.2	8.19	*8.3*	539	500	310	53	47	0.03
MMU-114/115	pH	26.2	**8.90**	**8.7**	657	610	370	11.5	10	2.3
MMU-116	Radon	30.0	8.04	*8.2*	514	460	270	110	110	0.05
MMU-117/118a	TDS, Cl, SO_4, NO_3, As, **F**, Mn	25.2	8.08	*8.4*	2743	2700	**1800**	88	79.5	31
MMU-118b	pH, TDS, Cl, SO_4, NO_3, As, **F**	23.5	**8.66**	**8.7**	2755	2700	**1800**	22	22	0.07
MMU-119/120	TDS, NO_3, **F** Gross α	26.4	8.03	*8.22*	2481	2400	**1600**	100	94	32
MMU-121	pH, TDS, As, **F**, Radon	30.6	**8.98**	*8.9*	906	870	**510**	ND	ND	14
MMU-122	Radon	31.4	7.84	*8.2*	583	560	320	84	100	0.42
MMU-123/124	TDS, Cl, SO_4, NO_3, As, Se Radon	25.3	7.87	*8.1*	5383	5200	**3450**	280	285	1.05
MMU-125	-	28.6	7.66	8.0	736	710	410	160	180	0.66
MMU-127/128	pH, As, **F**, Radon	30.7	**9.68**	*9.45*	450	420	260	ND	ND	1.05
MMU-129	Radon	26.3	7.32	*8.0*	598	590	340	180	200	0.21
MMU-130	Radon	29.6	7.41	8.0	729	710	420	220	230	1.1
MMU-131	F	24.8	8.26	*8.3*	764	760	430	43	46	2.2
MMU-132	**F**, As, Radon	32.3	8.32	*8.4*	367	340	220	32	34	0.31
MMU-133	Radon	28.5	7.96	*8.2*	692	700	390	69	71	0.77
MMU-134/135a	**F**, Radon	35.5	7.89	*8.2*	428	410	245	55.5	56.5	ND
MMU-135b/136	NO_3, As, F Gross α, Radon	27.7	7.78	*7.9*	615	595	370	180	170	0.045
MMU-137/138	TDS, Cl, SO_4, NO_3, As, Radon	27.5	7.23	*6.81*	4086	3950	**2900**	1600	1600	0.36
MMU-139	Radon	25.5	7.81	*8.2*	741	760	450	71	74	0.04

italics = constituent exceeded holding time

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	MCL Exceedances	Temp (ºC)	pH-field (su)	pH-lab (su)	SC-field (µS/cm)	SC-lab (µS/cm)	TDS (mg/L)	Hard (mg/L)	Hard - cal (mg/L)	Turb (ntu)
MMU-140	Radon	24.8	7.76	*8.2*	730	720	430	98	100	0.02
MMU-141	Radon	25.4	7.79	8.2	594	580	350	84	82	0.06
MMU-144	Radon	26.5	8.24	*8.3*	775	750	430	30	30	0.39
MMU-145/146	TDS, NO_3, Gross α, Radon	23.2	7.78	*8.1*	1492	1500	**865**	180	180	2.45
MMU-147	F, Radon	24.3	8.06	*8.3*	613	590	350	42	42	0.30
MMU-148	F	24.4	8.11	*8.2*	680	650	400	41	43	16
MMU-149	NO_3	-	7.87	8.2	719	700	440	99	97	0.09
MMU-151/152	TDS, SO_4, NO_3, **F**,	21.4	8.20	*8.65*	2050	2100	**1300**	120	120	11.5
MMU-155	**F**, As, Radon	25.0	8.29	*8.4*	449	430	250	50	52	0.06
MMU-156	**F**, As, Radon	23.4	8.18	8.3	509	490	280	75	75	0.24
MMU-157	pH, **F**, As	-	**9.13**	*9.0*	519	500	290	ND	ND	0.06
MMU-158	pH, F, As, Radon	25.3	**9.00**	*8.8*	664	640	380	ND	ND	1.0
MMU-159	pH, **F**, As, Radon	32.5	**8.77**	8.7	567	530	320	ND	ND	0.07
MMU-160/161	NO_3, Gross α	22.7	7.37	*7.85*	733	710	440	280	295	1.01
MMU-162	F	28.7	8.46	*8.3*	464	430	260	44	54	0.03
MMU-163	As, **F**	31.5	8.76	*8.6*	497	450	270	ND	ND	3.9
MMU-164	**F**	32.3	8.19	*8.3*	483	440	270	47	51	2.2
MMU-165-66	TDS, Cl, SO_4, NO_3, As, F, Se	26.6	7.76	8.15	6448	6250	**4400**	550	610	0.015
MMU-168	TDS, Cl, SO_4, NO_3, F	27.2	8.09	*8.4*	3229	3100	**2100**	140	130	0.93
MMU-170	TDS, As, **F**	31.3	8.37	*8.5*	1272	1200	**760**	37	24	0.93
MMU-171	F	25.8	7.35	7.9	674	640	400	170	180	0.16
MMU-172	F, Gross α, U	26.1	7.51	*7.9*	758	710	450	130	150	0.01
MMU-173	F	26.9	7.35	*7.9*	821	780	490	140	150	0.02
MMU-176	F	30.4	8.05	*8.2*	513	470	290	83	86	0.04

italics = constituent exceeded holding time

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	**Calcium** (mg/L)	**Magnesium** (mg/L)	**Sodium** (mg/L)	**Potassium** (mg/L)	**T. Alk** (mg/L)	**Bicarbonate** (mg/L)	**Carbonate** (mg/L)	**Chloride** (mg/L)	**Sulfate** (mg/L)
MMU-1	140	17	260	7.0	140	170	ND	**360**	200
MMU-2/153/154	150	30.5	175	5.6	280	330	ND	190	230
MMU 3	100	37	71	4.1	150	180	ND	ND	88
MMU-4	43	15	130	4.4	170	210	ND	7.9	72
MMU-5	-	-	-	-	-	-	-	-	-
MMU-6	19	7.3	91	3.3	180	220	ND	10	46
MMU-7/8	2.65	ND	135	2.8	150	140	21	65.5	55
MMU-9	-	-	-	-	-	-	-	-	-
MMU-10	6.4	ND	140	2.8	140	170	3.0	70	73
MMU-11	16	5.8	150	3.9	130	160	ND	110	68
MMU-12	44	19	88	4.8	160	200	ND	92	70
MMU-14	80	37	160	5.1	210	250	ND	200	200
MMU-15/16	21.5	6.55	91	2.65	140	170	ND	42	62.5
MMU-17	-	-	-	-	-	-	-	-	-
MMU-18	37	11	63	4.1	160	200	ND	36	44
MMU-19	110	34	200	4.8	220	270	ND	**270**	160
MMU-21	38	16	68	2.0	220	270	ND	28	30
MMU-22/23	-	-	-	-	-	-	-	-	-
MMU-24	35	11	120	2.8	210	260	ND	8.2	62
MMU-25	34	18	71	4.9	180	220	ND	49	47
MMU-26	-	-	-	-	-	-	-	-	-
MMU-27	26	9.7	120	5.1	160	200	ND	36	120
MMU-28	6.9	3.1	120	1.5	130	150	4.9	48	56
MMU-31	-	-	-	-	-	-	-	-	-
MMU-32/33	4.35	0.70	130	1.7	120	130	6.5	59	78.5
MMU-34	-	-	-	-	-	-	-	-	-
MMU-35	62	14	120	2.9	150	190	ND	120	110
MMU-36	20	6.2	100	2.3	190	230	ND	8.6	49

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	T. Alk (mg/L)	Bicarbonate (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Sulfate (mg/L)
MMU-37/150	42	13	120	3.6	150	180	ND	120	89
MMU 38	-	-	-	-	-	-	-	-	-
MMU-39	-	-	-	-	-	-	-	-	-
MMU-40	22	7.0	95	2.3	200	240	ND	31	38
MMU-41	39	13	110	3.4	240	290	ND	54	72
MMU-42	150	45	340	4.8	250	300	ND	**400**	**380**
MMU-43	73	29	210	2.9	310	380	ND	150	160
MMU-44	220	69	120	7.9	120	140	ND	**530**	110
MMU-45	43	11	59	4.1	160	200	ND	47	45
MMU-46	-	-	-	-	-	-	-	-	-
MMU-47/167	42	12	74	3.4	160	190	ND	64	41
MMU-48	36	9.2	78	3.6	160	200	ND	50	48
MMU-49/50	3.45	ND	105	1.3	130	140	11.5	44	48
MMU-51	-	-	-	-	-	-	-	-	-
MMU-52	6.7	ND	120	1.3	120	120	14	53	79
MMU-53/174	22	2.8	130	4.8	130	160	ND	100	38
MMU-54	40	5.8	109	5.2	140	170	ND	110	40
MMU-55/169	7.1	2.1	140	1.6	140	160	6	46	90
MMU-57	-	-	-	-	-	-	-	-	-
MMU-58/59	59	5.2	271	5.2	120	150	ND	**330**	160
MMU-60/61/175	13	3.8	120	1.8	130	160	ND	77	51
MMU-62	12	3.9	105	1.6	140	170	ND	15	50
MMU-63	69	21	178	3.4	250	310	ND	150	140
MMU-64/65	10.5	3.65	93	2.45	130	150	ND	36.5	33
MMU-66	12	6.7	59	2.1	140	170	ND	16	18
MMU-67	17	11	60	2.3	130	150	ND	37	31
MMU-68	17	12	54	2.5	130	160	ND	28	29
MMU-69/70	19	9.7	63	2.65	150	180	ND	27.5	27

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	T. Alk (mg/L)	Bicarbonate (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Sulfate (mg/L)
MMU-71	7.1	3.2	91	1.4	130	150	2.2	19	39
MMU-72/73	13	5.6	60	1.95	130	160	ND	18	21
MMU-74	9	2.4	89	1.5	110	130	ND	47	29
MMU-76	20	11	67	2.6	120	150	ND	55	24
MMU-77	19	9.4	66	2.5	130	160	ND	39	22
MMU-78	16	6.9	88	2.1	130	160	ND	48	46
MMU-79	17	7.6	92	2.3	130	160	ND	59	43
MMU-80	36	12	94	2.2	210	250	ND	51	47
MMU-81	19	5.7	110	2.4	210	250	ND	38	35
MMU 82	33	9.5	120	5.1	140	170	ND	47	160
MMU-83/84	14	ND	140	2.95	140	165	ND	97.5	45
MMU-85/86	175	47.5	125	8.4	99.5	120	ND	**445**	80.5
MMU-87	37	5.2	98	4.4	150	180	ND	89	35
MMU-88/89	81	15	230	4.1	180	220	ND	220	160
MMU-90	40	8.0	200	2.8	130	150	ND	180	88
MMU-91	16	2.9	130	3.4	140	170	ND	74	58
MMU-92	4.9	ND	120	1.5	140	150	7.0	37	49
MMU-93	24	7.4	94	2.7	150	190	ND	60	41
MMU-94	12	2.9	100	2.1	150	190	ND	47	34
MMU-95	6.9	ND	100	1.7	130	150	4.0	46	50
MMU-96	35	2.6	120	4.4	130	160	ND	140	46
MMU-97	71	11	120	5.4	120	150	ND	230	49
MMU-98	2.3	ND	100	0.72	130	130	10	37	42
MMU-99	14	7.9	54	2.0	120	150	ND	32	31
MMU-100	1.9	ND	98	ND	94	81	16	62	43
MMU-101	2.6	1.6	78	0.77	120	100	20	33	34
MMU-102	11	6.5	48	1.9	140	170	ND	13	17
MMU-103	12	6.9	47	2.0	140	170	ND	15	17

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	T. Alk (mg/L)	Bicarbonate (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Sulfate (mg/L)
MMU-104	14	ND	110	2.9	130	160	ND	88	50
MMU-105	29	15	67	3.6	180	220	ND	47	44
MMU-106	37	9.2	66	4.7	160	200	ND	65	38
MMU-107/108	14	1.6	103	4.25	150	180	ND	67.5	40.5
MMU-109	42	13	41	1.3	180	220	ND	45	18
MMU-110	18	14	50	2.5	140	170	ND	40	31
MMU-111	4.3	ND	100	1.9	170	190	7.6	28	61
MMU-112	23	1.3	280	1.9	67	81	ND	**290**	80
MMU-113	10	5.4	73	1.1	150	180	ND	34	37
MMU-114/115	3.8	ND	105	0.755	120	130	6.9	64	47.5
MMU-116	18	15	48	2.7	140	170	ND	37	31
MMU-117/118a	12	12.5	625	0.71	585	70	6.65	**265**	**345**
MMU-118b	4.3	2.8	670	ND	390	420	28	**270**	**410**
MMU-119/120	18	12.5	500	2.4	245	300	ND	245	140
MMU-121	2.2	ND	190	1.0	200	200	57	57	84
MMU-122	26	9.3	75	2.6	160	190	ND	45	40
MMU-123/124	54	36.5	985	1.65	150	180	ND	**850**	**810**
MMU-125	51	14	64	3.9	160	200	ND	96	37
MMU-127/128	1.3	ND	84.5	0.50	100	65	29	26	35
MMU-129	49	19	45	1.9	240	300	ND	26	24
MMU-130	60	19	52	4.4	190	230	ND	85	34
MMU-131	11	4.4	120	3.0	88	110	ND	110	74
MMU-132	8.2	3.2	60	1.7	120	140	ND	15	18
MMU-133	20	5.1	100	2.0	140	170	ND	79	45
MMU-134/135a	13.5	5.6	63	2.3	140	170	ND	15	25
MMU-135b/136	50	12	50.5	2.15	170	210	ND	24	41.5
MMU-137/138	445	120	260	13	73.5	85	ND	**710**	**725**
MMU-139	20	5.8	130	2.8	210	260	ND	17	100

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	T. Alk (mg/L)	Bicarbonate (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Sulfate (mg/L)
MMU-140	27	7.9	120	3.2	200	240	ND	35	77
MMU-141	18	9.1	92	3.8	210	260	ND	9.4	44
MMU-144	9.4	1.7	140	3.4	140	170	ND	98	37
MMU-145/146	52	11	220	4.5	170	210	ND	220	140
MMU-147	13	2.3	110	2.4	150	180	ND	46	46
MMU-148	12	3.1	120	2.2	170	210	ND	49	53
MMU-149	26	7.7	110	3.1	200	250	ND	34	78
MMU-151/152	14	20.5	400	0.985	365	385	28.5	195	**250**
MMU-155	8.9	7.3	72	1.4	130	150	2.4	23	32
MMU-156	16	8.4	72	1.6	100	120	ND	31	49
MMU-157	1.5	ND	100	ND	110	100	12	29	48
MMU-158	2.6	ND	130	1.1	140	140	11	48	70
MMU-159	3.4	ND	110	1.1	120	130	7.0	27	63
MMU-160/161	88.5	18	33	1.9	215	260	ND	40	28
MMU-162	11	6.4	75	2.2	120	140	ND	31	34
MMU-163	4.7	ND	91	0.82	94	110	4.1	27	43
MMU-164	9.7	6.4	76	1.4	120	150	ND	27	36
MMU-165-66	110	81.5	1300	1.9	165	205	ND	**930**	**1350**
MMU-168	24	18	640	1.1	280	330	7	**330**	**680**
MMU-170	5.8	2.4	260	1.9	260	300	10	76	170
MMU-171	49	14	69	2.6	220	260	ND	25	46
MMU-172	39	12	100	2.8	220	270	ND	41	61
MMU-173	41	12	110	3.3	200	240	ND	59	75
MMU-176	19	9.3	65	2.3	130	160	ND	37	26

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	T. Nitrate-N (mg/L)	Nitrite-N (mg/L)	TKN (mg/L)	Ammonia (mg/L)	T. Phosphorus (mg/L)	SAR (value)	Irrigation Quality	Perchlorate (ug/L)
MMU-1	**54**	ND	ND	ND	ND	5.5	C3-S2	4.81
MMU-2/153/154	**50.3**	ND	ND	ND	ND	3.3	C3-S1	4.11
MMU 3	**17**	ND	ND	ND	ND	1.5	C3-S1	2.82
MMU-4	6.5	ND	0.084	ND	ND	4.3	C3-S1	1.52
MMU-5	**32**	-	-	-	-	-	-	3.17
MMU-6	2.5	ND	ND	ND	ND	4.5	C2-S1	0.669
MMU-7/8	0.605	ND	0.069	ND	ND	21.0	C2-S4	1.05
MMU-9	4.0	-	-	-	-	-	-	1.41
MMU-10	2.5	ND	0.083	ND	ND	15.2	C2-S3	1.58
MMU-11	5.0	ND	ND	ND	ND	8.2	C3-S2	2.77
MMU-12	4.6	ND	ND	ND	ND	2.8	C2-S1	2.36
MMU-14	3.5	ND	ND	ND	ND	3.7	C3-S1	1.82
MMU-15/16	2.8	ND	ND	ND	ND	4.3	C2-S1	1.06
MMU-17	5.2	-	-	-	-	-	-	1.16
MMU-18	3.2	ND	ND	ND	ND	2.3	C2-S1	1.75
MMU-19	**34**	ND	ND	ND	ND	4.3	C3-S1	3.09
MMU-21	2.6	ND	ND	ND	ND	2.3	C2-S1	0.872
MMU-22/23	1.6	-	-	-	-	-	-	0.336
MMU-24	4.3	ND	ND	ND	ND	4.5	C3-S1	1.15
MMU-25	2.2	ND	ND	ND	ND	2.5	C2-S1	1.66
MMU-26	4.1	-	-	-	-	-	-	1.36
MMU-27	2.3	ND	ND	ND	ND	5.1	C2-S1	0.905
MMU-28/29	2.8	ND	ND	ND	ND	9.5	C2-S2	1.055
MMU-31	2.2	-	-	-	-	-	-	-
MMU-32/33	2.86	ND	ND	ND	ND	16.7	C2-S3	1.08
MMU-34	2.5	-	-	-	-	-	-	-
MMU-35	3.2	ND	ND	ND	ND	3.6	C3-S1	-
MMU-36	4.6	ND	ND	ND	ND	5.0	C2-S1	-

italics = constituent exceeded holding time

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	Nitrate-N (mg/L)	Nitrite-N (mg/L)	TKN (mg/L)	Ammonia (mg/L)	Phosphorus (mg/L)	SAR (value)	Irrigation Quality	Aluminum (mg/L)	Strontium (mg/L)
MMU-37/150	**11.55**	ND	ND	ND	ND	4.1	C3-S1	-	-
MMU 38	2.9	-	-	-	-	-	-	-	-
MMU-39	4.6	-	-	-	-	-	-	-	-
MMU-40	3.6	ND	ND	ND	ND	4.5	C2-S1	-	-
MMU-41	2.8	ND	ND	ND	ND	3.9	C3-S1	-	-
MMU-42	**16**	ND	ND	ND	ND	6.3	C4-S2	-	-
MMU-43	**18**	ND	ND	ND	0.021	5.3	C3-S2	-	-
MMU-44	**20**	ND	ND	ND	0.022	1.8	C3-S1	-	-
MMU-45	3.4	ND	ND	ND	ND	2.1	C2-S1	-	-
MMU-46	3.2	-	-	-	-	-	-	-	-
MMU-47/167	4.05	ND	ND	ND	ND	2.6	C2-S1	ND	0.58
MMU-48	3.1	ND	ND	ND	ND	3.0	C2-S1	-	-
MMU-49/50	3.9	ND	ND	ND	ND	16.2	C2-S3	-	-
MMU-51	4.0	-	-	-	-	-	-	-	-
MMU-52	3.4	ND	ND	ND	ND	12.8	C2-S2	-	-
MMU-53/174	5.2/6.8	ND	ND	ND	ND	6.9	C2-S2	ND	1.5
MMU-54	8.7	ND	ND	ND	ND	4.3	C3-S1	-	-
MMU-55/169	5.3	ND	ND	ND	ND	11.9	C2-S2	ND	0.42
MMU-57	6.5	-	-	-	-	-	-	-	-
MMU-58/59	**28.5**	ND	ND	ND	ND	9.1	C3-S2	-	-
MMU-60/61/175	6.3	ND	ND	ND	ND	7.5	C2-S1	ND	0.42
MMU-62	3.0	0.026	ND	ND	ND	6.7	C2-S1	-	-
MMU-63	6.9	ND	ND	ND	0.021	4.8	C3-S1	-	-
MMU-64/65	2.69	-	ND	-	0.18/ND	5.9	C2-S1	-	-
MMU-66	2.0	ND	ND	ND	ND	3.4	C2-S1	-	-
MMU-67	2.7	ND	ND	ND	0.021	2.8	C2-S1	-	-
MMU-68	1.9	ND	0.16	ND	0.035	2.5	C2-S1	-	-
MMU-69/70	2.6	ND	ND	ND	0.023	2.9	C2-S1	-	-

italics = constituent exceeded holding time

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	T. Nitrate-N (mg/L)	Nitrite-N (mg/L)	TKN (mg/L)	Ammonia (mg/L)	T. Phosphorus (mg/L)	SAR (value)	Irrigation Quality	Perchlorate (ug/L)
MMU-71	2.6	ND	ND	ND	ND	7.1	C2-S1	-
MMU-72/73	1.85	ND	0.11	ND	0.215	3.5	C2-S1	-
MMU-74	6.0	ND	0.15	ND	ND	6.8	C2-S1	-
MMU-76	5.4	ND	0.10	ND	ND	3.0	C2-S1	-
MMU-77	5.3	ND	ND	ND	ND	3.1	C2-S1	-
MMU-78	2.8	ND	ND	ND	ND	4.6	C2-S1	-
MMU-79	3.3	ND	ND	ND	ND	4.7	C2-S1	-
MMU-80	4.0	ND	ND	ND	ND	3.5	C2-S1	-
MMU-81	3.4	ND	0.24	ND	ND	5.7	C2-S1	-
MMU 82	3.4	ND	0.21	ND	ND	4.7	C3-S1	-
MMU-83/84	6.05	ND	0.485	ND	ND	10.3	C3-S2	-
MMU-85/86	**32.15**	ND	0.87	ND	ND	2.1	C3-S1	-
MMU-87	6.4	ND	ND	ND	ND	4.0	C2-S1	-
MMU-88/89	**36.5**	ND	ND	ND	ND	6.2	C3-S2	-
MMU-90	**29**	0.78	0.30	0.18	ND	7.6	C3-S2	-
MMU-91	5.0	ND	0.55	ND	ND	7.9	C2-S2	-
MMU-92	5.0	ND	0.31	ND	ND	14.9	C2-S3	-
MMU-93	4.8	ND	0.41	ND	ND	4.3	C2-S1	-
MMU-94	3.9	ND	0.94	ND	ND	6.7	C2-S1	-
MMU-95	2.9	ND	0.29	ND	ND	10.5	C2-S2	-
MMU-96	7.0	ND	0.31	ND	ND	5.3	C3-S1	-
MMU-97	**15**	ND	0.29	ND	ND	3.5	C3-S1	-
MMU-98	2.5	ND	0.26	ND	ND	18.2	C2-S3	-
MMU-99	1.9	ND	0.17	ND	ND	2.9	C2-S1	-
MMU-100	3.5	ND	0.12	ND	ND	19.6	C2-S3	-
MMU-101	2.8	ND	ND	0.63	ND	9.4	C2-S2	-
MMU-102	1.7	ND	0.20	ND	ND	2.8	C2-S1	-
MMU-103	1.7	ND	0.15	ND	ND	2.7	C2-S1	-

italics = constituent exceeded holding time

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	T. Nitrate-N (mg/L)	Nitrite-N (mg/L)	TKN (mg/L)	Ammonia (mg/L)	T. Phosphorus (mg/L)	SAR (value)	Irrigation Quality	Perchlorate (ug/L)
MMU-104	3.8	ND	0.34	ND	0.063	8.1	C2-S2	-
MMU-105	2.0	ND	ND	ND	0.047	2.5	C2-S1	-
MMU-106	4.1	ND	0.32	ND	0.064	2.5	C2-S1	-
MMU-107/108	4.8	ND	0.23	ND	0.075	6.7	C2-S1	-
MMU-109	3.0	ND	0.37	ND	0.070	1.4	C2-S1	-
MMU-110	2.6	ND	ND	ND	0.032	2.1	C2-S1	-
MMU-111	2.6	ND	0.69	ND	0.060	13.3	C2-S2	-
MMU-112	**27**	ND	ND	ND	ND	15.4	C3-S3	-
MMU-113	2.8	ND	0.15	ND	0.037	4.6	C2-S1	-
MMU-114/115	7.5	ND	0.21	ND	0.073	14.1	C2-S3	-
MMU-116	2.4	ND	0.21	ND	0.044	2.0	C2-S1	-
MMU-117/118a	**28**	0.795	0.46	0.084	0.105	30.8	C4-S4	-
MMU-118b	**58**	ND	ND	ND	0.062	61.8	C4-S4	-
MMU-119/120	**122**	ND	ND	0.020	0.023	22.4	C4-S4	-
MMU-121	1.0	ND	ND	ND	0.088	35.3	C3-S4	-
MMU-122	3.1	ND	ND	ND	ND	3.2	C2-S1	-
MMU-123/124	**62**	ND	ND	ND	ND	25.3	C4-S4	-
MMU-125	2.2	ND	ND	ND	ND	2.0	C2-S1	-
MMU-127/128	2.5	ND	ND	ND	ND	20.5	C2-S3	-
MMU-129	2.1	ND	ND	ND	ND	1.4	C2-S1	-
MMU-130	1.5	ND	ND	ND	ND	1.5	C2-S1	-
MMU-131	4.7	ND	ND	ND	ND	7.7	C3-S2	-
MMU-132	0.98	ND	ND	ND	ND	4.5	C2-S1	-
MMU-133	5.4	ND	ND	ND	ND	5.2	C2-S1	-
MMU-134/135a	1.45	ND	ND	ND	ND	3.6	C2-S1	-
MMU-135b/136	10.1	ND	ND	ND	ND	1.7	C2-S1	-
MMU-137/138	**87.5**	ND	ND	ND	ND	2.8	C4-S1	-
MMU-139	2.7	ND	ND	ND	ND	6.6	C2-S1	-

italics = constituent exceeded holding time

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	Nitrate-N (mg/L)	Nitrite-N (mg/L)	TKN (mg/L)	Ammonia (mg/L)	Phosphorus (mg/L)	SAR (value)	Irrigation Quality	Aluminum (mg/L)	Strontium (mg/L)
MMU-140	4.7	ND	ND	ND	ND	5.2	C2-S1	-	-
MMU-141	1.8	ND	ND	ND	ND	4.4	C2-S1	-	-
MMU-144	8.7	ND	ND	ND	ND	11.0	C3-S2	-	-
MMU-145/146	**17**	ND	ND	ND	ND	7.2	C3-S2	-	-
MMU-147	3.3	ND	ND	ND	0.92	7.4	C2-S2	-	-
MMU-148	2.4	ND	ND	ND	ND	8.0	C2-S2	-	-
MMU-149	**13**	ND	ND	ND	ND	4.9	C2-S1	-	-
MMU-151/152	**42**	ND	ND	2.4	ND	15.1	C3-S3	-	-
MMU-155	2.5	ND	ND	ND	ND	4.3	C2-S1	-	-
MMU-156	3.3	ND	ND	ND	ND	3.6	C2-S1	-	-
MMU-157	0.90	ND	ND	ND	ND	22.5	C2-S4	-	-
MMU-158	2.8	ND	ND	ND	ND	22.2	C2-S4	-	-
MMU-159	2.7	ND	ND	ND	ND	16.4	C2-S3	-	-
MMU-160/161	**16**	ND	ND	ND	ND	0.8	C2-S1	-	-
MMU-162	2.3	ND	ND	ND	ND	4.4	C2-S1	-	-
MMU-163	1.5	ND	ND	ND	ND	11.6	C2-S2	ND	-
MMU-164	2.9	ND	ND	ND	ND	4.7	C2-S1	ND	-
MMU-165-66	**72**	ND	ND	ND	ND	22.9	C4-S4	ND	4.1
MMU-168	**32**	0.069	ND	ND	ND	24.1	C4-S4	ND	0.97
MMU-170	1.8	ND	ND	ND	ND	22.9	C3-S4	ND	0.30
MMU-171	6.4	ND	ND	ND	ND	2.2	C2-S1	ND	0.92
MMU-172	4.8	ND	ND	ND	ND	3.6	C2-S1	ND	0.80
MMU-173	6.7	0.11	ND	ND	ND	3.9	C3-S1	ND	0.83
MMU-176	4.3	ND	ND	ND	ND	3.1	C2-S1	ND	0.37

italics = constituent exceeded holding time

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Fluoride (mg/L)
MMU-1	ND	ND	ND	ND	0.66	ND	ND	ND	0.39
MMU-2/153/154	ND	ND	0.0575	ND	1.55	ND	0.011	0.015/ND	0.40
MMU 3	ND	ND	0.13	ND	0.11	ND	ND	ND	1.2
MMU-4	ND	ND	ND	ND	0.26	ND	ND	0.020	0.69
MMU-5	-	-	-	-	-	-	-	-	-
MMU-6	ND	0.0062	ND	ND	0.22	ND	ND	ND	1.2
MMU-7/8	ND	ND	ND	ND	0.20	ND	ND	ND	0.475
MMU-9	-	-	-	-	-	-	-	-	-
MMU-10	ND	0.0054	ND	ND	0.19	ND	ND	ND	0.44
MMU-11	ND	0.0058	ND	ND	0.18	ND	ND	ND	0.54
MMU-12	ND	ND	ND	ND	0.16	ND	ND	ND	0.59
MMU-14	ND	ND	ND	ND	0.43	ND	ND	ND	**2.3**
MMU-15/16	ND	**0.0105**	0.044	ND	0.17	ND	0.0245	ND	1.25
MMU-17	-	-	-	-	-	-	-	-	-
MMU-18	ND	0.0071	ND	ND	ND	ND	ND	0.016	0.60
MMU-19	ND	ND	ND	ND	0.30	ND	ND	ND	1.7
MMU-21	ND	0.0073	ND	ND	0.12	ND	ND	ND	**2.8**
MMU-22/23	-	-	-	-	-	-	-	-	-
MMU-24	ND	ND	ND	ND	0.17	ND	0.016	0.050	**2.2**
MMU-25	ND	0.0050	ND	ND	0.15	ND	ND	ND	0.69
MMU-26	-	-	-	-	-	-	-	-	-
MMU-27	ND	0.0095	ND	ND	0.28	ND	0.019	0.011	0.83
MMU-28	ND	0.0094	ND	ND	0.20	ND	0.036	ND	**4.2**
MMU-31	-	-	-	-	-	-	-	-	-
MMU-32/33	ND	0.00735	0.0275	ND	0.525	ND	0.0495	ND	**4.1**
MMU-34	-	-	-	-	-	-	-	-	-
MMU-35	ND	ND	0.011	ND	0.32	ND	ND	ND	**3.6**
MMU-36	ND	0.0068	0.062	ND	0.23	ND	0.018	ND	**2.9**

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Fluoride (mg/L)
MMU-37/150	ND	0.0056	0.071	ND	0.25	ND	0.024	ND	**2.4**
MMU 38	-	-	-	-	-	-	-	-	-
MMU-39	-	-	-	-	-	-	-	-	-
MMU-40	ND	0.0054	0.059	ND	0.22	ND	0.017	ND	**3.4**
MMU-41	ND	0.0060	0.062	ND	0.28	ND	0.012	ND	**3.5**
MMU-42	ND	ND	0.089	ND	0.61	ND	0.035	0.019	**3.0**
MMU-43	ND	ND	0.037	ND	0.38	ND	0.012	0.011	**3.4**
MMU-44	ND	ND	0.24	ND	ND	ND	ND	ND	0.40
MMU-45	ND	0.0074	0.11	ND	ND	ND	ND	ND	0.50
MMU-46	-	-	-	-	-	-	-	-	-
MMU-47/167	ND	0.0060	0.052	ND	0.16	ND	ND	ND	0.75
MMU-48	ND	0.0060	0.099	ND	0.15	ND	ND	ND	0.72
MMU-49/50	ND	**0.013**	0.0285	ND	0.25	ND	0.045	ND	**3.6**
MMU-51	-	-	-	-	-	-	-	-	-
MMU-52	ND	**0.013**	0.026	ND	0.30	ND	0.078	ND	**4.4**
MMU-53/174	ND	ND	0.092	ND	0.14	ND	0.012	ND	0.48
MMU-54	ND	ND	0.15	ND	0.17	ND	0.010	ND	0.41
MMU-55/169	ND	**0.017**	ND	ND	0.47	ND	0.049	ND	**4.4**
MMU-57	-	-	-	-	-	-	-	-	-
MMU-58/59	ND	ND	0.16	ND	0.54	ND	0.010	0.033	0.93
MMU-60/61/175	ND	0.0058	0.050	ND	0.21	ND	0.022	ND	**2.9**
MMU-62	ND	0.0080	0.049	ND	0.21	ND	0.028	ND	**3.4**
MMU-63	ND	0.0059	0.086	ND	0.53	ND	0.015	0.012	**3.5**
MMU-64/65	ND	0.0082	0.0395	ND	0.265	ND	0.020	ND	**6.2**
MMU-66	ND	0.0055	0.036	ND	0.13	ND	0.078	ND	**2.7**
MMU-67	ND	0.0058	0.11	ND	0.13	ND	0.046	ND	**2.5**
MMU-68	ND	ND	ND	ND	0.13	ND	0.048	ND	**2.1**
MMU-69/70	ND	ND	0.0315	ND	0.14	ND	0.0415	ND	**2.8**

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Fluoride (mg/L)
MMU-71	ND	**0.018**	0.060	ND	0.21	ND	ND	ND	**13**
MMU-72/73	ND	0.0076	0.0205	ND	0.15	ND	0.045	ND	**3.6**
MMU-74	ND	0.0079	0.072	ND	0.17	ND	0.021	ND	**4.4**
MMU-76	ND	ND	0.046	ND	0.12	ND	0.0425	ND	**2.4**
MMU-77	ND	0.0050	0.036	ND	0.13	ND	0.046	ND	**2.7**
MMU-78	ND	0.0073	0.10	ND	0.26	ND	0.035	ND	**5.9**
MMU-79	ND	0.0074	0.088	ND	0.25	ND	0.034	ND	**5.8**
MMU-80	ND	ND	0.032	ND	0.20	ND	ND	ND	**2.6**
MMU-81	ND	ND	0.0057	ND	0.19	ND	0.018	0.010	**3.1**
MMU 82	ND	ND	0.051	ND	0.33	ND	ND	ND	0.66
MMU-83/84	ND	ND	ND	ND	0.30	ND	0.018	ND	1.6
MMU-85/86	ND	0.0052	0.225	ND	ND	ND	0.022	ND	0.43
MMU-87	ND	ND	0.11	ND	0.16	ND	0.011	ND	0.62
MMU-88/89	ND	ND	0.091	ND	0.715	ND	ND	ND	0.685
MMU-90	ND	ND	0.11	ND	0.24	ND	ND	ND	1.8
MMU-91	ND	ND	0.081	ND	0.20	ND	0.013	ND	0.40
MMU-92	ND	0.0093	0.029	ND	0.29	ND	0.054	ND	**4.3**
MMU-93	ND	0.0056	0.092	ND	0.20	ND	0.023	ND	1.4
MMU-94	ND	0.0060	0.085	ND	0.20	ND	0.017	ND	1.8
MMU-95	ND	0.007	ND	ND	0.26	ND	0.033	ND	**4.0**
MMU-96	ND	ND	0.10	ND	0.17	ND	ND	ND	1.0
MMU-97	ND	ND	0.22	ND	0.14	ND	ND	ND	0.61
MMU-98	ND	**0.013**	0.010	ND	0.31	ND	0.053	ND	**4.7**
MMU-99	ND	ND	0.072	ND	0.12	ND	0.024	ND	1.5
MMU-100	ND	0.008	ND	ND	0.17	ND	0.040	ND	1.8
MMU-101	ND	**0.017**	ND	ND	0.22	ND	0.068	ND	**3.1**
MMU-102	ND	0.0056	0.057	ND	0.13	ND	0.044	ND	**2.4**
MMU-103	ND	0.0055	0.021	ND	0.12	ND	0.045	ND	**2.5**

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Fluoride (mg/L)
MMU-104	ND	ND	ND	ND	0.22	ND	0.024	ND	**2.1**
MMU-105	ND	ND	0.47	ND	0.20	ND	ND	ND	0.93
MMU-106	ND	ND	0.089	ND	0.13	ND	ND	ND	0.32
MMU-107/108	ND	ND	0.0945	ND	0.16	ND	0.015	ND	0.38
MMU-109	ND	ND	0.14	ND	ND	ND	ND	ND	0.41
MMU-110	ND	ND	0.067	ND	0.15	ND	0.034	ND	1.3
MMU-111	ND	0.0066	0.031	ND	1.1	ND	0.096	ND	**3.7**
MMU-112	ND	0.0085	0.064	ND	0.26	ND	ND	ND	**2.2**
MMU-113	ND	**0.015**	0.063	ND	0.15	ND	0.037	ND	**2.8**
MMU-114/115	ND	ND	0.0079	ND	0.16	ND	0.0705	ND	1.95
MMU-116	ND	ND	0.034	ND	0.14	ND	0.037	ND	1.4
MMU-117/118a	ND	**0.012**	0.054	ND	2.5	ND	ND	ND	**17**
MMU-118b	ND	**0.035**	0.050	ND	2.1	ND	0.016	ND	**5.5**
MMU-119/120	ND	0.0076	0.065	ND	2.2	ND	0.0225	ND/.02	**7.85**
MMU-121	ND	**0.110**	0.017	ND	2.4	ND	0.022	0.029	**22**
MMU-122	ND	ND	0.098	ND	0.24	ND	0.040	0.022	1.6
MMU-123/124	ND	**0.013**	0.0405	ND	0.75	ND	0.054	0.020	1.8
MMU-125	ND	0.005	0.091	ND	0.12	ND	ND	ND	0.53
MMU-127/128	ND	**0.0155**	0.0455	ND	0.235	ND	0.032	ND	**8.3**
MMU-129	ND	ND	0.064	ND	0.11	ND	ND	ND	0.62
MMU-130	ND	ND	0.14	ND	ND	ND	ND	ND	0.32
MMU-131	ND	ND	0.021	ND	0.23	ND	0.037	ND	**2.7**
MMU-132	ND	**0.010**	0.026	ND	0.13	ND	0.034	ND	**4.2**
MMU-133	ND	0.0050	0.049	ND	0.28	ND	0.015	0.014	1.5
MMU-134/135a	ND	0.0065	0.086	ND	0.14	ND	0.031	ND	**6.8**
MMU-135b/136	ND	**0.013**	0.0935	ND	0.175	ND	0.0215	ND	**3.6**
MMU-137/138	ND	**0.0115**	0.0665	ND	ND	ND	0.049	0.010	0.37
MMU-139	ND	ND	ND	ND	0.47	ND	ND	ND	1.4

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Fluoride (mg/L)
MMU-140	ND	ND	ND	ND	0.44	ND	ND	ND	0.68
MMU-141	ND	ND	0.053	ND	0.36	ND	ND	ND	1.3
MMU-144	ND	ND	0.12	ND	0.19	ND	ND	ND	0.32
MMU-145/146	ND	ND	0.16	ND	0.415	ND	ND	ND	1.2
MMU-147	ND	ND	0.038	ND	0.23	ND	0.020	ND	**3.8**
MMU-148	ND	0.008	0.012	ND	0.24	ND	0.021	ND	**3.3**
MMU-149	ND	ND	0.035	ND	0.43	ND	ND	ND	0.76
MMU-151/152	ND	0.0093	0.043	ND	1.95	ND	0.0115	ND	**12**
MMU-155	ND	**0.011**	ND	ND	0.23	ND	0.046	ND	**5.1**
MMU-156	ND	**0.013**	ND	ND	0.29	ND	0.012	ND	**11**
MMU-157	ND	**0.022**	ND	ND	0.30	ND	ND	ND	**15**
MMU-158	ND	**0.015**	ND	ND	0.39	ND	0.037	ND	**3.2**
MMU-159	ND	**0.015**	0.015	ND	0.35	ND	0.061	ND	**7.0**
MMU-160/161	ND	ND	0.016	ND	ND	ND	ND	ND	0.435
MMU-162	ND	0.0068	0.031	ND	0.16	ND	0.034	ND	**2.6**
MMU-163	ND	**0.022**	ND	ND	0.31	ND	ND	ND	**14**
MMU-164	ND	0.0084	ND	ND	0.23	ND	0.030	ND	**5.4**
MMU-165-66	ND	**0.015**	ND	ND	1.2	ND	0.0265	ND	**3.0**
MMU-168	ND	0.0082	ND	ND	1.1	ND	0.033	ND	**3.6**
MMU-170	ND	**0.022**	ND	ND	2.5	ND	0.044	ND	**17**
MMU-171	ND	ND	0.053	ND	0.20	ND	0.010	ND	**2.3**
MMU-172	ND	0.0068	ND	ND	0.26	ND	0.014	ND	**3.0**
MMU-173	ND	ND	0.058	ND	0.24	ND	0.017	ND	**2.1**
MMU-176	ND	0.0050	ND	ND	0.14	ND	0.044	ND	**2.7**

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	Iron (mg/L)	Lead (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Thallium (mg/L)	Zinc (mg/L)
MMU-1	ND	ND	ND	ND	ND	0.0072	ND	ND	ND
MMU-2/153/154	ND	ND	ND	ND	ND	0.0067/ND	ND	ND	ND
MMU 3	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-4	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-5	-	-	-	-	-	-	-	-	-
MMU-6	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-7/8	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-9	-	-	-	-	-	-	-	-	-
MMU-10	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-11	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-12	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-14	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-15/16	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-17	-	-	-	-	-	-	-	-	-
MMU-18	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-19	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-21	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-22/23	-	-	-	-	-	-	-	-	-
MMU-24	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-25	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-26	-	-	-	-	-	-	-	-	-
MMU-27	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-28	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-31	-	-	-	-	-	-	-	-	-
MMU-32/33	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-34	-	-	-	-	-	-	-	-	-
MMU-35	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-36	ND	ND	ND	ND	ND	ND	ND	ND	ND

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	Iron (mg/L)	Lead (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Thallium (mg/L)	Zinc (mg/L)
MMU-37/150	ND	ND	ND	ND	ND	0.0057	ND	ND	ND
MMU 38	-	-	-	-	-	-	-	-	-
MMU-39	-	-	-	-	-	-	-	-	-
MMU-40	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-41	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-42	ND	ND	ND	ND	ND	0.0064	ND	ND	ND
MMU-43	ND	ND	ND	ND	ND	ND	ND	ND	0.059
MMU-44	ND	ND	ND	ND	ND	0.0079	ND	ND	ND
MMU-45	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-46	-	-	-	-	-	-	-	-	-
MMU-47/167	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-48	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-49/50	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-51	-	-	-	-	-	-	-	-	-
MMU-52	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-53/174	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-54	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-55/169	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-57	-	-	-	-	-	-	-	-	-
MMU-58/59	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-60/61/175	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-62	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-63	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-64/65	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-66	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-67	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-68	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-69/70	ND	ND	ND	ND	ND	ND	ND	ND	ND

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	Iron (mg/L)	Lead (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Thallium (mg/L)	Zinc (mg/L)
MMU-71	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-72/73	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-74	ND	ND	ND	ND	ND	ND	ND	ND	0.13
MMU-76	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-77	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-78	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-79	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-80	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-81	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU 82	ND	ND	ND	ND	ND	ND	ND	ND	0.070
MMU-83/84	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-85/86	ND	ND	ND	ND	ND	0.0119	ND	0.0013/ ND	0.0695
MMU-87	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-88/89	ND	ND	ND	ND	ND	0.0115	ND	ND	ND
MMU-90	ND	ND	**0.089**	ND	ND	ND	ND	ND	ND
MMU-91	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-92	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-93	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-94	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-95	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-96	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-97	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-98	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-99	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-100	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-101	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-102	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-103	ND	ND	ND	ND	ND	ND	ND	ND	ND

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	Iron (mg/L)	Lead (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Thallium (mg/L)	Zinc (mg/L)
MMU-104	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-105	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-106	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-107/108	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-109	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-110	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-111	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-112	ND	ND	ND	ND	ND	0.015	ND	ND	ND
MMU-113	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-114/115	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-116	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-117/118a	ND	ND	**0.0777**	ND	ND	0.020	ND	ND	ND
MMU-118b	ND	ND	ND	ND	ND	0.022	ND	ND	ND
MMU-119/120	ND	ND	ND	ND	ND	0.0105	ND	ND	ND
MMU-121	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-122	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-123/124	ND	ND	ND	ND	ND	**0.069**	ND	ND	ND
MMU-125	ND	ND	ND	ND	ND	0.0059	ND	ND	0.059
MMU-127/128	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-129	ND	ND	ND	ND	ND	ND	ND	ND	0.74
MMU-130	ND	ND	ND	ND	ND	0.007	ND	ND	0.21
MMU-131	ND	ND	ND	ND	ND	0.0055	ND	ND	ND
MMU-132	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-133	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-134/135a	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-135b/136	ND	ND	ND	ND	ND	ND	ND	ND	0.155
MMU-137/138	ND	ND	ND	ND	ND	0.0225	ND	ND	ND
MMU-139	ND	ND	ND	ND	ND	ND	ND	ND	ND

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	**Iron** (mg/L)	**Lead** (mg/L)	**Manganese** (mg/L)	**Mercury** (mg/L)	**Nickel** (mg/L)	**Selenium** (mg/L)	**Silver** (mg/L)	**Thallium** (mg/L)	**Zinc** (mg/L)
MMU-140	ND	ND	ND	ND	ND	ND	ND	ND	0.16
MMU-141	ND	ND	ND	ND	ND	ND	ND	ND	0.055
MMU-144	ND	ND	ND	ND	ND	0.0061	ND	ND	ND
MMU-145/146	ND	ND	ND	ND	ND	0.011	ND	ND	ND
MMU-147	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-148	ND	ND	ND	ND	ND	ND	ND	ND	0.68
MMU-149	ND	ND	ND	ND	ND	ND	ND	ND	0.37
MMU-151/152	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-155	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-156	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-157	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-158	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-159	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-160/161	ND	ND	ND	ND	ND	ND	ND	ND	0.16
MMU-162	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-163	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-164	ND	ND	ND	ND	ND	ND	ND	ND	0.074
MMU-165-66	ND	ND	ND	ND	ND	**0.0755**	ND	ND	ND
MMU-168	ND	ND	ND	ND	ND	0.025	ND	ND	0.16
MMU-170	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-171	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-172	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-173	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMU-176	ND	ND	ND	ND	ND	ND	ND	ND	ND

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	Radon-222 (pCi/L)	Alpha (pCi/L)	Beta (pCi/L)	Ra-226 + Ra-228 (pCi/L)	Uranium (µg/L)	∗^{18} O ($^0/_{00}$)	∗ D ($^0/_{00}$)	Type of Chemistry
MMU-1	**739**	**55**	40	< LLD	**80**	- 10.1	- 75	sodium-mixed
MMU-2/153/154	**750**	**130**	110	< LLD	**91**	- 9.6	- 70	mixed-mixed
MMU 3	**555**	6.5	7.7	< LLD	-	- 8.7	- 61	mixed-mixed
MMU-4	**478**	7.1	7.6	< LLD	-	- 7.1	- 50	sodium-bicarbonate
MMU-5	-	-	-	-	-	-	-	-
MMU-6	**544**	4.6	5.5	-	-	- 7.4	- 51	sodium-bicarbonate
MMU-7/8	199	7.0	4.2	< LLD	-	- 9.3	- 66	sodium-mixed
MMU-9	-	-	-	-	-	-	-	-
MMU-10	**598**	9.6	5.7	< LLD	-	- 8.7	- 61	sodium-mixed
MMU-11	**433**	5.1	4.0	< LLD	-	- 9.6	- 68	sodium-mixed
MMU-12	**410**	-	-	-	-	- 9.1	- 64	mixed-mixed
MMU-14	**411**	12	11	< LLD	-	- 8.1	- 57	mixed-mixed
MMU-15/16	299	-	-	-	-	- 10.9	- 77	sodium-bicarbonate
MMU-17	-	-	-	-	-	-	-	-
MMU-18	245	1.3	4.5	-	-	- 10.9	- 78	mixed-bicarbonate
MMU-19	**630**	8.4	8.3	< LLD	-	- 8.8	- 66	sodium-mixed
MMU-21	**468**	6.3	5.4	< LLD	-	- 8.8	- 59	mixed-bicarbonate
MMU-22/23	-	-	-	-	-	-	-	-
MMU-24	**446**	-	-	-	-	- 9.5	- 69	sodium-bicarbonate
MMU-25	**331**	-	-	-	-	- 8.7	- 62	mixed-bicarbonate
MMU-26	-	-	-	-	-	-	-	-
MMU-27	**322**	5.9	4.7	< LLD	-	- 7.0	- 49	sodium-mixed
MMU-28	82	3.4	3.3	-	-	- 10.8	- 77	sodium-mixed
MMU-31	-	-	-	-	-	-	-	-
MMU-32/33	**1,248**	3.9	3.5	-	-	- 10.8	- 78	sodium-mixed
MMU-34	-	-	-	-	-	- 11.5	- 77	-
MMU-35	**686**	4.5	5.7			- 9.0	- 67	sodium-mixed
MMU-36	**1,216**	-	-	-	-	- 8.8	- 64	sodium-bicarbonate

LLD = Lower Limit of Detection

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	Radon-222 (pCi/L)	Alpha (pCi/L)	Beta (pCi/L)	Ra-226 + Ra-228 (pCi/L)	Uranium (µg/L)	∗^{18} O ($^{0}/_{00}$)	∗ D ($^{0}/_{00}$)	Type of Chemistry
MMU-37/150	**977**	-	-	-	-	- 10.1	- 73	sodium-mixed
MMU 38	-	-	-	-	-	-	-	-
MMU-39	-	-	-	-	-	-	-	-
MMU-40	**1,458**	12	12	0.80	-	- 8.6	- 61	sodium-bicarbonate
MMU-41	**9,465**	**21**	17	3.1	19	- 9.4	- 65	sodium-bicarbonate
MMU-42	**10,241**	-	-	-	-	- 9.5	- 68	sodium-mixed
MMU-43	-	-	-	-	-	- 9.3	- 66	sodium-mixed
MMU-44	-	-	-	-	-	- 9.5	- 70	mixed-chloride
MMU-45	**592**	-	-	-	-	- 10.4	- 74	mixed-bicarbonate
MMU-46	-	-	-	-	-	-	-	-
MMU-47/167	-	-	-	-	-	- 9.9	- 69	sodium-bicarbonate
MMU-48	-	4.9	6.9			- 9.8	- 69	sodium-bicarbonate
MMU-49/50	-	-	-	-	-	- 10.5	- 77	sodium-mixed
MMU-51	-	-	-	-	-	-	-	-
MMU-52	**1,106**	-	-	-	-	- 10.7	- 77	sodium-mixed
MMU-53/174	-	-	-	-	-	- 10.8	- 75	sodium-mixed
MMU-54	-	-	-	-	-	- 10.3	- 75	sodium-mixed
MMU-55/169	-	-	-	-	-	- 10.8	- 76	sodium-mixed
MMU-57	-	-	-	-	-	-	-	-
MMU-58/59	-	-	-	-	-	- 10.0	- 72	sodium-mixed
MMU-60/61/175	-	-	-	-	-	-	-	sodium-mixed
MMU-62	-	-	-	-	-	- 10.2	- 73	sodium-bicarbonate
MMU-63	**6,894**	-	-	-	-	- 9.4	- 67	sodium-mixed
MMU-64/65	**602**	6.6	3.8	0.9	-	- 10.4	- 74	sodium-mixed
MMU-66	-	10	4.2	-	-	- 10.6	- 75	sodium-bicarbonate
MMU-67	-	-	-	-	-	- 10.4	- 76	sodium-bicarbonate
MMU-68	**500**	-	-	-	-	- 10.5	- 75	sodium-bicarbonate
MMU-69/70	-	-	-	-	-	-10.65	- 75.5	sodium-bicarbonate

LLD = Lower Limit of Detection

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	Radon-222 (pCi/L)	Alpha (pCi/L)	Beta (pCi/L)	Ra-226 + Ra-228 (pCi/L)	Uranium (µg/L)	∗^{18}O ($^{0}/_{00}$)	∗D ($^{0}/_{00}$)	Type of Chemistry
MMU-71	**3956**	9.4	6.0	1.3	-	- 9.9	- 76	sodium-bicarbonate
MMU-72/73	**681**	-	-	-	-	- 10.7	- 77	sodium-bicarbonate
MMU-74	**868**	4.8	2.4	-	-	- 10.4	- 75	sodium-mixed
MMU-76	**1025**	-	-	-	-	- 10.6	- 76	sodium-mixed
MMU-77	-	-	-	-	-	- 10.6	- 76	sodium-bicarbonate
MMU-78	**1654**	-	-	-	-	- 10.3	- 76	sodium-mixed
MMU-79	**1079**	-	-	-	-	- 10.2	- 74	sodium-mixed
MMU-80	**830**	14	7.1	< LLD	-	- 9.0	- 62	sodium-bicarbonate
MMU-81	**446**	-	-	-	-	- 8.8	- 63	sodium-bicarbonate
MMU-82	**582**	3.7	1.7	-	-	- 8.2	- 59	sodium-mixed
MMU-83/84	**3024**	6.9	4.0	< LLD	-	- 11.0	- 79	sodium-mixed
MMU-85/86	**460**	-	-	-	-	- 10.6	- 74	mixed-chloride
MMU-87	-	-	-	-	-	- 10.2	- 70	sodium-mixed
MMU-88/89	-	**68**	48	< LLD	**120**	- 9.5	- 67	sodium-mixed
MMU-90	-	-	-	-	-	- 9.3	- 71	sodium-mixed
MMU-91	**664**	-	-	-	-	- 10.0	- 78	sodium-mixed
MMU-92	**460**	-	-	-	-	- 10.8	- 77	sodium-mixed
MMU-93	-	-	-	-	-	- 10.7	- 79	sodium-bicarbonate
MMU-94	**732**	-	-	-	-	- 11.0	- 74	sodium-bicarbonate
MMU-95	-	-	-	-	-	- 10.6	- 77	sodium-mixed
MMU-96	-	-	-	-	-	- 10.6	- 77	sodium-mixed
MMU-97	-	-	-	-	-	- 10.5	- 76	sodium-chloride
MMU-98	-	-	-	-	-	- 10.7	- 78	sodium-mixed
MMU-99	**1227**	-	-	-	-	- 10.4	- 76	sodium-bicarbonate
MMU-100	**1476**	-	-	-	-	- 10.0	- 74	sodium-mixed
MMU-101	**1551**	-	-	-	-	- 10.3	- 76	sodium-mixed
MMU-102	**757**	6.4	4.1	< LLD	-	- 10.6	- 76	sodium-bicarbonate
MMU-103	-	-	-	-	-	- 10.6	- 76	sodium-bicarbonate

LLD = Lower Limit of Detection

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	**Radon-222** (pCi/L)	**Alpha** (pCi/L)	**Beta** (pCi/L)	**Ra-226 + Ra-228** (pCi/L)	**Uranium** (µg/L)	$\ast^{18}$ **O** $(^{0}/_{00})$	$\ast$ **D** $(^{0}/_{00})$	**Type of Chemistry**
MMU-104	**936**	8.6	6.0	< LLD	-	- 10.9	- 79	sodium-mixed
MMU-105	-	-	-	-	-	- 8.8	- 61	sodium-bicarbonate
MMU-106	-	-	-	-	-	- 10.5	- 75	sodium-bicarbonate
MMU-107/108	118	-	-	-	-	- 10.8	- 78	sodium-mixed
MMU-109	13	0.64	1.5	-	-	- 8.8	- 61	mixed-bicarbonate
MMU-110	-	-	-	-	-	- 10.3	- 76	mixed-bicarbonate
MMU-111	-	-	-	-	-	- 10.7	- 79	sodium-bicarbonate
MMU-112	**433**	2.9	5.6	-	-	- 10.1	- 76	sodium-chloride
MMU-113	106	1.9	1.4	-	-	- 10.6	- 75	sodium-bicarbonate
MMU-114/115a	260	12	7.6	< LLD	-	- 9.9	- 72	sodium-mixed
MMU-116	**367**	6.8	4.7	< LLD	-	- 10.3	- 75	mixed-bicarbonate
MMU-117/118a	-	8.5	5.8	< LLD		- 9.8	- 74	sodium-mixed
MMU-118b	-	-	-	-	-	- 9.7	- 73	sodium-mixed
MMU-119/120	-	**16**	12	< LLD	27	- 7.9	- 60.5	sodium-mixed
MMU-121	**307**	12	21	< LLD	-	- 10.6	- 76	sodium-mixed
MMU-122	**318**	-	-	-	-	- 10.8	- 78	sodium-bicarbonate
MMU-123/124	**649**	-	-	-	-	- 9.8	- 74	sodium-chloride
MMU-125	98	2.2	5.0	-	-	- 8.9	- 62	mixed-mixed
MMU-127/128	**766**	1.6	2.1	-	-	- 9.2	- 67	sodium-mixed
MMU-129	**542**	4.8	2.9	-	-	- 8.7	- 63	mixed-bicarbonate
MMU-130	**316**	-	-	-	-	- 8.4	- 58	mixed-bicarbonate
MMU-131	-	-	-	-	-	- 10.9	- 80	sodium-mixed
MMU-132	**863**	3.8	2.3	-	-	- 10.5	- 76	sodium-bicarbonate
MMU-133	**810**	-	-	-	-	- 10.9	- 80	sodium-mixed
MMU-134/135a	**306**	-	-	-	-	- 10.5	- 77	sodium-bicarbonate
MMU-135b/136	**688**	**20**	5	< LLD	5.0	- 9.4	- 66	mixed-bicarbonate
MMU-137/138	**338**	-	-	-	-	- 9.7	- 72	calcium-chloride
MMU-139	**699**	-	-	-	-	- 7.5	- 52	sodium-bicarbonate

LLD = Lower Limit of Detection

Appendix B. Groundwater Quality Data, McMullen Valley Basin, 2008-2009---Continued

Site #	Radon-222 (pCi/L)	Alpha (pCi/L)	Beta (pCi/L)	Ra-226 + Ra-228 (pCi/L)	Uranium (µg/L)	δ^{18}O ($^0/_{00}$)	δD ($^0/_{00}$)	Type of Chemistry
MMU-140	**752**	-	-	-	-	- 7.0	- 51	sodium-bicarbonate
MMU-141	**850**	-	-	-	-	- 7.2	- 51	sodium-bicarbonate
MMU-144	**1,261**	-	-	-	-	- 10.7	- 76	sodium-mixed
MMU-145/146	**416**	**18**	8.7	< LLD	25	- 9.4	- 68	sodium-mixed
MMU-147	**413**	-	-	-	-	- 10.1	- 72	sodium-bicarbonate
MMU-148	293	-	-	-	-	- 10.5	- 74	sodium-bicarbonate
MMU-149	-	-	-	-	-	- 7.1	- 49	sodium-bicarbonate
MMU-151/152	269	8.3	16	< LLD	-	- 9.9	- 70	sodium-mixed
MMU-155	**820**	5.6	3.8	< LLD	-	- 10.3	- 75	sodium-bicarbonate
MMU-156	**469**	-	-	-	-	- 9.9	- 74	sodium-mixed
MMU-157	-	-	-	-	-	- 9.9	- 75	sodium-mixed
MMU-158	**1,164**	-	-	-	-	- 11.1	- 78	sodium-mixed
MMU-159	**1,397**	-	-	-	-	- 11.0	- 77	sodium-mixed
MMU-160/161	-	**30**	7.3	< LLD	4.1	- 8.5	- 58	calcium-bicarbonate
MMU-162	-	-	-	-	-	- 10.9	- 76	sodium-bicarbonate
MMU-163	-	-	-	-	-	- 10.3	- 72	sodium-mixed
MMU-164	-	6.5	4.2	< LLD	-	- 10.2	- 74	sodium-bicarbonate
MMU-165-66	-	-	-	-	-	- 9.7	- 72	sodium-mixed
MMU-168	-	-	-	-	-	- 10.1	- 73	sodium-mixed
MMU-170	-	-	-	-	-	- 11.2	- 79	sodium-mixed
MMU-171	-	1.3	7.2	< LLD	-	- 9.2	- 57	mixed-bicarbonate
MMU-172	-	**19**	7.9	< LLD	**30**	- 9.2	- 63	sodium-bicarbonate
MMU-173	-	14	6.2	< LLD	-	- 9.4	- 64	sodium-bicarbonate
MMU-176	-	-	-	-	-	- 10.7	- 76	sodium-bicarbonate

LLD = Lower Limit of Detection