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COASTAL AND HYDRAULICS LABORATORY
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CEERD-HFR 15 December 2016

MEMORANDUM FOR: Commander, U.S. Army Engineer District, Fort Worth, (ATTN: CESWF-PEC/ Morrow, Robert M.), 829 Taylor St., Fort Worth, TX 76102-6124

SUBJECT: White Sands Missile Range 40-Year Water Development Plan, ERDC/CHL LR-16-13

1. The U.S. Army Corps of Engineers, Fort Worth District requested that the U.S. Army Engineer Research and Development Center (ERDC), Coastal and Hydraulics Laboratory (CHL) develop a 40-year water management plan for the White Sands Missile Range in New Mexico. The attached letter report, ERDC/CHL LR-16-13, describes the analysis of groundwater rights, groundwater availability, hydrology, water distribution, and projected water use of the White Sands Missile Range over the next four decades.

2. If you have any questions, please contact Dr. James Lewis at (601) 634-3895 (James.W.Lewis@usace.army.mil).

Encl

For JOSÉ E. SANCHEZ, PE, SES
Director

ERDC/CHL LR-16-13

ERDC/Coastal and Hydraulics Laboratory

White Sands Missile Range 40-Year Water Development Plan

Lewis, James W.

December 2016

ERDC/CHL LR-16-13
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White Sands Missile Range 40-Year Water Development Plan

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With support from the White Sands Missile Range Department of Public Works

White Sands Missile Range
U.S. Army
White Sands, NM

Prepared for Fort Worth District, U.S. Army Corps of Engineers
Washington, DC 20314-1000

Executive Summary

This forty year water development plan has been prepared in accordance with the requirements and recommendations of the New Mexico Office of the State Engineer (NMOSE). The purpose of this water development plan is to provide the NMOSE all required information showing an assessment of the White Sands Missile Range water supply, current water use, existing water rights, and the projected water demands of the next forty years.

The majority of the WSMR water use occurs within the Main Post water supply system which is currently supplied by a total of 15 wells. Additional wells around the WSMR installation area with a much smaller water use include wells at the Stallion Range Center, wells within the Central Range, wells used for construction purposes, and wells used for wildlife. The historic water rights of the WSMR Main Post water supply system are a combined total of 6.9 billion gallons per year, or 21,224 acre-feet per year (ac-ft/yr) across the T-688 et al. and HU-151 et al. well fields. The maximum beneficial use demonstrated by the WSMR Main Post water supply system was 939 million gallons (2,881 ac-ft) in the year 1971. The average water use by WSMR for the recent time period 2007 – 2014 was 446 million gallons per year (MGPY), or 1,369 ac-ft/yr. According to the hydrogeological and groundwater assessment, the groundwater aquifers used by the WSMR Main Post water supply system have a safe long-term yield of 645 MGPY (1,980 ac-ft/yr).

Multiple ongoing water conservation efforts have decreased the recent water usage of WSMR and are expected to reduce the future GPCD (gallons per capita per day) demand. Future water use is also expected to decrease due to continued water conservation and population fluctuations. However, the WSMR location is a potential site for military reconsolidation, or large fluctuations of soldiers, which could increase the water demand to approximately 800 MGPY (2,455 ac-ft/yr), or a water usage similar to the 1971 level.

WSMR needs to maintain its unused water rights in order to preserve the water quality of the aquifer and to be prepared for possible military reconsolidation. If unused water rights were taken from WSMR and used by others, the groundwater aquifer could be negatively impacted by saline intrusion from the surrounding aquifer. An increase in salinity, or brackish water, at the wells used for WSMR water supply would be problematic.

Contents

1 Baseline of Current Water Use

1.1 Overview of the present water delivery system

The White Sands Missile Range (WSMR) covers an 8,860 km^2 (3,420 mi^2) area in the southern part of New Mexico as shown in Figure 1. WSMR is roughly a rectangle about 167 km (104 mi) long (north to south) and 63 km (39 mi) wide that extends into parts of five New Mexico counties; namely Doña Ana, Lincoln, Otero, Sierra, and Socorro counties. Its northeast coordinate is roughly 106.1042° W, 33.8308° N, and the southwest coordinate is roughly 106.7406° W, 32.3214° N. It is the largest single land holding of the United States Department of Defense. The range is managed by the U.S. Army and operated to support military readiness programs involving the research, development, and testing of weapons and space systems.

The primary water delivery system of the White Sands Missile Range is within the Main Post, as indicated in Figure 1, which is also the primary location of the WSMR population. The Main Post is in the southwest corner of the WSMR and is approximately 16 miles east of the City of Las Cruces, New Mexico. There are also smaller independent water delivery systems used by WSMR in other locations; namely the Stallion Range Center, the Central Range complexes, and approximately 7 wells used for construction purposes. Additionally, there are approximately 18 older wells which pre-date permitting requirements spread around the WSMR installation area which withdraw up to 200 gallons each day for wildlife. Some of these wildlife wells used to be operated by windmills, but the wells currently use small solar power pumps. The majority of the WSMR water use occurs within the Main Post Area. Some of the water from the WSMR's Main Post delivery system goes to the Oro Grande Range Camp of Fort Bliss to the east.

Figure 1. Location map of the White Sands Missile Range (WSMR) within the State of New Mexico

1.1.1 Main Post Water Supply System

All of the water used by WSMR for municipal, irrigation, and domestic uses comes from groundwater sources. There are currently 15 deep water withdrawal wells which can be used to supply water to the primary WSMR water delivery system of the Main Post as shown in Figure 2. Eleven of these wells are within the Main Post, withdrawing water from the Tularosa Basin, and the other 4 are located in the Soledad Canyon area, which is 6-10 miles southeast of the Main Post, withdrawing water from the Hueco Basin. The water rights descriptions of these wells are explained in more detail in Section 5 of this report. WSMR does not currently use one of the wells, Well #16 (T-688-S-5), because the WSMR Public Works Division has found low levels of nitrates in water pumped from this well. However, Well #16 could be used for water supply as necessary using a blending plan with other wells. Note that WSMR well labels are not completely sequential; see Table 2 later in Section 1.2.1 of this report for the WSMR well labels and the New Mexico Office of the State Engineer (NMOSE) file numbers of the current wells.

Water is pumped from the wells to the Main Post Water Treatment Plant (WTP). The water from the Soledad Canyon wells is first pumped to the Soledad Canyon booster pump station then boosted to the WTP through a 16-inch supply line. The WSMR Main Post water distribution system is shown in Figure 3. It is divided into three pressure zones: upper, intermediate and downrange. The upper pressure zone serves the west side of the main post area that includes the Housing Area, Community buildings and some other support facilities. The intermediate pressure zone serves the central portion of the WSMR main post that includes the Administrative buildings, Research and Development and Industrial areas. The downrange pressure zone is east of the intermediate zone and includes the area along Nike Avenue, the missile launch and testing complexes and Ft. Bliss Oro Grande. An American Water Works Association (AWWA) assessment of the WSMR water delivery supply system was performed by WSMR and is shown in the Appendix, Section 9.3.1.

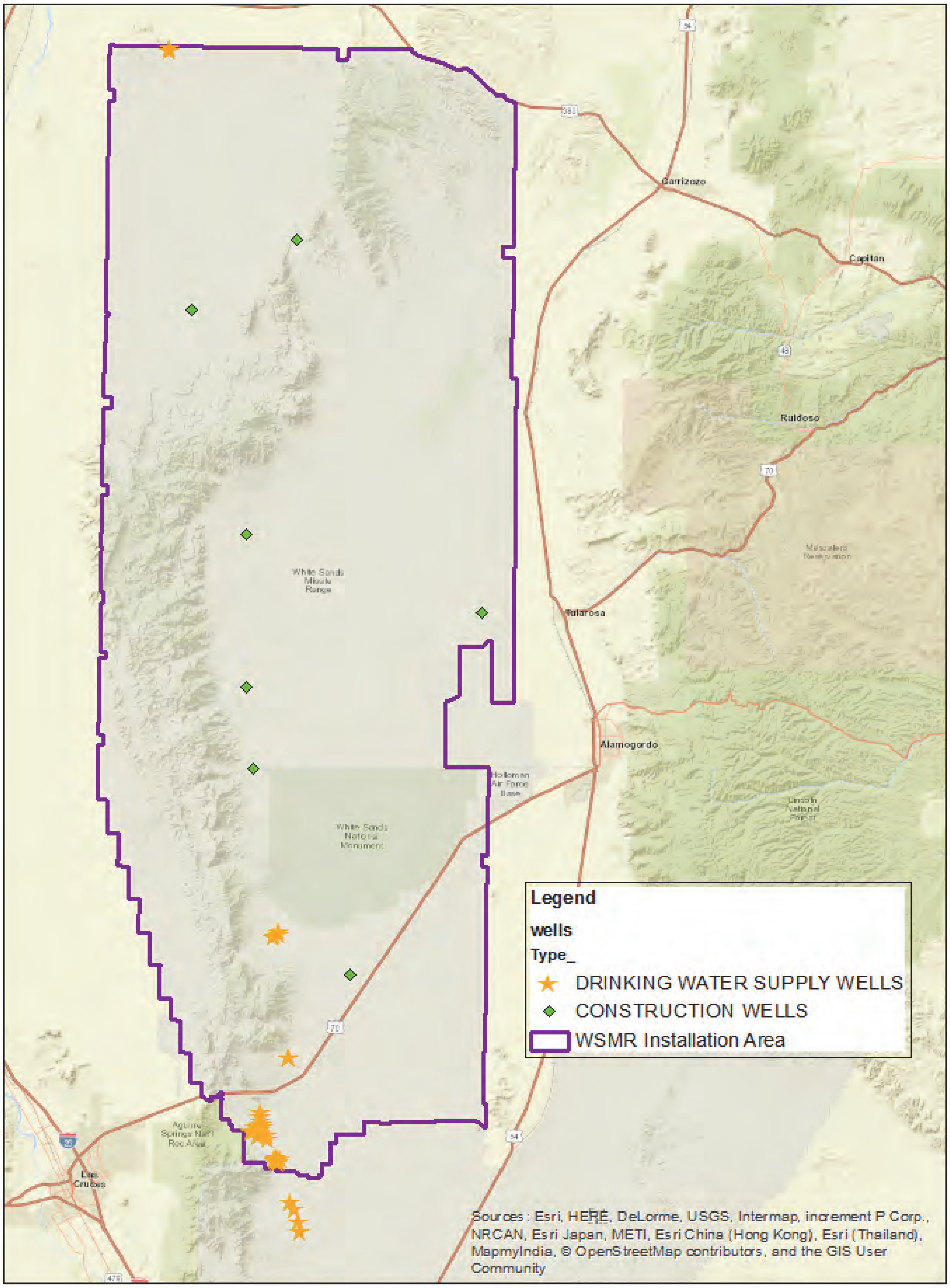

Figure 2. Map of water supply and construction wells for WSMR

Water exiting the WTP is stored in two 400,000 gallon ground storage tanks. From the ground storage tanks, water is conveyed by gravity to the downrange system or to the High Service Pump Station at the WTP. The High Service Pump Station has four booster pumps. Booster Pump No. 1 feeds the Intermediate

Elevated Tank (200,000 gallons) that is on the WTP site. Booster Pumps No. 2 and 3 fill the South 1-MG Elevated Storage Tank on the lower west side of the Housing Area. These two pumps cannot be operated at the same time due to shared piping hydraulic limitations. Booster Pump No. 4 fills the North 1-MG Elevated Storage Tank on the upper west side of the Housing Area. In addition to the three elevated storage tanks mentioned, there is also a 200,000 gallon elevated storage tank located downrange near Missile Range 38. The well pumps and booster pump stations are controlled by water levels in the elevated storage tanks on the WSMR main post. These pumps are operated by a Supervisory Control and Data Acquisition (SCADA) system.

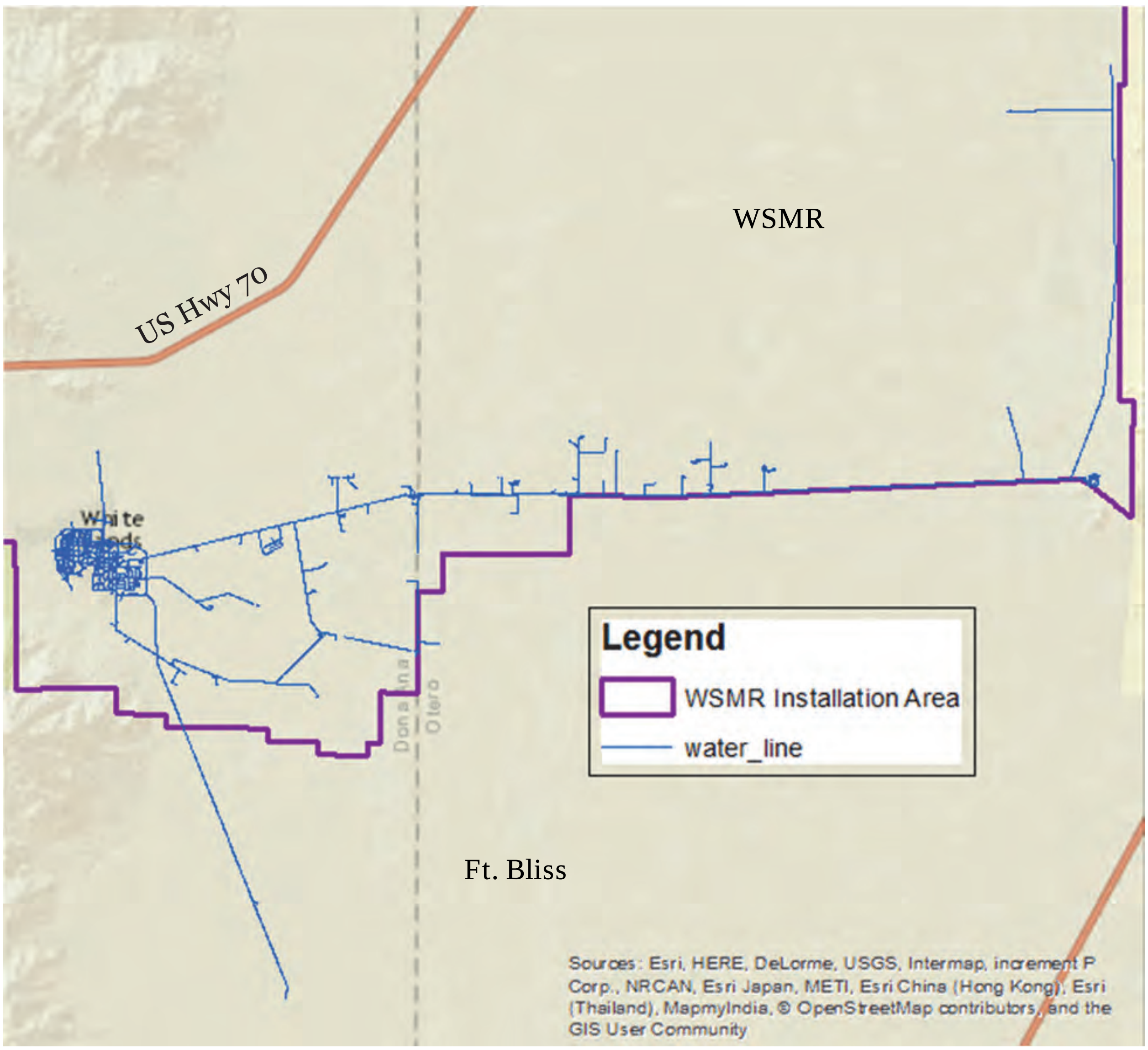

Figure 3. WSMR Main Post water delivery system

1.1.2 Construction Wells

There are approximately seven wells located throughout WSMR labeled as active construction wells. Water is typically withdrawn to fill large water trucks, typically 4,000 gallons each. This water is used for dust control and during geotechnical construction to maintain compaction requirements. Many of these wells pump non-potable water that is higher in salinity. The average water withdrawals from the construction wells are shown in Table 1. The estimated average water withdrawal from construction wells is 7.8 million gallons per year (MGPY), or 24 acre-feet per year (ac-ft/yr).

Table 1. WSMR active construction wells and their usage

NMOSE ID (File No.)	Basin	WSMR Well ID	Estimated average withdrawal, MGPY (ac-ft/yr)
RG-94945 POD 1	Rio Grande	Range Road 5 well	0.009 (0.03)
T-02073	Tularosa	NW-30	1.5 (4.6)
T-01497	Tularosa	NED-E	0
T-03602	Tularosa	RG Well	0
T-04087	Tularosa	Tula Gate	0.5 (1.4)
T-03634	Tularosa	THEL Well	3.4 (10.5)
T-05570	Tularosa	Rhodes C	2.4 (7.3)

1.1.3 Stallion Range Center

There is also a small water delivery system at the Stallion Range Center. Water from the two Stallion wells is pumped to the Stallion Treatment Plant (a reverse osmosis system) and then to a storage tank. The Stallion water system provides water to a fluctuating population of civilians and soldiers who are spread across sections of WSMR. For short periods of time, the fluctuating population can be as high as 4,000 civilians and soldiers in the area. There are no residents in the Stallion Range Center area. The Stallion Range Center wells are hydrologically located within the closed Jornada Del Muerto subbasin. The Stallion Range Center withdraws approximately 8.4 MGPY (26 ac-ft/yr). Approximately 2 million gallons is hauled away by truck for water supply at remote sites within WSMR and another 2 million gallons is used for construction purposes. The remaining amount (approximately 4.4 MGPY, or 14 ac-ft/yr) is used at the Stallion Range Center.

1.1.4 The Central Range

There are four complexes within the Central Range of WSMR with smaller independent water withdrawals. All of the Central Range wells are located within the Tularosa Basin and used for water supply. There are no residents of the Central Range area. Water supplies within the Central Range are from six individual wells which are north of the Main Post watershed. The combined total water use at the Central Range complexes is an average of 17.7 MGPY (54 ac-ft/yr).

1.1.5 Environmental note about the White Sands Pupfish

While not an endangered species, the White Sands Pupfish is a Federal Species of Concern and New Mexico Threatened species which requires internal monitoring and management. WSMR works closely with the U.S. Fish and Wildlife Service to ensure the population of the species is adequately protected. WSMR does not use surface water, and well water use on WSMR does not occur in quantities or locations that would affect the population of White Sands Pupfish. However, outside water use east of the WSMR property boundary may affect spring waters proposed for future use by the species.

1.1.6 Note about the White Sands National Monument

The White Sands National Monument is owned and operated separately by the National Park Service and lies within the eastern part of WSMR. The WSMR water withdrawals have not exhibited, and are not expected to exhibit, any negative impacts to the dunes at the White Sands National Monument. A study by Newton and Allen (2014) showed that the shallow aquifer of the White Sands National Monument is primarily recharged by local precipitation with a weaker connection to deeper regional aquifers. Their pumping tests from the deeper groundwater aquifer did not induce leakage from the White Sands National Monument's shallow aquifer.

1.2 Description of the WSMR current water use

The Main Post serves as the center of operations for most organizations and tenants of the White Sands Missile Range. The Main Post administrative and technical complex includes WSMR Headquarters, an operations control center, administrative offices, technical laboratories and work areas, warehouses, and service centers. The Main Post also serves as a self-contained community with military and family housing, shopping facilities, medical clinics, emergency and fire services, educational and recreational facilities, and churches.

The White Sands Missile Range ("WSMR") Main Post Water Treatment Plant ("WTP") has been providing potable water to the buildings and houses, the main cantonment Golf Course on the southwest side of the Main Post, the launch complexes and down range to Oro Grande. The WSMR Department of Public Works (DPW) does not meter the water usage at each building and residence. However, the WSMR Golf Course is metered, and the downrange launch complexes including Oro Grande are metered at Launch Complex 38 beside the elevated water storage tank. The WSMR DPW furnished the water meter readings for the Golf Course, and off post LC 38 Range complex and Oro Grande (also known as Down Range). The historical data provided has been divided into three categories of water usage: Total Water Usage, Golf Course irrigation, and Down Range Usage.

1.2.1 Total water usage

All of the 15 wells used for the Main Post are continuously metered and documented in monthly meter reports. The annual totals of water withdrawn over the eight year period, from 2007 to 2014, is shown in Figure 4. The average withdrawal over the past eight years is 446 MGPY (1,369 ac-ft/yr). According to Andreoli et al. (1998), the average water withdrawal was 733 MGPY (2,249 ac-ft/yr) for the time period 1967 to 1992, so the recent average of 446 MGPY (1,369 ac-ft/yr) is much less. Of the 446 million gallons withdrawn annually, an average of 431.3 MGPY (1,324 ac-ft/yr) come from the Tularosa basin wells and 14.5 MGPY (44 ac-ft/yr) come from the Soledad Canyon area wells in the Hueco Basin. The Soledad Canyon wells are currently in need of repair, so their withdrawals have been relatively low in recent years. WSMR plans to repair these wells and pump a greater portion from the Soledad Canyon wells in the near future to more evenly distribute water withdrawals.

Figure 4. Recent well withdrawals for water supply to the WSMR Main Post

There is a strong seasonal pattern to the water withdrawals, as shown in Figure 5, with a typical increase of water use during the summer months and a typical decrease of water use in the winter months. Water withdrawals by calendar month vary from a June (high) average of 60 million gallons (184 ac-ft) to a December (low) average of 13 million gallons (40 ac-ft). Within the 2007 to 2014 time period, the greatest withdrawal during a single month was 88 million gallons (246 ac-ft), occurring in July of 2011.

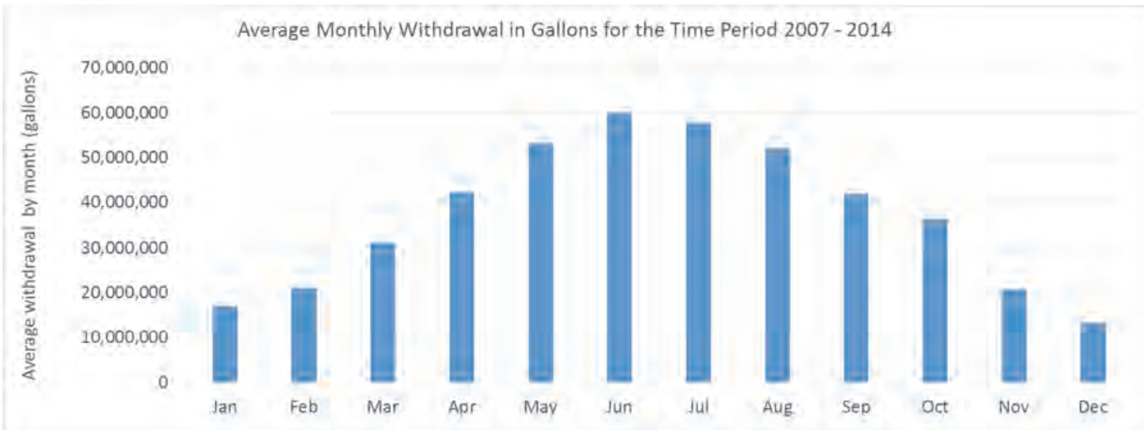

Figure 5. Average withdrawals by calendar month in gallons

Table 2 lists all of the groundwater supply wells used for the Main Post water delivery system, including their New Mexico Office of the State Engineer (NMOSE) File Number, the WSMR well ID, and the estimated average water withdrawal for the recent eight year time period from January 2007 through December 2014 based on the monthly meter reports.

Table 2. Ground water supply wells used for the Main Post water delivery system

NMOSE ID (File No.) [4]	WSMR well ID	Estimated average withdrawal for 2007-2014, gpm (MGPY)[1]
T-688	11	138 (72.5)
T-688-S	13	43 (22.5)
T-688-S-10	19	119 (62.8)
T-688-S-11	21	64 (33.5)
T-688-S-12	22	37 (19.7)
T-688-S-4	15	122 (64.4)
T-688-S-5	16	[2]
T-688-S-6	17	103 (54.2)
T-688-S-7	10	80 (41.9)
T-688-S-8	18	71 (37.6)
T-688-S-9	20	41 (21.8)
HU-151-S	Soledad 2	11 (5.9)
HU-151	Soledad 3	7.9 (4.1)
HU-151/HU-233	Soledad 4	3.8 (2.0) [3]
HU-151/HU-240	Soledad 5	4.7 (2.5) [3]

[1]Units of gpm are gallons per minute, and MGPY are millions of gallons per year.
[2]Well #16 was only used for WSMR water supply during one month in this period (3.5 MG in Nov. 2009).
[3]Soledad 4 and Soledad 5 were not used for water supply prior to 2011, so their averages are based on Jan. 2011 to Dec. 2014.
[4]Well labels with a "T" are in the Tularosa Basin and well labels with an "HU" are in the Hueco Basin.

1.2.2 Golf Course and irrigation

The WSMR DPW provided water meter readings for the meter measuring the water use at the WSMR golf course. The water is primarily used for irrigating the greens and fairways of the 11-hole golf course. The golf course uses 87.2 million gallons annually (268 ac-ft/yr), which is 20% of the total water withdrawn for the Main Post delivery system. Figure 6 shows the annual water usage, and Figure 7 shows the average golf course water use by calendar month. Using aerial pictometry from 2013, the maintained grass area of the WSMR Golf Course is approximately 81.5 acres, resulting in an average water use of 1,070,000 gallons per year per acre. This would be equivalent to irrigating the grassy area with 1.3 inches of water per week assuming a roughly 30-week irrigation season.

Figure 6. Annual water usage by the WSMR Golf Course

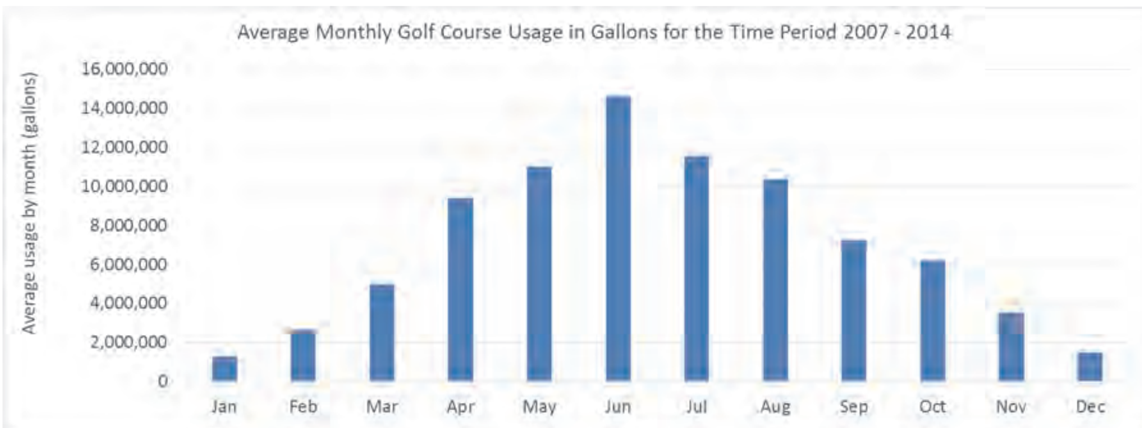

Figure 7. Golf course water usage by calendar month

There are also other irrigation areas in addition to the golf course, but these additional areas are not metered. In particular, the athletic fields at the Goddard Field, the WSMR school, and the Youth Sports Field are likely irrigated. The estimated area of the athletic fields is 33 acres according to the Jacobs/Huitt-Zollars (2009a) "Potable Water System Analysis" report. Using the same irrigation rate per acre as the WSMR Golf Course, this annual water use is estimated to be roughly 35,300,000 gallons per year (108 ac-ft/yr) which is used by irrigation of the athletic fields.

1.2.3 Downrange water usage

The water meter near the elevated storage tank near Launch Complex 38 measures the downrange water usage, including LC38 and Oro Grande. Monthly water meter readings for the downrange zone were provided by WSMR DPW. The yearly water usage of the downrange zone for the time period 2007 to 2014 is shown in Figure 8. Higher water usage by Oro Grande occurs during six months of the year when the staff is an estimated 303 people. For the other six months of the year the staff drops to an estimated 35 people, and lower water usage occurs during those six months. Increased water use in 2009 through 2012 was due to construction activities associated with the expansion of Oro Grande and would not be expected in the future. The average annual water use is 27.8 MGPY (85.3 ac-ft/yr). On average, the downrange water use is 6.2% of the total water withdrawn for the Main Post water delivery system.

Figure 8. Metered annual water usage by the downrange zone

1.2.4 Water usage for smaller systems

In addition to the wells used for the WSMR Main Post water delivery system, Table 3 summarizes the water usage for the smaller wells of WSMR.

Table 3. Water usage for smaller WSMR use wells

	Basin	Typical Annual Withdrawal, units of MGPY (ac-ft/yr)
Stallion Range Center	Rio Grande	8.4 (26)
Central Range	Tularosa	17.7 (54)
Construction wells	Tularosa	7.8 (24)
Wildlife wells	Tularosa	1.3 (4)

1.3 Gallons per Capita per Day (GPCD) analysis

One way to summarize the water use of the White Sands Missile Range Main Post system is to evaluate the gallons per capita per day (GPCD). The Main Post water delivery system withdraws an average of 431.3 MGPY (1,324 ac-ft/yr) from the Tularosa Basin and 14.5 MGPY (44 ac-ft/yr) from the Hueco Basin. The NMOSE requests that all water management plans include a calculation of the gallons per capita per day (GPCD), and tools are freely available on the NMOSE website for a standardized calculation of the GPCD. Using these tools from the NMOSE website, the GPCD calculator (v2.05) was implemented to determine the water use of the Main Post water system. Estimating the GPCD for the smaller well fields (e.g. Stallion Range Center, Central Range, etc.) was not feasible due to the lack of a residential population in those locations.

One challenge in estimating the GPCD for WSMR Main Post is determining the population. The WSMR Main Post population fluctuates significantly from year to year and most of the workforce does not reside within the WSMR. The 2010 census recorded 1,651 residents. However, the full workforce of WSMR is much larger; it was 6,932 in 2015 according to the official U.S. Army Stationing and Installation Plan (ASIP). Most of the workforce are not residents, and it is estimated from historic data that approximately one fourth of the workforce resides within the Main Post. There are also a relatively steady number of dependents, roughly 2,000, who also reside within the Main Post. The effective population is calculated by assuming that the non-residents work a typical 8-hour shift, or 1/3 of a 24-hour day, so the number of non-residents is divided by 3 in the GPCD calculation. Therefore the effective population is the number of residents plus one-third of the number of non-residents. Table 4 below lists the approximate effective population (using ASIP data) for each year of the time period 2007-2014. The average effective population was 4,171.

Table 4. Approximate Effective Population (2007-2014)

Year	ASIP Total Population	**Effective Population**
2014	8,932	**5,466**
2013	8,932	**5,466**
2012	5,728	**3,864**
2011	5,734	**3,867**
2010	5,740	**3,870**
2009	5,765	**3,883**
2008	4,913	**3,457**
2007	4,992	**3,496**
Average		**4,171**

Another challenge with estimating the GPCD is the lack of information available by water use category at WSMR. Here, the GPCD is based on the combined total of all commercial, industrial, and domestic water uses. The GPCD can be calculated by either the total water use subtracting only the water leaving downrange, or by also subtracting the estimates of leakage and irrigation. The following equations in Table 5 show the GPCD calculation. The overall GPCD, including all water uses, is 275. When subtracting the Golf Course irrigation, athletic field irrigation, and leakage, WSMR uses 170 GPCD. The overall summary of current water use is shown in Figure 9.

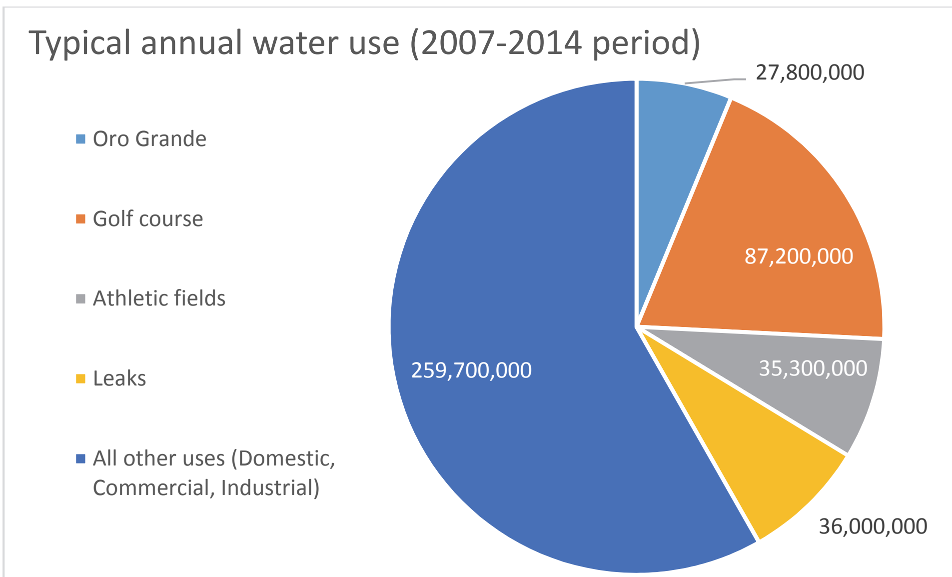

Figure 9. Average annual water usage

Table 5. GPCD Calculation Details

Including all water use categories			
Annual water usage:	446,000,000	Total water withdrawn	*[metered]*
	– 27,800,000	Water leaving downrange (Oro Grande)	*[metered]*
Subtotal:	418,200,000	All water usage	
	÷ 4,171	Effective Population	
GPC per year	100,264		
GPCD	275		

Subtracting irrigation and leakage			
Annual water usage:	446,000,000	Total water withdrawn	*[metered]*
	– 27,800,000	Water leaving downrange (Oro Grande)	*[metered]*
	– 87,200,000	Golf Course irrigation	*[metered]*
	– 35,300,000	Other irrigation (including athletic fields)	*[estimated]*
	– 36,000,000	Leakages	*[estimated]*
Subtotal:	259,700,000	All other water uses (commercial, industrial, domestic)	
	÷ 4,171	Effective Population	
GPC per year	62,263		
GPCD	170		

2 Existing and future conservation efforts

2.1 Description of existing water conservation programs

Several Executive Orders and Laws have been passed the past few years that address water conservation. EPAct 2005 mandates that water conservation technologies must be included whenever their life-cycle water conservation is cost-effective. Executive Order 13423 mandated that water consumption intensity must be reduced 2% annually through the end of FY15. Executive Order 13514 mandates that water consumption intensity be reduced by 2% annually thru FY20 or 26% by the end of FY20. It also mandates that beginning FY10, industrial, landscaping, and agricultural water consumption be reduced by 2% annually or 20% by the end of FY20 relative to a FY10 baseline. Implementation guidance from the U.S. Department of Energy (DOE) set a requirement for each federal agency to reduce potable water usage by implementing life cycle, cost effective water efficiency programs that include a water management plan, and a minimum of four Federal Energy Management Program (FEMP) Best Management Practices (BMPs). The new goal is no longer for installations to develop and submit four of the ten best management practices (BMPs) but to utilize as many BMPs required to achieve the mandatory water conservation intensity (efficiency) goal of 2% annually.

WSMR has developed a water conservation plan (WSMR 2013) to reduce water consumption through the implementation of multiple strategies into operational and facility plans. This plan aims to gain full compliance with Executive Orders 13423 and 13514 and to follow EPAct 2005 by incorporating water conservation technologies through Life-Cycle Cost effective and associated U.S Department of Energy (DOE) implementation guidance on behalf of White Sands Missile Range (WSMR), USA. To develop the plan WSMR personnel relied upon a process defined in the *Air Force Water Conservation Guidebook*, published by HQ Air Force Civil Engineer Support Agency in May 2002 (CH2M Hill, 2002). Much of the content in this section mirrors the WSMR Final Draft Water Conservation Report (WSMR 2013).

2.1.1 Supply-side conservation programs

2.1.1.1 Stormwater Low Impact Developments (LID)

Since FY12, WSMR DPW Engineering Section is implementing projects for the repair/upgrade of storm drains based on the "2009 Infrastructure Report--Storm Water Drainage Study for BCT" (Jacobs/Huitt-Zollars 2009b). Critical drains were identified and prioritized, and the upgrade sizes were recommended. WSMR incorporates low impact development (LID) structures in compliance with the Deputy under Secretary of Defense (DUSD) Memorandum dated 19 Jan 10 and Army Policy directing the implementation of the Energy Independence and Security Act Section 438 (DUSD Memo 2010) on sustainment, restoration, and modernization projects disturbing more than 5,000 square feet of land.

WSMR has designed a few bioretention basins; one has been constructed, one is under construction and two have been designed but not constructed. The typical LID is to implement vegetated swales and channels. These improvements remove asphalt lining of the channels and re-establish natural vegetative surfaces. In general, the projects allow the stormwater to slow down and infiltrate into the soil, which reduces the runoff and recharges the aquifer.

WSMR is also requesting implementation of LID best management practices on parking lot improvement projects disturbing more than 5000 sf.

2.1.1.2 Saltcedar Removal

Over the past three years (FY14, FY15, and FY16), WSMR has treated a total of 250 acres for saltcedar tree removal. According to the U.S. Department of Agriculture Forest Service Field Guide for Managing Saltcedar (USDAFS 2014), the saltcedar tree is an invasive plant which has been listed as a noxious weed in the state of New Mexico. Saltcedars have multiple negative impacts to the local hydrology:

- Evapotranspiration rates are higher than native riparian species, reducing the amount of water available for aquifer recharge.
- Leaf drop of the saltcedars increases the salinity of the soil and lessens microbial activity.

Since mortality of saltcedars takes 2 to 4 years, WSMR has been focused on the same treatment areas for the past three years. These areas are shown in Figure 10. In the fall of 2016, WSMR plans to begin new treatments at Malpais and Mound Springs. If WSMR continues to receive funding for this effort, treatments will also begin along Salt Creek in 2017.

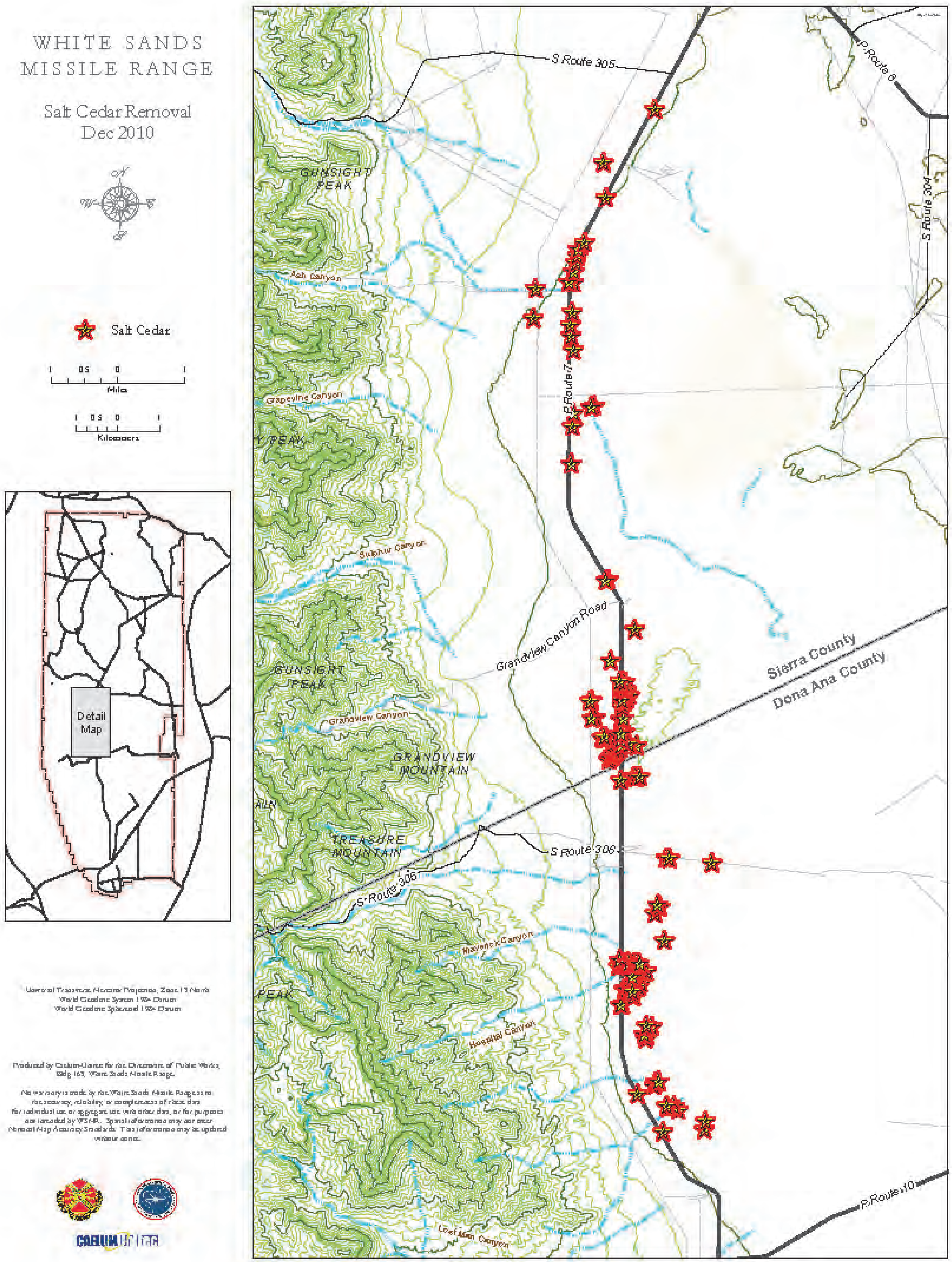

Figure 10. Map of some of the saltcedar treatment locations within WSMR

2.1.2 Demand-side conservation programs

Implementation guidance from the U.S. Department of Energy (DOE) set a requirement for each federal agency to "reduce potable water usage by implementing life cycle, cost effective water efficiency programs that include a water management plan, and not less than four Federal Energy Management Program (FEMP) Best Management Practices (BMPs)". Four implemented BMP's have been selected for the purpose of summarizing the conservation programs within this water management plan.

List of BMP's implemented by WMSR

1. Public information and education programs
2. Water efficient landscaping
3. Boiler and steam systems
4. Cooling tower management

2.1.2.1 Public information and education programs

The benefits and cost-effectiveness associated with this BMP were readily obvious and required practically no analysis to justify implementation. Utility districts implementing Public Information and Education programs report average annual savings between 10 and 15 percent of total water use. A public information and education program can provide a strong foundation for all water conservation efforts at WSMR. Implementation can largely be achieved through currently established public information vehicles at little or no cost. To implement this BMP and to receive proper credit, WSMR has:

- Published articles in the Post newspaper that promote water conservation.
- Developed water conservation rules as part of the Building Energy Monitor (BEM) program.
- Informed the BEM to have service orders submitted to the Garrison Service Order Office.

2.1.2.2 Water efficient landscaping

The landscape irrigation requirement for WSMR is a large portion of the total water demand. The Air Force Water Conservation Guidebook (CH2M Hill, 2002) advises installations with an irrigation requirement in excess of 10% to implement the following operations and maintenance (O&M) options: verify irrigation schedules are appropriate, monitor / inspect irrigation systems for effectiveness, and check service order reports (see Section 2.1.2.1) for any irrigation system problems. WSMR has taken appropriate steps to implement these O&M options. Building Energy Monitors (BEMs) have been provided with water conservation rules. The existing turf areas watered by the grounds maintenance contractor are watered between 10:00 PM and 4:00 AM except areas where they have to water manually, those may be watered at any time. The service contract also covers maintenance of the irrigation systems. Additionally, WSMR is also doing the following to expand on this BMP:

- Xeriscaping (landscaping that reduces or eliminates the need for irrigation) of existing grass areas will continue as funding becomes available.
- The Building Energy Monitor (BEM) Program will be expanded to include more buildings and landscaped areas.
- New construction is designed using native plants and Leadership in Energy and Environmental Design (LEED) Silver requirements (Silver is a level of certification within the LEED system).

All of the recreational areas in the housing area with grass already have automated sprinkler systems installed. The White Sands Missile Range Design Guide calls for native plants for all new landscaping. The installation is in the planning stages to convert to natural landscaping at existing facilities that have turf and non-native plants as funds become available. Therefore, WSMR claims credit for water conservation purposes for implementing this BMP.

2.1.2.3 Boiler and steam systems

Operation and maintenance (O&M) activities for boiler and steam systems are governed by the Directorate of Public Works. WSMR complies with the operation and maintenance guidelines of boiler and steam systems. Retrofit/replacement options for boiler and steam systems were studied by Siemens as part of the Energy Savings Performance Contract (ESPC) with WSMR. Potential projects were developed and one will potentially be implemented. It involves replacing existing inefficient electric boilers with new premium efficient natural gas boilers. Based upon the implementation of O&M options, and the possible favorable economics of retrofit/replacement options, WSMR claims credit for water conservation purposes for implementing this BMP.

2.1.2.4 Cooling tower management

Similar to the boiler and steam systems BMP, WSMR complies with the guidelines in the operation and maintenance of cooling towers. Retrofit/replacement options for this BMP have been implemented at Building

335 which had new cooling towers installed in FY12. Based upon the implementation of O&M options, WSMR claims credit for water conservation purposes for implementing this BMP.

2.1.3 Documented or estimated results from programs that have been implemented

Overall water withdrawals for the WSMR Main Post water system (Tularosa and Hueco basins) have dropped to 394 million gallons (1,209 ac-ft) in 2013 and 286 million gallons (878 ac-ft) in 2014, compared with an average of 446 MGPY (1,369 ac-ft/yr) over the 2007 to 2014 time period.

The estimated benefit of the public information and education programs BMP is 10 to 15% of water usage (see Section 2.1.2.1). This BMP is therefore estimated to save at least 44.6 million gallons (137 ac-ft) annually.

The amount of landscaping which has been converted from irrigated grass area to xeriscaping area was calculated using aerial photometry from 2013 and infrared imagery from 1985. The estimated area of maintained grass landscape was 365 acres in 1985. In 2013, the maintained grass area is 153 acres. The reduction in maintained grass landscape is 212 acres, or 58% since 1985, which is a very large water savings.

2.2 Description of future water conservation programs

2.2.1 Implementation schedules (short and long-term) of planned conservation activities

2.2.1.1 Distribution system audits, leak detection, and repair

The annual estimate of water lost due to leaks is 36,000,000 gal (110 ac-ft), or 8 percent of WSMR's total annual water production, according to Jacobs/Huitt-Zollars (2009a). With an incremental cost of water of $1.36 per Kgal, a loss of this amount costs the installation approximately $48,960.00 annually. On average, a leak detection survey and repair program could result in a savings of at least 25 percent of estimated losses. This would translate into an annual savings of $12,240.00. The estimated cost for a leak detection survey ranges from $100 to $200 per mile of main, and with WSMR having 250-miles of water main the estimated total cost to the installation would be $50K at the most. The simple payback period would be $50,000/$12,240 = 4.08 years (Note: the cost of repairing leaks identified by the survey are not counted as implementation costs but rather as routine O&M costs associated with water system operations).

According to the Air Force Water Conservation Guidebook (CH2M Hill, 2002), BMPs with a simple payback of less than ten years should be deemed cost effective for implementation. Therefore, this BMP is judged cost effective for implementation at WSMR.

2.2.1.2 Toilets and urinals

A large portion of the toilets and urinals in service at WSMR have been on the installation for several years; these toilets typically consume 4.0 gpf and urinals 1.0 gpf. WSMR performed a detailed calculation of the cost-effectiveness for replacing toilets and urinals with low-water use features. The cost of replacing the toilets and urinals was very high compared to the amount of money saved by lower water use. The simple payback period was 44 years, which is much higher than the ten years or less recommendation in the Air Force Water Conservation Guidebook (CH2M Hill, 2002). Hence it was not recommended that toilet and urinal replacements be pursued, because the simple payback period is 44 years. However, low-water use plumbing fixtures are being recommended for all new construction projects. The current estimated rate of low-water use plumbing fixtures installed for any new construction is 90%.

The ESPC Contractor recommends installing flushometers which restrict the flow in existing fixtures. The payback is better with that technology, and this option may be pursued by WSMR at a later date.

2.2.1.3 Faucets and showerheads

A series of plumbing retrofits/replacements has replaced older, inefficient faucets. Given the average age of facilities at WSMR is 36 years, the average faucet flow rate was typically 2.5 gallons per minute (gpm) and the typical showerhead flow rate was 3.0 gpm. Seeing the potential for significant and cost-effective savings, WSMR elected to target the lavatory faucets for retrofit with aerators that reduce the flow rate to 0.5 gpm. Because of the relatively small number of showerheads in use in administrative facilities (i.e., laboratories), it was decided to exclude showerheads from the retrofit program at this time.

A detailed calculation of the expenses of retrofitting faucets with aerators, and the cost savings of the reduced water use, results in a 0.6 year payback period. In addition to the water savings there is also energy savings associated with consuming less hot water from lavatory faucets. Statistics indicate that 50 percent of the water used from a lavatory faucet is hot water. Adding energy savings will only enhance the payback period of this BMP. This simple payback of less than ten years indicates this will be a cost effective BMP according to the

Air Force Water Conservation Guidebook (CH2M Hill, 2002). It is recommended that faucet retrofits be pursued sometime within the next few years.

2.2.1.4 Smart meters

WSMR has received funding to install "Smart" water meters around the Main Post area. These water meters will provide valuable information about the spatial locations of high water usage. A strategic approach of implementing smart water meters is to identify specific areas where water usage can be improved and to track the progress toward greater water use efficiency. The water meters are planned to be installed beginning in 2017.

2.2.2 Financing methods of implementing future water conservation programs

The implementation of the previously mentioned BMP's will be performed only as funding is available. Funding for the smart water meters has already been planned, and that BMP is expected to occur by the end of 2017. Funding will be sought for the other mentioned programs through an Energy Saving Performance Contract or the Energy Conservation Investment Program.

Since leak detection surveys are not funded under an Energy Savings Performance Contract (ESPC), another funding avenue will be required to conduct the survey. Leak detection surveys have historically been found to be cost-effective at Army installations, but funding obstacles make the surveys difficult to execute. Hence, a strategy must be developed for WSMR to budget or otherwise request funds for performing the survey if the installation is to receive credit for implementing this BMP.

2.2.3 Anticipated results of each program

The anticipated results of the smart meter installation and the distribution system audits, leak detection, and repair are expected to be at least a 25% reduction in the estimated leakage. Therefore, this is anticipated to reduce the overall water use by 9 MGPY (28 ac-ft/yr).

The retrofitting of the WSMR lavatory faucets, about 140 in total, with aerators is anticipated to reduce the overall water use by 2.9 MGPY (9 ac-ft/yr).

2.2.4 Statement of future GPCD

The calculation of future GPCD is based on a slight fluctuation in population (see Section 3) and an expected reduction in water use due to public information and education programs (45 MGPY or 137 ac-ft/yr), retrofitting lavatory faucets (2.9 MGPY or 9 ac-ft/yr), and the repairing of leaks (25% once each 10 years). In addition, the U.S. Navy plans to increase their water use from WSMR wells by 2 MGPY (6 ac-ft/yr) within the next few years due to an expected population and mission expansion. The biggest factor in reducing the future GPCD is the estimated impact of the public information and education programs. Under these future water use assumptions, Table 6 shows that the overall GPCD is expected to decrease from 222 GPCD to 204 GPCD over the next 40 years. The main reason that the GPCD does not reduce further is that the irrigation water use is not assumed to decline. The GPCD calculated after subtracting major irrigation and leakages, as was also done in Table 5, is projected to decrease from 138 GPCD to 103 GPCD 40 years from now. The overall water use is expected to decline over the next 40 years, decreasing from 446 MGPY (1,369 ac-ft/yr) to 298 MGPY (915 ac-ft/yr). The next section of this report discusses the expected future population changes in more detail, including the potential for large fluctuations in population.

Table 6. Estimated Future GPCD

	Effective Population	Total Well Withdrawals (Mgal)	Oro Grande (Mgal)	GPCD (including all water use categories)	Leakage and Irrigation (Mgal)	GPCD (subtracting leakage and irrigation)
2016	5163	446	27.8	222	158.5	138
2026	4610	363	27.8	199	149.5	110
2036	4189	335	27.8	201	142.8	108
2046	3865	314	27.8	203	137.7	105
2056	3617	298	27.8	204	133.9	103

3 Projected Future Population

3.1 Projections to support amount requested

The U.S. Census Bureau has population data for White Sands Missile Range, NM available for 1990, 2000, and 2010. These populations are shown in Table 7.

Table 7. Population data from U.S. Census Bureau for 1990, 2000, and 2010

1990	2000	2010
2,616	1,323	1,651

The U.S. Census Bureau statistics do not reflect the total workforce of WSMR, which is much larger than the resident population. The total workforce is roughly 4 times the resident population. Therefore, another method is used below to estimate the population for the purpose of estimating water demands.

The U.S. Army has its own Master Plan of staffing requirements. The staffing levels at WSMR fluctuate from year to year. Over the next five years, the U.S. Army is expected to experience a temporary downward change in the staffing level required at the WSMR.

However, WSMR is a likely candidate for relocation and consolidation due to its large area. In the case of an Army consolidation effort to WSMR, the population of WSMR could increase significantly, up to a workforce of approximately 19,400 (effective population 9,600). This size of a workforce would have a water demand of roughly 800 MGPY (2,455 ac-ft/yr), similar to the historic high water demand of 939 million gallons (2,882 ac-ft) which was beneficially used in 1971 (a time when the facilities and capabilities of WSMR were rapidly expanding). Additionally, WSMR always has a potential of having a large fluctuation of up to an additional 4,000 soldiers and military personnel arriving to WSMR, which may require a further expansion of the infrastructure. As will be noted in Section 5, it is important for WSMR to maintain its unused water rights in order to maintain adequate water quality and to be fully prepared for possible U.S. Army increased staffing scenarios.

3.2 Population projections customarily used by applicant for other general planning efforts

The U.S. Army uses the Army Stationing and Installation Plan (ASIP) as a source for historic and future population data. These are more accurate for WSMR than generalized population projections for the area.

3.3 If not relying on U.S. Census Bureau (UNM-BBER) data, provide supporting documentation

The U.S. Army uses the ASIP as a source for historic and future population data. The population projections typically extend 7 years into the future. The projected workforce population of WSMR for 2016 to 2022 is shown in Table 8. The average change is a 2.6% decline in workforce per year. However, the population for 2020, 2021, and 2022 is expected to remain steady. From all discussions with WSMR staff, the workforce is expected to fluctuate around its current level. For these reasons, this report will use two possible population projections, one which is expected to decline from 2022 to 2056 by 2.6% per year and another which is constant from 2022 to 2056.

Table 8. Officially Projected Workforce Population of WSMR

2016	2017	2018	2019	2020	2021	2022
6,326	5,898	5,669	5,631	5,624	5,624	5,624

3.4 Statement of future population

A summary of the expected future population for a 2.6 percent annual decline is shown in Table 9 and for steady population levels is shown in Table 10. However, these numbers could vary significantly if WSMR is chosen as an Army consolidation location, which could increase a workforce of approximately 10,000 using the current infrastructure. This would be a similar staffing level as was experienced in the 1970's and 1980's at WSMR. Additionally, WSMR has a potential of receiving a large fluctuation of soldiers and military personnel. It is important for WSMR to maintain its unused water rights in order to preserve adequate water quality and to be fully prepared for possible U.S. Army increased staffing scenarios.

Table 9. Projected future population of WSMR with 2.6% annual decline

	2016	2026	2036	2046	2056
Estimated Workforce	6,326	5,220	4,378	3,731	3,234
Resident	3,582	3,305	3,094	2,933	2,808
Non-resident	4,745	3,915	3,283	2,798	2,425
Effective Population	5,163	4,610	4,189	3,865	3,617

Table 10. Projected future population of WSMR with steady population levels

	2016	2026	2036	2046	2056
Estimated Workforce	6,326	5,624	5,624	5,624	5,624
Resident	3,582	3,406	3,406	3,406	3,406
Non-resident	4,745	4,218	4,218	4,218	4,218
Effective Population	5,163	4,812	4,812	4,812	4,812

4 Statement of Anticipated Demand

4.1 Calculation of future demand based on future GPCD and future population

The future water demand of WSMR is expected to decrease from the current demand due to water saving BMP's and possible fluctuations in population. Therefore, WSMR will not need to obtain further water rights, only to continue using the current water rights.

In the event of a possible U.S. Army consolidation to WSMR and/or the arrival of a large fluctuation of soldiers, the population of WSMR could increase significantly. However, WSMR has sufficient water rights to accommodate both of these types of future water demand expansions. Under these scenarios, the approximate water demand could be approximately 800 MGPY (2,455 ac-ft/yr). Historic pumping has demonstrated beneficial use of 939 MGPY (2,881 ac-ft/yr) in 1971. The Main Post well field (the wells listed previously in Table 2) is permitted under NMOSE 688 through T-688-S12 to yield 6,916,000,000 gallons per year (21,224 ac-ft/yr) with a declared water right. Water rights information is described in more detail in Section 5.1. Additionally, the Soledad Canyon well field is permitted to yield 735 MGPY (2,258 ac-ft/yr) under H-151 of NMOSE. It is important for WSMR to maintain unused water rights in order to preserve adequate aquifer water quality and to be fully prepared for possible U.S. Army increased staffing scenarios.

Although water withdrawals for the WSMR Main Post water system are expected to decline in the future, withdrawals at the Stallion Range Center, the Central Range, and the construction wells are not expected to decrease. From the available planning estimates, WSMR expects to continue, or possibly increase, the use of water for construction purposes. An increase of water demand for construction activities could increase withdrawals from the construction wells, the Stallion Range Center wells, or the Central Range wells. The GPCD analysis is not feasible for these wells because of their use category and the lack of residential population.

4.1.1 Description of any mandates requiring developers in Applicant's jurisdiction to obtain water rights for development

This section is not applicable. The U.S. Army abides by the State of New Mexico procedures to properly apply for any significant changes to its current wells or any new installations of wells. WSMR's historic water rights, as a whole for the entire installation (or the totals by basin), are greater than the current and future water demand.

4.1.2 Additional demand forecasts, if available

This section is not applicable.

4.2 Alternative statement of demand for Applicants who are non-drinking water suppliers or where use of GPCD would otherwise be inappropriate

This section is not applicable.

4.3 Demonstration that the future demand projections do not constitute a "self-fulfilling" prophesy; must recognize that absence of water is a limitation on growth

This section is not applicable because the future demand is expected to decrease.

5 Discussion of Water Availability

5.1 Water Rights Information

The WSMR water rights are officially recognized by the State of New Mexico and filed within the New Mexico Water Rights Reporting System (NMWRRS). According to the NMWRRS database, the water rights for WSMR are 6.9 billion gallons per year (21,224 ac-ft/year) and are seen as a combined total of the following list of wells: T-550, T-688, T-688-S, T-688-S-2, T-688-S-3, T-688-S-4, T-688-S-5, T-688-S-6, T-688-S-7, T-688-S-8, T-688-S-9, T-688-S-10, T-688-S-11, T-688-S-12, HU-151, HU-151-S, HU-151/HU-233, and HU-151/HU-240 as shown in Table 11. Some individual limitations exist within the NMWRRS, such as the combined total of the Soledad Canyon wells HU-151, HU-151-S, HU-151/HU-233, and HU-151/HU-240 can only withdraw 736 million gallons (2,258 ac-ft) in any given year. The exact wording within one of the recent water rights summary reports (file "T 00688 528058 2286787") is:

> "The total combined shall not exceed 21,224 acre-feet per annum from wells T-688 et. al. and T-550. The quantity of water diverted shall be further limited to the amount required for beneficial use for municipal and industrial purposes associated with White Sands Missile Range."

Table 11. Water rights of Main Post water supply wells

Well field name	Wells ("T": Tularosa Basin, "HU": Hueco Basin)	Water rights, ac-ft/year
Main Post Water Supply wells	T-550, T-688, T-688-S, T-688-S-2, T-688-S-3, T-688-S-4, T-688-S-5, T-688-S-6, T-688-S-7, T-688-S-8, T-688-S-9, T-688-S-10, T-688-S-11, T-688-S-12, HU-151, HU-151-S, HU-151/HU-233, and HU-151/HU-240	Overall total shall not exceed 21,224
Soledad Canyon wells	HU-151, HU-151-S, HU-151/HU-233, and HU-151/HU-240	Combined total of these wells shall not exceed 2,258

According to WSMR's well records, the maximum total amount of water beneficially used in one year by WSMR within the T-688 well system was 939 million gallons (2,881 ac-ft), occurring in 1971. The greatest amount of water beneficially used in one year from the HU-151 well system was 401 million gallons (1,231 ac-ft), occurring in 1993.

WSMR has a Memorandum of Understanding with the Fort Bliss U.S. Army post that Ft. Bliss has water rights to use 33% of the water withdrawn from the Soledad Canyon area wells, since those wells are located within Ft. Bliss. This Down Range water usage goes to Oro Grande, which is part of Ft. Bliss, and is approximately 27.8 MGPY (85 ac-ft/year). The quantity of water being shared with, and beneficially used by, Ft. Bliss is more than the agreed upon 33% of the water withdrawn from the Soledad Canyon area wells. In the event of a water shortage at Ft. Bliss, WSMR would likely increase the amount of water shared with Ft. Bliss.

WSMR needs to maintain its unused water rights in order to be prepared for possible military reconsolidation and to preserve the water quality of the aquifer. If unused water rights were to be taken from WSMR and used by others, the water quality of the entire groundwater aquifer would be negatively impacted. An increase in the salinity, or brackish water, at the wells used for WSMR water supply would be problematic, because it would require expensive treatment options to make the water potable. More information about the groundwater aquifer is available in Section 5.2.2.

Water rights for the smaller well field systems and construction wells are summarized in Table 12.

Table 12. Water rights information for the smaller well fields of WSMR

Well field name	**NMOSE ID wells ("RG": Rio Grande Basin, "T": Tularosa Basin)**	**Water rights, ac-ft/year**
Stallion Range Center	RG-66540, RG-66540-S, RG-66540-EXPL	1,261.9
Central Range	T-00550, T-00550-D, T-00550-POD2, T-00550-S	100
	T-01570, T-01570-S, T-01570-S-2, T-01570-S-3, T-01570-S-4	2,891
	T-02170	134
Construction wells	RG-94945 POD 1	3
	T-02073	20

	T-01497	1,401
	T-03602	376.4
	T-04087	3
	T-03634	3
	T-05570	3

WSMR is going through the process with the State of New Mexico of publishing an additional construction well, T-06102, with water rights of 330 ac-ft/year. Well T-06102 is located in the Socorro-Sierra basin. Well T-06102 is not expected to increase the total construction water usage, but it is expected to allow for redistributing the construction water usage from other wells.

5.1.1 Availability of unappropriated water, or if a transfer, the validity of the move-from water rights

This section is not applicable. WSMR has the water rights outlined above.

5.1.2 Statement of application's effect on tribal, pueblo, and native water right interests

This section is not applicable. There is no known or foreseen effect on tribal, pueblo, or native water rights interests.

5.2 Hydrology Information

5.2.1 Surface water availability analysis

This section is not applicable since there are no reliable surface water sources available for WSMR water supply.

5.2.2 Groundwater availability analysis

The hydrology and groundwater interactions were analyzed to determine their long-term safe yield. The long-term safe yield represents the pumping amount which balances the expected natural recharge to the aquifer and also considers the prevention of saline intrusion. Much of the analysis included within this report is from a recent 2009 study (Jacobs/Huitt-Zollars, 2009c), which has been validated with data and observations since that time. All of the WSMR Main Post supply wells access fresh groundwater, defined as having less than 1,000 milligrams per liter of total dissolved solids content, and there have not been any reported instances of saline intrusion within the WSMR wells. Some of the other

WSMR wells (those not used for the WSMR Main Post water supply) do not have as high of water quality as the Main Post well field. The Stallion Range Center applies a reverse osmosis system to reduce the total dissolved solids to an acceptable level. Other wells (e.g. construction wells) also withdraw water which does not meet drinking water quality standards but is acceptable for construction purposes.

The general aquifer framework of WSMR is made up of mountain bedrock to the west consisting of consolidated igneous and sedimentary rocks and a basin to the east of the bedrock consisting of unconsolidated gravel, sand, silt, and clay (Risser, 1988; Jacobs/Huitt-Zollars, 2009c). The bedrock has generally very low permeability, except where there are fractures in the bedrock which transmit recharge into the basin fill from precipitation that falls on the mountains. The basin fill contains the primary aquifer for WSMR.

There are two primary fault zones near the WSMR well field. The Organ Mountain Fault zone and the Artillery Range Fault zone are shown in Figure 11. Wells near and west of the Organ Mountain Fault zone typically have poor yield (Jacobs/Huitt-Zollars, 2009c). The majority of the Main Post water supply wells are east of the Organ Mountain Fault zone. The Soledad Canyon supply wells are east of the Artillery Range Fault zone where basin fill is thick and well yield is high.

The basin-fill sediments were deposited by erosion and transport from the adjacent mountains to alluvial fans, sheet wash deposits, and playa lakes. Sediments are generally coarse-grained along the mountain front and fine-grained toward the basin center (Risser, 1988; Jacobs/Huitt-Zollars, 2009c). The grain size also generally decreases with respect to depth. Sediments along the mountain front contain discontinuous lenses of gravel, sand, silt, and clay; as a result, groundwater prefers to flow laterally and is less likely to flow vertically due to aquifer stratification. Basin-fill sediments become more stratified toward the basin center, with thinner sequences of sand and thicker sequences of clay.

Groundwater generally flows west to east from the recharge areas along the mountain to the basin fill and then typically turns south towards Fort Bliss and the Hueco Basin due to the density differences between this freshwater and the saltwater to the east (Risser, 1988). Some freshwater continues traveling east to mix with the saline groundwater, creating a zone of dispersion between the different density fluids. Hydraulic conductivity is low in the bedrock, 0.1 to 3.0 ft/day, and higher in the basin fill, 1.0 to over 200 ft/day (Jacobs/Huitt-Zollars, 2009c). The median hydraulic conductivity in the basin fill is approximately 6.8 ft/day. Vertical upwelling of saline groundwater due to pumping is not a concern because of aquifer stratification and preferential horizontal flow over vertical flow. To ensure the greatest protection from saline intrusion, pumping should be spread along the mountain front and the drawdown limited.

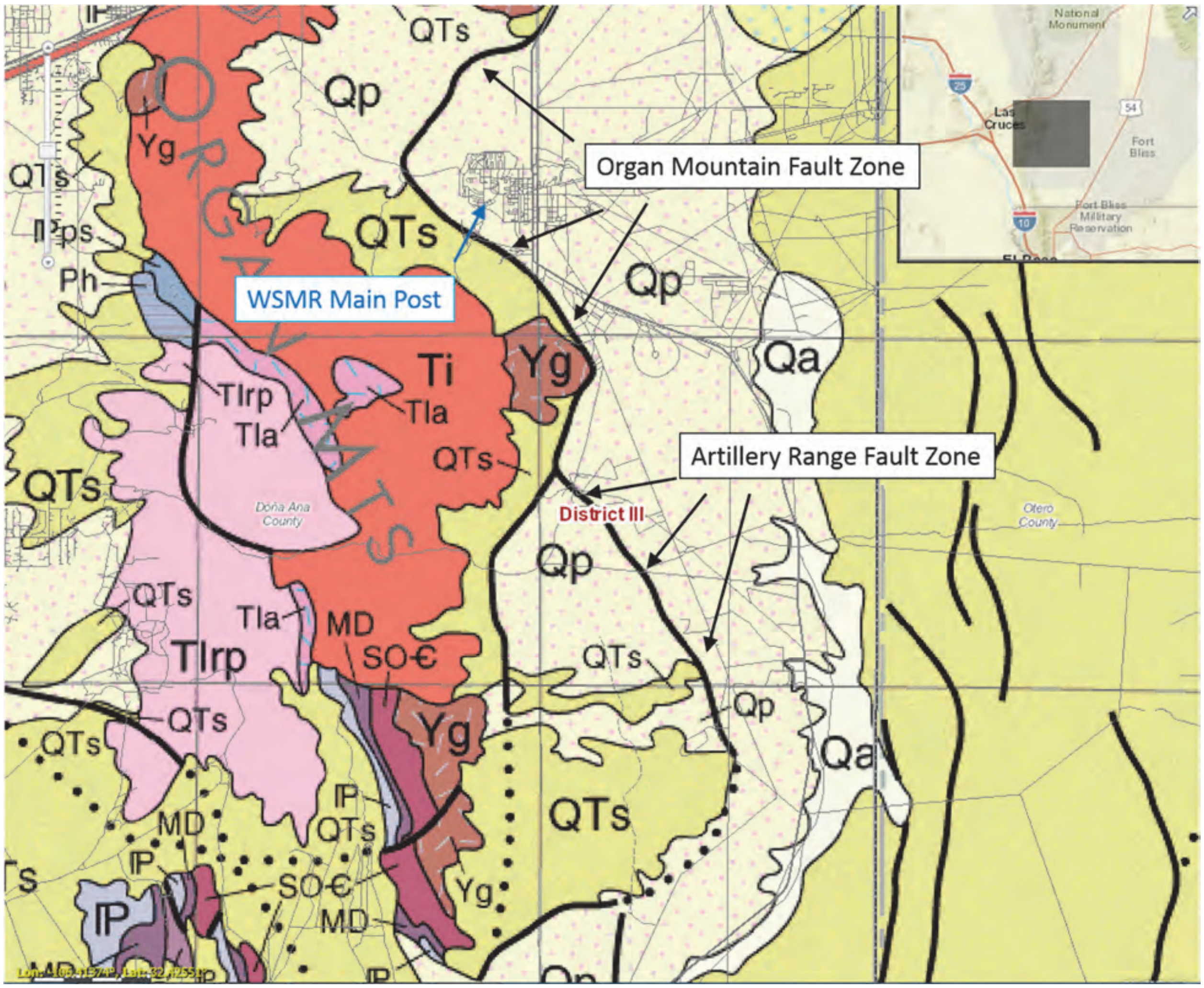

Figure 11. Fault zones near WSMR (USGS)

Groundwater recharge maintains the elevation difference (about 150 ft) between the Main Post well field and saline groundwater to the east. A range of aquifer recharge estimates exist from previous studies of the WSMR hydrogeology. Each of the recent studies (Jacobs/Huitt-Zollars, 2009c; North Wind, 2013) point to the work of Risser (1988) as a foundational estimate in understanding the aquifer recharge. Risser (1988) estimated that 1,140 ac-ft/yr recharged the Main Post well field and 500 ac-ft/yr recharged the Soledad Canyon well field. The Risser

(1988) estimate of 1,140 ac-ft/yr was very similar to the previous estimate of Kelly and Hearne (1976) of 1,300 ac-ft/yr for the Main Post well field. The Kelly and Hearne (1976) estimate was equivalent to 3% of the precipitation which fell onto the 52 square mile watershed at the Main Post becoming recharge. Jacobs/Huitt-Zollars (2009c) used a recharge estimate of 1,920 ac-ft/yr for the combined Main Post and Soledad Canyon wells based on a larger drainage area than used by Risser (1988) to include the mountain block drainage. In addition to this recharge, Risser (1988) stated that a portion of the water withdrawn and beneficially used by WSMR also recharges back into the aquifer. This type of recharge comes from a portion of irrigation for the Golf Course and athletic fields, leakage, and the treated wastewater effluent. The combined total recharge from these additional sources is roughly 30% of the water withdrawn (Risser, 1988; Jacobs/Huitt-Zollars, 2009c). 30% of the average water withdrawn for the Main Post water system is approximately 410 ac-ft/yr. The total recharge estimate of the Jacobs/Huitt-Zollars (2009c) analysis was 2,330 ac-ft/yr. However, North Wind (2013) estimated that none of the water withdrawn by WSMR becomes aquifer recharge but rather evapotranspiration. North Wind (2013) calculated a range of 900 – 1600 ac-ft/yr for the estimated aquifer recharge to the Main Post well field (not including the Soledad Canyon area recharge) based on runoff and hydraulic conductivity.

Based on the available groundwater studies and assessments of the groundwater monitoring data near the WSMR wells (shown in the Appendix, Section 9.3.2), this water development plan projects a safe long term yield over the next forty years of 482 MGPY (1,480 ac-ft/yr) for the Main Post well field and 163 MGPY (500 ac-ft/yr) for the Soledad Canyon well field for a total of 645 MGPY (1,980 ac-ft/yr) for the Main Post water system. The Main Post well field recharge estimate is calculated from an average of the Kelly and Hearne (1976), Risser (1988), Jacobs/Huitt-Zollars (2009c), and North Wind (2013) estimates plus 15% of withdrawals. Well withdrawals greater than 645 MGPY (1,980 ac-ft/yr) from the Main Post and Soledad Canyon well fields may cause water levels within the aquifer to slightly decline over time. The Jacobs/Huitt-Zollars (2009c) groundwater model estimated that a higher annual usage of 782 MGPY (2,400 ac-ft/yr), where 619 MGPY (1,900 ac-ft/yr) is pumped from the Main Post well field and 163 MGPY (500 ac-ft/yr) is pumped from the Soledad Canyon well field, may result in an approximate lowering of 18 - 28 feet of the aquifer drawdown at the Main Post well locations after 40 years. This would also result in a drawdown approximately 9 feet lower in the Soledad Canyon aquifer after 40 years.

The total WSMR water withdrawals (446 MGPY, 1369 ac-ft/yr) are less than the safe long-term yield. Since the projected future demand is likely to decline, the groundwater availability is sufficient. In the scenario of a U.S. military reconsolidation or large fluctuation of soldiers causing a significant increase to WSMR's water usage, the safe long-term yield of 645 MGPY (1,980 ac-ft/yr) would be kept in mind. Water withdrawals as high as the 1971 level, 939 MGPY (2,881 ac-ft/yr), are expected to lower the aquifer water levels. The pattern of aquifer decline from the high water demand of the 1970's is visible in many of the observations in Appendix Section 9.3.2. Most of the water levels have rebounded since that time period. There are significant fluctuations in the water levels due to changes in withdrawals at each well from year to year. Changes in regional precipitation also cause significant fluctuations in aquifer water levels. Relocation of a couple of wells to other areas along the mountain front could also assist with reducing the magnitude of the drawdown.

5.2.3 Return flow planning/Reuse availability

The treated effluent from the wastewater treatment plant, located about 3 miles southeast of the Main Post, flows by gravity into an unlined free water surface area named Davies Tank, encompassing approximately 225 acres. Davies Tank absorbs the inflows through infiltration into the ground or evaporation. The option of reusing treated effluent for irrigating the WSMR Golf Course has been discussed on multiple occasions. Since the wastewater effluent is located at a significantly lower elevation than, and a large distance from, the golf course, the energy and infrastructure expenses are not expected to be cost-effective. WSMR is currently exploring the possibility of converting one of the wells which is higher in nitrates (WSMR well 16), and not currently used, into a separate water source solely for irrigation purposes including the WSMR Golf Course. As mentioned in the groundwater availability section, approximately 30% of water used by WSMR is recharged back into the groundwater aquifer.

6 Proposed Planning Period

6.1 Planning period generally used by the Applicant for other (non-water) planning purposes

WSMR generally follows the U.S. Army protocol for all planning purposes which extends 5 to 7 years into the future.

6.2 Extent of public input in Applicant's planning process

For the purposes of this application, WSMR announced a public meeting in September 2016 and held a public meeting in the City of Tularosa on October 12, 2016 from 3-6pm. The public meeting announcement was made in September 2016 by publishing within the local White Sands Missile Range publication, by emailing regional stakeholders, and by posting it to the Otero Soil and Water Conservation District website, as shown in Figure 12. The announcement included the draft of this document and provided information for the location, date, and time for the public meeting as well as contact information for other methods of providing comments. The amount of time between the announcement and the meeting was more than two weeks to provide a reasonable amount of scheduling considerations. The public meeting included a summary of the management plan and provided an opportunity for public input. Public input was addressed and resolved, and this final version of the WSMR water plan incorporated changes based on the public input.

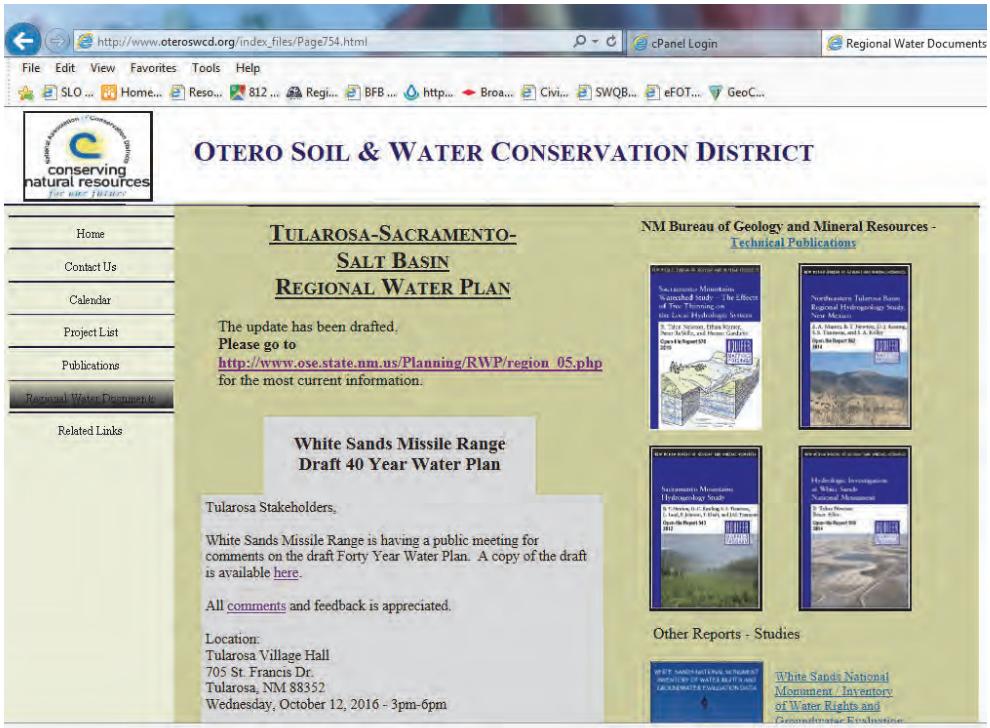

Figure 12. Public meeting announcement posted to the Otero SWCD website and stakeholders

6.2.1 Adoption of water development plan by local governing body

Many of the items within this application's plan, including the conservation measures, are already incorporated into the WSMR plans for continued improvement.

6.2.2 Discussion of Regional Water Planning

A member of WSMR attended the Tularosa Basin Regional Water Planning meeting to make sure the WSMR water plans were consistent with the regional efforts. Regional Water Plans available through the NMOSE website have also been reviewed. From the review of Regional Water Plans, everything within this WSMR 40-year water plan fits well with the other Regional Water Plans.

6.3 Statement of planning period used in this application

This application's planning period is 40 years, which is consistent with the New Mexico Statutes Annotated (NMSA) 72-1-9, administered by the Office of the State Engineer.

6.4 Basis on which the Applicant's request to hold water rights unused for an extended period of time would promote the public welfare and the conservation of water within the state

WSMR needs to hold a significant portion of the unused water rights in order to be fully prepared for a population expansion due to a military reconsolidation or the arrival of a large fluctuation of soldiers. Either, or both, of these scenarios are realistic possibilities, depending on decisions within the Federal government and the Department of Defense. Holding the unused water rights would prevent a future conflict over the water demand under either of these scenarios.

Additionally, transfer of water rights from the region could harm the local ecosystem, economy, and the community. If unused water rights were to be taken from WSMR and used by others, the groundwater aquifer could be negatively impacted by saline intrusion from the surrounding aquifer. An increase in the salinity, or brackish water, at the wells used for WSMR water supply would be problematic. By holding the unused water rights, WSMR would be conserving regional groundwater reserves for drought or unexpected growth scenarios.

6.5 Basis for belief that planning period used in this application is reasonable

In accordance with the Office of the State Engineer, and dictated by NMSA 72-1-9, the planning period will be 40 years in order to provide regional consistency for all stakeholders.

6.6 Ability of Applicant to obtain other sources of water in the future

WSMR does not have any other cost-effective sources of water to meet demands. The current aquifer supply is expected to be sufficient to meet future demands. Changes in regional precipitation can cause significant fluctuations in aquifer water levels. In the very unlikely event that WSMR needs to find other sources of water, the possibilities of either treating brackish water or relocating wells further away to other sources may be investigated.

7 Application is Non-Speculative

7.1 Must demonstrate the current or future ability to physically store, divert or otherwise put the water to beneficial use

WSMR has demonstrated beneficial use of up to 939 million gallons (2,881 ac-ft) from the Main Post water supply system (well field T-688, which includes the HU-151 well field) in a single year according to monthly water records; that maximum recorded water usage occurred in 1971. WSMR has exhibited beneficial use of an average of 446 MGPY (1,369 ac-ft/yr) for the most recent time period 2007 to 2014. Many years are significantly higher than this average amount. A safe long-term yield for the aquifer is estimated to be 645 MGPY (1,980 ac-ft/yr). The estimated capacity of the Main Post water distribution system infrastructure is 1.4 billion gallons per year (4,260 ac-ft/yr), although this system capacity is intended to accommodate peak water usages over shorter durations. Beneficial use of water withdrawals from the smaller well fields of WSMR have also been demonstrated in Section 1.2.4.

7.2 Description of specific project or plan in place for putting a specific amount of water to beneficial use

WSMR plans to continue using the current available groundwater supply and current water distribution system to meet future water needs over the next 40 years. WSMR has the potential for withdrawing up to the historical maximum amount of water withdrawn, 939 MGPY (2,881 ac-ft/yr), for beneficial use.

7.3 Non-municipal entities must:

7.3.1 Demonstrate a legal interest in the lands to be served or a reasonable expectation in procuring a legal interest in the lands to be served by the water

This section is not applicable to the WSMR water plan.

7.3.2 Identification of actual customer(s) and documents of intent from customers

This section is not applicable to the WSMR water plan.

7.4 Demonstrate that all legal, administrative, and licensing or other governmental permits or requirements necessary to proceed with this project have been or will be met

All WSMR water rights are on record with the New Mexico Office of the State Engineer and discussed in section 5.1. WSMR does not have a need to propose new water supply projects at this time to meet the projected future water demand, but there may be future requests to relocate water rights to the drilling of new wells for operational efficiency, construction, military, and/or mission purposes.

7.5 Demonstrate financial capability of moving forward with the project

7.5.1 Provide anticipated financial needs timeline

In order to meet future water demands, WSMR needs to continue receiving the U.S. Federal Government funding each fiscal year to maintain the current water supply system equipment. There are no anticipated problems with meeting this annual financial need.

7.5.2 Provide methods of finance for project throughout timelines

WSMR receives funding through the U.S. Federal Government each fiscal year, and the expected funds are sufficient to cover the costs of meeting the future water demands of WSMR.

7.6 Planning, design and infrastructure completed for proposed project

WSMR expects to continue using the current water supply system. WSMR does not have a need to propose new water supply projects at this time to meet the projected future water demand, but there may be future requests to relocate water rights to the drilling of new wells for operational efficiency.

8 Application Implementation

8.1 Total project timeline and proposed timeframe for demonstrating a physical attempt to divert water and put it to beneficial use ("reasonable diligence")

The WSMR water supply system currently has the capacity to put the expected future water needs to beneficial use. WSMR has demonstrated a historical beneficial use of up to 939 MGPY (2,881 ac-ft/yr).

8.2 Reasonable diligence

8.2.1 Means a consistent effort to complete the appropriation in an expeditious and efficient manner, consistent with the project timelines or time frames established above

WSMR performs ongoing maintenance and rehabilitation of the water supply system to meet all water demands. Water conservation measures are already in place and ongoing, as detailed in Section 2. WSMR does not have a need to propose new water supply projects at this time to meet the projected future water demand, but there may be future requests to relocate water rights to the drilling of new wells for operational efficiency, construction, military, and/or mission purposes.

8.2.2 Matters that are out of the control of the Applicant shall not be considered in determining whether the Applicant is proceeding with "reasonable diligence"

WSMR has been, and continues, implementing all aspects of this 40 year water plan. Conservation measures are in place and ongoing, as detailed in Section 2, to reduce the GPCD water usage within WSMR over the next 40 years. Maintenance and rehabilitation to the water supply system are performed timely as needed to meet ongoing water demands. WSMR does not have a need to propose new water supply projects at this time to meet the projected future water demand, but there may be future requests to relocate water rights to the drilling of new wells for operational efficiency, construction, military, and/or mission purposes.

8.2.3 Periodic updates as established by the NMOSE shall be submitted by the Applicant in support of demonstration of "reasonable diligence"

The U.S. Army abides by the State of New Mexico procedures to properly apply for any significant changes to its current wells or any new installations of wells. Any periodic updates requested and required by the NMOSE will be submitted by WSMR.

8.3 Identification of completion of project milestones

The WSMR water supply system currently has the capacity to put the expected future water needs to beneficial use. WSMR does not have a need to propose new water supply projects at this time to meet the projected future water demand, but there may be future requests to relocate water rights to the drilling of new wells for operational efficiency, construction, military, and/or mission purposes.

9 Conclusions and Other Supporting Information

9.1 Conclusions

The following bulleted list summarizes the WSMR 40 year water plan:

- The historic water rights of the WSMR Main Post water supply system are a combined total of 6.9 billion gallons per year (21,224 ac-ft/yr) across the T-688 et al. and HU-151 et al. well fields.
- The maximum beneficial use demonstrated by the WSMR Main Post water supply system was 939 million gallons (2,881 ac-ft) in the year 1971.
- The existing Main Post water supply system infrastructure has an estimated capacity of 1.4 billion gallons per year (4,259 ac-ft/year), although this system capacity is intended to accommodate peak water usages over shorter durations.
- Multiple ongoing conservation efforts, discussed in detail in Section 2, have decreased the recent water usage and are expected to reduce the future GPCD.
- According to hydrogeological and groundwater assessment, the groundwater supply used by WSMR Main Post water supply system has a safe long-term yield of 645 MGPY (1,980 ac-ft/yr). This estimate includes 482 MGPY (1,480 ac-ft/yr) from the Tularosa Basin and 163 MGPY (500 ac-ft/yr) from the Hueco Basin.
- The average water use by WSMR for the recent time period 2007-2014 was 446 MGPY (1,369 ac-ft/yr).
- Future water use in the Main Post water system is expected to decrease due to conservation measures.
- The WSMR location is a potential site for military reconsolidation, or an arrival of a large fluctuation of soldiers, which could increase the water demand to approximately 800 MGPY (2,455 ac-ft/yr), or a water usage similar to the 1971 level.
- WSMR needs to maintain its unused water rights in order to be prepared for possible military reconsolidation and to preserve the water quality of the aquifer. If unused water rights were to be taken from WSMR and used by others, the groundwater aquifer could be negatively impacted by saline intrusion from the surrounding aquifer. An increase in the salinity, or brackish water, at the wells used for WSMR water supply would be problematic.
- The Stallion Range Center uses 8.4 MGPY (26 ac-ft/yr) through the RG-66540 well field which has water rights of 1,261.9 ac-ft/yr.

- The Central Range complexes use an average of 17.7 MGPY (54 ac-ft/yr) through the T-00550, T-01570, and T-02170 well fields which have total water rights of 3,125 ac-ft/yr.
- Construction wells use an average of 7.8 MGPY (24 ac-ft/yr) through wells with total water rights of 1,807 ac-ft/yr.

9.2 References

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9.3 Appendices

9.3.1 AWWA

As requested by the New Mexico Office of the State Engineer, members of the WSMR staff attended an American Water Works Association (AWWA) water loss assessment training workshop to learn how to perform an AWWA water loss assessment of the WSMR water supply system. This section of the appendix shows the results of the WSMR AWWA assessment.

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WHITE SANDS MISSILE RANGE WATER AUDIT

October 2016

FOR OFFICIAL USE ONLY

White Sands Missile Range

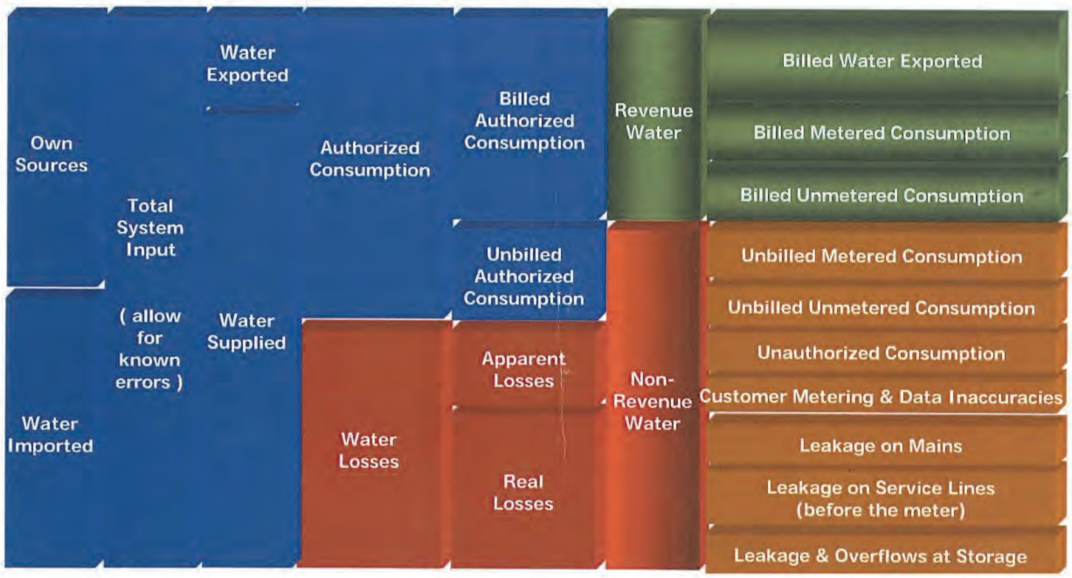
Water Audit

Prepared by:

Alicia Rodriguez, P.E.
October 2016

INTRODUCTION

The New Mexico Environmental Department offered a Small System Training Program for Water Loss Control in 6 training sessions from Nov. 10, 2015 through May 2016, including an Introduction webinar (Oct. 2015) and a Final webinar (May 2016). As per AWWA, the terminology of "unaccounted water" and "water loss as a percentage of the water supply" are obsolete and are replaced by a water balance using volume, value and validity. The objectives of the program were (1) to establish a foundation of a water loss audit; (2) validate data; (3) analyze the water loss; and (4) develop a strategy to improve data and audit. The AWWA Water Audit method is based on the water balance table below.



This program assisted White Sands Missile Range (WSMR) to establish a baseline water balance of the existing water system and to assess the areas which may need improvements in order to reduce losses, improve efficiency and identify opportunities for water conservation. The water audit traces the flow of water from the site of water withdrawal source or treatment, through the water distribution system, and into the customer. Using the water balance table and theory that it provides accountability of the water withdrawn and used, the water loss is categorized into 2 major components: real losses and apparent losses plus further subcomponents that enables to identify and/or resolve specific issues. This audit follows standard AWWA methods and performance indicators. This audit was done for the fiscal year 2015, October 2014 through

September 2015 and the data was collected from WSMR personnel with respect to its water production, billing system, and operations characteristics.

WATER SYSTEM SUMMARY

The water source for WSMR Main Post is groundwater from the Tularosa Basin and the Hueco Basin. There are 11 wells in the Main Post, and 4 wells located in the Soledad Canyon area, a booster pump station, two 1MG elevated storage tanks, one 200,000 gallon elevated water storage tank, two 400,000 gallon ground storage tanks and the water distribution system (pipeline, valves, meters, backflow preventers, fire hydrants, etc.). The average water production is 286 million gallons per year (FY15). This data is obtained from metering each water well. The Water Dept. reads the meters and forwards it to Alicia Gray on a monthly basis for water conservation record purposes. They also forward it to April Banks for the water production reports required by the NMOSE.

The number of customer meters on Main Post does not represent the number of water service connections to the water distribution system. For metering purposes, the connections are not broken down into residential, commercial and/or industrial water usage. The residential water usage is captured in one master meter. The Water Dept. reads the meters and forwards the data to Alicia Gray for billing purposes.

AUTHORIZED CONSUMPTION

As per the AWWA definition, the authorized consumption is "the volume of metered and/or unmetered water taken by registered customers, the water utility's own uses, and uses of others who are implicitly or explicitly authorized to do so by the water utility; for residential, commercial, industrial and public-minded purposes." In other words, the water quantity that is used by customers that is known to the water utility.

<u>Billed Metered</u>: the following entities are billed monthly for the water consumption that is metered.

1. WSMR School
2. Commissary
3. Bldg 501
4. Bldg 501 landscape
5. Bldg 502
6. Bldg. 506

The above meters are read manually and billed manually. There are no regular audits of customer billing data, except on unusual circumstances, such as inconsistent water usage for no known reason.

Billed Unmetered: the following entities are billed monthly based on estimated consumption (gpcd) and/or a flat fee.

1. DTRA
2. AF MIT Lincoln lab
3. AF DET 1, 18th Space Surveillance Squandron
4. Navy
5. Center for Countermeasures
6. Post Office
7. Housing
8. San Antonio Lighthouse

Unbilled metered: the following entities are metered but not billed.

1. WSMR Golf course
2. Down range/Oro Grande
3. Engineering Battalion Bldg 21075
4. Engineering Battalion Bldg 21090
5. HTA Bldg
6. Gas Station

The above meters are read manually and have not been tested and/or calibrated.

Unbilled unmetered: This is authorized water usage for firefighting, fire hydrant flushing, flushing of water mains, water used for construction, irrigation and landscaping. Since this water is not metered, the program recommends 1.25% of the water supplied volume.

WATER LOSSES

By definition, the water loss equals the water supplied minus authorized consumption; however, water loss can be further categorized as apparent and real losses.

Apparent losses is the water that is lost that could have been sold or accounted for as authorized consumption. It is identified in these three types:

1. Unauthorized consumption includes water theft, customer meter tampering, meter bypass and illegal line taps. We believe that any unauthorized consumption—as described above—that may exist in our water distribution system is unintentionally because there are no regulations and/or guidelines for water service connections. When water is used

from a fire hydrant such as for construction activities, it is allowed but not required to meter and bill for the water used. The operators do not think any customer meters have been tampered with and/or meter has been bypassed. Since the extent of "unauthorized consumption" is unknown, the program has a default value of 0.25%.

2. Customer meter inaccuracies occur when the meter under-registers quantity due to age, wear, broken, improper application of the meter, wrong type, wrong size and/or chemically aggressive water. There is no information available on the meters; therefore a default value of 5% was calculated.

3. Systematic data handling errors in the data gathered is always a possibility. The meters are read and processed by human. Even though Ms. Gray monitors the trend of the water usage, it is easy to make an error from illegible and mis-recorded hand written readings, inputting or omitting incorrect meter register unit conversion factors. Thus the default value of 0.25% is accepted.

Real losses are the water that is actually lost due to leaks. These leaks can occur in the distribution, transmission, storage (including overflow of water storage tanks) and water service connections. The water audit software automatically calculates the amount of real losses dependent on the apparent loss. However, a water system leakage investigation conducted in 2009 shows the amount of real loss is different than the amount calculated by the program. This indicates that the default values used for the apparent water loss are too low for our system. Leakage detection surveys were conducted across the cantonment and down range for both water distribution system and transmission system. Twenty-two (22) leaks were found during the surveys and the total estimated 20 MGY of real water loss. All the leaks found appear to be relatively small in nature (less than 5 gpm) but the total is significant in relation to the total water produced and treated. Overall, considering the age of the system, the results of the leak detection surveys showed that the main cantonment area potable water distribution system is currently in relatively good condition. There have been water main breaks that the Water Department fixed during the FY15 but were not recorded.

DATA VALIDATION AND ANALYSIS

Each data entry was graded with a number according to the AWWA Free Water Audit software Grading Matrix to assess how good the information is. Supporting data for this water audit included monthly water production volumes; monthly customer meter readings retail rate schedule for audit year; and cost spent on the Water Department in the audit year. The supporting documents were reviewed against the audit inputs to check calculations and look for common pitfalls. The data input and grades were analyzed or as the class called it: "Gremlin hunting" for inconsistencies, errors, unrealistic or not practical data. A component analysis was performed by going through each classification.

CONCLUSION

This water audit may be considered as the first step to initiate a Water Loss Control Program to defer, reduce and/or eliminate the need for repairs. Control of the water loss affects various interests, such as (1) water resource management; (2) financial by reducing operation and maintenance costs; and evaluating rate schedule; (3) operational; and (4) system integrity. This water audit received a high-level review from the training instructors.

The program calculates the overall data validity score and outputs priority areas for attention where audit accuracy can be improved by addressing these components:

1. Volume from own sources;
2. Billed metered; and
3. Customer metering inaccuracies.

The recommendations on the following section identifies tools that will assist WSMR to improve their water audit. Based on the grade of this water audit (25 out of 100), the program also outputs a Water Loss Control Planning Guide, see attachment B.

RECOMMENDATIONS

The following recommendation will improve the accuracy of the audit in all the categories, including the priority areas listed in the output of the water audit.

Volume from own sources:

1. Survey well meters to include information such as location, record drawings, installation details, type, size, age, wear/condition and photo.
2. Initiate meter accuracy testing as per AWWA standards and electronic calibration to obtain range of accuracy.
3. Dependent on the above testing, replace or repair meters.

4. Install new meters after treatment/storage to monitor water supply and treatment plant since some transmission lines are long.

Authorized consumption (billed metered and others):

1. Conduct a meter survey to verify that the meters are the right size and application, installed correctly, and in reliable condition.

2. Initiate meter accuracy testing as per AWWA standards and electronic calibration to obtain range of accuracy. Depending on the above testing, repair or replace meters.

3. On record documents, list building numbers for each customer accounts and update the basis of water consumption estimates (number of personnel, building usage type, square footage, etc .).

4. Assess sites with access difficulties to devise means to obtain water consumption volumes.

5. Improve documentation of costs incurred by the Water Department and sort into categories such as treatment chemicals, labor, maintenance, equipment, parts, etc.

6. Install meters on unmetered accounts.

7. Eliminate flat fee filling and establish appropriate water rate structure based upon measured consumption.

8. Meter more entities or install district meter areas (DMAs) to have more control and accountability of the water usage, reduce leakage awareness time and effectively prioritize leak detection.

9. Start billing more customers.

10. Generate and use a waterline flushing report to quantify authorized water usage for such purpose.

11. Record main break data to include date, size and type of pipe, location, type of break, estimate of water loss; time between notification & repair.

12. Install meters at the fire hydrant if flushing is at a fixed location and/or record water usage when flushing and for firefighting activities.

13. Install meters at the construction water points since they are at a fixed location.

14. Meter water usage when contractor uses fire hydrant for construction. Require permit to be issued for water use and request a temporary meter together with the backflow preventer.

15. Proposed leak repair procedures include installation of new hydrants, service lines and valves to repair old infrastructure connected with the leak locations found in 2009.

Water Losses (customer meter inaccuracies):

1. Implement policies to improve meter reading success.

2. Implement the water utility policy and procedures to improve customer metering participation for all.

3. Review historic written directives and policy documents allowing certain accounts to be billing exempt. Draft an outline of a revised policy regarding what water uses should be allowed to remain as unbilled and unmetered; identify criteria that grants an exemption, with a goal of keeping this number of accounts to a minimum.

4. Automate meter reading.

5. Automate billing system.

6. Launch regular meter replacement program.

7. Verify complete inventory of paper records of water main installations.

8. Review policy and procedures for commissioning and documenting new water main installation.

9. Convert to electronic database such as a GIS and link with asset management databases, conduct field verification of data.

REFERENCES

1. The Water Audit Handbook for Small Drinking Water Systems, 2013

2. Water Audits in the United States: A Review of Water Losses and Data Validity by EPA Water Research Foundation 2015

3. 2009 Infrastructure Report Potable Water System Analysis by Jacobs/Huitt-Zollars Inc. 22 May 2009

AWWA Free Water Audit Software:
Reporting Worksheet

WAS v5.0

? Click to access definition
+ Click to add a comment

Water Audit Report for: WHITE SANDS MISSILE RANGE-DPW
Reporting Year: 2015 | 10/2014 - 9/2015

Please enter data in the white cells below. Where available, metered values should be used; if metered values are unavailable please estimate a value. Indicate your confidence in the accuracy of the input data by grading each component (n/a or 1-10) using the drop-down list to the left of the input cell. Hover the mouse over the cell to obtain a description of the grades

All volumes to be entered as: MILLION GALLONS (US) PER YEAR

To select the correct data grading for each input, determine the highest grade where the utility meets or exceeds all criteria for that grade and all grades below it.

WATER SUPPLIED

<----------- Enter grading in column 'E' and 'J' ---------->

Volume from own sources:	3	286.930	MG/Yr
Water imported:	n/a	0.000	MG/Yr
Water exported:	n/a	0.000	MG/Yr
WATER SUPPLIED:		**286.930**	MG/Yr

Master Meter and Supply Error Adjustments

Pcnt:	Value:	Units
		MG/Yr
		MG/Yr
		MG/Yr

Enter negative % or value for under-registration
Enter positive % or value for over-registration

AUTHORIZED CONSUMPTION

Click here: ? for help using option buttons below

	Grade	Value	Units	Pcnt:	Value:	Units
Billed metered:	1	3.200	MG/Yr			
Billed unmetered:	2	93.570	MG/Yr			
Unbilled metered:	2	74.961	MG/Yr			
Unbilled unmetered:		3.587	MG/Yr	1.25%		MG/Yr

Default option selected for Unbilled unmetered - a grading of 5 is applied but not displayed

AUTHORIZED CONSUMPTION:		**175.318**	MG/Yr

Use buttons to select percentage of water supplied **OR** value

WATER LOSSES (Water Supplied - Authorized Consumption)

WATER LOSSES (Water Supplied - Authorized Consumption)		**111.612**	MG/Yr

Apparent Losses

	Grade	Value	Units	Pcnt:	Value:	Units
Unauthorized consumption:		0.717	MG/Yr	0.25%		MG/Yr

Default option selected for unauthorized consumption - a grading of 5 is applied but not displayed

	Grade	Value	Units	Pcnt:	Value:	Units
Customer metering inaccuracies:	1	4.114	MG/Yr	5.00%		MG/Yr
Systematic data handling errors:		0.008	MG/Yr	0.25%		MG/Yr

Default option selected for Systematic data handling errors - a grading of 5 is applied but not displayed

Apparent Losses:		**4.839**	MG/Yr

Real Losses (Current Annual Real Losses or CARL)

Real Losses = Water Losses - Apparent Losses:		**106.773**	MG/Yr
WATER LOSSES:		**111.612**	MG/Yr

NON-REVENUE WATER

NON-REVENUE WATER:		**190.160**	MG/Yr

= Water Losses + Unbilled Metered + Unbilled Unmetered

SYSTEM DATA

	Grade	Value	Units
Length of mains:	2	68.0	miles
Number of active AND inactive service connections:	1	493	
Service connection density:		7	conn./mile main
Are customer meters typically located at the curbstop or property line?		Select...	
Average length of customer service line:	1	100.0	ft
Average operating pressure:	3	65.0	psi

(length of service line, beyond the property boundary, that is the responsibility of the utility)

COST DATA

	Grade	Value	Units
Total annual cost of operating water system:	2	$93,940	$/Year
Customer retail unit cost (applied to Apparent Losses):	3		
Variable production cost (applied to Real Losses):	1		$/Million gallons

☐ Use Customer Retail Unit Cost to value real losses

WATER AUDIT DATA VALIDITY SCORE:

***** YOUR SCORE IS: 25 out of 100 *****

A weighted scale for the components of consumption and water loss is included in the calculation of the Water Audit Data Validity Score

PRIORITY AREAS FOR ATTENTION:

Based on the information provided, audit accuracy can be improved by addressing the following components:

1: Volume from own sources
2: Billed metered
3: Customer metering inaccuracies

AWWA Free Water Audit Software: Water Balance

WAS v5.0

Water Audit Report for:	WHITE SANDS MISSILE RANGE-DPW	
Reporting Year:	2015	10/2014 - 9/2015
Data Validity Score:	25	

Own Sources (Adjusted for known errors) 286.930	System Input 286.930	Water Exported 0.000	Billed Water Exported			Revenue Water 0.000
		Water Supplied 286.930	Authorized Consumption 175.318	Billed Authorized Consumption 96.770	Billed Metered Consumption (water exported is removed) 3.200	Revenue Water 96.770
					Billed Unmetered Consumption 93.570	
				Unbilled Authorized Consumption 78.548	Unbilled Metered Consumption 74.961	Non-Revenue Water (NRW) 190.160
					Unbilled Unmetered Consumption 3.587	
			Water Losses 111.612	Apparent Losses 4.839	Unauthorized Consumption 0.717	
					Customer Metering Inaccuracies 4.114	
					Systematic Data Handling Errors 0.008	
Water Imported 0.000				Real Losses 106.773	Leakage on Transmission and/or Distribution Mains *Not broken down*	
					Leakage and Overflows at Utility's Storage Tanks *Not broken down*	
					Leakage on Service Connections *Not broken down*	

AWWA Free Water Audit Software v5.0 Water Balance 1

AWWA Free Water Audit Software:
Determining Water Loss Standing

Water Audit Report for: WHITE SANDS MISSILE RANGE-DPW
Reporting Year: 2015 | 10/2014 - 9/2015
Data Validity Score: 25

Water Loss Control Planning Guide

	Water Audit Data Validity Level / Score				
Functional Focus Area	**Level I** (0-25)	**Level II** (26-50)	**Level III** (51-70)	**Level IV** (71-90)	**Level V** (91-100)
Audit Data Collection	Launch auditing and loss control team; address production metering deficiencies	Analyze business process for customer metering and billing functions and water supply operations. Identify data gaps.	Establish/revise policies and procedures for data collection	Refine data collection practices and establish as routine business process	Annual water audit is a reliable gauge of year-to-year water efficiency standing
Short-term loss control	Research information on leak detection programs. Begin flowcharting analysis of customer billing system	Conduct loss assessment investigations on a sample portion of the system: customer meter testing, leak survey, unauthorized consumption, etc.	Establish ongoing mechanisms for customer meter accuracy testing, active leakage control and infrastructure monitoring	Refine, enhance or expand ongoing programs based upon economic justification	Stay abreast of improvements in metering, meter reading, billing, leakage management and infrastructure rehabilitation
Long-term loss control		Begin to assess long-term needs requiring large expenditure: customer meter replacement, water main replacement program, new customer billing system or Automatic Meter Reading (AMR) system.	Begin to assemble economic business case for long-term needs based upon improved data becoming available through the water audit process.	Conduct detailed planning, budgeting and launch of comprehensive improvements for metering, billing or infrastructure management	Continue incremental improvements in short-term and long-term loss control interventions
Target-setting			Establish long-term apparent and real loss reduction goals (+10 year horizon)	Establish mid-range (5 year horizon) apparent and real loss reduction goals	Evaluate and refine loss control goals on a yearly basis
Benchmarking			Preliminary Comparisons - can begin to rely upon the Infrastructure Leakage Index (ILI) for performance comparisons for real losses (see below table)	Performance Benchmarking - ILI is meaningful in comparing real loss standing	Identify Best Practices/ Best in class - the ILI is very reliable as a real loss performance indicator for best in class service

For validity scores of 50 or below, the shaded blocks should not be focus areas until better data validity is achieved

9.3.2 Groundwater well hydrographs

Figure 13 shows the locations of wells with recent groundwater aquifer water level observations which are presented in this section (Figure 14 through Figure 24) to provide supplemental information to Section 5.2.2.

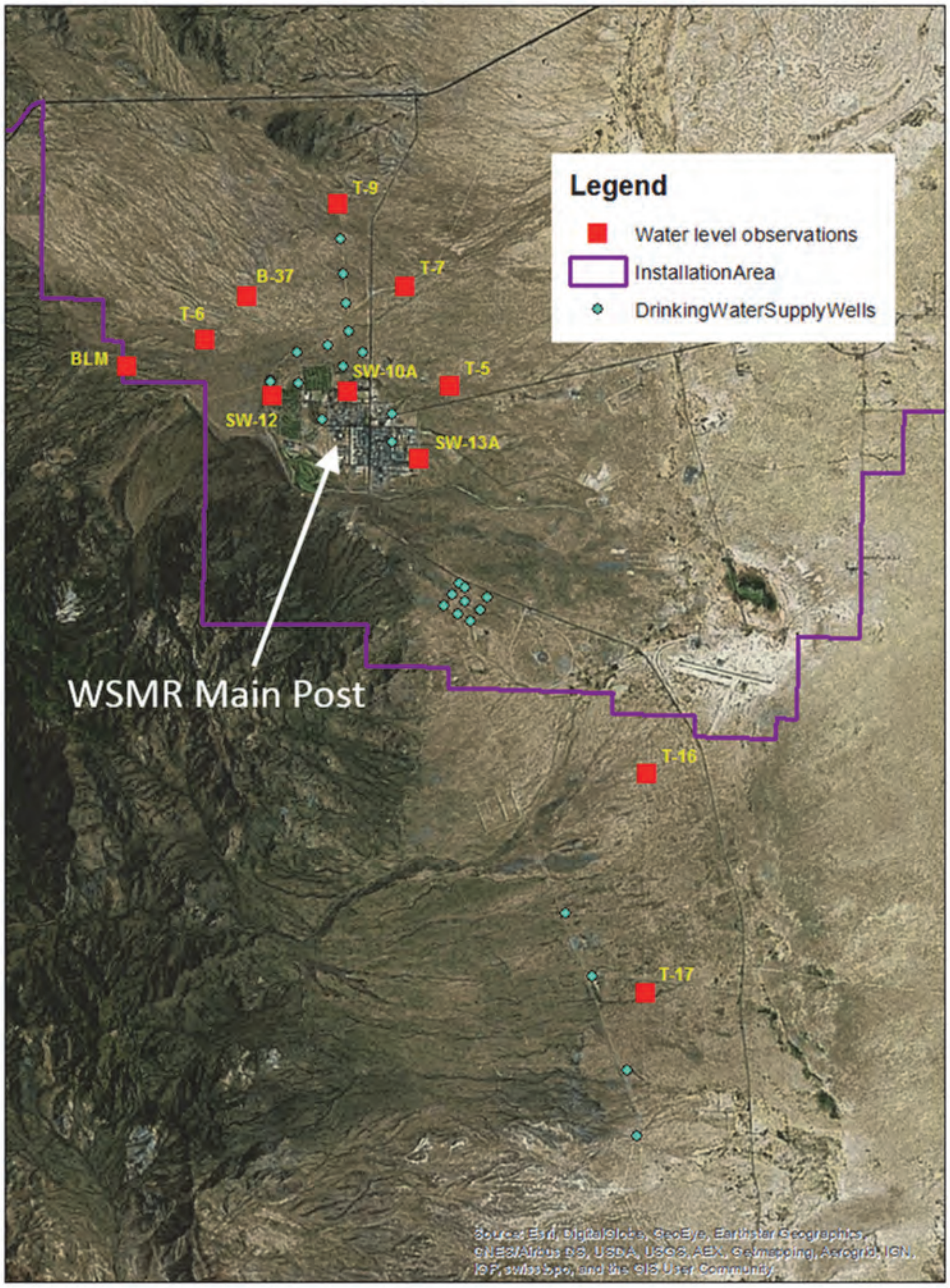


Figure 13. Map of wells near WSMR Main Post used to evaluate observed water levels

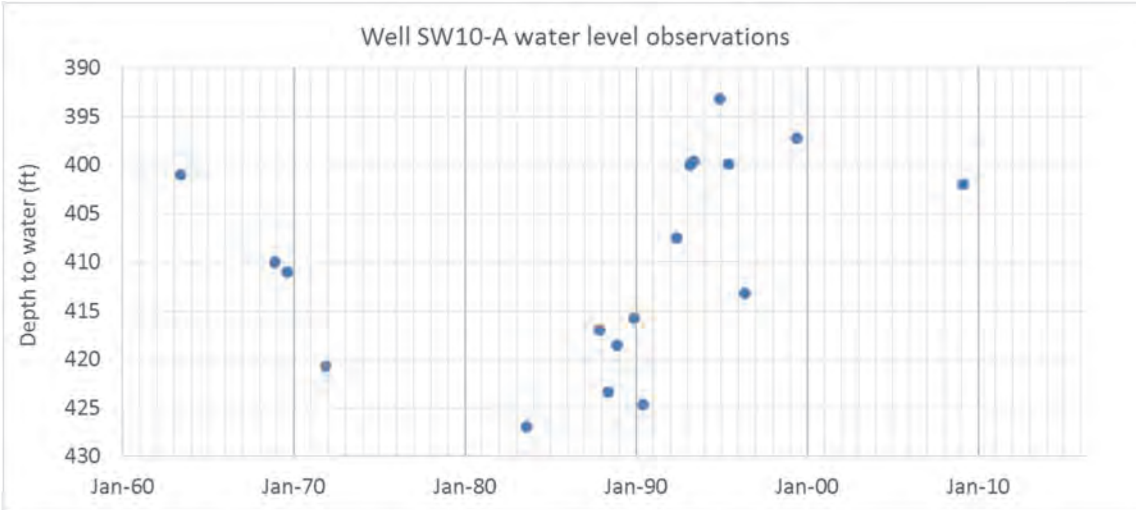


Figure 14. Well SW10-A water level observations

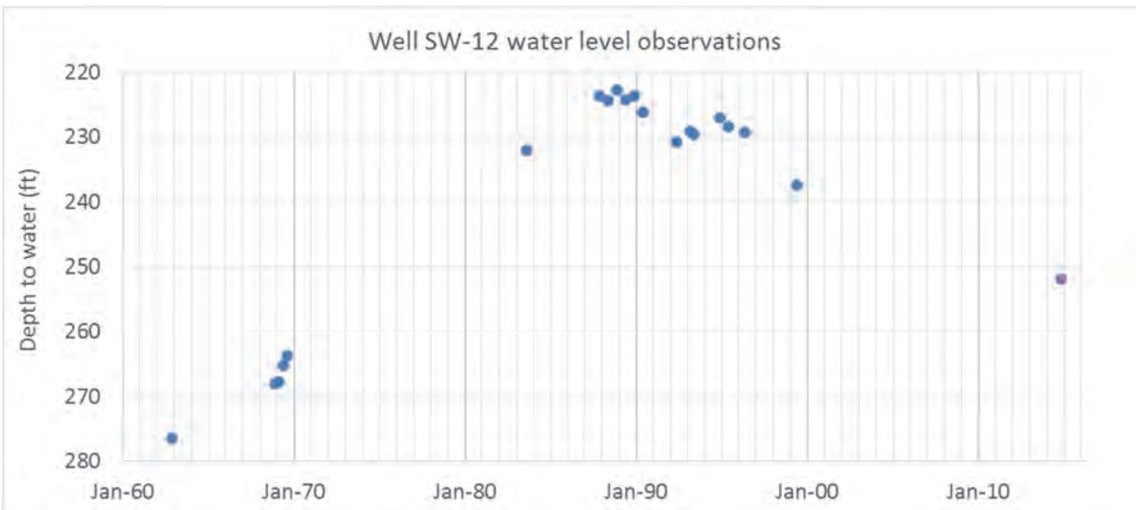


Figure 15. Well SW-12 water level observations

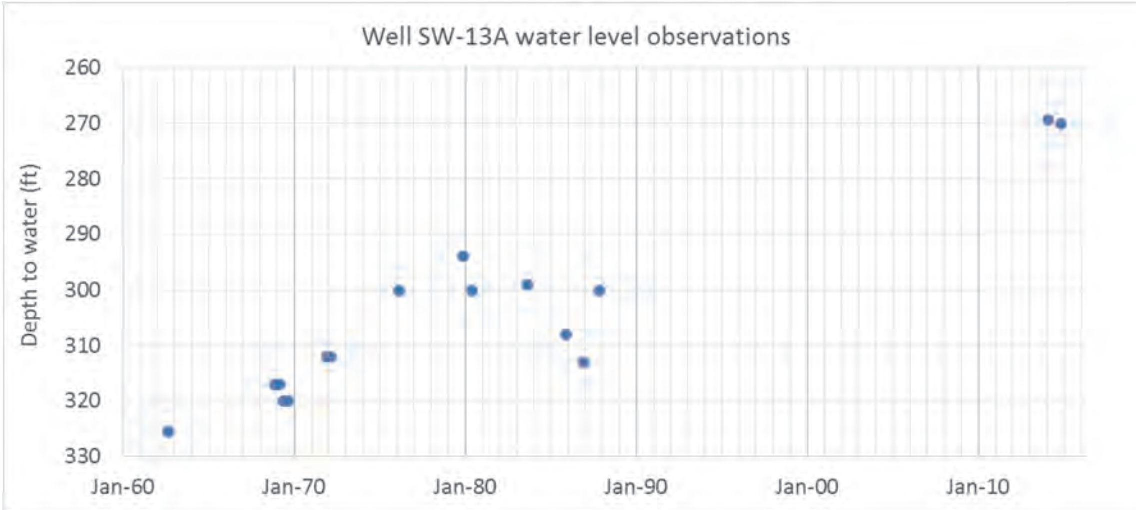


Figure 16. Well SW-13A water level observations

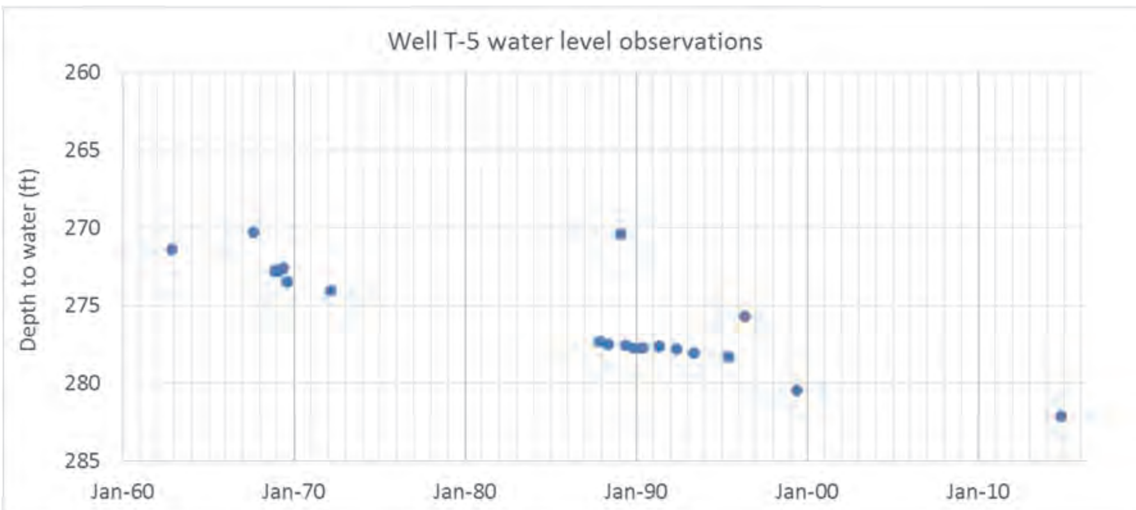


Figure 17. Well T-5 water level observations

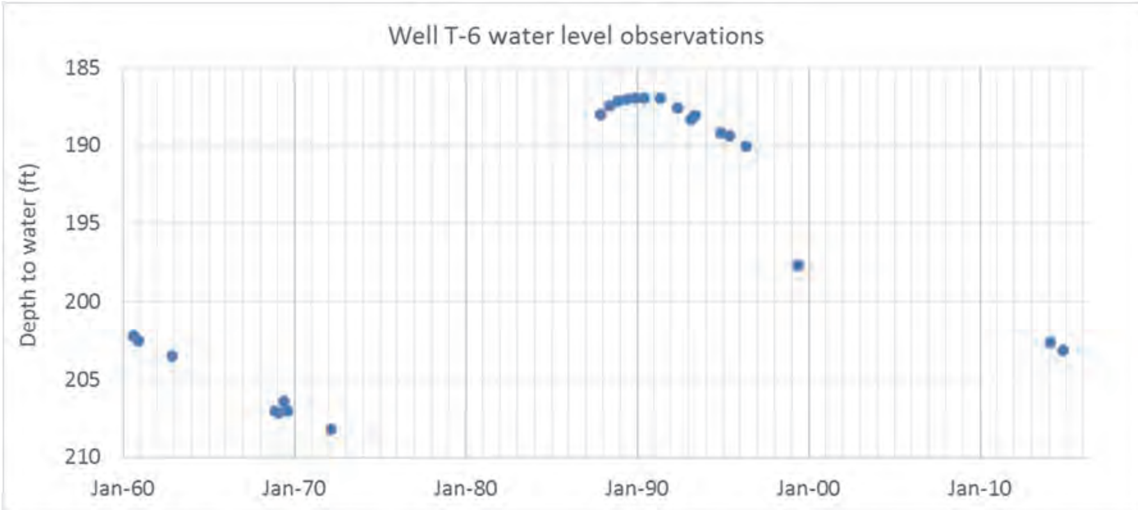


Figure 18. Well T-6 water level observations

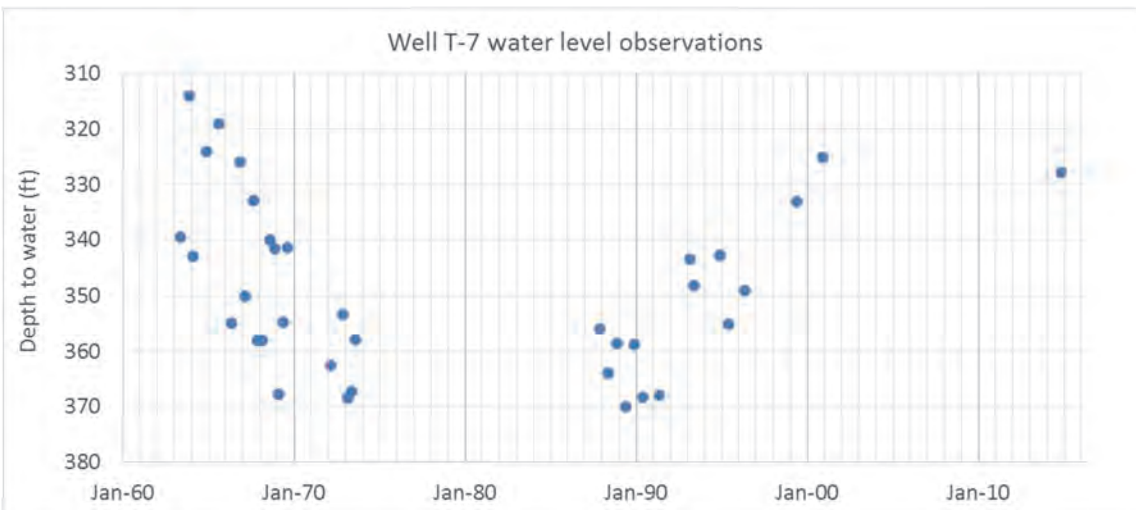


Figure 19. Well T-7 water level observations

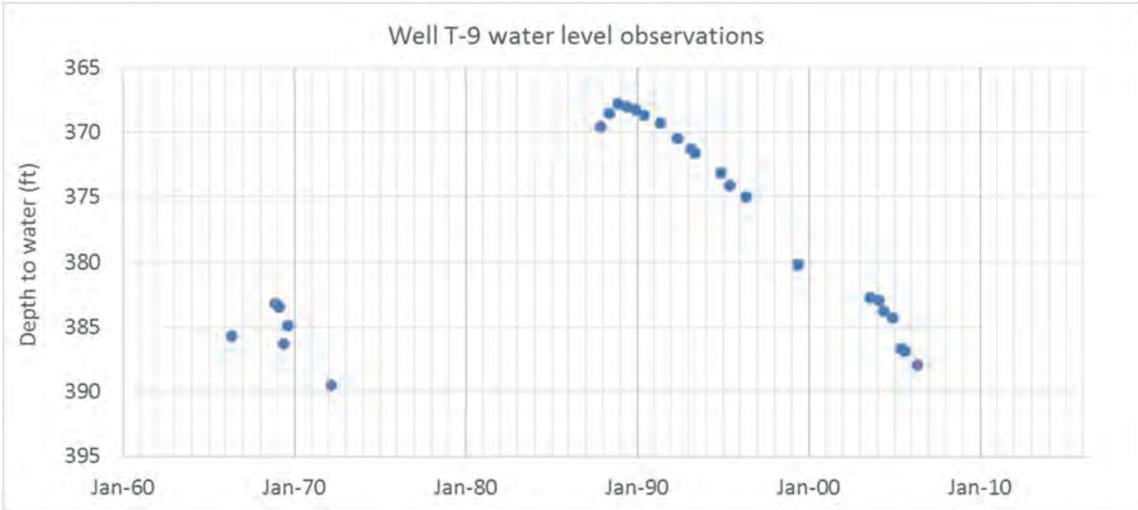


Figure 20. Well T-9 water level observations

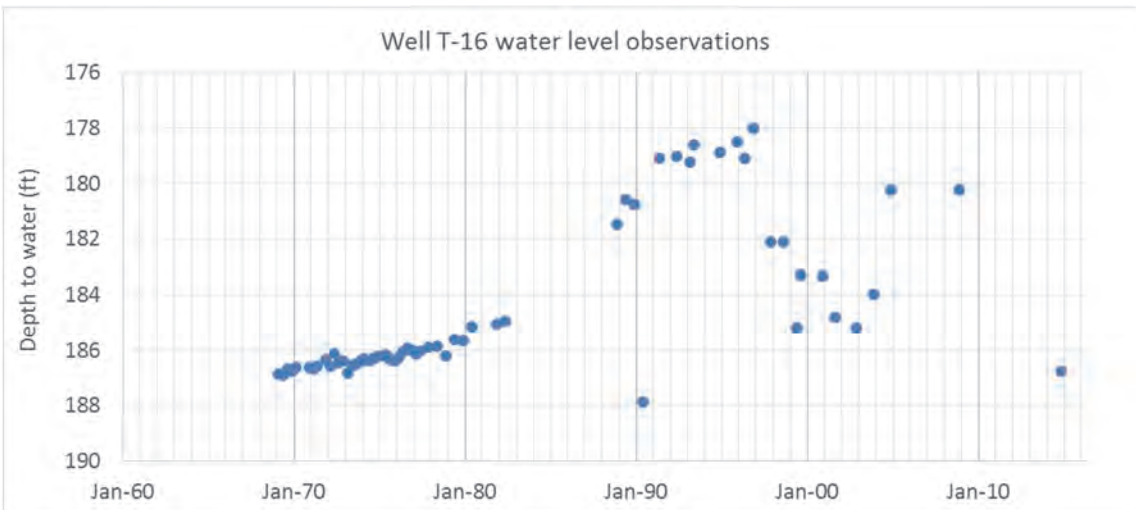


Figure 21. Well T-16 water level observations

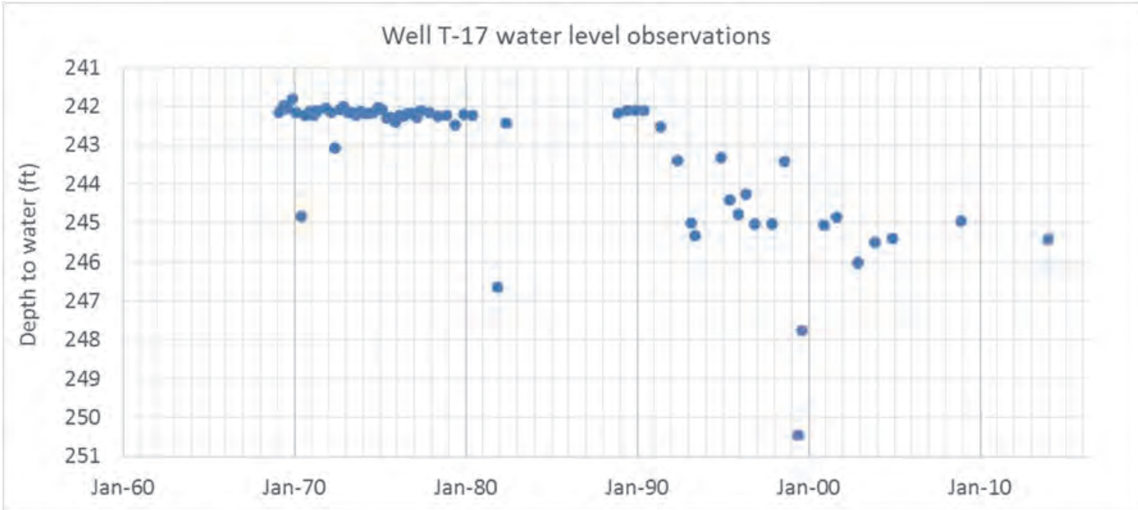


Figure 22. Well T-17 water level observations

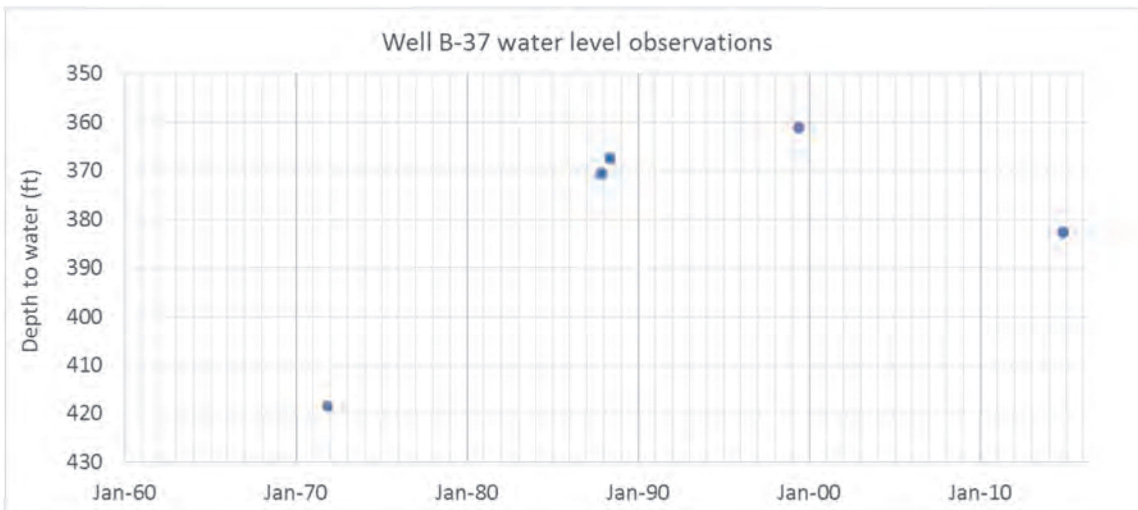


Figure 23. Well B-37 water level observations

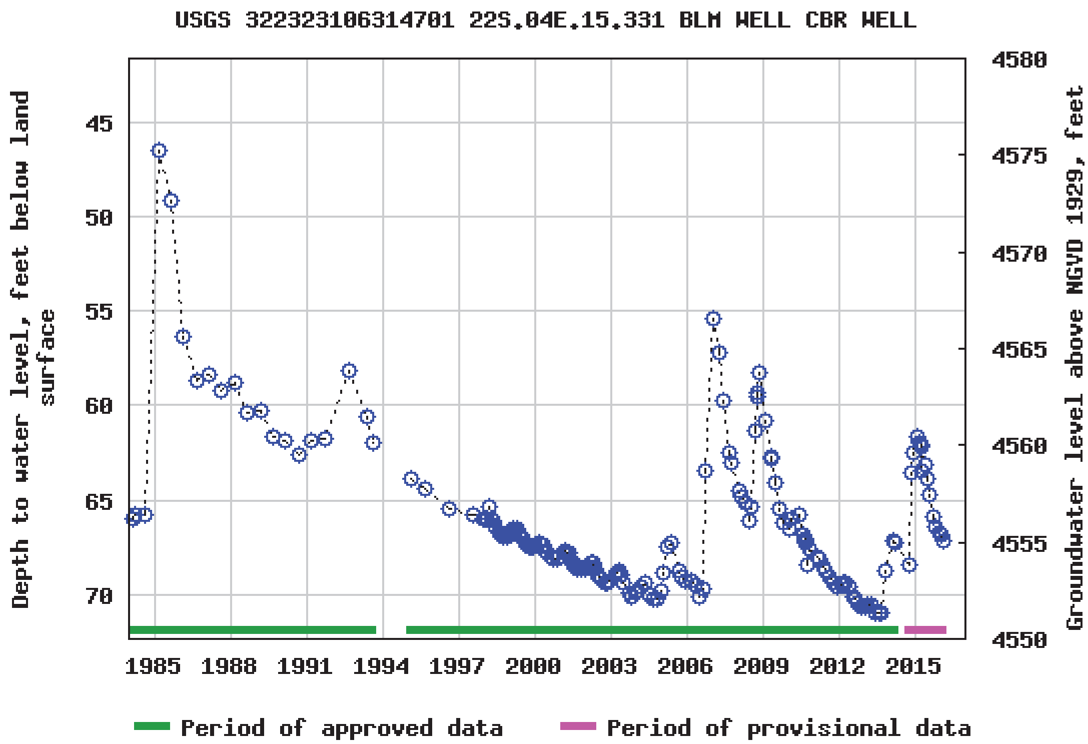


Figure 24. Well BLM water level observations (from USGS online database as of May 18, 2016)