Las Vegas Wash Water Quality Monitoring Program 2012 Report

A Water Quality Assessment

U.S Department of the Interior
Bureau of Reclamation

August 2014

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Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Cover Photo:
A brown pelican enjoys breakfast at the Las Vegas Wash/Las Vegas Bay interface, August 2013. Photograph by Bryan Wuerker.

Acknowledgements

The information in this report is available through the assistance and cooperation of various individuals and organizations. Thanks to Sierra Foothill Laboratory (SFL) and Reclamation's Lower Colorado Regional Laboratory (LCRL) for timely chemical analyses of water samples, with consistent quality and service. Mainstream flow data used in this report are from the U.S. Geological Survey (USGS) gaging station website with help from Chuck Savard of the Henderson USGS Office. Leanna Risso of the Clark County Wastewater Reclamation District, Adrian J. Edwards of the City of Henderson, and Randy Roberts and David Moore of TIMET Corporation provided flow data for discharges to the Wash from treatment facilities. Dave Commons provided flow data from the City of North Las Vegas Water Reclamation Facility. Local precipitation data are from the National Oceanic and Atmospheric Association website, with guidance from staff at the Las Vegas National Weather Service.

Special thanks to Reclamation's Denver Technical Services Center staff members who conducted the monitoring activities associated with this program for many years and provided the framework for this report (Mark Nelson and Rick Roline of Reclamation, and Doug Andersen and Jim Sartoris of USGS). This report would not exist without sampling help from Brandon Barrow and Becky Blasius from the LC Regional Office. Much gratitude goes to Martin P. Einert, who did the legwork and provided a write-up on the present conditions of the upper reaches of the Wash. Doug Blatchford deserves credit for making the hydrology discussion much more robust and for correction of some minor inaccuracies about the topology of the upper reaches of the Wash. Finally, thanks to Neal Muirhead for technical editing and to Mark Nelson for peer review.

This report is dedicated to the memory of Amelia Porter, who passed away in November 2012. We miss her, and she will be remembered for her more than 20 years of service to Reclamation. Amy guided me toward becoming a better writer.

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EXECUTIVE SUMMARY

This report responds to requirements of the Colorado River Basin Salinity Control Act of 1974 (Public Law 93-320), as amended. The Act authorizes the Secretary of the U.S. Department of the Interior (Interior) to enhance and protect the quality of water in the Colorado River for use in the United States and Mexico. Title II of the Act authorized several specific salinity control units in 1974 and 1984, one of which is the Las Vegas Wash Unit, to meet the objectives and numerical standards set pursuant to the Clean Water Act.

In April 1989, the Bureau of Reclamation (Reclamation) began a monitoring program in the Las Vegas Wash (Wash). The purpose of this program is to identify, record, and track trends associated with salinity and other contaminants carried by the Wash to Lake Mead and the lower Colorado River. Monitoring data also provide documentation of trends associated with activities conducted in the Wash by various entities, and maintains a history of general water quality and the quantities of nitrogen and phosphorus compounds discharged to Lake Mead. A series of annual Applied Sciences Referral Memoranda and Technical Memoranda by the Denver Technical Services Center (Bureau of Reclamation, 1990 through 2006) contain the results of previous monitoring and provide information for those who conduct work in and around the Wash. Beginning in 2007, staff at Reclamation's Lower Colorado Regional Office (LCRO) in Boulder City assumed responsibility for the monitoring program to promote a better understanding of the Las Vegas Valley's impacts to the Colorado River and to provide stakeholders with knowledgeable local contacts.

The objective of this report is to describe findings of Reclamation's 2012 Las Vegas Wash quarterly water quality monitoring activities and relate current data to earlier studies. In particular, this report notes the following:

- The City of North Las Vegas (CNLV) began releasing treated effluent to the Wash from its new water reclamation facility (WRF) in early June 2011, through the Sloan Channel. During its first full year of operation, complaints by nearby residents of nuisance gnats and other insects were manifold. By the end of 2012, the CNLV had begun a program of mechanical removal of algae from the Sloan Channel, which somewhat mitigated the problem. While overall flow in the Wash did not change when the new plant started discharging, there were marked changes to the long-term averages for most of the measured parameters at station LW11.1, as this site is downstream from the confluence of the Sloan Channel with the Wash. For example, in 2011 and 2012, pH values at LW11.1 reached highs never before recorded at that site.

- In 2012, the average flow rate through the Wash at Northshore Road (LW0.9) was approximately 293 cubic feet per second (8.29 cms), or approximately 189 MGD (million gallons per day). Figure 5 illustrates that the average annual flow rate in the Wash has plateaued for the past 8 years, ranging from 285 to 304 cfs (8.07 to 8.61 cms, or approximately 184 to 196 MGD).

- Average Wash water temperatures in 2012 were toward the high end of the range of variability established over the past 22 years of sampling (Figure 6), and were warmer than the long-term average temperatures at all but two of the mainstream monitoring sites.

- Average annual TDS (total dissolved solids) concentrations in 2012 were lower than the long-term averages at all sampling stations (Figure 10), and below the lower limits of variability established during the 22-year study. To date, the highest TDS load within the study period occurred in 2005 (Figure 11). In 2012, the average TDS load at LW0.9 was approximately 1,111,000 kg/day (kilograms per day), or about 1,225 tons/day.

- Construction of the Ducks Unlimited (DU) Wetlands No. 1 was completed in 2012. The Upper Narrows and Duck Creek Confluence weir projects were initiated and are scheduled for completion in 2013. To date, 15 of the 22 planned erosion control structures are in place and more than 10 miles of bank stabilization works have been installed along the Wash. About 40 acres of tamarisk were removed in 2012, for a total of 280 acres to date. More than 361 acres of Wash lands have been revegetated, 75 of them in 2012, toward an end goal of 550 acres total. (See http://www.lvwash.org/html/)

- These structures and plantings appear to have reduced channel erosion in the Wash as evidenced by a significant reduction in TSS (total suspended solids) concentrations. The 2012 average TSS concentrations were equal to or lower than the 18-year averages at each station (Figure 12). Long-term average values include natural channel erosion that peaked in about 1998, as well as turbidity caused by weir construction during the last decade.

- Turbidity is also impacted by local precipitation, and 2012 was slightly wetter than average for the Las Vegas Valley. Three major storms in August through October produced high flows in the Wash, with the flow on September 11 measuring as high as 11,000 cfs (cubic feet per second) at station LW11.5. Average flow in the Wash was 1,390 cfs for 22 hours during and after that storm.

- Precipitation measured at McCarran Airport (McCarran) in Las Vegas for 2012 was 5.31 inches (13.5 cm), about 27 percent greater than the long-term average of 4.19 inches (10.6 cm).

- Most of the inorganic nutrients (nitrogen (N) and phosphorus (P)) in the Wash originate from effluent discharges by the Valley's five wastewater treatment plants. Average loads and concentrations of dissolved and total P in the Wash in 2012 were lower than in 2011 (Figures

14 through 17), but higher than historic averages at three mainstream stations, possibly due to discharges from the newly-operating CNLVWRF and interception of runoff during local storms. Combined inorganic N concentrations in the Wash have a much narrower range of variability than P values over the period of record, and for 2012, average N concentrations were below the 15-year averages and lower limits of variation at all stations.

- 2012 average concentrations of total Se (selenium) were near the lower limits of variation at LW11.5 and LW11.1, and commensurate with 13-year averages at all other sampling stations, as seen in Figure 20.

- Perchlorate (ClO_4^-) concentrations in the lower Wash were higher in 2012 than they were in 2011, but remained below the 13-year averages for all stations (Figure 21). The ClO_4^- load carried to Lake Mead has remained relatively stable over the last 5 years (Figure 22), largely due to ongoing remediation efforts overseen by the Nevada Division of Environmental Protection (NDEP) Bureau of Corrective Actions in Henderson. On average, quarterly sampling revealed that an estimated 41 kg/day (89.2 pounds/day) of ClO_4^- reached Lake Mead through the Wash in 2012, as measured above Northshore Road.

- Clark County population data for the Las Vegas Valley showed a slight increase in 2012 to over 2 million residents in its cities and unincorporated areas, maintaining the relatively stable population trend seen since 2007. Flow data in the Wash have trended similarly to population, also remaining fairly stable since 2007. However, flow rates for 2012 were slightly lower than in 2011, and releases to the Wash by the City of Las Vegas Water Pollution Control Facility (CLVWPCF) were nearly 9 MGD lower than in 2011. Some of this decrease is due to the City of North Las Vegas processing its own wastewater, instead of sending it to the CLVWPCF. Additionally, programs supporting "water-smart" landscaping, reclaimed water reuse, and increasing public awareness of ongoing drought may contribute to conservation efforts at the household level, leading to decreased discharges from the Valley's wastewater treatment plants.

Finally, no discussion of water quality in the Las Vegas Wash is complete without examining the quality of water in the Colorado River. This is because the average flow in the Wash was approximately 85 percent wastewater by volume in 2012, most of which was initially pumped from Lake Mead for municipal use. About 10 percent of the Valley's water is pumped from groundwater wells from October through May.

Examination of salinity data gathered during Reclamation's quarterly Lake Mead monitoring from 1999 through 2012 reveals that concentrations of total dissolved solids entering Lake Mead have declined within this period since 2004, when the TDS peaked in April to 654 mg/L. At the end of 2012, an average of 528 mg/L (milligrams per liter, or ppm (parts per million)) of TDS entered the Lake at the Colorado River inflow (Figure 1), a decline of nearly 20 percent since 2004.

It is acknowledged that these values are based on only quarterly measurements of both the Wash and Lake Mead, but Figure 1 illustrates the trend. Examining a longer period of record may allow better interpretation of this trend, but current data allow speculation. Reclamation has implemented several salinity control projects in its Upper Colorado Region, and stratification of Lake Powell may trap higher salinity/higher density water below the level of the outtake structures at Glen Canyon Dam. Precipitation or the lack of it, in the form of snow in the upper Colorado River Basin and rain in the lower Colorado River Basin, may also influence salinity levels in the inflow and Lake Mead. Salinity concentrations and rates of flow in the Virgin and Muddy Rivers also influence TDS concentrations at Hoover Dam, since they converge in the Overton arm and combine with the Colorado River inflow in Virgin Basin. These inflows, along with inflow from the Las Vegas Wash, converge and ultimately pass through Hoover Dam. See Appendix C for a discussion of net salt loading to Lake Mead from the Wash.

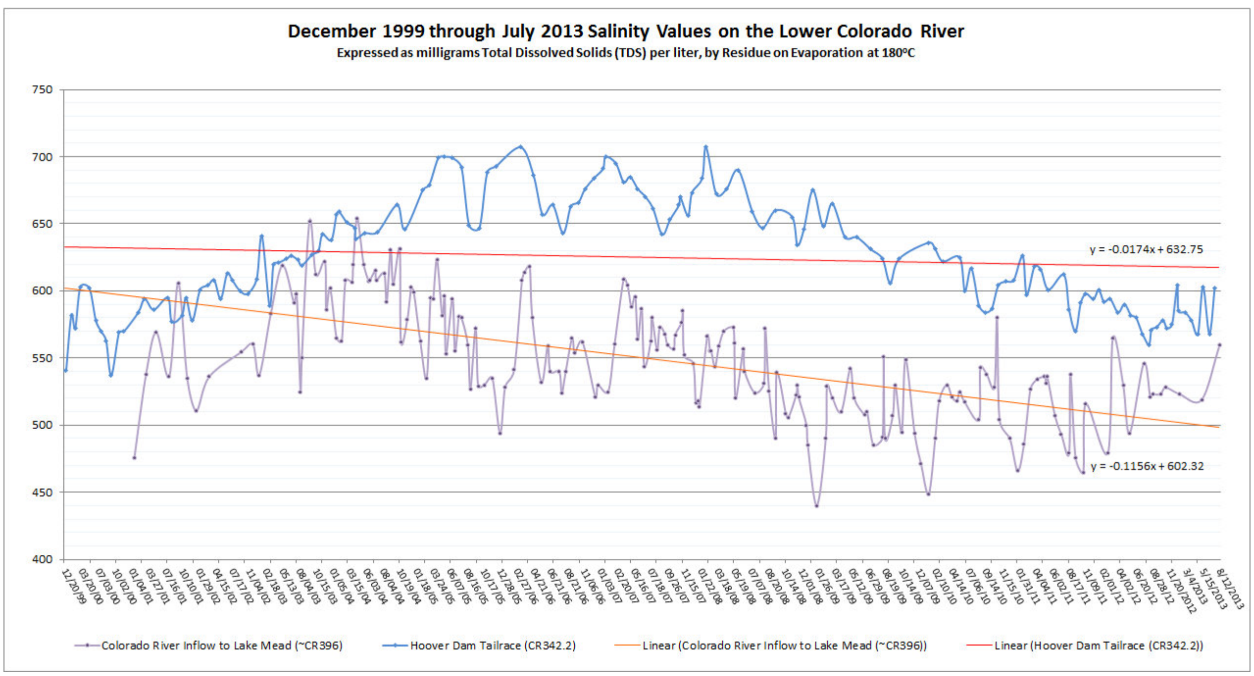


Figure 1. Total dissolved solids entering and leaving Lake Mead, measured at the Colorado River inflow and at the Hoover Dam tailrace. Includes trendlines for each trace, and trendline equations. Reclamation data.

1.0 INTRODUCTION

The Las Vegas Wash (Wash) is a natural drainage channel east of Las Vegas, Nevada (Figure 2), that transports stormwater, groundwater drainage, urban landscape runoff, and effluent from four wastewater treatment plants[1] to Lake Mead. The Wash is the drainage outlet for the entire 2,384 square miles (6,175 square kilometers) of the Las Vegas Valley (Valley) watershed.

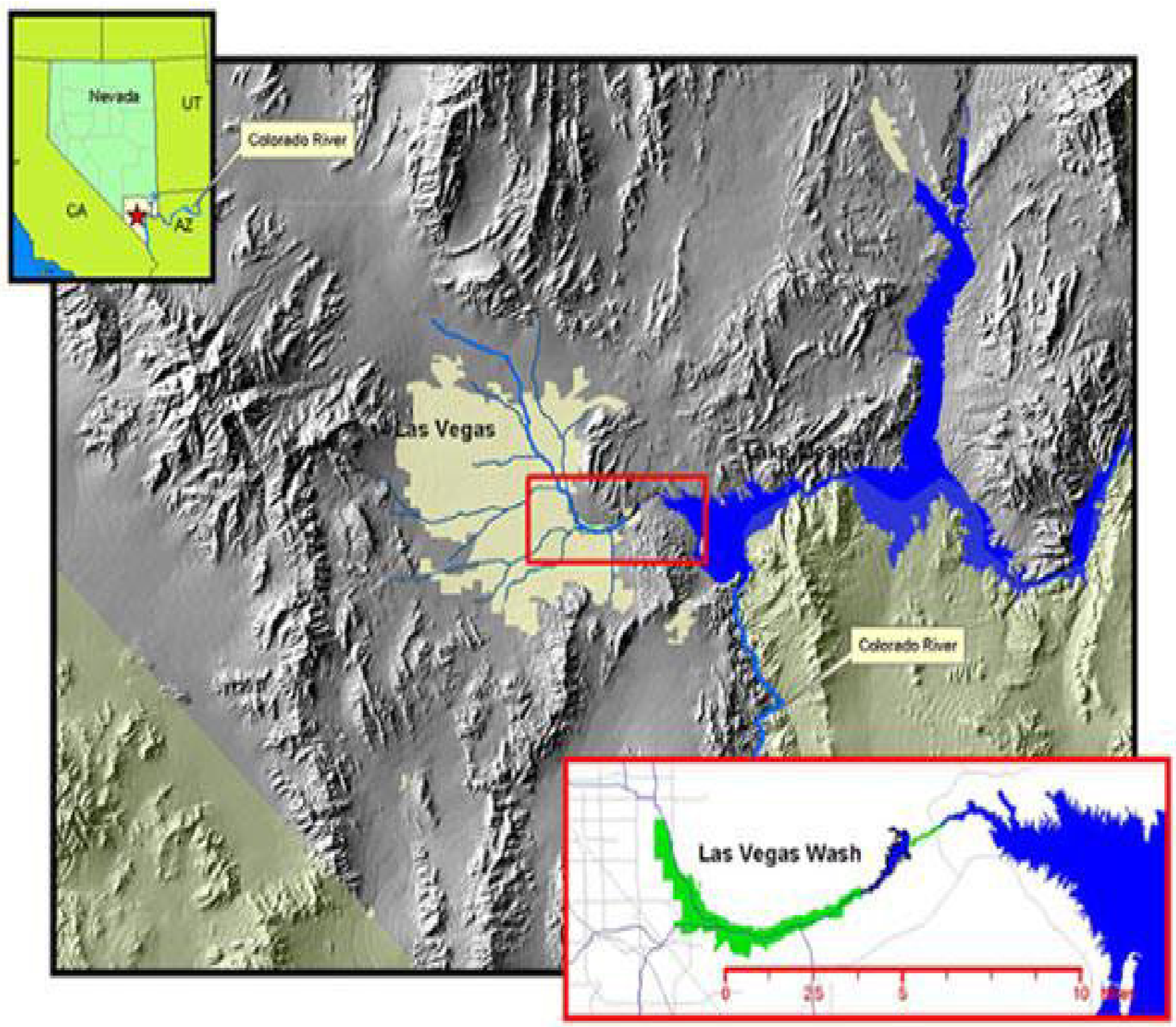


Figure 2. Location map of the Las Vegas Wash in Las Vegas, Nevada. Source: Southern Nevada Water Authority (SNWA) www.lvwash.org

1 The City of North Las Vegas began discharging effluent from its new plant through the Sloan Channel to the Wash in June 2011. The City of Las Vegas and Clark County wastewater treatment plants discharge treated effluent directly to Las Vegas Wash. The City of Henderson's wastewater treatment plant disposes of its treated effluent in rapid infiltration basins located south of the Wash near Pabco Road, and as reclaimed water for reuse. In November 1993, the City of Henderson also began discharging treated effluent directly into Las Vegas Wash during periods of low demand for reclaimed water.

The study reach discussed in this report extends from above Vegas Valley Drive at mile LW11.5 to downstream of Lake Las Vegas at LW0.9 (see Figure 2), a distance of just under 11 stream miles (17.7 km). Prior to 1928, the Wash was an ephemeral stream, existing as a barren, sandy channel that flowed on the surface only during brief periods of major storm runoff (Stave, 2001). During that time, the estimated normal summer flow was approximately 1 cfs (cubic foot per second) (0.03 cms (cubic meters per second)). Groundwater was the primary water source for residents of the Las Vegas and Henderson areas in their early days and, other than stormwater runoff, contributions to flow in the Wash were limited. Lake Mead water was first imported to Henderson in 1942 for industrial use, from which wastewater was discharged into the Wash (Bureau of Reclamation, 1982).

After World War II, the Las Vegas metropolitan area continued to grow, and the Valley became the largest population center in the State of Nevada (Appendix A provides a chronology of water use in Southern Nevada and its influence on the Wash). To accommodate growth, wastewater treatment plants were built that discharged treated effluent to the Wash, causing the Wash to become a perennial stream and producing a wetland area that extended nearly the entire length of the lower Wash. These wetlands provided important habitat for waterfowl and other wildlife.

As growth in the Valley increased, wastewater discharges to the Wash increased. Wastewater discharge is typically void of entrained sediment and tends to create scour conditions when discharged to a stream. In the Wash, this "hungry" water contributed to significant bank and bottom erosion, by first downcutting narrow channels that grew wider during flood events. By 1999, continuous flow had eroded the Wash into a deep channel. A water pipeline initially buried by SNWA 100 feet beneath the bottom of the Wash (the Historic Lateral Pipeline near LW5.5) later became exposed and was abandoned because of this cycle of downcutting and erosion.

Downcutting and channelization also resulted in a falling water table adjacent to the Wash, effectively draining much of the previously inundated floodplain in the Valley (Bureau of Reclamation, 1982) and reducing the size and composition of its wetlands. In the 23 years covered by this report (1990-2012), the average daily flow rate increased from 172 to 304 cfs (4.87 to 8.61 cms) on the lower reach of the Wash, or from 111 MGD (million gallons per day) in 1990, to 197 MGD in 2006. In 1999, the Las Vegas Wash Coordination Committee planned and completed the first of 22 proposed grade-control structures designed to retard flow and stabilize the channel. These bioengineered structures were designed to create wider and shallower areas in the Wash that slow the flow during storms, allowing native vegetation to reestablish in and around the mainstream Wash, and mitigating wetland loss. By the end of 2012, 15 structures were completed within the Wash (Table 1). Information about additional grade-control structures that are under construction or planned on the Wash and its tributaries is available in the Wash Capital Improvement Plan at http://www.lvwash.org/assets/pdf/beingdone_washplan_cip_2008.pdf.

The flow rate and solute load carried by the Wash fluctuate according to the volume of discharged effluent generated by the Valley's population, and according to precipitation in the Valley and its surrounding mountains. Based on stream gages operated by the USGS (United States Geological Survey) on the Wash, the 2012 average daily discharge to Lake Mead measured at LW0.9 was 293 cfs (8.29 cms). This equates to approximately 189 MGD, an estimated 2 MGD lower than the average in 2011. In 2012, population in the Valley increased by more than 2 percent to an estimated 2 million residents (see Appendix D). The National Weather Service in Las Vegas reported 5.31 inches of precipitation at McCarran Airport, where its official weather station is located. Based on these data, we expected the average flow rate in the Wash to increase in 2012, but that was not the case. Local conservation measures such as turf removal and wastewater reuse may be having their desired effects.

Table 1. List of grade-control structures completed in the Las Vegas Wash since 1999.

Completed Las Vegas Wash Control Structures	Year Completed	Completed By
Demonstration Weir	1999	SNWA/Henderson
Fire Station Weir	2000	Lake Las Vegas
Historic Lateral Weir	2000	SNWA
Pabco Road Weir	2000	Clark County
Monson Outfall Weir	2002	SNWA
Visitor Center Weir	2002	SNWA
Bostick Weir	2003	SNWA
Rainbow Gardens Weir	2004	SNWA
Calico Ridge Weir	2004	SNWA
Powerline Crossing Weir and Bridge	2008	SNWA
Upper Diversion Weir and Bridge	2008	SNWA
DU (Ducks Unlimited) Wetlands No. 2 Weir	2009	SNWA
Lower Narrows Weir	2011	SNWA
Homestead Weir	2011	SNWA
DU Wetlands No. 1 Weir	2012	SNWA

The 1974 Colorado River Basin Salinity Control Act, Title II (Public Law 93-320), authorized designation of several salinity control units intended to reduce salt loading in the Colorado River. The Las Vegas Wash is a designated unit and several methods to reduce its saline discharges to Lake Mead and the Colorado River were studied in the 1970s and 80s. A bypass pipeline was planned to convey wastewater effluent around the wetlands in the Wash to reduce salt pickup from the underlying saline alluvium. Also planned was a cutoff trench across the Wash to intercept the saline underflow for treatment, initially in evaporation ponds and later by the addition of a desalting plant as flows increased (Bureau of Reclamation, 1977). Construction of the interception facility to collect saline groundwater started in 1977, but was suspended in 1978 to allow time to reevaluate changing groundwater conditions.

Other salinity control strategies were addressed during the reevaluation period. One strategy would have conveyed wastewater and minor storm runoff in a bypass channel running parallel to the Wash for about 4 miles to reduce salt pickup from saline alluvium. However, some local entities viewed the bypass channel as being in conflict with wildlife habitat-improvement objectives and nutrient control, because the wastewater would no longer benefit from natural nutrient removal by contact with wetlands vegetation. A consensus of local support for this bypass channel was not obtained (Interior, 2003).

Reducing groundwater flow by constructing detention dikes across the Wash was another strategy for salinity control studied by Reclamation. The hypothesis was that groundwater detained behind the dikes would stratify, with relatively high-quality water collecting at the top. This higher-quality water would then spill to the Wash channel. However, computer modeling of the concept by USGS indicated that stratification would not occur, and the groundwater detention strategy would not effectively reduce salinity in the Wash.

Ultimately, the Pittman Bypass pipeline was determined to be the most cost-effective salinity control strategy for the Las Vegas Wash Unit, and construction was completed in 1985. The Pittman Bypass pipeline is approximately 4 miles long and daylights at the end of Pabco Road into an open channel about 100 meters from the Wash. Prior to construction of the Bypass, an open, unlined channel called the Alpha Ditch carried treated industrial wastewater from the Basic Magnesium Incorporated (BMI) [2] plant in Henderson to the Wash. The Bypass prevents this surface flow from coming into contact with native salt deposits and leaching salt from the soil, and has reduced salt loading of the Colorado River by an estimated 3,800 tons (3,447,295 kg) per year.

Reclamation has discontinued developing and implementing further salt reduction strategies for the Las Vegas Wash Salinity Control Unit. A strategy is apparently not available that is cost-effective, technically feasible, and publicly acceptable at this time. Reclamation published a final report for the Unit in September 1989, and quarterly water quality monitoring is continuing.

2.0 SAMPLING LOCATIONS AND METHODS

2.1 Sampling Sites and Descriptions

Descriptions of the sampling sites used in this study are presented in Table 2, and Figure 3 shows the locations and coordinates of present sampling sites on the Wash. Site names are based on nomenclature presented in the *Interagency Lake Mead and Las Vegas Wash Monitoring Program — Standard Operating Procedures Manual* (LVWCC, 1999). Under this system of site identification, the prefix "LW" indicates that the site is located on the mainstream Wash, while the prefix "LWC" indicates a site located on a contributing channel, such as an effluent discharge

2 Basic Magnesium Incorporated has undergone several changes in ownership and production since its inception, and has at times been known as Basic Management Incorporated, Basic Water Company, and most recently as the Black Mountain Industrial complex.

channel, seep, or adjacent groundwater well. The numbers following the letter prefix are the site's distance in river miles upstream from the high water mark of Lake Mead in Las Vegas Bay (LVB).

Station LW11.5 is the uppermost mainstream monitoring location in the study reach and is North of Vegas Valley Drive. It is about 50 m upstream from the Sloan Channel confluence with the Wash, and immediately upstream of the concrete apron that provides armoring for the confluence. At LW11.5, the Wash flows in the bottom of an unlined channel with adjacent broad sloping banks to accommodate large storm flow, armored by concrete on the north bank and by riprap and large boulders on the south bank. Boulders and riprap are lightly scattered in the streambed also, which consists of fine silt covered with macrophytes. Wading birds often forage upstream at this site and there are many tadpoles and snails in the water. The sampling site is characterized by urban trash, such as shopping carts and myriad plastic containers interwoven through patches of riparian vegetation. The flow at LW11.5 is calm and typically about 1 m deep just before it hits the concrete apron. The quarter-mile reach of the Wash immediately upstream passes through a residential golf course, where it receives flow from the Flamingo Wash tributary carrying runoff from the vicinity of the Las Vegas Strip and beyond, to the west. Under normal field sampling conditions, stream flow at LW11.5 is relatively light, with a median flow of 7.5 cfs (0.21 cms) and average flow of 28.11 cfs (0.80 cms) in 2012.

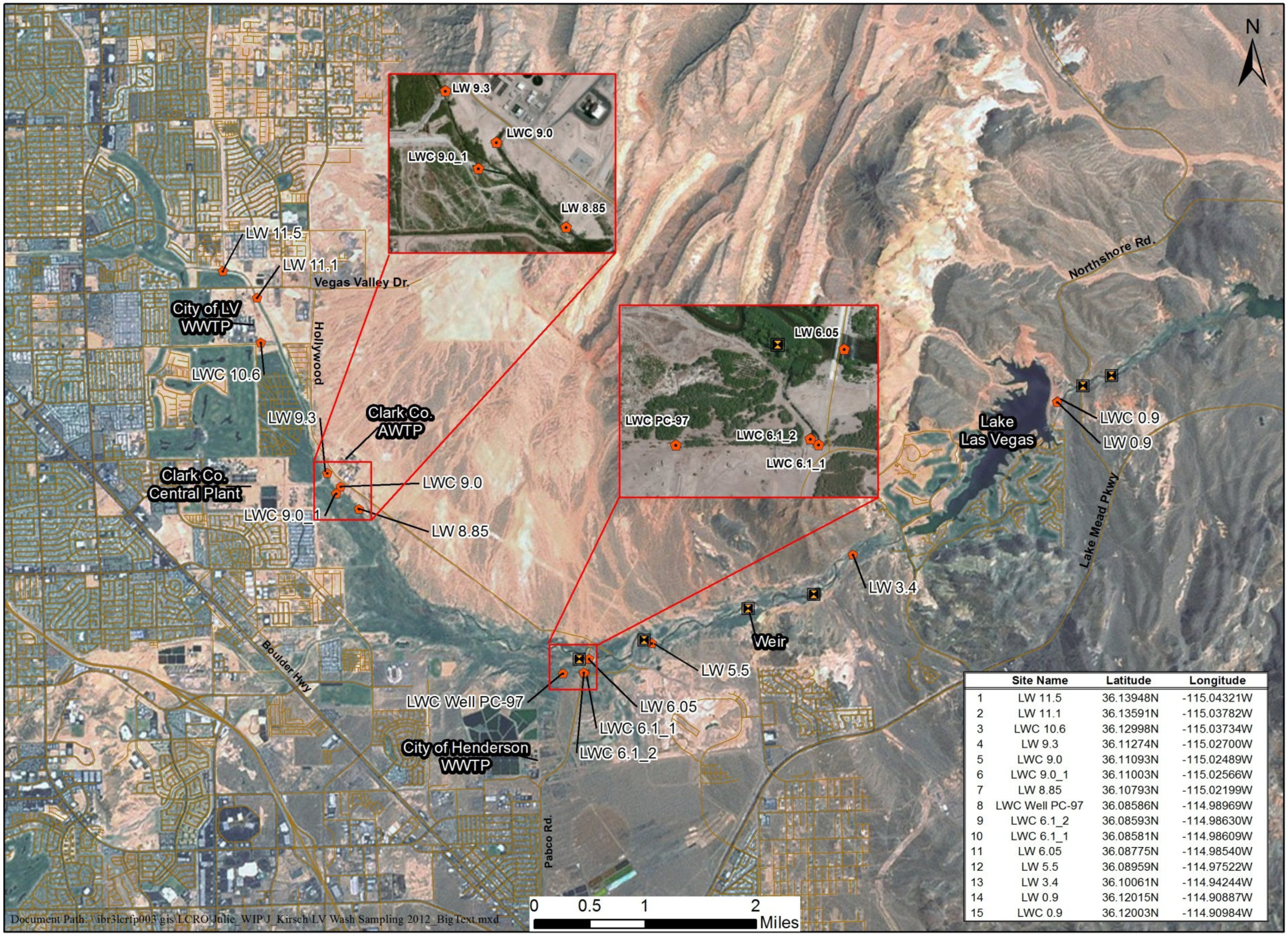
Because LW11.5 is upstream from all wastewater inflows to the Wash, conditions at this site are influenced by a combination of groundwater inflow and urban runoff. For purposes of this report, this site represents the baseline flow and ambient water quality conditions of the Wash. Since the Valley gets approximately 90 percent of its water from Lake Mead, it is important to bear in mind that, even in this stretch, urban runoff from irrigation or other outdoor uses of municipal water is composed largely of water that originated in Lake Mead. Therefore, water quality conditions at LW11.5 are influenced by the composition of treated water taken from Lake Mead. For example, perchlorate concentrations at LW11.5 reflect background levels of perchlorate from Pleistocene soils combined with the concentrations found in the Valley's drinking water (Rao, et al, 2007).

The wide, trapezoidal concrete armoring that protects the Wash from storm flows through the Sloan Channel where they intersect extends from immediately downstream of LW11.5 to immediately upstream of LW11.1. In prior years of this report, the flow between LW11.5 and LW11.1 was typically very shallow and spread across 50 to 60 percent of the floor of the concrete channel at a depth of less than 2 inches. Since June 2011, when the City of North Las Vegas began discharging treated effluent through the Sloan Channel from its new wastewater treatment facility, the flow spreads over 90 to 100 percent of the concrete floor at a depth of almost 4 inches. Flow became much greater at LW11.1 (57.9 cfs (1.64 cms)) on average in 2012 and the site harbored increased algae and unpleasant odors characteristic of anaerobic decomposition. Downstream from LW11.1, the mainstream Wash flows in a broad unlined natural channel characterized by urban trash and plastics intermixed with riparian vegetation such as cattails and phragmites (common reed). Concrete riprap fortifies the banks and streambed at LW11.1.

Station LWC10.6 is sampled from the effluent discharge channel for the City of Las Vegas Water Pollution Control Facility (CLVWPCF). Prior to 2010, this sample was collected from an open concrete channel, but site improvements at the facility included routing effluent through a submerged channel to the Wash. The channel was accessed inside a concrete structure with steps, and the sample was grabbed in a bucket where physical parameters such as temperature, pH, conductivity, and dissolved oxygen were measured with a Eureka Manta multiprobe. Samples for laboratory analysis were also grabbed by bucket. The CLVWPCF discharged 38.7 MGD in 2012 (almost 9 MGD less than in 2011), increasing flow in the mainstream Wash by about 60 cfs (1.69 cms) downstream of its outfall.

Table 2. Sampling Site Descriptions for 2012.

Site Name	Site Description
LW11.5	Mainstream Las Vegas Wash immediately above concrete apron that armors the Sloan Channel confluence (USGS gauging station is located upstream at Flamingo Wash confluence).
LW11.1	Mainstream Las Vegas Wash at end of apron below Vegas Valley Drive.
LWC10.6	City of Las Vegas Water Pollution Control Facility, effluent discharge inside concrete structure by outfall.
LW9.3	Mainstream Las Vegas Wash upstream of Clark County discharges, immediately north of the Rochelle Road Bridge.
LWC9.0_1	Clark County Advanced Water Treatment Plant, effluent discharge channel from landing inside caged stairs.
LWC9.0	Clark County Central Plant effluent discharge channel, accessed via ramp on concrete structure.
LW8.85	Mainstream Las Vegas Wash immediately below confluence with both Clark County treatment plant discharges (at USGS gage).
LWC Well PC-97	Nevada Environmental Response Trust Site well approximately 260 feet (80 m) south/southeast of LWC6.3. Replaced LWC6.3 as of September 2010.
LWC6.1_2	Pittman Bypass Pipeline, discharge from TIMET; formerly known as the Alpha Ditch.
LWC6.1_1	City of Henderson Wastewater Treatment Plant effluent discharge channel.
LW6.05	Mainstream Las Vegas Wash, from blocks in the Pabco Road grade-control weir (USGS gaging station is located immediately upstream).
LW5.5	Mainstream Las Vegas Wash, above SNWS historic lateral crossing.
LW3.4	Mainstream Las Vegas Wash, below Rainbow Gardens Weir.
LW0.9	Mainstream Las Vegas Wash, immediately downstream of Lake Las Vegas. This site permanently replaced LW0.55 beginning in 2012.
LWC0.9	Seep at toe of Lake Las Vegas Dam, approximately 10 feet (3 m) north of the mainstream Las Vegas Wash at LW0.9.



	Site Name	Latitude	Longitude
1	LW 11.5	36.13948N	-115.04321W
2	LW 11.1	36.13591N	-115.03782W
3	LWC 10.6	36.12998N	-115.03734W
4	LW 9.3	36.11274N	-115.02700W
5	LWC 9.0	36.11093N	-115.02489W
6	LWC 9.0_1	36.11003N	-115.02566W
7	LW 8.85	36.10793N	-115.02199W
8	LWC Well PC-97	36.08586N	-114.98969W
9	LWC 6.1_2	36.08593N	-114.98630W
10	LWC 6.1_1	36.08581N	-114.98609W
11	LW 6.05	36.08775N	-114.98540W
12	LW 5.5	36.08959N	-114.97522W
13	LW 3.4	36.10061N	-114.94244W
14	LW 0.9	36.12015N	-114.90887W
15	LWC 0.9	36.12003N	-114.90984W

Figure 3. 2012 Las Vegas Wash water quality monitoring sites with corresponding location coordinates, and major weirs and treatment plants.

LW9.3 is located in the mainstream Wash 1.3 miles (2.1 km) downstream from the CLVWPCF discharge. This sampling site is immediately upstream of the Rochelle Road Bridge located within the boundaries of the Clark County Water Reclamation District (CCWRD) facility. The sample is collected about 400 m upstream from LWC9.0_1, the discharge from the Clark County Central Plant on the west side of the Wash. At LW9.3, the Wash is about 1.2 m deep and the relatively narrow streambed has a silty cobble/riprap substrate with little macrophyte growth. At flood stage, water spreads over the west bank of the channel here, periodically inundating one of the patches of vegetation that have been restored along the Wash. The County is in the planning stage of a project that will deepen and pave the Wash within its property boundaries to prevent this flooding, as it makes Rochelle Road impassable and isolates their Central Plant from their Advanced Plant during storm flows. The Wash will be rerouted during construction, but how that will look and when the work will begin are presently unknowns.

Downstream from the Rochelle Road Bridge, discharge from the CCWRD treatment plants occurs from both the east and west sides of the Wash at LWC9.0 and LWC9.0_1, respectively. LWC9.0_1 opens to the Wash from the west side about 300 feet (91 m) upstream from where LWC9.0 discharges to the Wash from the east side. Samples are collected from both concrete discharge channels and undergo laboratory analyses separately. However, the data are averaged and discussed as one in terms of flow and loads contributed to the Wash by the County. The combined average flow from Clark County in 2012 was 88.8 MGD (about 137 cfs, or 3.89 cms).

LW8.85 is in the mainstream Wash approximately 150 m downstream from the CCWRD discharge channels, just inside the County's treatment facility boundaries. This station is adjacent the patch of revegetation that is periodically flooded, as mentioned earlier, and will be impacted by the upcoming construction. At LW8.85 presently, the Wash is a few meters deep and relatively narrow, but it has widened over the last few years during storm flows that have eroded its steep west bank. The collection platform for this site is located near the toe of an exposed bedrock or caliche shelf that creates a small turbulent waterfall, so the Wash here is well aerated. During the channel relocation/lining project, this caliche/bedrock will be removed in order to deepen the channel.

LWC Well PC-97 is a groundwater monitoring well located in the perchlorate remediation area near the end of Pabco Road, now known as the Nevada Environmental Response Trust Site (NERT). This well is one in a cluster of about 17 wells that make up the Seep Well Field where groundwater used to surface near the Wash, which is located about 500 feet (150 m) to the north. This well is monitored as a means of tracking the salinity of groundwater that is intercepted by the Wash and to take the pulse of one of the plumes carrying perchlorate and chromium from the BMI complex. More background on the BMI complex and information about perchlorate are presented in the discussion section of this report.

Also located near the end of Pabco Road are the outfalls from the City of Henderson Wastewater Treatment Plant (CHWTP) at LWC6.1_1, and from the Pittman Bypass Pipeline at LWC6.1_2 that carries discharged process water from the BMI complex. These pipes discharge roughly 330 feet (100 m) south of the Wash into riprap-lined natural channels that merge before joining the Wash just above the Pabco Road Weir. Combined, these discharges contributed approximately 25.9 cfs (0.73 cms, or 16.8 MGD) in 2012 to the mainstream flow measured at LW6.05. Samples are collected from the Wash mainstream at LW6.05, mid-channel, from the concrete 'teeth' of the Pabco Road Weir. The water drops at least 5 vertical feet (1.52 m) from the top of the weir 65 feet (20 m) upstream of the sampling point, so the water is well aerated and frequently turbid at this location. The concrete weir channel is very wide at this location to allow the flow to spread and slow down during heavy storm flow events.

Downstream from LW6.05 at approximately LW5.5, a rock weir was constructed at the Historic Lateral Crossing. Samples for station LW5.5 are collected just upstream from this weir at a relatively narrow, deep, and slow-flowing stretch of the mainstream Wash. The banks here are covered in Phragmites and during storm flow, floodwaters spread to lower ground on both sides of the Wash. The flood plain is characterized by gravel and Phragmites, with tall willow and cottonwood stands planted on both sides of the Wash during construction of the weir in 2000.

Station LW3.4 is located on the mainstream Wash at the toe of the Rainbow Gardens Weir, upstream from the Lake Las Vegas Fire Station. This wide concrete outfall structure provides aeration through its stairstepped design, so the water here is often turbid and can produce loosely cohesive foam under natural conditions. Flow is recorded at a USGS gage here every 15 minutes and at this site, measured flow is often higher than it is downstream at the gage at LW0.9. Therefore, the stretch of the Wash between LW3.4 and LW 0.9 is considered a 'losing stream' where water is leaving the channel through an unknown route. Not far downstream from this site, the Wash flows underneath Lake Las Vegas in a large pipe during normal flows.

Just below the earthen dam that creates Lake Las Vegas, the mainstream Wash emerges from its large pipe. This is the location of station LW0.9, which was sampled for the first time for this program in 2011. At flood stage, the Wash also flows into and around the north side of Lake Las Vegas and reenters the mainstream channel at a waterfall upstream of the Northshore Road bridge. Because LW0.9 can be accessed by motor vehicle and it is near the USGS gaging station downstream at LW0.55, this site completely replaced LW0.55 in 2012. Sampling both sites in 2011 revealed similar data. For purposes of maintaining the historic record, all data from LW0.9 are appended to data from LW0.55 from prior years, and labeled as LW0.9 from 2012 forward.

A seep located just a few yards (meters) north at LW0.9, site LWC0.9 was sampled only during 2012. The flow emerges from a metered concrete block 'box' constructed and monitored by dam safety staff at Lake Las Vegas and from the State of Nevada (personal conversation with Doug Blatchford (Reclamation) and Robert Martinez (State Engineer, Carson City, NV)). A chimney drain constructed within the dam collects seepage and eventually drains it from the dam through the concrete box, at a rate of about 20 gallons (75 L) per minute (2.67 cfs, or 0.001 cms). From the box, a narrow stream of water flows through a natural channel that joins the mainstream Wash a few feet downstream from where LW0.9 samples are grabbed.

Compared to field and laboratory results from other sites on the Wash, this seep emerging near the foundation of the Lake Las Vegas Dam has very low dissolved oxygen content (1 mg/L or less) and high electrical conductivity (2,700 to 3,000 µS/cm). The calcium and sulfate concentrations are more than double those in mainstream Wash samples, and most similar to data from LWC Well PC-97. Perchlorate and selenium were analytes of particular interest among those analyzed in this sample. Perchlorate concentrations in this seep water ranged from 0.88 to 2.10 ppb, and selenium concentrations were below the reporting level of 0.5 ppb in all samples. See Appendix B for complete chemistry and field data tables.

2.2 Sample and Data Collection

Water quality of the Wash is sampled quarterly under the auspices of Reclamation's Colorado River Water Quality Improvement Program (CRWQIP). The CRWQIP's purpose is to develop a comprehensive, cost-effective program for water quality improvement and salinity control in the Colorado River Basin in cooperation with the Basin States and other Federal agencies. For the 2012 monitoring year, water samples were collected and ambient water quality parameters were measured in the Wash on March 14, June 12, September 11, and December 11.

Measurements of water temperature in degrees Celsius (^{o}C), dissolved oxygen concentration as milligrams per liter (mg/L), pH in Standard Units (SU), and specific conductivity in micro-Siemens per centimeter (µS/cm) were taken in the field during each sampling event using a Eureka Manta 2® multiprobe and Archer™ handheld display by staff from the Lower Colorado Region's Resources Management Office. Appendix B contains complete results of the 2012 field parameter measurements and laboratory analyses.

Water samples for the analysis of major ions, total suspended and total dissolved solids, nitrogen, phosphorus, selenium, and perchlorate were collected at 15 locations by surface grab in poly bottles and immediately stored on ice in insulated containers in the field. Samples to be analyzed for cations and orthophosphate phosphorus were passed through a 0.45-µm membrane filter immediately upon collection and stored on ice. One aliquot of the filtered sample was immediately acidified with nitric acid in preparation for dissolved cation analysis. An aliquot of unfiltered sample was acidified with sulfuric acid in preparation for total phosphorus analysis, while another was acidified with ultrapure nitric acid for total selenium analysis. Sample analyses were performed by two different laboratories, as specified in Table 3. All samples were received by both laboratories within 26 hours of collection of the first sample on each survey date.

2.3 Laboratory Methodologies

Beginning in 2007, Reclamation contracted all laboratory analyses with Sierra Foothill Laboratory (SFL), a certified, accredited lab that has maintained continuous certification with the California Department of Health Environmental Laboratory Accreditation Program since the lab's inception in 1979. SFL is also accredited under the National Environmental Lab Accreditation Program (NELAP) and adheres to all guidelines set forth therein.

The analytical methods used to generate data for this report and their detection and reporting limits are shown in Table 3.

Table 3. Summary of Laboratories and Analytical Methods used in 2012.

Laboratory Name	Constituent	Method of Analysis	Method Detection Limit	PQL
SFL	Total Suspended Solids	EPA160.2/SM2540 D	0.80 mg/L	1.0 mg/L
LCRL	Total Dissolved Solids	SM2540 C	2.0 mg/L	2.0 mg/L
LCRL	Cations, Dissolved	SM3120 B	0.25-1.0 mg/L	1.0–5.0 mg/L
SFL	Selenium, Total	EPA200.8, ICP/MS	0.1 µg/L	0.5 µg/L
LCRL	Chloride	SM4110 C	0.010 mg/L	0.50 mg/L
LCRL	Fluoride	SM4110 C	0.05 mg/L	0.15 mg/L
LCRL	Sulfate	SM4110 C	0.025 mg/L	0.50 mg/L
SFL	Silica, Dissolved	EPA370.1/SM4500-SiO2 D	0.026 mg/L	0.10 mg/L
SFL	Ortho-Phosphate	EPA365.2/SM4500-P E	0.0001 mg/L	0.001 mg/L
SFL	Total Inorganic Nitrate /Nitrite	EPA300.0/SM4110 B	0.006 mg/L	0.05 mg/L
SFL	Ammonia	EPA350.1/SM4500-NH3 F	0.004 mg/L	0.20 mg/L
LCRL	Total Alkalinity	SM2320 B, calculated	1.40 mg/L	1.40 mg/L
SFL	Perchlorate	EPA6850 (HPLC/EIS)	0.020 µg/L	0.50 µg/L

EPA = Environmental Protection Agency
HPLC/EIS = High-Performance Liquid Chromatography/Electrospray Ionization Mass Spectrometry
LCRL = Lower Colorado Regional Laboratory, Bureau of Reclamation, Boulder City, Nevada
PQL = Practical Quantitation Limit, aka Reporting Limit
SFL = Sierra Foothill Laboratory, Jackson, California, with perchlorate and selenium analyses subcontracted to ALS Environmental
SM = Standard Methods for the Examination of Water and Wastewater, 19th edition

In 2011, the Lower Colorado Regional Laboratory (LCRL) resumed analysis of Wash samples for TDS, major cations and anions, and fluoride. The LCRL is a Reclamation-operated laboratory specializing in salinity and soils work. Both laboratories' staffs use approved methods designed for the concentration ranges of constituents found in these samples, citing the 19th Edition of Standard Methods as their reference, as all methods in that edition are EPA-approved.

3.0 RESULTS AND DISCUSSION

3.1 Hydrology

The Wash is a natural drainage channel that transports stormwater, groundwater discharge, landscape irrigation runoff, and wastewater effluent from 2,384 square miles (6,175 square kilometers) of lands that constitute the Las Vegas Valley watershed, shown in Figure 4. The Valley is located in the Basin and Range Physiographic Province (Purkey, 1994). This region is characterized by a series of generally north-south trending mountain ranges and intervening valleys filled with eroded sediments. The eroded sediments disperse from the mountains surrounding the Valley in the form of alluvial fans. These fans, and the washes they contain, drain the watershed eastward into the Wash, then into Lake Mead, which is part of the Colorado River system. The Las Vegas Valley is very prone to flash flooding due to its geologic and orographic composition.

The upper reaches of the Wash that lie outside the greater Las Vegas urban area are typically dry, flowing only during localized heavy precipitation events. This area, north and west of the present study reach, is characterized by alluvial fans consisting of materials ranging in size from silt to boulders that have been carried to the bases of surrounding mountains, where several fans often merge into a single apron at the base of the slope (some refer to this landscape as a 'bajada,' Spanish for 'slope'). During precipitation events, flooding can occur quickly on the fans, where many unnamed washes form a braided network of incised channels that eventually carry runoff to the mainstream Wash and, ultimately, to Lake Mead. Ephemeral flows in these upper reaches are estimated to range from a few dozen cfs to several thousand cfs (Bureau of Land Management, 2010).

The Spring Mountains are located on the west side of the Valley, while the Sheep Range borders it on the north. Smaller mountain ranges are located on the east and southeast sides of the Valley. The Spring Mountains are composed primarily of limestone rock. The alluvial fans around the Valley are coated with calcium carbonate, which is part of the geologic composition of limestone. Calcium carbonate is better known as caliche, or hardened natural cement binding other sedimentary materials such as gravel, sand, clay, and silt. Caliche is common to arid environments and is usually fairly close to the surface, where its impervious nature causes

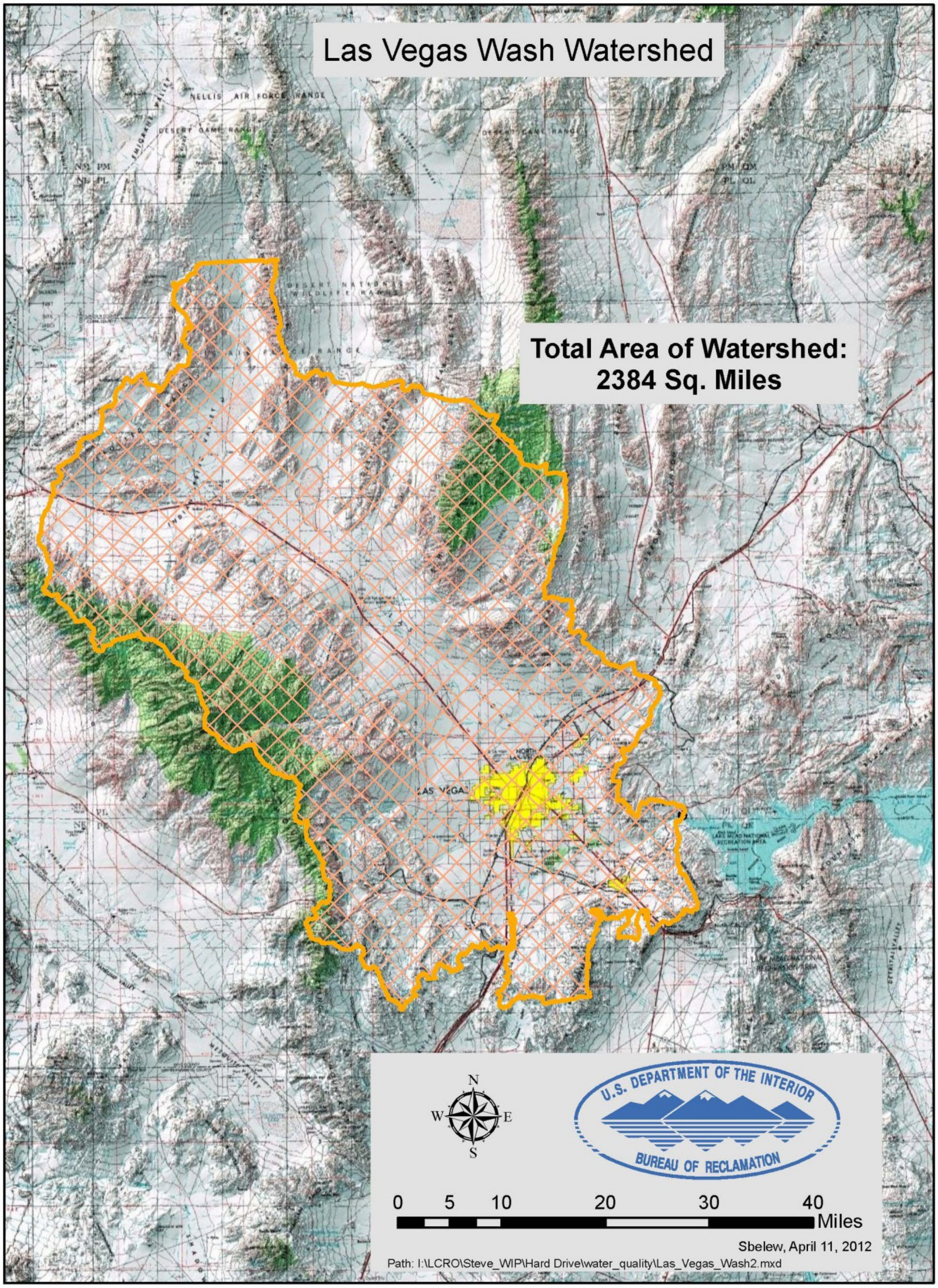


Figure 4. Map of the Las Vegas Wash watershed.

almost 100 percent of rainfall to run off.

Increased urban development in the northern reach of the Wash is creating greater expanses of impermeable land cover, with more engineered channelization of storm flows generated by an ongoing flood control program administered by the Clark County Regional Flood Control District (CCRFCD). The CCRFCD is a funding agency that integrates countywide flood protection throughout the unincorporated areas of Clark County, and the cities of North Las Vegas, Las Vegas, Henderson, and Boulder City. The CCRFCD Master Plan delineates where the Valley is channelized and where construction is planned. The CCRFCD also regulates land use in flood hazard areas. Local agencies in the county are members of the National Flood Insurance Program (NFIP) with a point of contact within each entity who acts as the NFIP coordinator. Flood plain management within the greater Clark County area is a joint process between respective local agencies and the CCRFCD. Where development encroaches on a regulatory floodplain, conditions for development are set to protect future homeowners and businesses, and to modify Special Flood Hazard Areas (SFHAs) accordingly.

Significant infrastructure has been funded and built throughout the Valley, such as detention basins, flood control channels, and storm drainage infrastructure. Because the Las Vegas Valley is a part of the arid Southwest and alluvial by nature, flow along alluvial fans entering the upper, northern, and western Valley from the Sheep Range and Spring Mountains has been cut off by a series of levees and detention basins. Detention facilities generally hold the entire volume of the hydrograph and allow for slow, uniform discharge from a primary spillway. Although much infrastructure is in place, Valley locations where channel and detention basin facilities are yet to be built may still experience extreme flooding.

Before development, the tectonic setting of the Valley generally controlled subsurface flow along the Wash. Springs located on the western side of the Valley near Valley View and US 95 flowed downstream in the Las Vegas Creek (as distinguished from the Wash) towards downtown. Artesian conditions contributed to base flow in the Wash on the eastern side of the valley; however, pumping of groundwater has now lowered the piezometric head well below artesian conditions. Today, subsurface flow may occur frequently in ephemeral washes throughout the watershed, but surface flow appears only within the southwestern quadrant of the watershed where urban runoff and municipal wastewater inflows to the Wash are constant. Flow rates in the Wash vary annually, and are locally dependent on precipitation events and on effluent discharges from the four Valley wastewater treatment plants. Together, these plants discharged approximately 161 MGD (249 cfs or 7.04 cms) in 2012, roughly 10 MGD less than in 2011. Because the majority of surface flow in the Wash comes from effluent discharges, the annual average flow rates also vary in accordance with changes in population in the Valley and in response to local conservation measures.

Total precipitation for the greater Las Vegas area is officially measured at McCarran Airport (McCarran) as shown in Table 4, but it is also measured at weather stations located throughout the Valley. Data from these dispersed stations illustrate how precipitation in the Valley varies depending on location, and flood conditions in the Wash occasionally result from localized heavy rains that are not reflected in the measurements at McCarran. For example, at McCarran the total precipitation measured for Las Vegas in 2012 was 5.31 inches (13.5 cm), a good deal greater than the long-term average of 4.19 inches (10.6 cm). Totals from other weather stations across the Valley ranged from 2.28 inches (5.79 cm) at the Cheyenne Peaking Basin in the northeast part of Las Vegas, to 9.93 inches (25.2 cm) at Pabco Road (near site LW6.05) in the southeast part of the Valley on the Wash. According to the local National Weather Service website, the majority of the Valley's precipitation fell in the Henderson area in 2012, with nearly all of those weather stations receiving more than 5 inches, and many had more than 7 inches (17.8 cm). Because of this localized distribution of major rainstorm events, one of the best locations to observe major flood flows for the entire Valley is at the end of Pabco Road, at one of the first erosion control structures constructed on the Wash.

During a 24-hour period spanning August 21 and 22, 2012, 1.98 inches (5.03 cm) of rain were measured at McCarran. Most of that fell on the 22nd (1.65 inches, 4.19 cm), ranking it the second-wettest day on record (National Weather Service, 1937-present). Based on flow data reported at the USGS gage at station LW0.55, Wash flows in January, August, September, and October were greater than the annual average of approximately 293 cfs (8.29 cms). Another significant flood event hit the Valley on September 11, 2012, when the flow rate at LW11.5 peaked at 11,300 cfs (320 cms) at 3:30 p.m. Water samples were collected that day, but all sample grabs were completed by 2:30 p.m. However, there was a small but noticeable increase in the flow by that time, and at LW0.9, a strong odor of anaerobic decomposition wafted from the Wash; probably resulting from scouring long-undisturbed sediments from the Wash. The Weather Service called this flood the "most significant flash flood since August 2003," and estimated its damages at $20 million. The August 22 flash flood, in comparison, caused an estimated $5 million in damages. One life was lost in each of these storms; both victims swept away in flowing washes.

The period of record for precipitation data at McCarran is from 1937 to the present. As seen in Table 4 (1990 to 2012), three years in the 10 driest years on record occurred during the first decade of the twenty first century: in 2002, 2006, and 2009. These were the sixth-, ninth-, and eighth-driest years, respectively. Interestingly, although the Colorado River watershed has been in drought since 2000, 3 of the 10 wettest years for the Valley also occurred in that decade. The years 2003, 2004, and 2005 were the ninth-, fourth-, and sixth-wettest years on record for Las Vegas since 1937, according to the local office of the National Weather Service (2012 Summary). They also reported that 2012 was the warmest year on record in Las Vegas with an average temperature of 21.8 ^{o}C (71.2 ^{o}F), largely because of exceptionally warm low temperatures. The average low of 60.5 ^{o}F (15.8 ^{o}C) broke the previous record of 60.2 ^{o}F (15.7

$^{\circ}$C) set in 2007. The highest temperature for 2012 (115 $^{\circ}$F, or 46.1 $^{\circ}$C) was recorded on July 10. For 81 days in 2012, temperatures exceeded 100 $^{\circ}$F (37.8 $^{\circ}$C), which is 11 days more than average.

Although 2012 was wetter than average (the twentieth-wettest year on record), there were only 42 days with more than a trace of precipitation, 5 days fewer than average. This pattern of drier climate yet higher flood flows is consistent with other locations throughout the western United States. Anecdotal evidence suggests that increased atmospheric energy caused by climate change and natural variability allows more moisture to be entrained in weather systems that, when combined with orographic lift or other physiographic conditions, contributes to high-intensity rainfall and flood control conditions (Li et al, 2003). See Appendix E for further discussion of specific rainfall events in the Valley.

Table 4. Total annual precipitation measured at McCarran Airport for Las Vegas, Nevada, from 1990 through 2012, and the 10 wettest and driest years on record since 1937. Source: National Weather Service.

Calendar Year	Total Precipitation (inches)	Total Precipitation (cm)	10 Wettest Years in the Las Vegas Valley		10 Driest Years in the Las Vegas Valley	
			Calendar Year	Inches	Calendar Year	Inches
1990	3.75	9.53	1941	10.72	1953	0.56
1991	4.06	10.3	1992	9.88	1948	0.76
1992	9.88	25.1	1964	7.96	1968	1.11
1993	5.05	12.8	2004	7.76	1964	1.12
1994	2.56	6.50	1978	7.65	1985	1.27
1995	3.69	9.37	2005	7.37	2002	1.44
1996	2.76	7.01	1998	7.35	1962	1.45
1997	3.63	9.22	1939	7.30	2009	1.59
1998	7.35	18.7	2003	6.86	2006	1.69
1999	3.73	9.47	1984	6.85	1966	1.91
2000	3.47	8.81				
2001	3.94	10.0				
2002	1.44	3.66				
2003	6.86	17.4				
2004	7.76	19.7				
2005	7.37	18.7				
2006	1.69	4.29				
2007	2.73	6.93				
2008	2.64	6.71				
2009	1.59	4.04				
2010	5.90	15.0				
2011	2.34	5.94				
2012	5.31	13.5				

3.1.1 Flow Measurements

The present study reach stretches from above Vegas Valley Drive at LW11.5 (see Figure 3) to the downstream side of Northshore Road at LW0.55 (now sampled at LW0.9), a distance of approximately 11 stream miles. The 2012 annual mean flow data for the study reach were measured and recorded at five mainstream and five tributary sites within this reach. Average annual flow rates are calculated using daily average data over the calendar year (January 1 through December 31) and plotted in Figure 5 for the years 1990 through 2012.

USGS gaging stations are permanently located in the study reach at or near sampling stations LW11.5, LW8.85, LW6.05, LW3.4, and LW0.9, and record stream flows every 15 minutes. The uppermost USGS gaging station on the mainstream Wash in the study reach is located below the Flamingo Wash confluence, about one-half mile upstream from station LW11.5. This gage (number 094196783) was established in June 1999, and the annual average flow record begins with calendar year 2000. In versions of this monitoring report that are prior to 2010, station LW11.1 was considered to be the reference site for conditions in the Wash, because it was upstream of any wastewater effluent discharges. However, in late June of 2011, the City of North Las Vegas began discharging effluent from their new Wastewater Reclamation Facility (CNLVWRF) into the Sloan Storm Channel, which eventually joins the flow of the mainstream Wash about 0.25 miles above LW11.1. That left station LW11.5 as the only site in this reach of the Wash that is upstream from all wastewater effluent discharges; therefore, data from this site represent the base flow and ambient water quality of the Wash as of June 2010, when monitoring at LW11.5 first commenced.

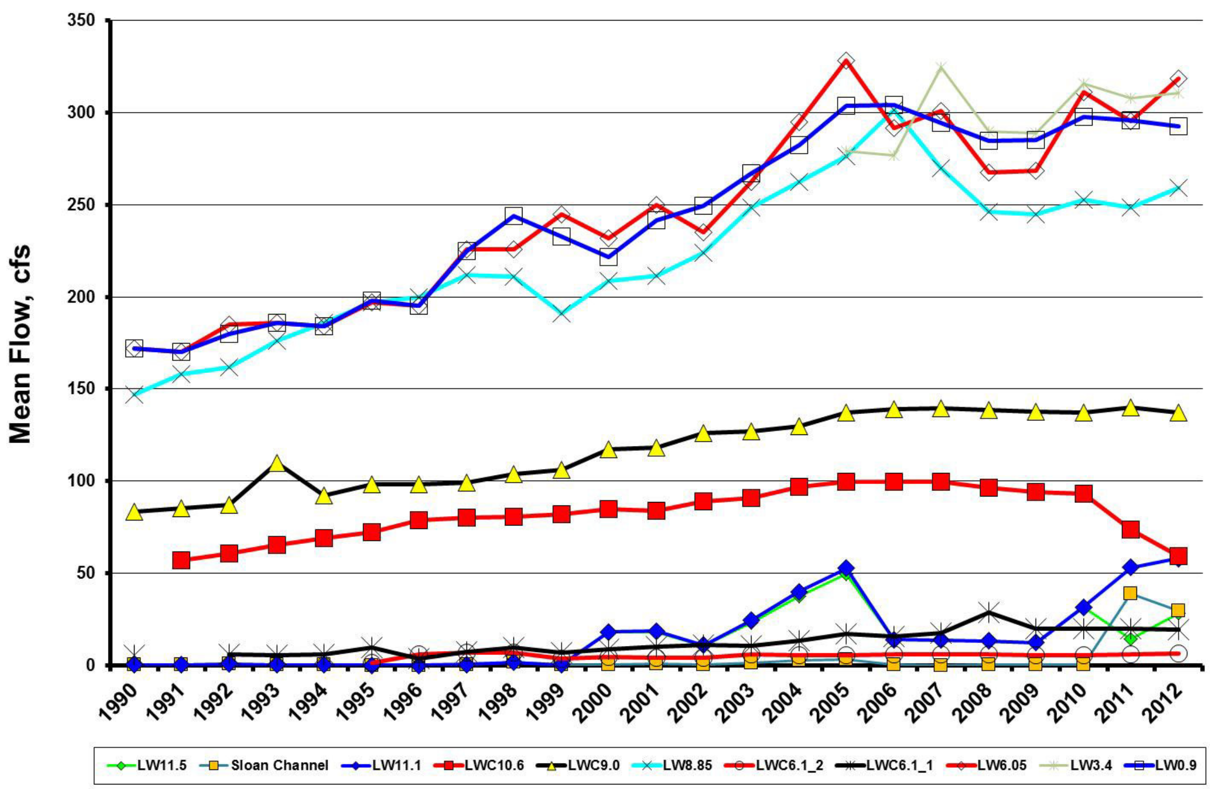


Figure 5. 2012 mean daily flow in cubic feet per second at sites measured in the Las Vegas Wash mainstream and some of its tributaries from 1990 through 2012. Legend displays sites from upstream to downstream.

Flow data for LW11.5 and LW11.1 were similar prior to CNLVWRF releases, since the Sloan Channel flow was negligible at all times except during localized storm events. For this and future reports, the sum of the flows at LW11.5 and Sloan Channel at Charleston Blvd (gage number 09419665) is used to estimate flow at LW11.1. Gage data are available through the USGS online database and are approved for publication on a water year basis, which is October 1 through September 30 each year. Thus, the 2012 flow data for most of the mainstream sites are final and approved only through September 30. Most of the data from October 1 through December 31, 2012 are provisional and will be corrected for the water quality report covering 2013, if there are changes to the USGS data for that period. Flow data from 1990 through 1999 are a combination of approved and provisional data as seen in past reports. The flow data from the USGS gage at LW0.55 is the exception to this rule, as this value is used to calculate the Valley's consumption of Colorado River water on a calendar year basis. Therefore, the data for that gage are approved daily and are final for the entire calendar year.

Figure 5 illustrates that between 1990 and 2006, the median flow in the Wash as measured at LW0.55 nearly doubled, from 172 cfs (4.87 cms) to 304 cfs (8.61 cms). This increase in flow was mainly due to increasing wastewater effluent discharges resulting from the rapidly growing population in the Valley. The general rate of growth to the year 2000, as shown in Table 5, continued to 2007, when the population of the Valley reached an estimated 1.93 million residents (Clark County Demographics, 2012). However, the national economic downturn in 2008/2009 was particularly hard-felt in the Valley, as new home starts and commercial development nearly ceased. The city's population became comparatively stable during this period, and at the end of 2009, the population of the Valley remained at approximately 1.94 million. Data from the official 2010 US Census revealed that while population growth in the Las Vegas urban area has slowed, it continues. Additional details of population dynamics in 2012 in the Las Vegas Urban Area and in Clark County are presented in Appendix D.

Table 5. Official US Census Bureau data for Las Vegas, Metropolitan Area from 1960-2010.

Las Vegas, NV Population, 1960-2010						
	1960	**1970**	**1980**	**1990**	**2000**	**2010**
Total	139,126	304,744	528,000	852,737	1,563,282	1,951,269
Change		165,618	223,256	324,737	710,545	387,987
Percent Change		119.04%	73.26%	61.50%	83.33%	24.82%

Source: www.CensusScope.org. Social Science Data Analysis Network, University of Michigan. www.ssdan.net.

Figure 5 also illustrates that the stretch of the Wash between LW6.05 and LW0.9 typically loses flow volume, with the highest flow rates recorded at either LW3.4 or LW6.05, and not at LW0.9, the most downstream gage within the study reach. USGS is aware of the data anomaly and carefully calibrates their flow gages on the Wash. It is likely that a fault zone within this stretch is causing the small reduction in flow, based on personal conversations with personnel from the

USGS office in Henderson, and with Doug Blatchford of Reclamation's Regional Office in Boulder City.

Flow data for the tributaries monitored for this report came from personnel at the cities of North Las Vegas, Las Vegas, and Henderson Wastewater Treatment plants, the Clark County Water Reclamation District, and TIMET Corporation. The Wash tributary sites at which flow was measured and reported are:

- Sloan Channel (new to this report in 2011);
- LWC10.6, the discharge from the City of Las Vegas Water Pollution Control Facility (CLVWPCF);
- LWC9.0 and LWC9.0_1, the combined effluent discharges from the Clark County Advanced Wastewater Treatment Plant (CCAWTP) and the Clark County Central Plant (collectively the Clark Country Water Reclamation District, CCWRD);
- LWC6.1_2, the discharge from TIMET through the Pittman Bypass Pipeline (formerly Alpha Ditch);
- LWC6.1_1, the discharge from the City of Henderson Wastewater Treatment Plant (CHWTP).

With the advent of wastewater discharge 0.8 miles (1.29 km) further upstream in 2011, the lower 11.4 miles (18.3 km) of the Wash, from the confluence of the Sloan Channel to Las Vegas Bay in Lake Mead, is characterized as an effluent-dominated stream except during occasional high flows resulting from major storm events. Treated wastewater effluent discharges totaled about 249 cfs (7.04 cms), or approximately 161 MGD for all Valley dischargers combined in 2012. Using this estimate, the water in the lower Wash was approximately 85 percent treated wastewater by volume this year. Figure 5 illustrates that effluent discharge rates, and the average flow in the Wash as a whole, have been relatively stable over the last several years (see traces for LWC9.0, LWC6.1_1, and for LW0.9). The exception is the discharge from the City of Las Vegas, which has decreased since the City of North Las Vegas began to collect and treat its wastewater locally in June 2011. Previously, wastewater from CNLV was treated at the CLVWPCF.

In a typical year, stormwater flood events may impact the Wash to a great degree, causing extensive channel erosion and influencing salt load quantities and composition from overland flow. The annual average flow in the Wash at LW11.5 can be quite variable, depending on time of day and on precipitation locations and intensities. The 2012 average flow rate was 28.1 cfs (0.80 cms), which is twice the 2011 average rate at LW11.5. Flow rates measured every 15 minutes at that site in 2012 ranged from 1.90 to 11,300 cfs (0.054 to 320 cms), with monthly averages ranging from 5.96 cfs in April to 317 cfs in August (0.169 to 8.97 cms). Flow rates measured every 15 minutes at the gage below the Northshore Road Bridge (LW0.9) on the lower end of the study reach ranged from 13.0 to 6,900 cfs (0.368 to 195.4 cms) in 2012. Monthly average flows there ranged from a low of 243 cfs in June to a high of 412 cfs in October (6.88 to

11.65 cms). The annual average flow at LW0.9 in 2012 (293 cfs, or 8.29 cms) was barely lower than the average flow reported for that site in 2011 (296 cfs, or 8.38 cms), even though there was more precipitation in 2012. The slightly lower average daily flow in 2012 could be from an increase in conservation measures implemented by homes and businesses, and from increased wastewater reuse.

Table 6. 2012 monthly mean, maximum, and minimum flow rates at both ends of the study reach; LW11.5 and LW0.9 (gaged at LW0.55 below Northshore Road bridge).

	LW11.5 USGS Data Approved through 9/30/12, Provisional through 12/31/12						**LW0.55** USGS Flow Data Approved through 12/31/12					
Month	Cubic Feet per Second			Cubic Meters per Second			Cubic Feet per Second			Cubic Meters per Second		
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
January	6.395	9.500	3.90	0.181	0.269	0.110	298.7	599	16.0	8.458	16.96	0.453
February	6.995	16.00	3.90	0.198	0.453	0.110	275.1	376	167	7.790	10.65	4.729
March	10.08	307.0	3.90	0.285	8.693	0.110	278.6	807	13.0	7.890	22.85	0.368
April	5.958	29.00	1.90	0.169	0.821	0.054	259.2	359	156	7.339	10.17	4.417
May	7.305	17.00	2.10	0.207	0.481	0.059	249.3	326	156	7.059	9.231	4.417
June	8.283	15.00	5.30	0.235	0.425	0.150	242.8	315	145	6.876	8.920	4.106
July	38.02	2040	5.30	1.077	57.77	0.150	276.3	1100	13.0	7.823	31.15	0.368
August	316.9	4200	15.0	8.974	118.9	0.425	353.7	6900	178	10.01	195.4	5.040
September	71.85	11300	5.70	2.035	320.0	0.161	318.8	6810	133	9.028	192.8	3.766
October	98.21	7090	5.70	2.781	200.8	0.161	411.6	6370	157	11.65	180.4	4.446
November	7.360	16.00	4.90	0.208	0.453	0.139	273.2	381	172	7.738	10.79	4.871
December	11.34	235.0	5.70	0.321	6.654	0.161	270.7	585	147	7.667	16.57	4.163

Storm flows in the Wash at LW0.9 were high for several extended periods in 2012, with notable storms in August, September, and October. In each of these stormy periods, the three-day average flow in the Wash exceeded 1,000 cfs (28.32 cms). While the storm rolled in from the north on September 11, we collected samples from the Wash well ahead of the storm flow, or so we thought. Precipitation was not falling in the immediate area, but it turns out that during sampling at LW11.5, flows in the Wash were four times higher than during the other three sampling events in 2012. At LW0.9 at about 2 p.m., the Wash flow was very turbid and noticeably a little higher than usual, with a strong rotten-egg odor. To finish sampling more quickly and ahead of the storm, LWC Well PC-97, LWC6.1_1 and LWC6.1_2 were bypassed on September11. The thinking was that there would not be much impact to the well from the storm, and that, because 6.1_1 and 6.1_2 are treatment plant discharges, neither of them would be affected. Visiting the well on the following day revealed that the intensity of the storm had nearly washed the wellhead out. Many of the analytes appeared to be slightly lower than average in the well sample collected that day, and slightly higher than average in the two discharge channels, LWC6.1_1 and LWC6.1_2. Later, we discovered that the heaviest rainfall during that storm was centered immediately over these three sites.

For this 2012 monitoring report, analyte loads at each sampling site were calculated using the average concentration from the quarterly sample values and the annual average flows in the Wash as measured and reported by USGS and Valley dischargers. Since sampling during storm flows is usually avoided, flows in the Wash have remained relatively stable during sampling events from year to year at any given sampling site. Sites are usually visited at about the same time of day during each monitoring event and even nearly the same dates from year to year; still, it is recognized that results provide only a snapshot of conditions in the Wash at that given moment, and that the power of even distant storms can easily be underestimated in the desert. Thus, using the four snapshots at each site to determine the annual average can provide, at best, only a fair estimate of average conditions on the Wash throughout the year, and readers should bear in mind the limitations of using quarterly sampling to describe 'average' conditions of any dynamic system.

3.2 Field Water Quality Measurements

The effluent-dominated nature of the Wash is reflected at and below station LW11.1 in trends observed in various field-measured water quality parameters recorded for the past 22 years of this study. These parameters are water temperature, pH, dissolved oxygen concentration, and specific conductivity, shown in figures 5 through 8. Impacts on the water quality of the Wash from these effluent discharges are especially evident in the long-term trends of all four field-measured parameters between sampling stations LW11.1 and LW8.85, as the majority of wastewater effluent enters the Wash in this reach. Appendix B, Table 1 contains a compilation of all field-measured data for 2012. Concentrations of total dissolved solids (TDS) analyzed at the laboratory by residue on evaporation at 180°C are also included in this table because it can be compared with specific conductance measured in the field, and both parameters denote salinity. The following discussion of field-measured water quality parameters describes ambient conditions beginning with LW11.5 and moves in a downstream progression to LW0.9.

3.2.1 Temperature

Water temperatures measured at LW11.5 reflect ambient, seasonal air temperatures, as this site is upstream from all wastewater effluent discharges to the Wash. The average water temperature at LW11.5 for 2012 was slightly lower than the 22-year average at this site (Figure 6). The 22-year average temperature was 15.9 ºC, and the 2012 average was 15.6 ^{o}C, slightly warmer than the average temperature there in 2011. LW11.1 was previously upstream of all wastewater discharges, until the City of North Las Vegas (CNLV) began discharging their wastewater effluent to the Wash through the Sloan Channel in June 2011. This effluent enters the Wash about 0.3 miles (0.48 km) upstream from LW11.1. At sampling station LW11.1, the 2012 average temperature was slightly higher than the 22-year average, a trend that is expected to continue and likely increase in subsequent years because treated effluent is typically warmer than ambient water temperatures.

Figure 6 shows that 2012 average temperatures at all sites are within the limits of variation (plus and minus one standard deviation from the mean) for the 22 years of this study. At LW9.3, downstream from the City of Las Vegas wastewater discharge but upstream from the Clark County discharges, the 2012 average temperature was slightly higher than the 22-year average temperature, a trend that held for all sites but the furthest downstream, LW0.9. At LW6.05 and LW5.5, the long-term average temperatures decreased very slightly in 2012, but less so than in past years. In 2012, the highest temperatures measured at each site occurred in September, and LW5.5 was again the warmest site on average, at 25.5 °C. The long-term average temperature was nearly two degrees cooler at LW3.4, the next site downstream, at 23.8 °C. This temperature drop lends support to the idea that geologic faults in this stretch of the Wash may capture some of the surface flow, where it circulates deep underground, pushing groundwater to the surface where it joins the flow of the Wash. Other parameters measured in this stretch also illustrate this groundwater inflow.

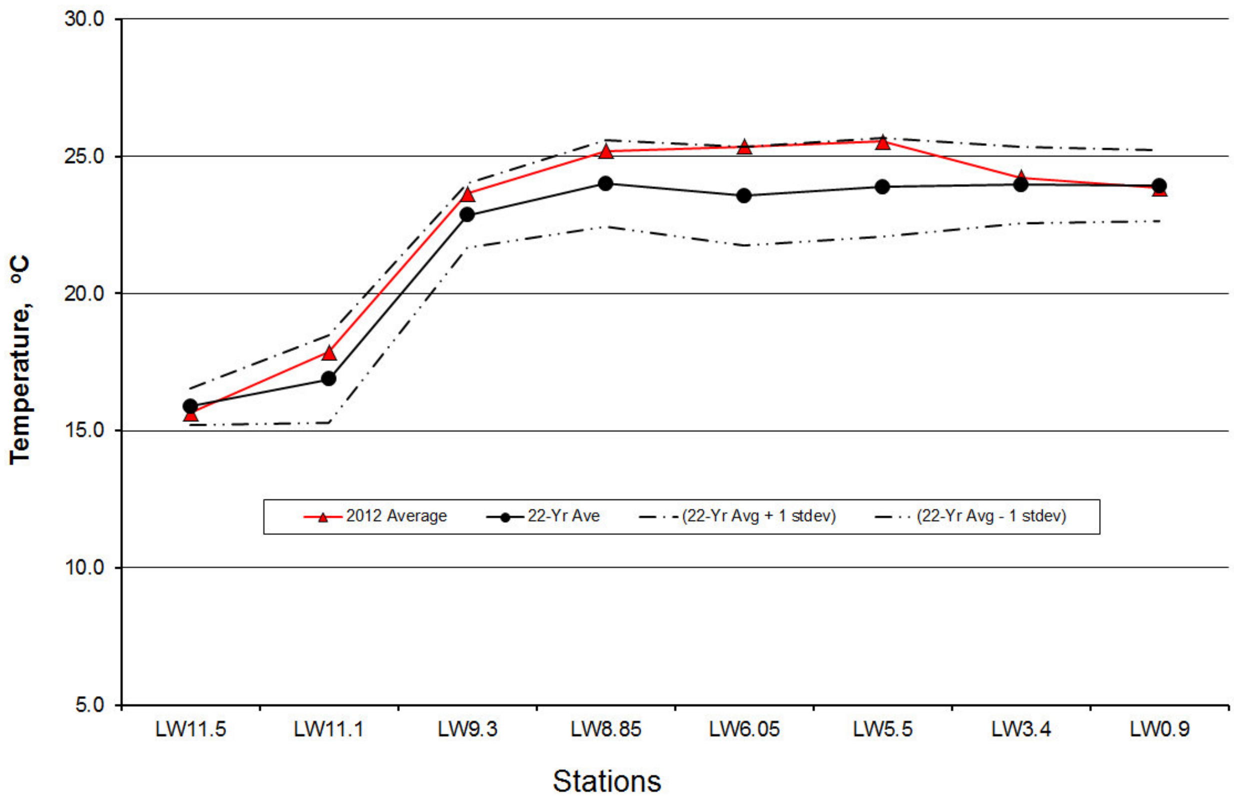


Figure 6. 2012 average water temperatures at sites in the Las Vegas Wash mainstream, upstream to downstream, compared to average values from 1991 through 2012. Dashed lines represent one standard deviation above and below 22-year average values measured at each site.

The average temperature at the last site in the study reach, LW0.9, was one-tenth degree Celsius cooler than the 22-year average of 23.9 °C. The warming trend seen between stations LW8.85 and LW5.5 is verification of a study conducted by Zhou et al. (2007) showing that water temperatures increase in the wetlands formed behind erosion control structures constructed in the Wash. Station LW8.85 is immediately upstream of the Ducks Unlimited #2 weir completed in

2009, and LW5.5 is upstream from the Homestead and Lower Narrows weirs that were completed in early 2011.

3.2.2 pH

The flow in the Wash at station LW11.5 is alkaline in nature, with an annual median pH of 8.20 for 2012, which is 0.20 units greater than the 2011 median and 0.1 unit greater than the 22-year median at this site. In contrast, 0.4 miles downstream at station LW11.1, pH values were highest in the study reach at 8.68 units, with a 22-year median of 8.30 units (Figure 7). Some of this elevated pH is due to the alkaline nature of the base flow combined with photosynthesis by benthic and attached algae in the wide concrete armoring in the channel, which extends for more than one-quarter mile immediately upstream of LW11.1. Additionally, LW11.1 is influenced by year-round wastewater discharges from the CNLV and pH values increased significantly at this site when they began discharging their effluent to the Wash in June 2011. Field measurements at LW11.1 ranged from 8.02 in March to 9.01 in September.

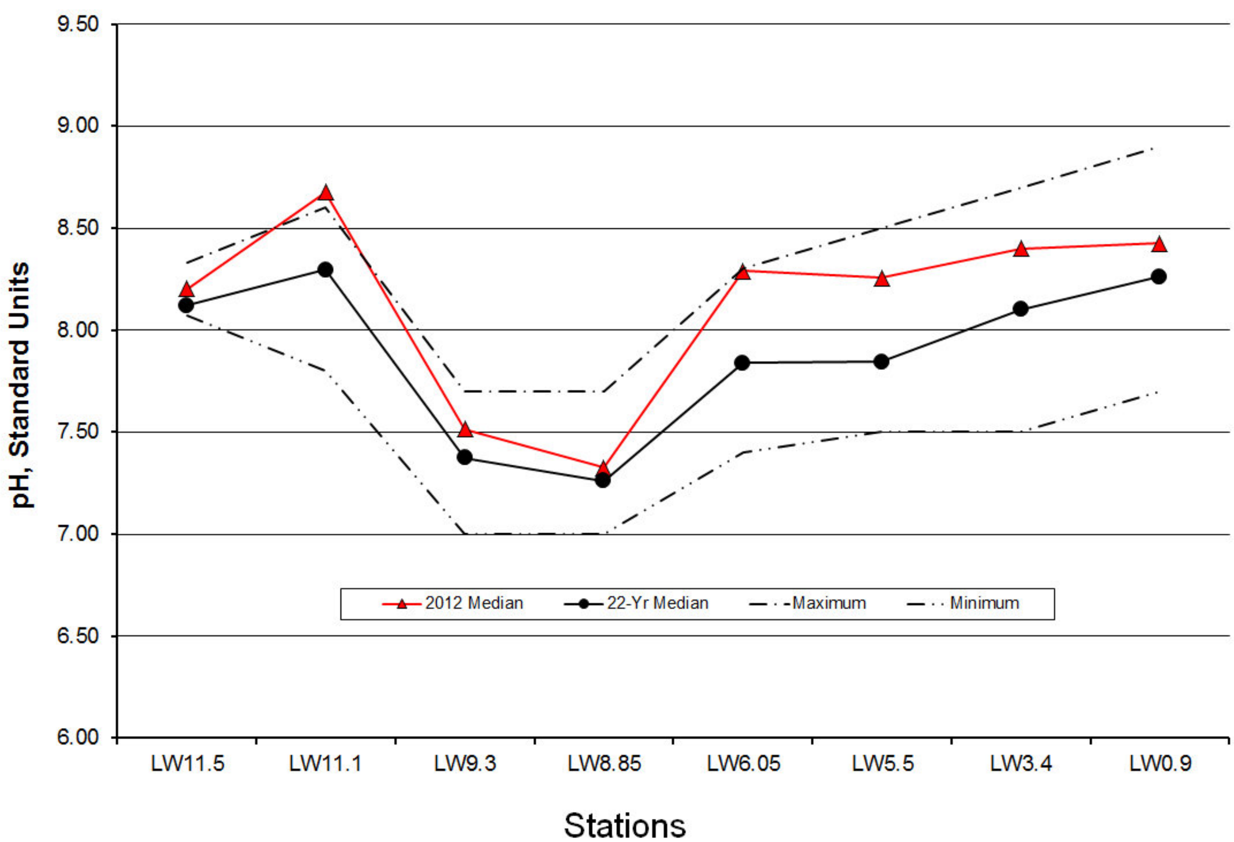


Figure 7. 2012 median pH units at sites in the Las Vegas Wash mainstream, from upstream to downstream, compared to medians from 1991 through 2012. Dashed lines represent 22-year maximum and minimum values measured at each site.

The lowest pH values in the 11.4-mile (18.34-km) study reach were measured at station LW8.85, with a 22-year median of 7.26 units. The 2012 median (7.33 units) was slightly higher than the long-term median, which is reasonable considering the higher pH values measured upstream where the CNLV effluent enters the Wash. Variations from the median at this site are slight across the 22-year period of record. There is an increase in pH measurements progressively downstream in the Wash, which is seen in both the 2012 and 22-year median values at each station downstream from LW8.85. The 2012 median pH increased from 7.33 units at LW8.85 to 8.43 units at LW0.9, which is 0.23 units higher than the 2012 median pH value measured at LW11.5, the baseline site. As a whole, the 2012 median pH values are the highest for any year in the 22-year study.

Possibly the most interesting thing to note about pH values over the last two years is the rapid rise in pH at station LW6.05 and relatively uniform values at stations downstream. While this is likely due to the erosion control structures (weirs) in the Wash, because they retard flow in the mainstream Wash by spreading it laterally and forming shallow ponds and creating wetlands, this could also cause an increase in biological oxygen demand, which would decrease pH values. However, based on a corresponding trend in the dissolved oxygen data, it is likely that increasing riparian vegetation and algae in these wetlands have increased photosynthesis in the mainstream Wash (also see Figure 8, describing dissolved oxygen concentrations). At LW6.05, parameters are measured and samples are collected on the Pabco weir (constructed in 2000) that creates a broad wetland just upstream. Similarly, the newly constructed Homestead and Lower Narrows weirs upstream from LW3.4 may be contributing to the pH increase at that site, which went from a median of 8.16 units in 2010 to 8.40 units in 2012. Future data will contribute to an understanding of this trend.

Median pH values have always been high in the Wash at the lower end of the study area, as shown by the 22-year median plot in Figure 7, at LW0.9. Prior to the construction of grade-control weirs, increases in pH at stations below LW8.85 were more likely caused by increased inputs of saline surface runoff and groundwater inflow caused by the rapid scouring flow in the Wash, rather than by photosynthesis of aquatic plants in the channel as mentioned above.

3.2.3 Dissolved Oxygen

The 2012 average dissolved oxygen concentrations at all sites downstream from LW11.1 are either at or slightly above the 22-year average concentrations, but all are within the limits of variation established over the study duration. As shown in Figure 8, dissolved oxygen (DO) concentrations at LW11.1 tend to be high, with a 22-year average of 11.4 mg/L. Oxygen concentrations at this site are often at or near supersaturation, containing more than 100 percent dissolved oxygen content. This is probably due in large part to aeration of the sheet flow in the wide, shallow concrete channel upstream that is covered by algae, making photosynthesis a likely causative factor at times. The 2012 average DO at LW11.1 was 13.4 mg/L, outside the upper limits of variation for that site. The highest concentrations at LW11.1 over the 22-year study period were measured in 2011 with an average of 14.02 mg/L. That value was a bit unexpected considering the recent addition of effluent to this stretch of the Wash, because wastewater effluent tends to have relatively low dissolved oxygen content. However, effluent from the CNLVWRF travels in the concrete-lined Sloan Channel for nearly 6 miles before it gets to station LW11.1. This is ample time and distance for photosynthesizing aquatic plants to add significant dissolved oxygen to the water, which can also increase pH, but perhaps the lower DO value at LW11.1 in 2012 was due to weekly scrubbing of the concrete Sloan Channel to help control algae growth, odors, and nuisance insects in local residential neighborhoods.

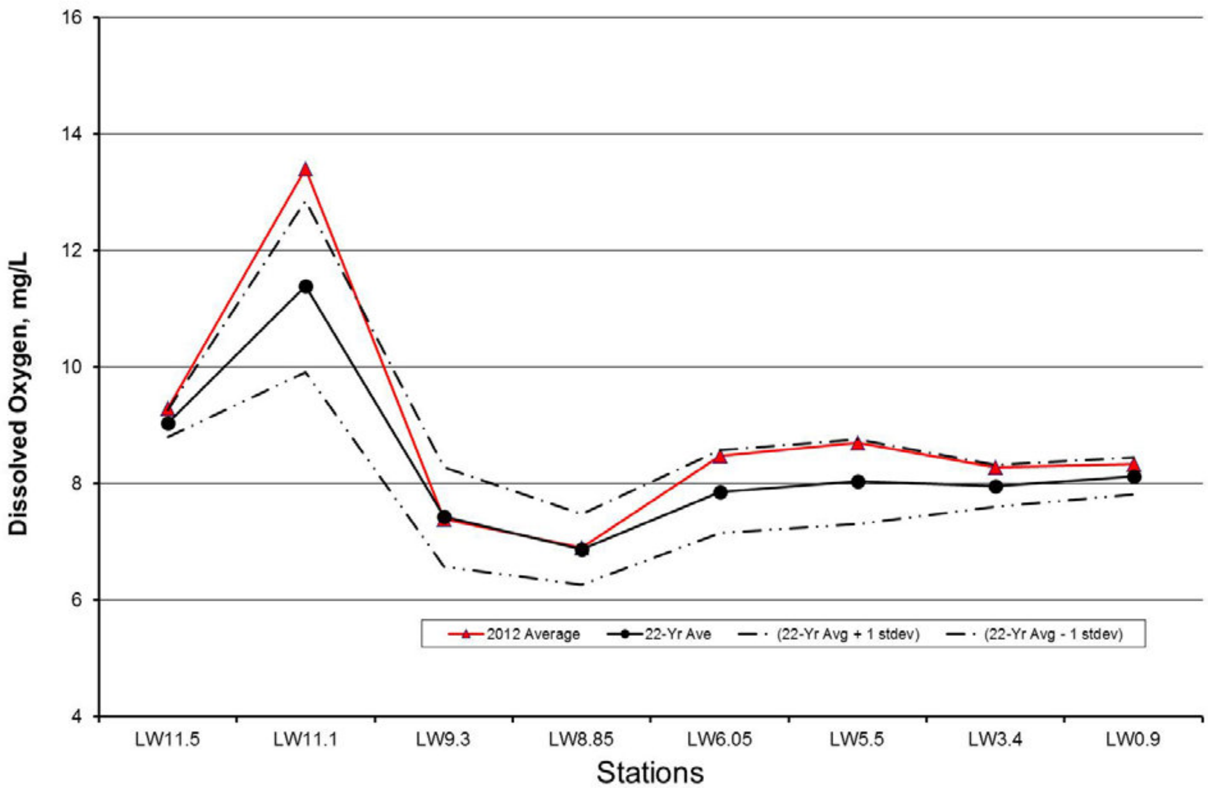


Figure 8. 2012 average dissolved oxygen concentrations at sites in the Las Vegas Wash mainstream, upstream to downstream, compared to average values from 1991 through 2012. Dashed lines represent one standard deviation above and below 22-year average values.

Oxygen supersaturation is a condition in which water is holding more oxygen than usual for water at a given temperature, as seen at station LW11.1. In stark contrast to that, concentrations of dissolved oxygen measured in the discharge channel for the City of Las Vegas Water Pollution Control Facility (CLVWPCF) at LWC10.6 ranged from 6.21 mg/L in September to 7.53 mg/L in March. The lowest dissolved oxygen concentrations in the Wash mainstream probably occur somewhere *between* stations LW9.3 and LW8.85, near where the two Clark County effluent discharges enter the mainstream. Dissolved oxygen concentrations appear fairly stable in the effluent discharges from both Clark County plants, ranging from 6.04 to 6.91 mg/L. The lowest dissolved oxygen concentrations actually measured in the mainstream Wash study reach occurred at LW8.85, ranging from 6.43 to 7.46 mg/L, in June and December, respectively.

As the Wash flows through the study reach from upstream to down (LW11.5 to LW0.9), aeration by turbulence at several drop structures along the way helps increase dissolved oxygen concentrations, as does retention in wetlands, as seen in concentrations at stations LW6.05 and LW5.5 in Figure 8. The limits of variation narrow at LW3.4, where the 2012 average dissolved oxygen concentration drops to just above the 22-year average. This declining trend at LW3.4, along with variations in flow measurements, TDS, and other parameter values at this station, may indicate oxygen-depleted groundwater inflow to the Wash.

3.2.4 Specific Conductivity

At LW11.5, the 2012 average specific conductivity (SC) value was 3,473 µS/cm (micro-Siemens per centimeter), which is higher than the average in 2011 but still within the relatively narrow limits of variation based on three years of sampling at this site. At LW11.1, measurements taken at the center of the channel show that discharge of treated wastewater from the CNLVWRF significantly reduced the salinity of the base flow of the Wash. The average SC at LW11.1 for 2012 is much lower than its 21-year average as a result, as seen in Figure 9. It needs to be noted that at LW11.1, the flow is quite divided between the base flow, which stays nearer the west bank, and the CNLVWRF flow that stays nearer the east bank of the Wash. Taking samples from the center is an attempt to get the mixture of the two waters with their varying chemistries.

Approximately 90 percent of the water for municipal use in the Valley is pumped from Lake Mead, and this has a direct effect on the quality of water in the Wash across the entire study reach. Water used for irrigation and other outdoor residential and industrial uses in developed areas upstream of LW11.5 eventually makes its way to the Wash, but it also largely originated from Lake Mead. Progressing downstream, the Wash picks up greater percentages of its volume from wastewater treatment plant discharges, most of which originated from Lake Mead. Discussion of the declining long-term average conductivity in the Wash cannot be separated from the quality of water in Lake Mead, and Figure 1 in the Executive Summary section shows that conductivity values have dropped in the lake, as well.

Although the 2012 average values for conductivity at all but one mainstream sampling site were just below the lower limits of variation, long-term average values continue to show a marked but somewhat flatter increase in the study area between sites LW8.85 and LW6.05, where the Duck Creek tributary and several stormwater drains enter the Wash from the west. Base flows in these contributing channels stem primarily from groundwater moving through saline soils are higher in specific conductance and dissolved ions than the mainstream flow of the Wash (Nelson et al., 2001, 2003, 2005; Zhou et al., 2005).

Specific conductivity increases progressively downstream in the Wash as it intercepts saline groundwater in the area between stations LW8.85 and LW0.9 (Bureau of Reclamation, 1982; Morris, 1983). While the 22-year average continues to illustrate this influence, the trend is becoming less pronounced compared to past years. Less-than-average precipitation from 2006 through 2009 and in 2011 may be a factor in the overall reduction in conductivity at all stations, and in this flattening of the annual curve at stations below LW6.05, due to decreases in overland flow and groundwater interception. In general, the limits of variation for SC at most sites have remained relatively narrow over the course of this study, as seen in Figure 9. The 2012 average data curve mimics the 22-year average at all sampling stations downstream from LW11.1, with all of the data points falling below the lower limits of variation established over the duration of this study. The increase in average SC at LW3.4 is again somewhat sharper in 2012 than for the long-term average, but it follows the long-term trend and again is indicative of groundwater interception in the stretch between LW5.5 and LW0.9.

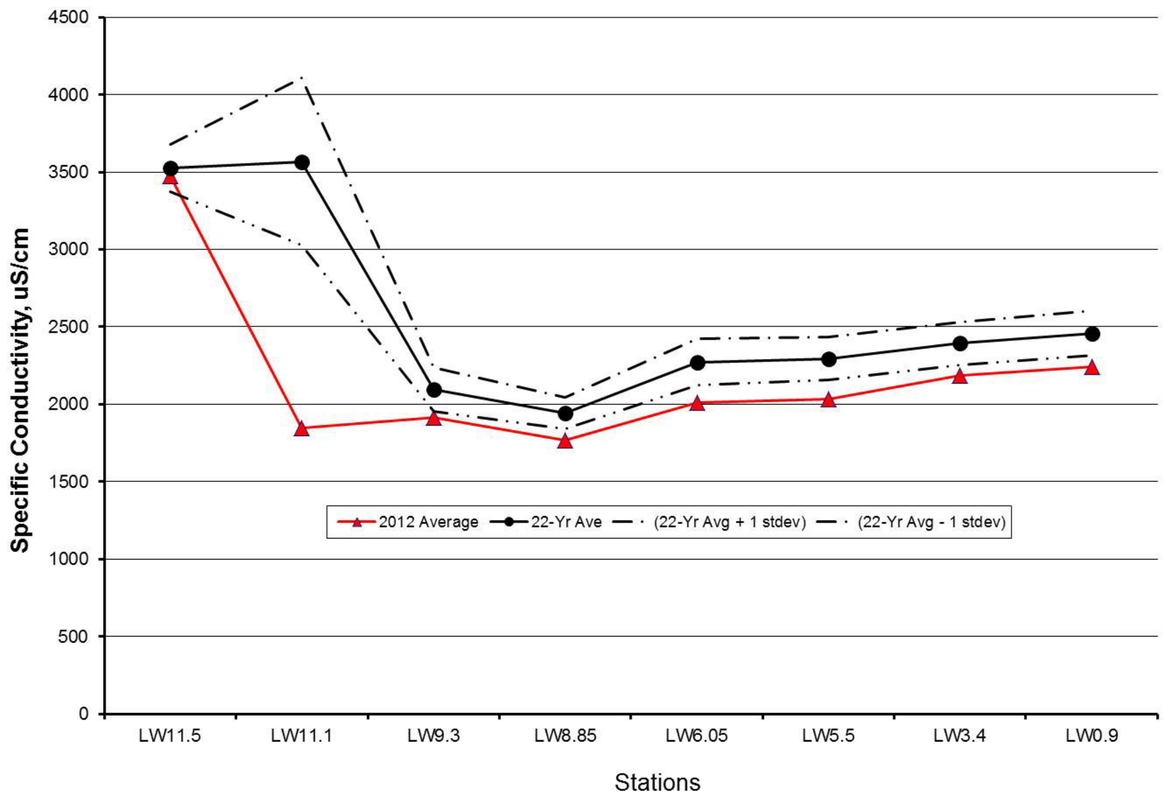


Figure 9. 2012 average specific conductivity values measured at sites in the Las Vegas Wash mainstream, upstream to downstream, compared to average values from 1991 through 2012. Dashed lines represent one standard deviation above and below cumulative average values.

In 2011, long-term sampling of the groundwater seep at station LWC6.3 was discontinued, and a nearby groundwater monitoring well located within the perchlorate remediation area on the south side of the Wash near Pabco Road was sampled in its place (see map, Figure 3). Both LWC6.3 and LWC Well PC-97 are located hydrologically 'downstream' from the City of Henderson's wastewater treatment plant effluent infiltration basins and from the BMI complex. Operations by both of these entities may affect the groundwater quality at this site (see Table 7). Also, stormwater and landscape irrigation runoff, surface hardening in expanding subdivisions upslope of this area, and groundwater-related operations of the perchlorate mitigation project are likely to affect measurements at these locations. Unlike Well PC-97, the seep water at LWC6.3 was exposed to the atmosphere and subject to evaporation and subsequent concentration of dissolved solids; therefore, the groundwater well data may better represent the quality of near-surface groundwater intercepted by the Wash in this area. Specific conductivity measurements of groundwater samples bailed from Well PC-97 greatly exceed values measured in the effluent-dominated mainstream Wash, ranging from 3,419 µS/cm in March to 3,950 µS/cm in December, with a 2012 average value of 3,695 µS/cm. In contrast, average conductivity of Well PC-97 samples is significantly lower than the 21-year average for LWC6.3 of 7,910 µS/cm. Specific conductivity data for both groundwater sites are shown in Table 7.

Table 7. Average specific conductivity values measured in the groundwater seep LWC 6.3 and LWC Well PC-97. In 2010, readings were taken at both sites for two quarters each. Beginning in 2011, the well replaced LWC6.3 permanently as a groundwater sampling site for this study.

	LWC6.3			LWC Well PC-97		
CALENDAR YEAR	AVERAGE CONDUCTIVITY (µS/cm)	CONDUCTIVITY MINIMUM (µS/cm)	CONDUCTIVITY MAXIMUM (µS/cm)	AVERAGE CONDUCTIVITY (µS/cm)	CONDUCTIVITY MINIMUM (µS/cm)	CONDUCTIVITY MAXIMUM (µS/cm)
1990	10,392	9,500	11,150	Not Sampled		
1991	9,300	7,500	11,570	Not Sampled		
1992	7,907	7,460	8,800	Not Sampled		
1993	8,375	8,220	8,650	Not Sampled		
1994	8,945	8,240	9,440	Not Sampled		
1995	10,050	9,480	10,400	Not Sampled		
1996	10,145	9,860	10,530	Not Sampled		
1997	9,883	8,080	11,450	Not Sampled		
1998	9,033	7,680	10,560	Not Sampled		
1999	9,028	8,110	10,360	Not Sampled		
2000	8,793	7,910	10,070	Not Sampled		
2001	10,533	8,410	12,520	Not Sampled		
2002	7,955	7,450	8,600	Not Sampled		
2003	6,710	5,250	5,250	Not Sampled		
2004	5,965	5,070	7,130	Not Sampled		
2005	5,973	5,510	6,390	Not Sampled		
2006	5,400	5,050	5,710	Not Sampled		
2007	4,719	2,020	5,890	Not Sampled		
2008	5,345	3,600	8,590	Not Sampled		
2009	7,125	5,500	9,380	Not Sampled		
2010	4,537	4,400	5,030	4,364 (n=2)	4,210	4,520
2011	Not Sampled	Not Sampled	Not Sampled	4,002	3,510	4,380
2012	Not Sampled	Not Sampled	Not Sampled	3,695	3,420	3,720
Long-term Averages	**21-year avg 7,910 µS/cm**	**21-yr avg min 6,871 µS/cm**	**21-yr avg max 8,927 µS/cm**	**3-yr avg 4,020 µS/cm**	**3-yr avg min 3,713 µS/cm**	**3-yr avg max 4,203 µS/cm**

3.3 Laboratory Chemical Analyses

3.3.1 Total Dissolved Solids

Total dissolved solids (TDS) concentrations for this study are determined in the laboratory by residue on evaporation at 180 ^{o}C. At all stations except LW11.5, the 2012 average values were below the lower limits of variation for the 22 years of this study (Figure 10). This trend has continued each year since 2008. Local precipitation and the timing of sampling in relation to precipitation events can undoubtedly have an effect on average TDS concentrations at all sampling sites. However, overland flow and surface runoff effects are probably most noticeable at LW11.5, because this station is upstream from all effluent discharges, and at stations downstream from LW8.85 due to tributary inflows and groundwater interception.

The graph in Figure 10 mimics the specific conductivity graph in Figure 9, and both illustrate an increase in the 22-year average salinity concentration between stations LW8.85 and LW6.05 and between stations LW5.5 and LW0.9. Again, these trends are consistent over the life of this study and indicate saline inflow to the Wash from surface drainage and groundwater interception by the Wash below LW5.5.

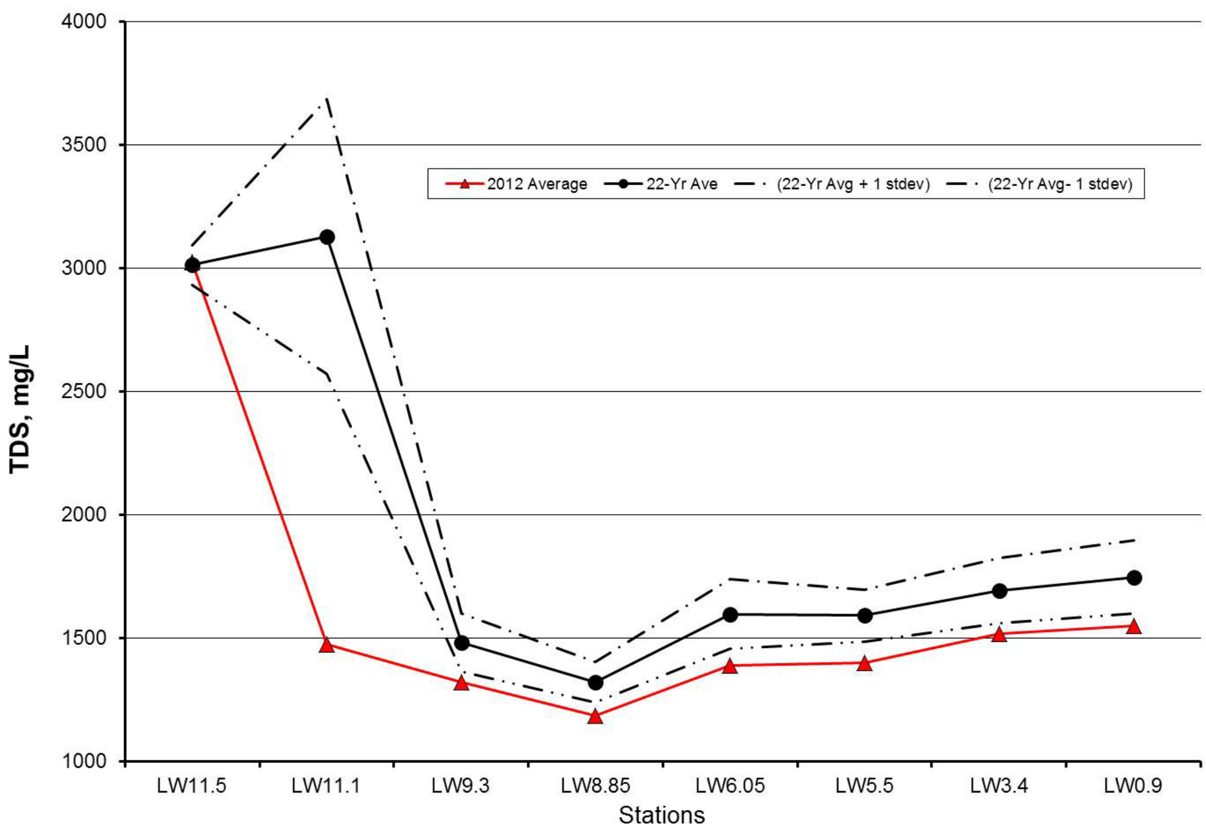


Figure 10. 2012 average total dissolved solids concentrations at sites in the Las Vegas Wash mainstream, upstream to downstream, compared to average values from 1991 through 2012. Dashed lines represent one standard deviation above and below cumulative average values.

Figure 11 illustrates the estimated average TDS load carried by the Wash at some of the gaged mainstream stations. In general, this figure reveals a clear trend of increasing salt load as flow rates increase in the Wash, whether due to population increase in the Valley or from precipitation events and groundwater interception, or both. TDS loads peaked in 2005 and 2006, following three of the wettest years on record in the Las Vegas Valley (2003-2005, see Table 4). Because much of the water in the Wash is return flow of water pumped from Lake Mead for domestic use in the Valley, the salt load carried by the Wash includes dissolved solids contained in the water pumped from Lake Mead initially, and dissolved solids gained during its domestic uses and in stormwater runoff. The net salt load carried by the Wash is expected to increase as effluent discharge volumes increase in conjunction with population growth in the Valley.

In 2012, a total of approximately 420,000 tons (381,000 metric tons) of salt passed through the Wash to Lake Mead. Because the Valley gets about 90 percent of its water from Lake Mead, which already contains a certain amount of salt, the *net* salt load to Lake Mead from the Wash was nearly 84,000 tons (about 76,200 metric tons). 2012 was a fairly wet year in the Las Vegas Valley, with 5.31 inches (13.5 cm) of precipitation recorded at McCarran Airport. In comparison, in 2005, during the third wetter-than-average year in a row, the net contribution of salt to Lake Mead through the Wash was approximately 170,900 tons (155,038 metric tons), from a total contribution of about 593,500 tons (538,414 metric tons). See Appendix C for further discussion of net and total salt load calculations compared with annual precipitation, which suggests that overland flow, groundwater recharge, and subsequent groundwater drainage are significant non-point sources of salinity for the Wash and for Lake Mead.

Station	2000 mg/L TDS	2000 cfs	2000 1000 kg/day	2001 mg/L TDS	2001 cfs	2001 1000 kg/day	2002 mg/L TDS	2002 cfs	2002 1000 kg/day	2003 mg/L TDS	2003 cfs	2003 1000 kg/day	2004 mg/L TDS	2004 cfs	2004 1000 kg/day	2005 mg/L TDS	2005 cfs	2005 1000 kg/day
LW11.5	2747	17.7	119.1	3132	17.9	137	3091	10.5	79.6	3207	23.3	182.7	3058	37.6	280.9	3110	49.7	378.2
LW11.1	2747	18.1	122.0	3132	18.6	143	3091	10.8	81.9	3207	24.4	191.2	3058	40.0	299.1	3110	52.7	401.2
LW8.85	1336	209	682.4	1271	211	658	1262	224	691	1316	249	800.2	1300	263	835.2	1503	276	1016
LW6.05	1569	232	890.6	1617	250	988	1549	235	890	1583	262	1016	1582	295	1141	1925	328	1546
LW0.9	1859	222	1009	1622	242	959	1599	249	975	1757	267	1149	1747	282	1207	1982	304	1473

Station	2006 mg/L TDS	2006 cfs	2006 1000 kg/day	2007 mg/L TDS	2007 cfs	2007 1000 kg/day	2008 mg/L TDS	2008 cfs	2008 1000 kg/day	2009 mg/L TDS	2009 cfs	2009 1000 kg/day	2010 mg/L TDS	2010 cfs	2010 1000 kg/day	2011 mg/L TDS	2011 cfs	2011 1000 kg/day	2012 mg/L TDS	2012 cfs	2012 1000 kg/day
LW11.5	2996	13.6	99.95	3037	13.6	100.88	3045	13.0	97.06	2833	12.2	84.34	3087	31.2	235.8	2927	14.1	101.0	3026	28.1	208.2
LW11.1	2996	14.0	102.34	3037	13.6	100.88	3045	13.1	97.93	2833	12.4	85.72	3075	31.5	237.2	1923	53.1	249.9	1475	57.9	208.9
LW8.85	1334	301	983.4	1335	270	881.7	1283	246	772.9	1233	245	738.4	1213	253	749.4	1230	249	748.1	1186	259	752.3
LW6.05	1635	292	1167	1562	301	1150	1460	267	955.2	1473	269	967.8	1358	311	1033	1401	295	1012	1391	319	1085
LW0.9	1796	304	1337	1710	294	1232	1649	285	1149	1593	285	1111	1515	298	1103	1581	296	1145	1553	293	1111

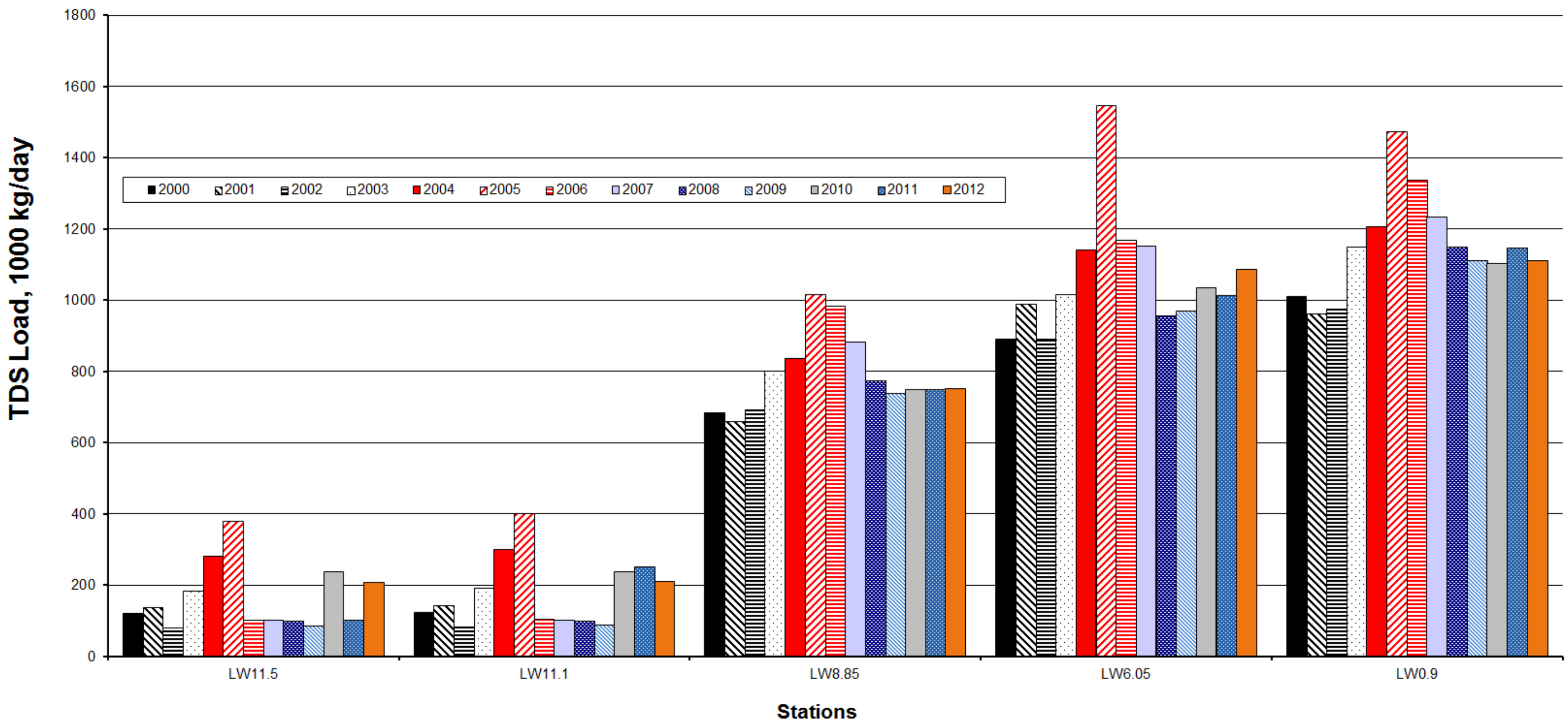


Figure 11. 2000 through 2012 average total dissolved solids loads in the Las Vegas Wash mainstream, upstream to downstream. Concentration data for station LW11.5 prior to 2010 are estimated.

3.3.2 Total Suspended Solids

Average TSS (total suspended solids) concentrations have varied widely at all stations over the past 18 years of monitoring for this parameter, but particularly so at monitoring sites downstream from station LW8.85 (Figure 12). The 2012 average TSS concentrations were well below the upper limits of variation at every site, and at all but three sites, the 2012 average TSS concentrations were nearly equal to the 18-year average concentrations. Construction of the Homestead and Lower Narrows weirs continued throughout 2012, both located between LW5.5 and LW3.4, causing an increase in average TSS at LW3.4. However, the 2012 average was still below the 18-year average at this site. The 2012 average TSS at LW0.9 was lower than at LW3.4, opposite the 18-year trend of TSS spiking upward at LW3.4 and LW0.9.

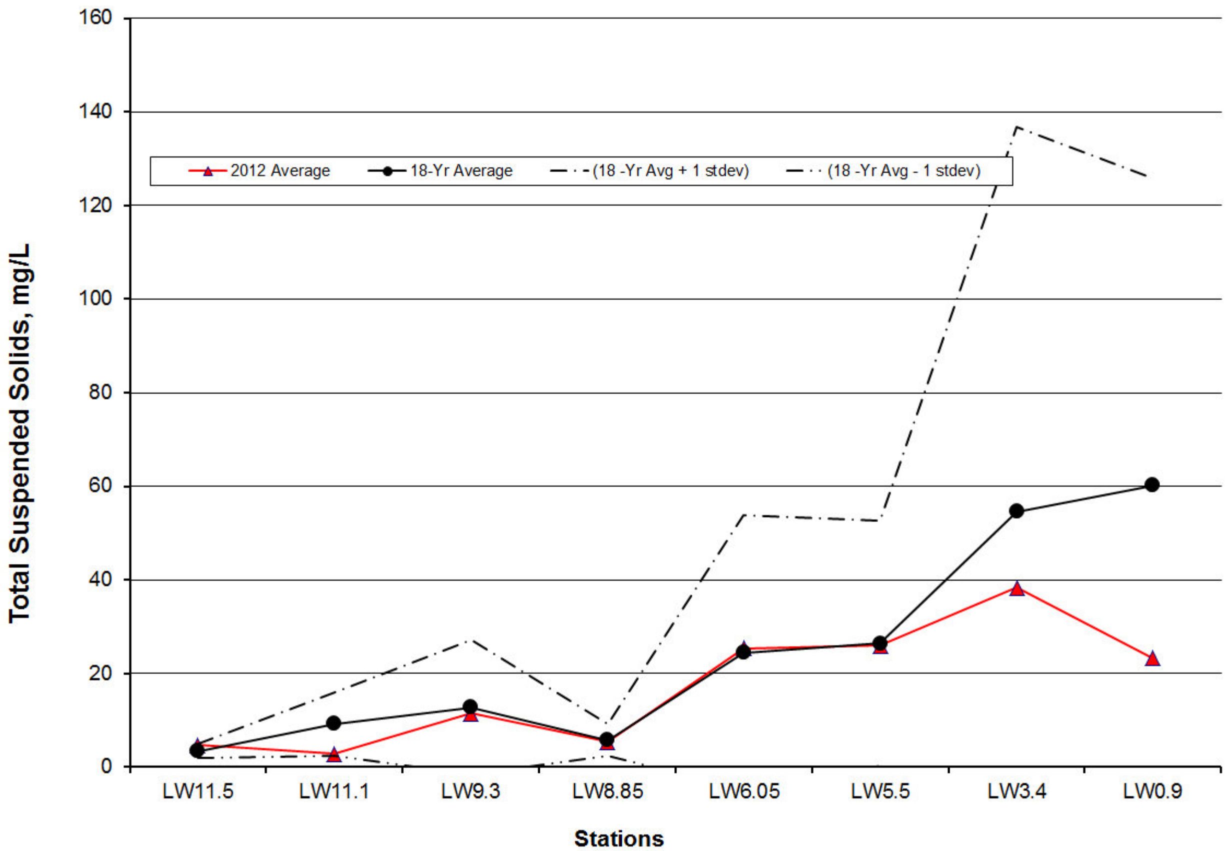


Figure 12. 2012 average total suspended solids at sites in the Las Vegas Wash mainstream, upstream to downstream, compared to average values from 1994 through 2012. Dashed lines represent one standard deviation above and below cumulative average values.

The load of total suspended solids carried by the Wash (Figure 13) has also fluctuated over the past 12 years, with marked decreases in magnitude since 2004. TSS loads in the last three years are greater than seen in 2009 at LW0.9, but increases in TSS loads carried by the Wash are likely due to construction of several weirs, maintenance of existing grade-control structures in the mainstream, bank stabilization activities, and revegetation projects managed by the Las Vegas Wash Coordination Committee. By the end of 2012, 16 of the 22 planned erosion control structures were completed, including the Homestead and Lower Narrows weirs. The DU Wetlands #1 weir was completed, and the Upper Narrows and Duck Creek Confluence were scheduled for completion in early 2013. A cumulative total of nearly 367 acres have been revegetated along the Wash (Las Vegas Wash Coordination Committee, 2013). A cumulative total of more than 10 miles of bank stabilization were completed as of 2012. About 40 acres of tamarisk were cleared in 2012, for a total of about 280 acres of tamarisk removal since 2008. Construction of all 22 weirs will be completed in 2015, if all goes as planned. While construction activities can disturb sediments in and around the Wash, temporarily increasing TSS concentrations, these structures will contribute to a reduction in the TSS load carried by the Wash in the future.

Station	2001			2002			2003			2004			2005			2006		
	mg/L TSS	cfs	1000 kg/day	mg/L TSS	cfs	1000 kg/day	mg/L TSS	cfs	1000 kg/day	mg/L TSS	cfs	1000 kg/day	mg/L TSS	cfs	1000 kg/day	mg/L TSS	cfs	1000 kg/day
LW11.5	9.63	17.9	0.42	12.2	10.5	0.31	7.35	24.4	0.44	6.65	37.6	0.61	6.65	49.7	0.81			
LW11.1	9.63	18.6	0.44	12.2	10.8	0.32	7.35	24.4	0.44	6.65	40.0	0.65	6.65	52.7	0.86	4.63	14.0	0.16
LW8.85	5.07	211	2.62	6.40	224	3.51	10.8	249	6.54	13.4	263	8.59	6.00	276	4.06	3.20	301	2.36
LW6.05	9.27	250	5.66	10.3	235	5.89	130	262	83.7	19.0	295	13.7	8.65	328	6.94	7.85	292	5.60
LW0.9	39.8	242	23.6	100	249	61.2	60.6	267	39.6	65.0	282	44.9	21.1	304	15.6	23.1	304	17.2

Station	2007			2008			2009			2010			2011			2012		
	mg/L TSS	cfs	1000 kg/day	mg/L TSS	cfs	1000 kg/day	mg/L TSS	cfs	1000 kg/day	mg/L TSS	cfs	1000 kg/day	mg/L TSS	cfs	1000 kg/day	mg/L TSS	cfs	1000 kg/day
LW11.5	4.63	13.6	0.15	4.16	13.6	0.14	6.05	13.0	0.19	7.13	12.2	0.21	3.83	14.1	0.13	4.70	28.1	0.32
LW11.1	4.16	13.6	0.14	6.05	13.1	0.19	7.13	12.4	0.22	5.60	31.5	0.43	5.15	53.1	0.67	2.87	57.9	0.41
LW8.85	4.69	270	3.10	2.98	246	1.79	2.38	245	1.42	2.58	253	1.59	2.48	249	1.51	5.40	259	3.43
LW6.05	29.8	301	21.9	11.6	267	7.6	17.3	269	11.3	8.58	311	6.53	10.4	295	7.48	23.3	319	18.1
LW0.9	12.0	294	8.65	16.3	285	11.3	20.7	285	14.4	27.18	298	19.8	33.5	296	24.3	25.4	293	18.2

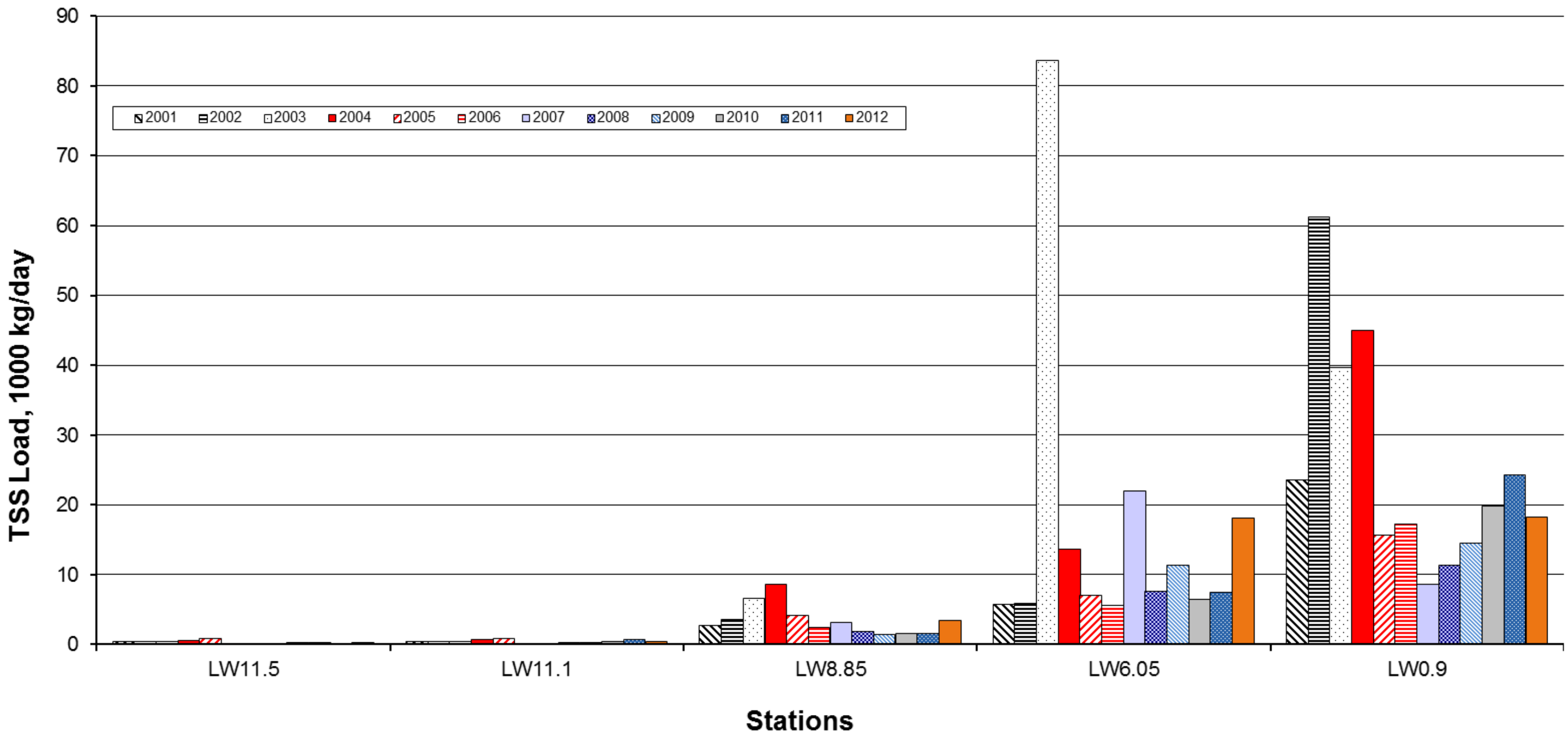


Figure 13. 2001 through 2012 average total suspended solids loads in the Las Vegas Wash mainstream, upstream to downstream. Concentration data for station LW11.5 prior to 2010 are estimated.

3.3.3 Orthophosphate Phosphorus

Orthophosphate phosphorus (OPO_4-P, or ortho-P), or dissolved reactive phosphorus, includes polyphosphates from detergents and phosphorus bound in adsorptive colloids, which are very fine suspended particles in water. Phosphorus (P) has been identified as the primary limiting nutrient for algal productivity in Las Vegas Bay of Lake Mead (Lieberman, 1995). Annual average phosphorus concentrations peaked in 1995 to 0.7 mg/L in the study reach from LW8.85 to LW0.9, the reach below the largest wastewater discharges to the Wash from treatment plants. The large increase in average ortho-P concentration at LW9.3 comes from inflows of highly treated wastewater from the City of Las Vegas treatment plant at LWC10.6. Phosphorus concentrations are typically very high in wastewater effluent, but the wide limits of variation for the lower study reach, as seen in Figure 14, reflect steady upgrades to all local treatment plant processes since this study began in 1990.

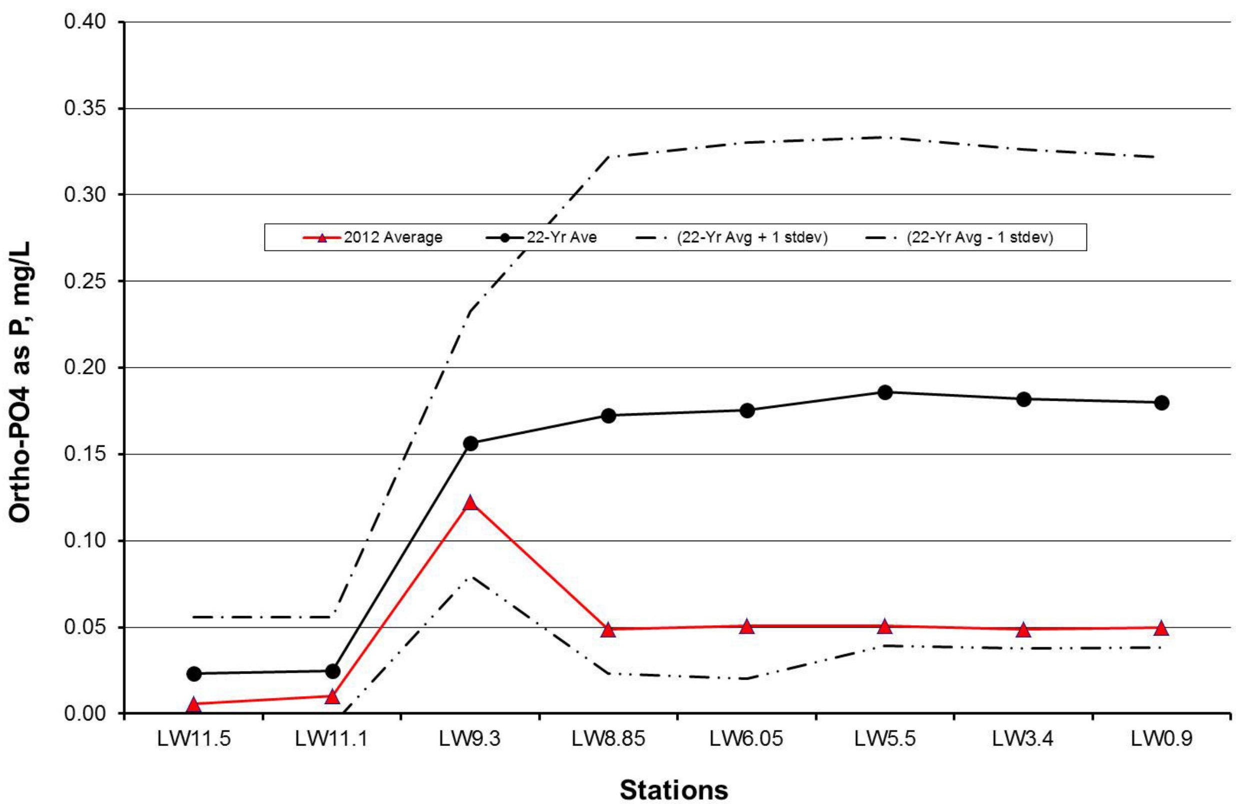


Figure 14. 2012 average ortho-phosphate concentrations as phosphorus at sites in the Las Vegas Wash mainstream, upstream to downstream, compared to average values from 1991 through 2012. Dashed lines represent one standard deviation above and below cumulative average values.

Prior to 2001, all wastewater plants in the Valley were operating according to their National Pollution Discharge Elimination System (NPDES) permits, which allowed effluent discharges containing higher concentrations of P from November to March each year. A severe algal bloom in Lake Mead in 2001 drove the decision by all Valley dischargers to commit voluntarily to treating their effluent for a higher degree of P removal year-round. Local City and County treatment plant operators made several upgrades over the years, and began optimizing P removal in 2004. Tertiary addition of alum for further reduction of P in their discharges began in January 2005 at all Valley treatment plants. In 2008, an additional upgrade at the CLVWPCF consisted of installing 33 separate filters in the final treatment process, allowing removal of one filter at a time for maintenance, with no compromise to the quality of water released. This bank of filters facilitates the City's commitment to a high degree of phosphorus removal year-round.

The large ortho-P spike seen at LW11.1 in the 2011 data is gone in 2012, and ortho-P loading was reduced in 2012 (Figure 15). The spike at this site last year stemmed from effluent discharge through the Sloan Channel from the new CNLVWRF, beginning in June 2011. In 2012, operational changes (and possibly the maturing of the membrane biological reactor at the plant) dropped the annual average concentration lower than the 22-year average at LW11.1. In fact, average 2012 ortho-P concentrations are lower than the 22-year average at all stations in the mainstream Wash, and all are near the lower limits of variation for the study period (Figure 14). At all mainstream stations downstream from LW8.85, the 2012 average concentrations are significantly lower than their 22-year averages. Quarterly concentrations at these stations ranged from 0.03 to 0.08 mg/L, but the 2012 average concentrations for LW6.05 through LW0.9 varied by only 0.001 mg/L, making the curve appear nearly flat in this stretch of the study area.

Figure 15 shows estimated mean annual ortho-P loads carried by the mainstream Wash from 2000 through 2012. As with all load calculations for this monitoring report, mean ortho-P load calculations used the average of all quarterly concentration data at each site and the average annual flow data provided by USGS gaging stations on the Wash. Even with the discharge of effluent from CNLVWRF, seen at LW11.1 in 2011 and 2012, these load estimates demonstrate that most of the ortho-P found in the Wash consistently originates from the combined City of Las Vegas and Clark County wastewater treatment plant discharges upstream from LW8.85. Smaller additions of ortho-P come from the City of Henderson treatment facility and Pittman Bypass discharges that reach the Wash just above station LW6.05. Reduced ortho-P concentrations in effluents from treatment plants operated by Clark County and the cities of North Las Vegas, Las Vegas, and Henderson over the years have mitigated the expected increase in ortho-P loading that would otherwise have accompanied steadily increasing discharge rates as the population in the Valley increased. See Appendix B, Table B-2, for a compilation of ortho-P and other nutrient concentrations at all stations for 2012.

	2000			2001			2002			2003			2004			2005			2006		
Station	mg/L O-P	cfs	kg/day	mg/L O-P	cfs	kg/day	mg/L O-P	cfs	kg/day	mg/L O-P	cfs	kg/day	mg/L O-P	cfs	kg/day	mg/L O-P	cfs	kg/day	mg/L O-P	cfs	kg/day
LW11.5	0.06	17.7	2.60	0.01	17.9	0.44	0.02	10.5	0.51	0.02	23.3	1.14	0.025	37.6	2.27	0.029	49.7	3.49	0.011	13.6	0.35
LW11.1	0.06	18.1	2.66	0.01	18.6	0.46	0.02	10.8	0.53	0.02	24.4	1.19	0.025	40.0	2.42	0.029	52.7	3.70	0.011	14.0	0.36
LW8.85	0.16	209	81.7	0.25	211	129	0.09	224	49.3	0.19	249	116	0.143	263	92.1	0.088	276	59.3	0.076	301	55.7
LW6.05	0.16	232	90.8	0.16	250	97.8	0.08	235	46.0	0.25	262	160	0.112	295	80.8	0.118	328	94.7	0.076	292	54.2
LW0.9	0.18	222	97.7	0.16	242	94.6	0.08	249	48.8	0.24	267	157	0.099	282	68.6	0.153	304	114	0.089	304	66.1

	2007			2008			2009			2010			2011			2012		
Station	mg/L O-P	cfs	kg/day	mg/L O-P	cfs	kg/day	mg/L O-P	cfs	kg/day	mg/L O-P	cfs	kg/day	mg/L O-P	cfs	kg/day	mg/L O-P	cfs	kg/day
LW11.5	0.0222	13.6	0.74	0.0029	13.0	0.09	0.0088	12.2	0.26	0.004	31.2	0.28	0.061	14.1	2.09	0.006	28.1	0.39
LW11.1	0.0222	13.6	0.74	0.0029	13.1	0.09	0.0088	12.4	0.26	0.003	31.5	0.22	0.141	53.1	18.3	0.010	57.9	1.44
LW8.85	0.0713	270	47.1	0.0680	246	41.0	0.0421	245	25.2	0.035	253	21.5	0.092	249	56.0	0.049	259	30.9
LW6.05	0.0965	301	71.0	0.0780	267	51.0	0.0463	269	30.4	0.042	311	31.9	0.104	295	75.4	0.051	319	39.6
LW0.9	0.0955	294	68.8	0.0900	285	62.7	0.0553	285	38.6	0.043	298	31.6	0.112	296	81.2	0.050	293	35.8

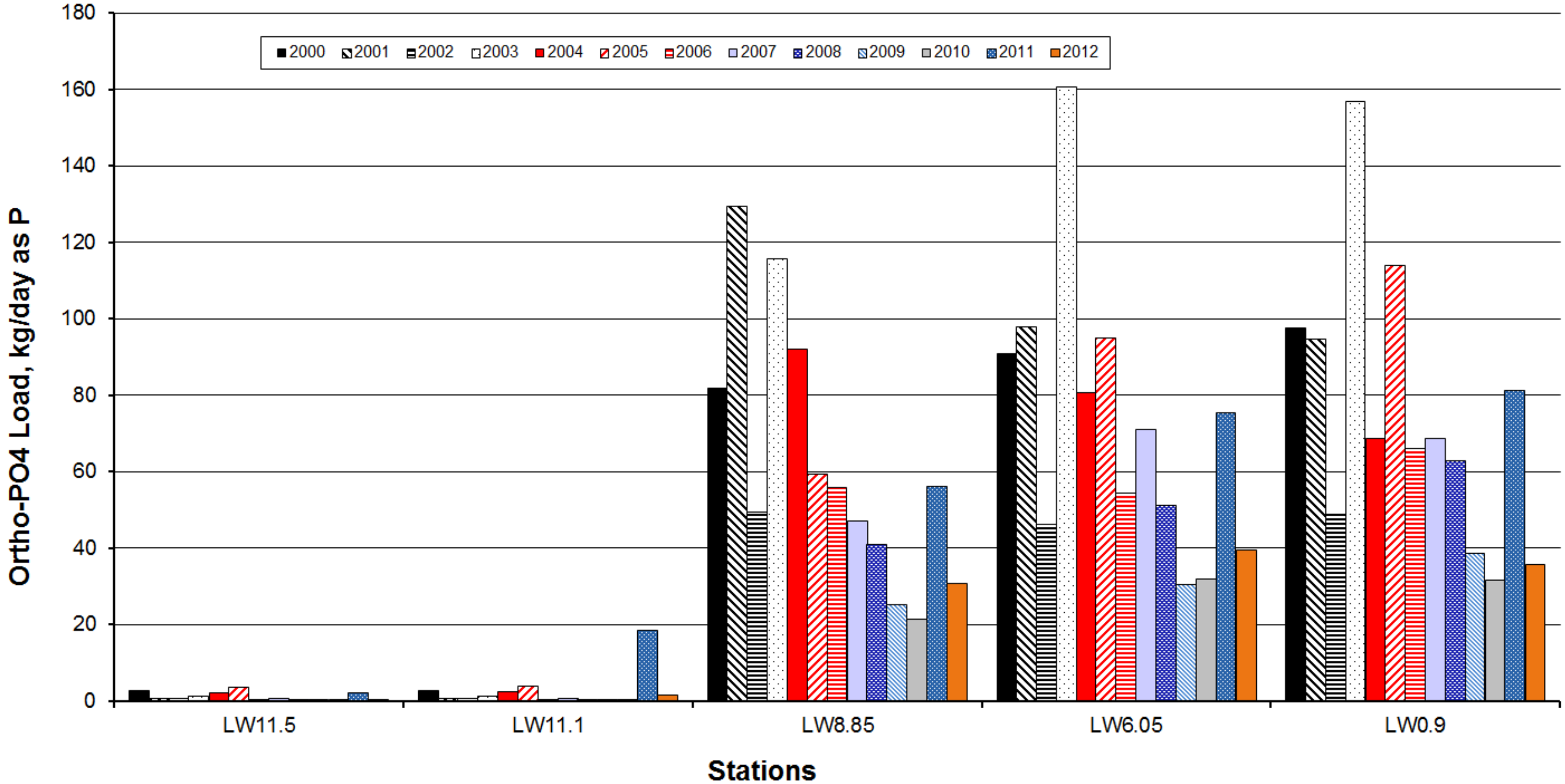


Figure 15. 2000 through 2012 average ortho-phosphate phosphorus loads in the Las Vegas Wash mainstream, upstream to downstream. Concentration data for station LW11.5 prior to 2010 are estimated.

3.3.4 Total Phosphorus

Since 2008, colorimetric determination of phosphorus in quarterly samples also provides estimates of total phosphorous (total P or TP) concentrations in the Wash and the average daily load delivered to Lake Mead. Total P is important for its contribution to metabolic characteristics in a water body and includes ortho-P and the particulate phosphates bound in suspended solid particles such as plankton, mineralized rock, and silt. Total P content can limit the productivity of a water body, as it is required for plant growth but is generally present in lower concentrations than is nitrogen, another element essential for plant growth.

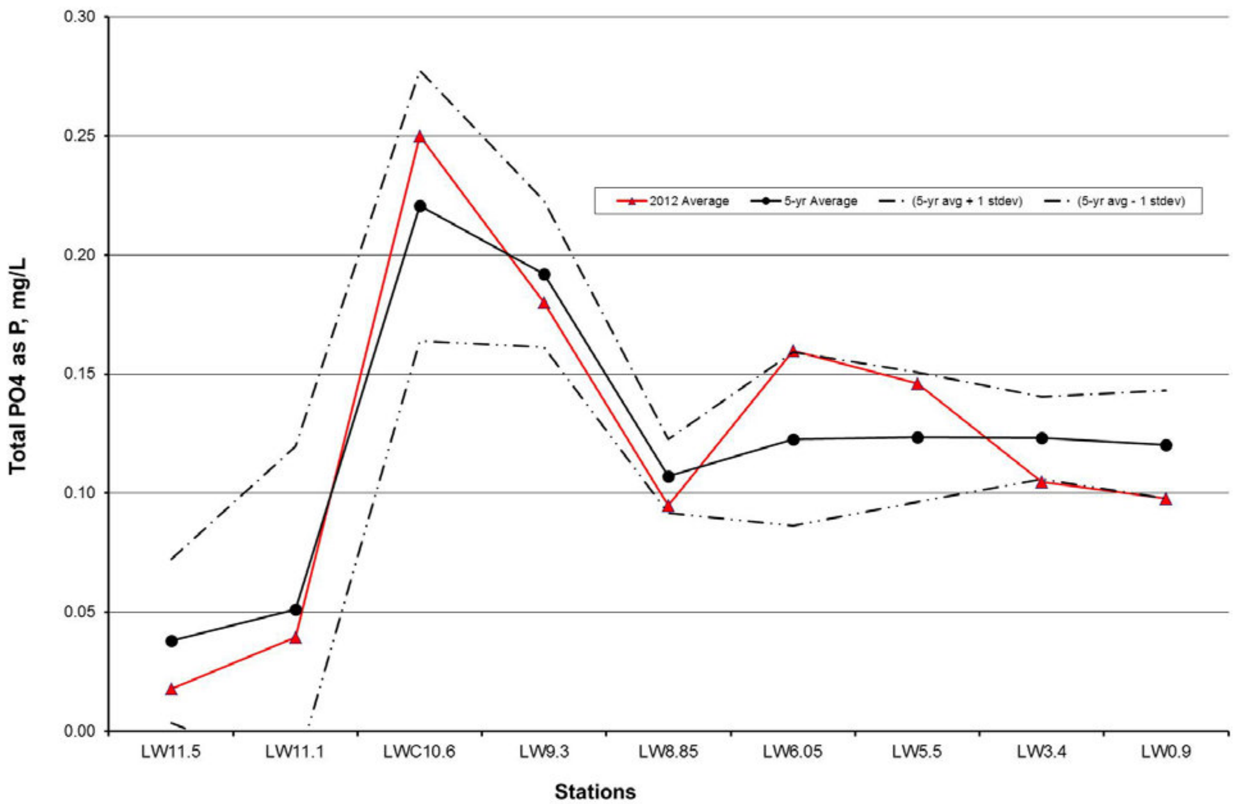


Figure 16. 2012 average total phosphate concentrations as phosphorus, compared with 2008 through 2012 concentrations at sites in the mainstream Las Vegas Wash, upstream to downstream. Graph includes concentrations released from the City of Las Vegas Wastewater Treatment Facility (LWC10.6). Dashed lines represent one standard deviation above and below cumulative average values.

Because total P has been analyzed in these samples for only five years, one of them being 2008 when the filters were offline at the CLVWPCF during December's sampling event, there is a relatively large variation around the mean at station LWC10.6. The 2012 average of 0.250 mg/L at LWC10.6 is the highest annual average value for that site over the five-year sampling period. This is true at LW6.05 also, with a 2012 average concentration of 0.160 mg/L, slightly higher than the second-highest average concentration occurring in 2008. Because ortho-P samples are filtered through a 0.45 µm pore filter upon collection and total P samples are not, graphical traces for total P may never look as uniform as do the ortho-P traces in Figure 14. Total P results are dependent on ambient conditions such as turbidity or increased surface runoff, both of which would cause total P to increase. As mentioned in the ortho-P discussion, all Valley wastewater treatment facilities are performing advanced P-removal prior to discharge to the Wash, but total P concentrations in discharge samples seem to fluctuate as much as in mainstream samples.

In 2012, the greatest concentrations of total P occurred during the September sampling event, on the day of one of the largest storms in the Valley's recorded history. The sampling team itself was ahead of the storm and remained dry all day, but of the four samples collected during 2012, September's concentrations of total P were highest at every station on the mainstream Wash except LW0.9. For most of the day, the storm was to the north and west. Just because it was not raining on the study reach of the Wash, however, does not mean the storm did not influence the water in the study reach of the Wash. Total P concentrations in mainstream samples were 50 to 300 percent higher in September than in other sampling months, and flow data were 50 to 300 percent higher than in other sampling months at some stations. This was the extreme case, but flow at LW11.5 at the time of sample collection in September was four times higher than during any other sampling event in 2012. Duck Creek drains the northern and western areas of the watershed and meets the Wash above LW6.05, possibly explaining the total P value that was almost four times higher there in September than in any other sampling month. Oddly, the flow and total P were not standouts during this storm at LW0.9, the bottommost sampling site in the study reach. The lesson learned here is that it may be most prudent to delay sampling when large storms are present even in the upper reaches of the Wash watershed.

The estimated total P load carried by the Wash to Lake Mead in 2012 was somewhere between 70 kg/day (0.08 tons/day) as measured at LW0.9, and 125 kg/day (0.14 tons/day), measured at LW6.05. As mentioned earlier in this report, the stretch of the Wash between LW5.5 and LW0.9 is a losing stretch, in terms of flow. A fault crosses the Wash near LW3.4, which often has a lower measured flow than the flow upstream at LW6.05, but greater concentrations of most analytes. It is recognized that quarterly monitoring provides only a limited view of the system that may or may not reflect reality very well for total P, because this sampling interval often misses what could be very large sediment loads carried by storm events. The September total P concentration data at LW6.05 influenced the average load at this site for 2012, being nearly four times higher than for the other three sampling events. The data were questioned, and laboratory staff closely reviewed the raw data, but they appeared to be reliably measured and reported. Concentrations of total P were higher than usual at LW5.5 and LW3.4 in September also, lending confidence in the values reported at LW6.05.

	2008			2009			2010			2011			2012		
Station	mg/L TP	cfs	kg/day	mg/L TP	cfs	kg/day	mg/L TP	cfs	kg/day	mg/L TP	cfs	kg/day	mg/L TP	cfs	kg/day
LW11.5	0.020	13.0	0.64	0.021	12.2	0.62	0.018	31.2	1.40	0.078	14.1	2.67	0.018	28.1	1.22
LW11.1	0.020	13.1	0.64	0.021	12.4	0.63	0.026	31.5	1.97	0.150	53.1	19.5	0.040	57.9	5.59
LWC10.6	0.419	96.5	99.0	0.118	94.2	27.1	0.138	93.1	31.3	0.180	73.5	32.4	0.250	59.3	36.3
LWC9.0	0.053	138	17.9	0.082	138	27.6	0.059	137	19.7	0.049	140	16.8	0.049	88.8	10.7
LWC6.1_1	0.110	28.6	7.70	0.143	19.9	6.95	0.153	20.0	7.48	0.103	19.9	5.02	0.110	19.5	5.25
LW8.85	0.170	246	102	0.082	245	49.1	0.079	253	48.7	0.110	249	66.9	0.095	259	60.1
LW6.05	0.157	267	103	0.097	269	63.8	0.088	311	67.0	0.113	295	81.3	0.160	319	125
LW0.9	0.165	285	115	0.095	285	66.3	0.104	298	75.9	0.140	296	101	0.098	293	70.0

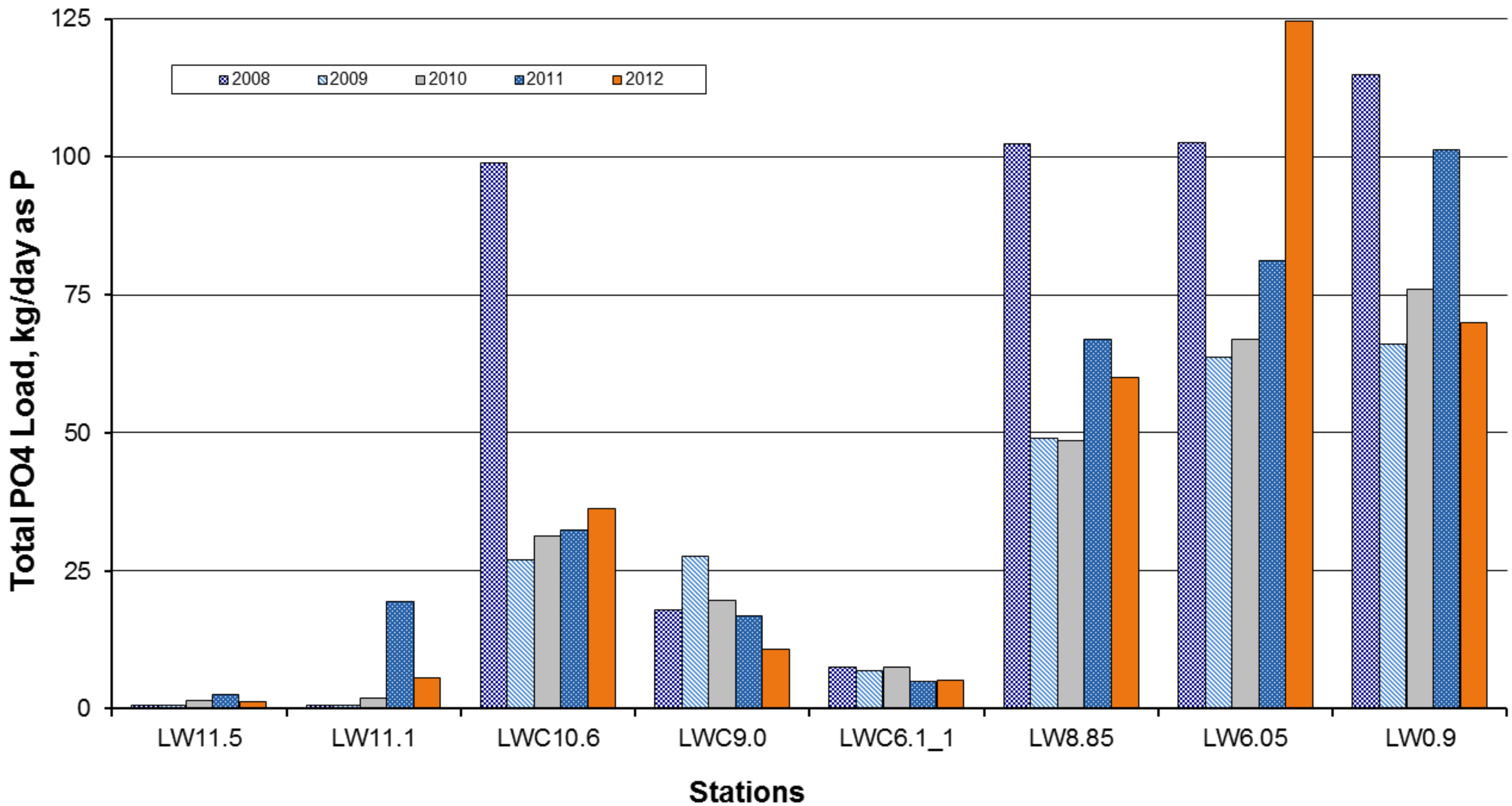


Figure 17. 2008 through 2012 average total phosphate phosphorus loads in the Las Vegas Wash mainstream, upstream to downstream. Concentration data for station LW11.5 prior to 2010 are estimated.

3.3.5 Combined Inorganic Nitrogen

Over the past 15 years of this monitoring program, there has been little variation in the overall trend of average nitrogen (N) concentrations throughout the study reach, as illustrated by the narrow limits of variation in Figure 18. Continuing the trend seen in 2011, the average concentrations of combined inorganic nitrogen (CIN, which is nitrate + nitrite + ammonia) in 2012 are below the lower limits of variation at all sites except LW11.5, which is upstream from any wastewater influents. Even downstream from wastewater additions, the 2012 averages at LW3.4 and LW0.9 were the lowest recorded during the last 15 years. According to earlier reports on the Wash, the relative proportions of total ammonia nitrogen and nitrate nitrogen changed significantly in 1995 due to operational changes at the Valley's wastewater treatment plants. Nitrification of the previously ammonia-dominated effluents in the treatment process reduced the potential for unionized ammonia toxicity to fish and other aquatic organisms in Lake Mead (Bureau of Reclamation, 1996). Because nitrification converts ammonia to nitrate nitrogen, concentrations of inorganic nitrogen ultimately available for plant assimilation in Lake Mead did not change significantly (Bureau of Reclamation, 2004).

Figure 18 shows that the average CIN concentration in the Wash increases sharply between stations LW11.1 and LW9.3, with the addition of wastewater effluent discharged by CLVWPCF at LWC10.6. Average concentrations of CIN for 2012 are well below the 15-year average at all sampling stations. Site LW11.1, which receives treated wastewater effluent from the CNLVWRF, had the lowest average CIN concentration measured in 2012, and was even lower than at the base site at LW11.5, which is above all wastewater effluent inflows. Wastewater is typically high in nitrogen compounds and as Figure 18 shows, it contributes most of the N measured in the Wash. Apparently, the CLNVWRF discharge is quite low in N compounds.

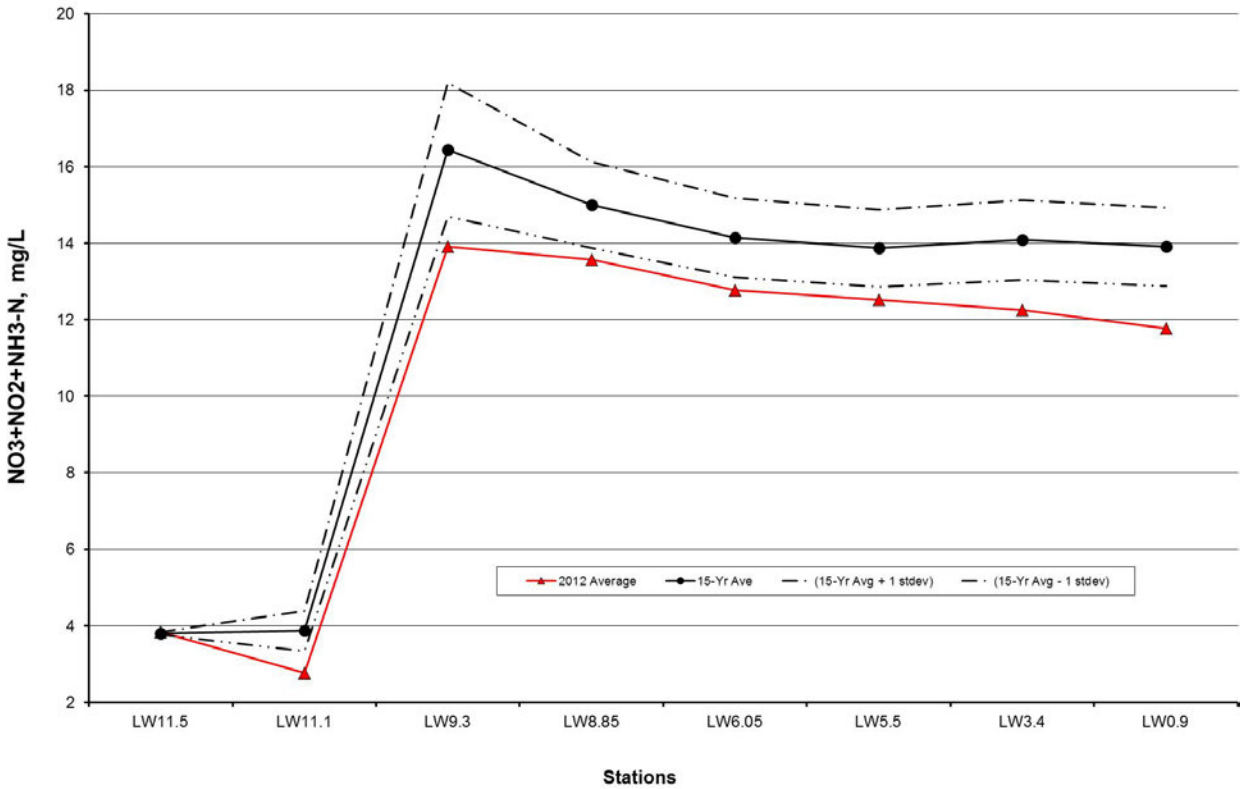


Figure 18. 2012 average combined inorganic nitrogen concentrations as N at sites in the Las Vegas Wash mainstream, upstream to downstream, compared to average values from 1998 through 2012. Dashed lines represent one standard deviation above and below cumulative average values.

While concentrations of N in the Wash are not as variable as those for some parameters measured for this report, the estimated combined N loading graph (Figure 19) displays a little more variability, since the rate of flow is used to calculate load. Estimates of 2012 average annual CIN loading of the Wash were calculated using 2012 annual average flow data obtained from mainstream USGS gages and average CIN concentrations based on quarterly sampling. According to estimates based on the data within this report, the CIN load carried by the Wash in 2012 was between 8,430 and 10,000 kg/day (9.3 to 11 tons/day), as measured at LW0.9 and LW6.05, respectively. This is a slight decrease from loads measured in 2011, and probably the smallest load carried by the Wash in 15 years of monitoring CIN for this study.

Note that CIN concentrations in the Wash are two orders of magnitude greater than ortho-P and total P concentrations (Figures 14, 16, and 18), and the estimated mean annual N loads far exceed the ortho- and total P loads (Figures 15, 17, and 19). Nitrogen and phosphorus are both important nutrients for health of aquatic organisms, but phosphorus is usually considered the limiting factor (the required nutrient that is present in the lowest quantity) that determines the amount of algal growth in a water body. See Appendix B, Table B-2, for quarterly concentrations of ammonia N and nitrate/nitrite N for 2012.

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Station	2001			2002			2003			2004			2005			2006		
	mg/L N	cfs	1000 kg/day	mg/L N	cfs	1000 kg/day	mg/L N	cfs	1000 kg/day	mg/L N	cfs	1000 kg/day	mg/L N	cfs	1000 kg/day	mg/L N	cfs	1000 kg/day
LW11.5	3.92	17.9	0.17	3.99	10.5	0.10	3.51	23.3	0.20	4.31	37.6	0.40	4.20	49.7	0.51	4.09	13.6	0.14
LW11.1	3.92	18.6	0.18	3.99	10.8	0.11	3.51	24.4	0.21	4.31	40.0	0.42	4.20	52.7	0.54	4.09	14.0	0.14
LW8.85	16.6	211	8.60	16.6	224	9.11	15.6	249	9.49	15.0	263	9.67	13.3	276	8.98	14.7	301	10.8
LW6.05	15.7	250	9.58	15.6	235	8.98	15.5	262	9.97	14.8	295	10.7	12.7	328	10.2	14.0	292	9.97
LW0.9	15.0	242	8.87	14.5	249	8.84	14.1	267	9.24	14.3	282	9.85	14.0	304	10.4	14.0	304	10.4

Station	2007			2008			2009			2010			2011			2012		
	mg/L N	cfs	1000 kg/day	mg/L N	cfs	1000 kg/day	mg/L N	cfs	1000 kg/day	mg/L N	cfs	1000 kg/day	mg/L N	cfs	1000 kg/day	mg/L N	cfs	1000 kg/day
LW11.5	4.07	13.6	0.14	3.93	13.0	0.13	3.70	12.2	0.11	3.78	31.2	0.29	3.79	14.1	0.13	3.83	28.1	0.26
LW11.1	4.07	13.6	0.14	3.93	13.1	0.13	3.70	12.4	0.11	3.90	31.5	0.30	2.90	53.1	0.38	2.77	57.9	0.39
LW8.85	15.4	270	10.1	15.1	246	9.07	14.3	245	8.56	14.8	253	9.14	13.6	249	8.27	13.6	259	8.61
LW6.05	14.5	301	10.7	14.3	267	9.35	13.8	269	9.05	14.8	311	11.2	13.3	295	9.63	12.8	319	10.0
LW0.9	14.9	294	10.7	13.6	285	9.44	13.5	285	9.44	13.8	298	10.0	12.5	296	9.08	11.8	293	8.43

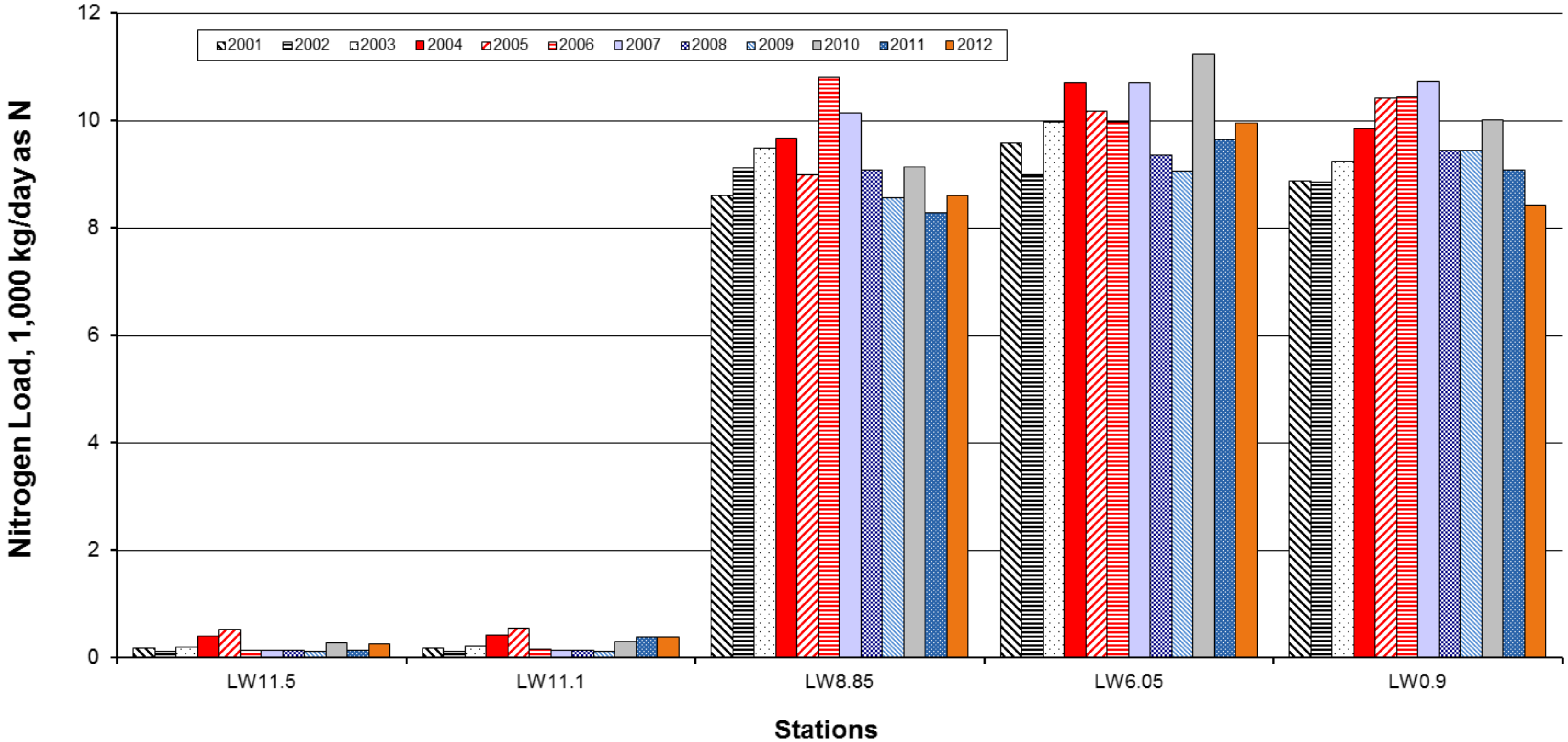

Figure 19. 2001 through 2012 average combined inorganic nitrogen loads in the Las Vegas Wash mainstream, upstream to downstream. Concentration data for station LW11.5 prior to 2010 are estimated.

3.3.6 Selenium

Beginning in June 2000, selenium (Se) analysis was added to the quarterly Wash water quality monitoring program. Selenium is an analyte of concern due to its effects on fish and aquatic birds and wildlife, since it may affect embryonic development at relatively low concentrations, often causing physical malformation (Lemly and Smith, 1987). Selenium is essential for life in small amounts but it tends to accumulate continuously in tissues of fish and wildlife even when exposure is to an environment with relatively low concentrations. Soils in the Las Vegas Valley are naturally rich in selenium due to their origin as marine sediment, thus irrigation and stormwater runoff can carry high concentrations of selenium to the Wash.

Over 13 years of analysis, average Se concentrations in the Wash have followed a general pattern of relatively high concentrations in the base flow at station LW11.5, with high volume inflows from Valley dischargers diluting it to lower levels downstream (Figure 20). Precipitation events or other surface runoff may affect Se concentrations at LW11.5, by increasing Se concentrations with increased precipitation (however, the September sample yielded the lowest Se concentration of the four samples; evidently it can go either way). Based on real-time flow data obtained from USGS gages on the Wash, there may be a delay for runoff entering the surface flow of the Wash from upper reaches of the Valley's watershed, seen in sustained above-average flows for a period of a week or more following significant precipitation events. During three of the four sampling events in 2012, flow rates at LW11.5 ranged from 7.5 to 7.9 cfs (0.21 to 0.22 cms), but the September flow rate at the time the samples were collected was 32 cfs (0.91 cms), four times the median flow rate for the year. Selenium concentrations at LW11.5 were very stable, ranging from 15µg/L in March and June to 9.7 µg/L in September. The 2012 average Se concentration at this uppermost site was 13.2 µg/L.

As seen in Figure 20, the 2012 average Se concentrations were at or below the 13-year average at each sampling station, and at all stations below inflows of treated wastewater, average annual concentrations were less than the 3.2 ug/L average value at LW9.3. See the table of concentrations of Se measured during each 2012 sampling event in Appendix A, Table B-4.

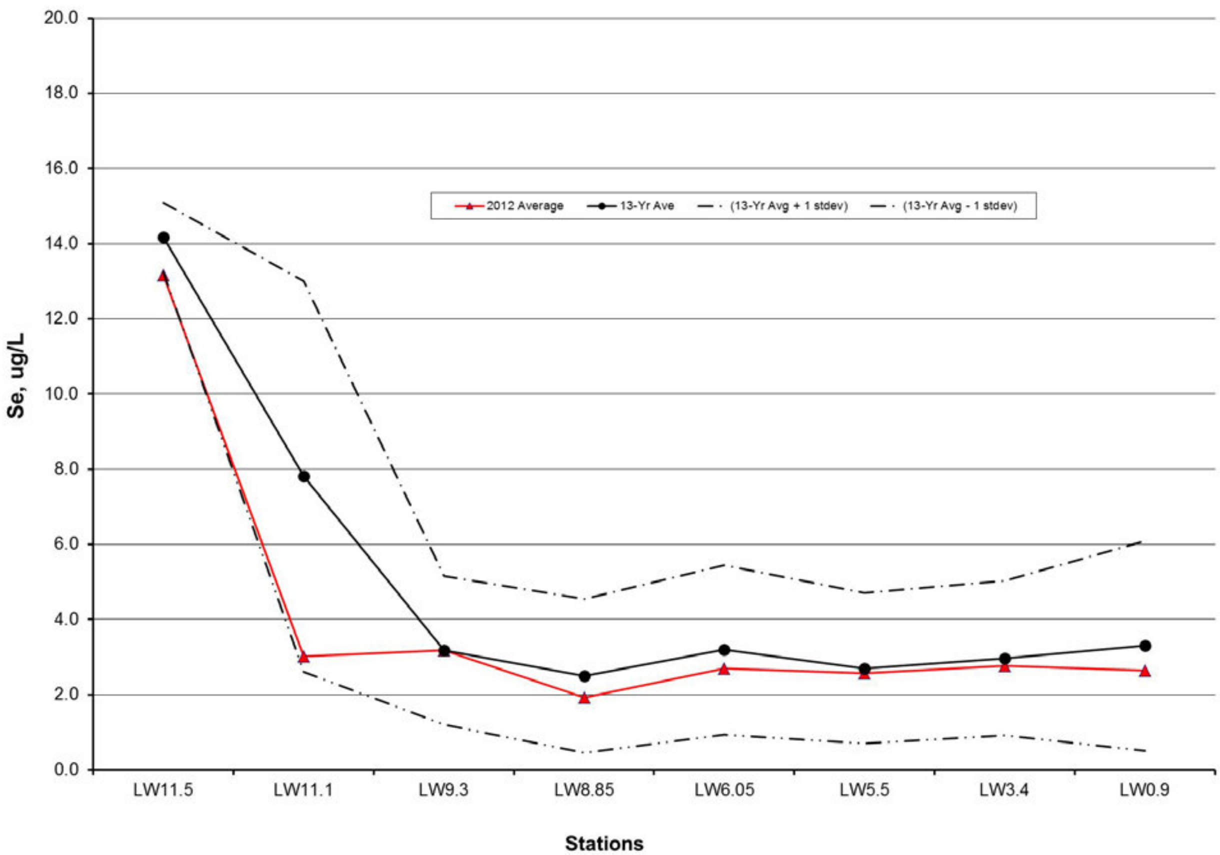

Figure 20. 2012 average total selenium concentrations at sites in the Las Vegas Wash mainstream, upstream to downstream, compared to average values from 2000 through 2012. Dashed lines represent one standard deviation above and below cumulative average values.

Selenium loads for each station (Figure 21) were calculated using the 2012 average concentrations from quarterly monitoring results at each station and 2012 average flow data reported by USGS at selected mainstream locations. By this method, an estimated 1.90 kg/day (4.19 lbs/day) of dissolved total Se passed the Northshore Road Bridge and entered the Las Vegas Bay of Lake Mead in 2012, which is a decrease from 2011 and slightly less than even the estimated load in 2010. Again, there is evidence in the flow data and resulting Se load calculation of a losing stretch of the Wash between LW5.5 and LW0.9. The fault that crosses the Wash near LW3.4 may cause a loss in flow while simultaneously forcing groundwater to the surface in this stretch, where the loads and concentrations of some analytes measured for this study increase, while parameters such as temperature and dissolved oxygen decrease (see figures 6 and 8).

	2001			2002			2003			2004			2005			2006		
Station	ug/L Se	cfs	kg/day	ug/L Se	cfs	kg/day	ug/L Se	cfs	kg/day	ug/L Se	cfs	kg/day	ug/L Se	cfs	kg/day	ug/L Se	cfs	kg/day
LW11.5	21	17.9	0.90	9.7	10.5	0.25	5.3	23.3	0.30	7.2	37.6	0.66	5.2	49.7	0.63	3.3	13.6	0.11
LW11.1	21	18.6	0.93	9.7	10.8	0.26	5.3	24.4	0.31	7.2	40.0	0.71	5.2	52.7	0.67	3.3	14.0	0.11
LW8.85	8.8	211	4.55	3.5	224	1.92	1.8	249	1.11	1.7	263	1.12	2.8	276	1.92	0.8	301	0.55
LW6.05	9.0	250	5.47	6.7	235	3.87	2.2	262	1.41	2.7	295	1.95	3.2	328	2.55	1.0	292	0.74
LW0.9	8.3	242	4.91	6.7	249	4.09	1.0	267	0.65	2.2	282	1.53	1.7	304	1.25	0.8	304	0.56

	2007			2008			2009			2010			2011			2012		
Station	ug/L Se	cfs	kg/day	ug/L Se	cfs	kg/day	ug/L Se	cfs	kg/day	ug/L Se	cfs	kg/day	ug/L Se	cfs	kg/day	ug/L Se	cfs	kg/day
LW11.5	3.4	13.6	0.11	9.1	13.0	0.29	3.3	12.2	0.10	14	31.2	1.10	15	14.1	0.52	15	28.1	1.03
LW11.1	3.4	13.6	0.11	9.1	13.1	0.29	3.3	12.4	0.10	16	31.5	1.20	9.3	53.1	1.21	9.3	57.9	1.31
LW8.85	1.8	270	1.16	2.0	246	1.22	0.5	245	0.33	1.9	253	1.19	2.4	249	1.43	2.4	259	1.49
LW6.05	1.9	301	1.37	3.2	267	2.08	0.6	269	0.37	2.4	311	1.83	3.0	295	2.19	3.0	319	2.36
LW0.9	1.8	294	1.31	2.3	285	1.62	0.6	285	0.45	2.7	298	1.94	3.4	296	2.43	2.7	293	1.90

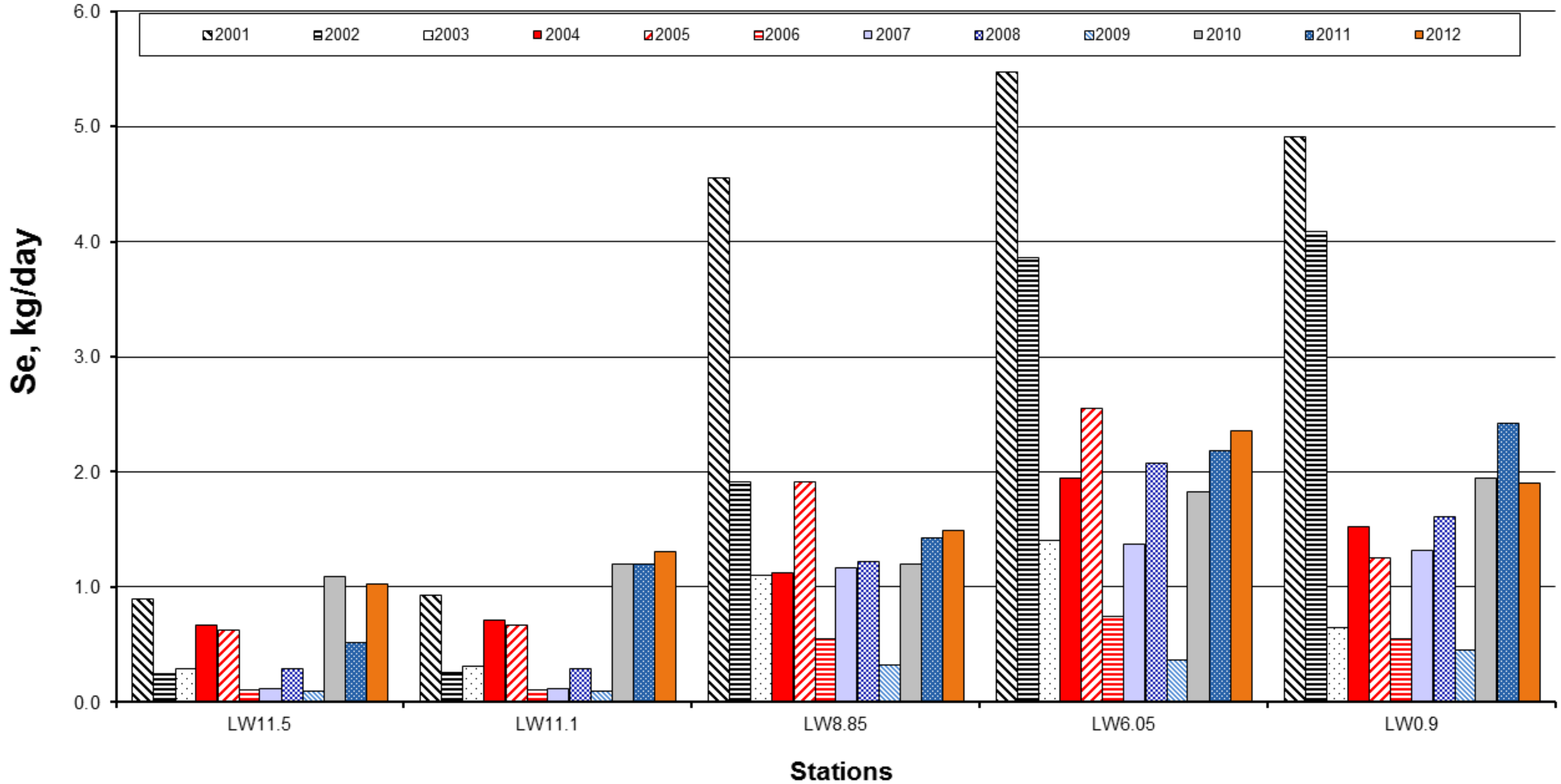

Figure 21. 2000 through 2012 average dissolved selenium loads in kilograms per day in the Las Vegas Wash mainstream, upstream to downstream. Concentration data for station LW11.5 prior to 2010 are estimated.

3.3.7 Perchlorate

Perchlorate exists naturally in arid climates with soils derived from ancient marine beds, which describes the soils found in the Las Vegas Valley and throughout the Mojave Desert. However, in 1997 the Metropolitan Water District of Southern California (MWD) found unusually high concentrations of perchlorate in Colorado River water diverted from Lake Havasu. The perchlorate source was eventually traced back to the Las Vegas Wash and ultimately to the site of its production in Henderson, Nevada, on the 5,000-acre Basic Magnesium Incorporated (BMI) manufacturing site set aside by the government in 1941. Today, commercial and residential developments surround the site, but at the time it was set aside, it was in wide-open desert. Production of ammonium perchlorate for the Department of Defense (DOD) and for the National Aeronautics and Space Administration (NASA) began here in the 1950s. The BMI site has a complicated history, as does the perchlorate problem, both summarized further in Appendix F.

Beginning in June 2000, Reclamation added perchlorate analysis to the list of parameters measured in quarterly Wash water samples. Perchlorate (ClO_4^-) is an analyte of concern in the Wash because it inhibits uptake of iodine by the thyroid gland by blocking iodine receptor sites, which can result in hypothyroidism and particularly negatively affect the growth of exposed children. Perchlorate is not a toxic substance, and when consumption of perchlorate stops, the thyroid typically resumes normal uptake of iodine (Sellers, et al, 2007).

In the Wash at LW11.5, upstream from any additions of treated wastewater, the 13-year average concentration of perchlorate was approximately 10.1µg/L, with narrow limits of variation as seen in Figure 22. The 2012 average perchlorate concentration measured at LW11.5 was 7.98µg/L, which is slightly higher than the 2011 average but lower than the long-term average concentration. This concentration equates to a load of approximately 0.55 kg/day (1.21 lbs/day), about twice the average load per day in 2011, due to the higher average flow rate reported at the USGS gage at the Flamingo Wash confluence upstream from LW11.5. Several high storm flows occurred in 2012 that increased the average annual flow at this site to 28.1 cfs (0.80 cms); about four times the 2012 median flow, and twice the average flow in 2011(14.1 cfs (0.40 cms)).

Figure 22 also shows that in 2012 contributions of perchlorate between stations LW5.5 and LW3.4, where concentrations undergo a significant increase, are well below the 13-year average, but still exhibited the same trend seen in these data for several years. At LW0.9, at the downstream end of the study reach, the 2012 average concentration based on quarterly sampling was 56.5 µg/L, which yielded a perchlorate load of approximately 40.5 kg/day (89.3 lbs/day) or 14,792 kg/year (16.3 tons/year). Using real-time flow data and concentrations of perchlorate in samples collected quarterly by Reclamation for this program, the load at Northshore Road ranged from 72 to 99 lbs/day, as seen in March and September, respectively. The limitations of deriving an average from quarterly data are recognized, and these values are for general trend reporting purposes only. These load estimates are somewhat higher than any average since 2007, even though perchlorate remediation efforts are still underway on the BMI complex and near the

Wash at Pabco Road, as described in Appendix F. The average 2012 estimated perchlorate load may be higher because samples were collected on September 12, when a major rainstorm hit the Valley and surrounding watershed, increasing flows in the Wash that day.

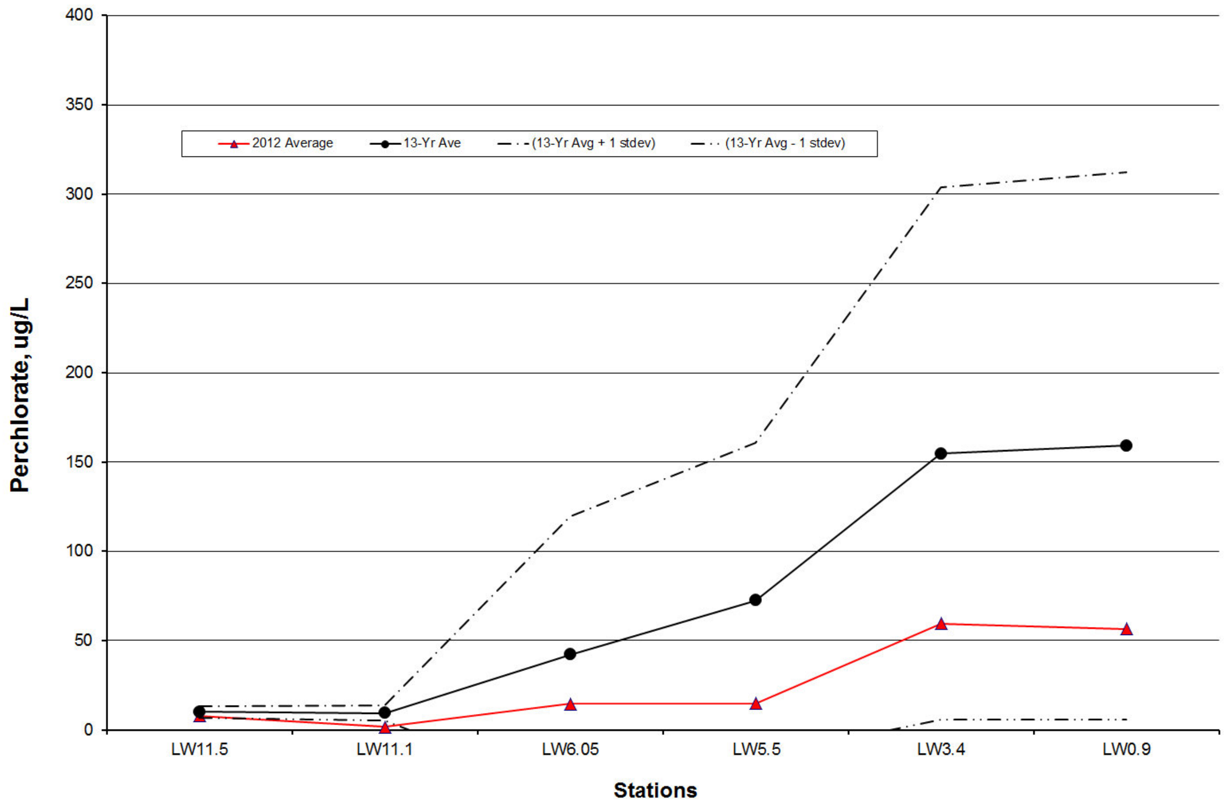

Figure 22. 2012 average perchlorate concentrations at sites in the Las Vegas Wash mainstream, upstream to downstream, compared to average values from 2000 through 2012. Dashed lines represent one standard deviation above and below average values.

NDEP also collected perchlorate samples on a quarterly basis below the Northshore Road. They sampled in January, April, July, and October 2012, always in the morning hours when flow rates were much lower than Reclamation encountered sampling later in the day. NDEP reported concentrations ranging from 42 to 71 µg/L in their samples, with estimated loads for 2012 ranging from 51 to 67 lbs/day. Reclamation's load estimate of 89 lbs/day on average may be biased high due to sampling on high flow days or by using the 2012 average annual flow and not the exact real-time flow at the time samples were collected. However, when calculated using real-time flow, the average load changed only slightly, to 40.05 kg/day, or 88.3 lbs/day.

	2001			2002			2003			2004			2005			2006		
Station	ug/L ClO_4	cfs	kg/day	ug/L ClO_4	cfs	kg/day	ug/L ClO_4	cfs	kg/day	ug/L ClO_4	cfs	kg/day	ug/L ClO_4	cfs	kg/day	ug/L ClO_4	cfs	kg/day
LW.11.5	9.60	17.9	0.42	9.80	10.5	0.25	6.75	23.3	0.38	10.7	37.6	0.98	11.6	49.7	1.41	9.90	13.6	0.33
LW11.1	9.60	18.6	0.44	9.80	10.8	0.26	6.75	24.4	0.40	10.7	40.0	1.04	11.6	52.7	1.49	9.90	14.0	0.34
LW6.05	23.7	250	14.5	38.5	235	22.1	28.0	262	18.0	18.8	295	13.5	23.5	328	18.9	23.8	292	17.0
LW5.5	156	250	95.3	159	235	91.4	73.8	262	47.3	39.0	295	28.1	44.8	328	35.9	35.5	292	25.3
LW3.4	360	250	220	324	235	186	252	262	162	144	295	103	99.5	279	68.0	63.1	277	42.7
LW0.9	392	242	232	270	249	165	254	267	166	160	282	111	99.3	304	73.8	72.8	304	54.2

	2007			2008			2009			2010			2011			2012		
Station	ug/L ClO_4	cfs	kg/day	ug/L ClO_4	cfs	kg/day	ug/L ClO_4	cfs	kg/day	ug/L ClO_4	cfs	kg/day	ug/L ClO_4	cfs	kg/day	ug/L ClO_4	cfs	kg/day
LW11.5	10.1	13.6	0.34	9.54	13.0	0.30	9.40	12.2	0.28	8.50	31.2	0.65	7.53	14.1	0.26	7.98	28.1	0.55
LW11.1	10.1	13.6	0.34	9.54	13.1	0.31	9.40	12.4	0.28	8.95	31.5	0.69	4.40	53.1	0.57	1.80	57.9	0.25
LW6.05	24.0	301	17.7	12.5	267	8.16	15.6	269	10.3	12.2	311	9.28	14.8	295	10.7	14.5	319	11.3
LW5.5	31.5	301	23.2	18.0	267	11.8	21.5	269	14.1	18.3	338	15.1	14.8	296	10.7	14.8	319	11.5
LW3.4	63.6	324	50.5	37.8	290	26.8	47.0	289	33.2	35.5	316	27.4	47.0	308	35.4	59.5	311	45.3
LW0.9	69.0	294	49.7	46.6	285	32.4	50.8	285	35.4	39.5	298	28.8	46.3	296	33.5	56.5	293	40.5

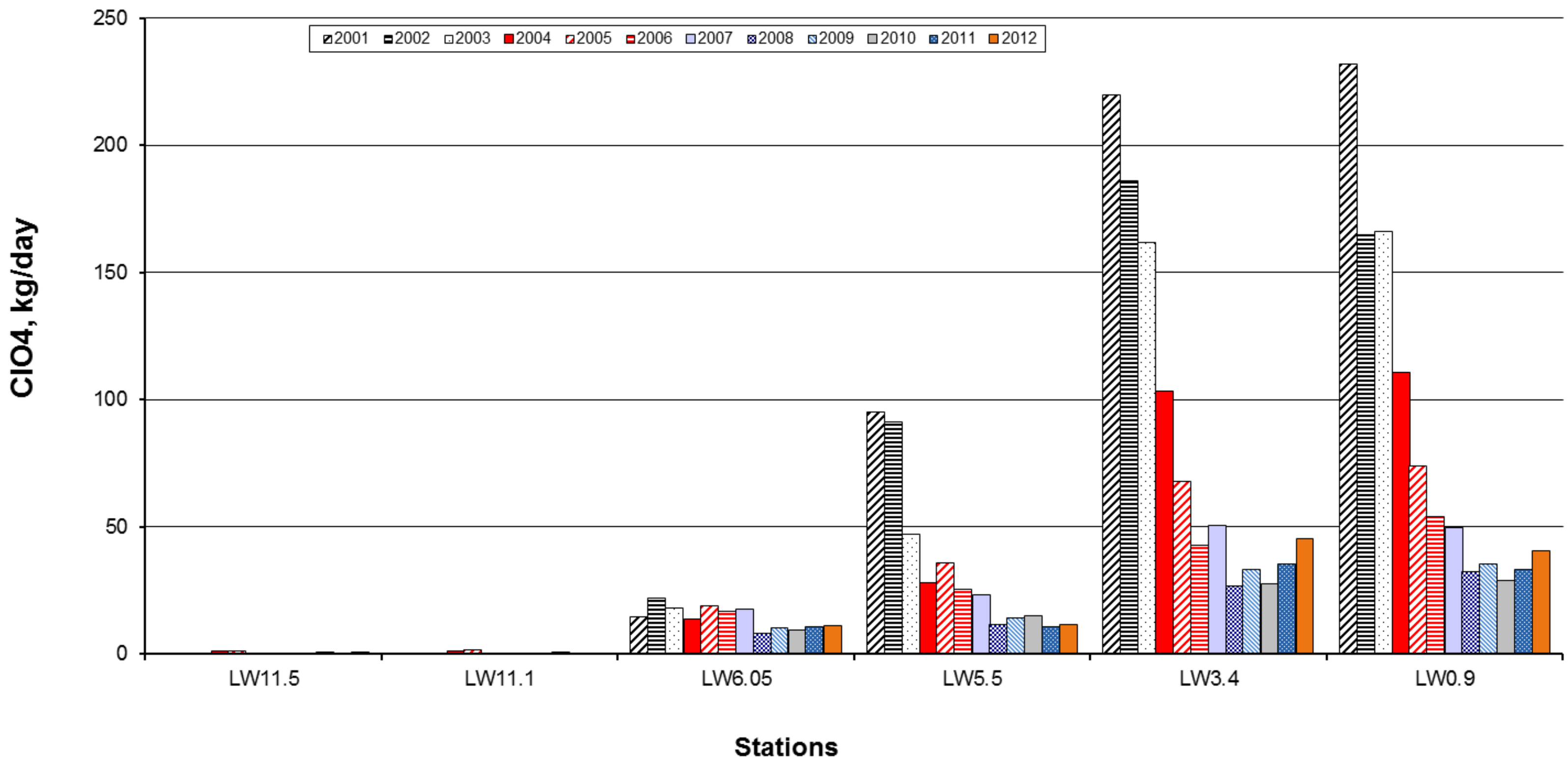

Figure 23. 2001-2012 mean perchlorate loads in the Las Vegas Wash mainstream, upstream to downstream. Concentrations at station LW11.5 prior to 2010 are estimated.

4.0 Conclusions

The Wash is an effluent-dominated stream in the reach that stretches from the confluence with Sloan channel at about LW11.4 to the Las Vegas Bay (LVB) in Lake Mead. In the early years of Wash monitoring, it appeared that as effluent discharges to the Wash continued to increase, it was likely that water quality in LVB would decline accordingly, with the degree of impact becoming more severe as declining Lake Mead levels reduced the volume of the LVB and Lake Mead as a whole. According to Welch (1992), it is difficult for ecosystems like the LVB to accept municipal wastewater discharges indefinitely without some costs to their structure and stability. LaBounty and Eckhardt (1994) concluded that the effluent-dominated waters of the Wash caused eutrophication of portions of Lake Mead from time to time; effects that may have extended to Hoover Dam and, under certain conditions, affected the drinking water source for Las Vegas. They determined that water quality in the LVB was generally poor and that enrichment of the Bay had exceeded desirable limits at that time.

Development of water quality mapping techniques using satellite imagery of Las Vegas Bay and Boulder Basin in the 1990s showed eutrophic conditions in LVB in spring, summer, and autumn that rendered much of the aquatic environment unsuitable for human uses and degraded the quality of habitat for fishes and other aquatic organisms. Severe spring algal blooms occurred periodically in the LVB, and adverse water quality impacts were noted as far away as the intakes of the Southern Nevada Water System on Saddle Island, roughly three miles downstream from the mouth of the LVB to Lake Mead. The most recent major algal bloom in Lake Mead occurred in 2001 when local precipitation carried heavy nutrient loads to Lake Mead in addition to those provided by the Wash, and eutrophic conditions in the LVB caused an algal bloom dominated by *Pyramichlamys dissecta* (Holdren, Horn, Lieberman, 2001) that turned most of Lake Mead bright green.

However, the Wash of today is very different in morphology as well as in the quality of water it carries. In the intervening years, improvements to local wastewater treatment plants and construction of weirs that slow storm flows give the Wash its relatively high quality waters today. In 1995, introduction of nitrification prior to discharge in the cities' wastewater treatment plants shifted the ammonia-dominated inorganic nitrogen balance to a nitrate-dominated balance and significantly reduced the risk of ammonia toxicity to aquatic biota of Las Vegas Bay. Voluntary year-round reduction of phosphorus concentrations in wastewater effluent at all Valley treatment plants beginning in 2002 has done much to increase the quality of water in the LVB of Lake Mead.

The completion of 15 of 22 planned erosion control structures in 2012 and other channel stabilization measures, such as revegetation and bank protection, have significantly reduced streambed erosion and sediment transport in the Wash, and provided increased water retention time in the resulting wetlands. All constructed weir facilities were designed with sufficient capacity to pass the "once in one-hundred years' frequency" flood events. During the 2012 flood events, all permanent weirs functioned well with some minor rock movement at only two sites. The only structural casualty in the Wash was a temporary weir installed in 1999 that washed out during the first 2012 flood and was not replaced (Gerry Hester, SNWA, personal communication February 20, 2014).

The City of North Las Vegas (CNLV) began treating wastewater and discharging effluent into the Wash through the Sloan Channel in June 2011, which continued throughout 2012 with apparent improvement of their treatment processes. Concentrations of nutrients (nitrogen and phosphorus species) and selenium in the Wash at LW11.1 were well below long-term averages in 2012, as were TSS and TDS. The unusually high pH values seen in 2011 (between 9 and 10) decreased somewhat in 2012, ranging from 8.02 to 9.01 units at LW11.1 The CNLV began mechanically cleaning the Sloan Channel five days a week, reducing complaints of odors and nuisance insects by nearby residents in 2012. CNLV also began planning for a pipeline that will discharge their effluent into the Wash near LW11.1 so that, upon its completion, no wastewater discharge would run in the open Sloan channel. The right for the CNLV to discharge into the Sloan Channel in the first place was under dispute by Clark County, and this pipeline plan may resolve concerns of Clark County managers and local residents as well.

Increased phosphorus and selenium loading seen in the Wash in 2011 is still present in 2012, and the total P load discharged by the CLVWPCF at LWC10.6 increased for the fourth year in a row; however, 2012 loads are not even close to what they were in 2008, before installation of the bank of individually removable filters

Drought conditions continued in the Colorado River Basin since the year 2000, even though the Las Vegas Watershed had a wet year locally in 2012. Because the majority of flow into Lake Mead comes from the upper Colorado River basin on the west slopes of the Rocky Mountains, the Lake Mead elevation dropped to 1,106.73 feet (337.1 m) above mean sea level (msl) on December 31, which is 26.1 feet (7.95 m) lower than this date in 2011. While Lake Mead on this date was significantly below the full pool elevation of 1,219.6 feet msl (371.7 m), reservoir releases were normal for the Lower Basin in 2012. However, recent forecasts of continued drought make it increasingly likely that the Colorado River will experience shortages by 2015 or 2016 (see *Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead*, Reclamation, 2007).

Flow rates at LW0.9 in the Wash have been relatively stable since 2005, hovering around 300 cfs (8.5 cms) through 2012. Salinity (or TDS) concentrations carried by the Wash in 2012 were less than the lower limits of variation for the 22-year period of record covered by this report, a trend that has continued since 2008. Discharge rates from the City of Las Vegas Water Pollution Control Facility in 2012 decreased for the second year to their lowest average since 1995, because the City of North Las Vegas began treating its own wastewater and discharging it into the Wash in June 2011. The average annual discharge rate from the Clark County Advanced Waste Treatment Plant has been stable since 2005. On average, 161 MGD of treated wastewater effluent was discharged to the Wash in 2012 from all plants combined (a decrease of more than 9 MGD since 2011), constituting approximately 85 percent of the total volume of water carried by the Wash. With increasing opportunities for conservation through reuse of treated wastewater and financial incentives for businesses and homeowners converting lawn to xeriscape, flows may remain stable until the next wave of rapid development in the Valley. As it is at the time of this writing, the flow rate is easily accommodated by the present structure of the Wash, and existing erosion control measures functioned as expected during 2012s high-flow storms (Hester).

Finally, groundwater interception and treatment to remove perchlorate from the Nevada Environmental Response Trust Site within the BMI complex has resulted in a significant reduction of perchlorate concentrations in the lower Wash and in the lower Colorado River over the last 13 years, as seen in Figure 22.

5.0 Need for Future Study

While the water quality and control of morphology of the Wash described in this report are encouraging, it remains important that the water quality monitoring presently conducted as part of the Colorado River Water Quality Improvement Program is continued in the future. Keeping a repository of current data and the trends revealed will be increasingly necessary to support decision-making over a range of issues, including whether or not to complete further stabilization of the Wash channel and determining ways and means to reduce quality-related impacts from overland runoff from Las Vegas Valley. In addition, impacts of this effluent-dominated stream on the water quality of Lake Mead and Las Vegas Bay need to be monitored continually, especially with the specter of long-term drought in the watershed's future. Additionally, as the wetlands formed by construction of erosion control structures continue to mature, study opportunities will abound that may yield results applicable to other urban streams and effluent discharge conveyances, as described below.

Wetlands rapidly formed behind the constructed grade-control structures in the Wash, and although floods have occasionally disrupted their vegetation, they continue to recover relatively quickly. Prior to 1983, retention time studies estimated transit time through the entire Wash to be 18 hours (Brown and Caldwell, 1982). In 1987, a dye study conducted by USGS and Reclamation (J. Sartoris and R. Roline) showed that retention time through the Wash had dropped to only 6 hours following severe flooding and erosion events in 1983 and 1984. Now that several of the constructed wetlands have had time to mature, a repeat dye study could determine whether or not retention time is approaching the historic value. In addition, a thorough evaluation of the water treatment functions and habitat value of these wetlands is important, such as their capacity to buffer stormwater inflows and wastewater treatment plant upsets. The variety of construction types, plant communities, retention times, and sizes in terms of area and volume of these wetlands provide opportunities to learn best practices that may be adapted to other urban wetlands. Their functionality pertaining to sediment trapping, nutrient and carbon sequestration, and groundwater recharge are areas of study that may become increasingly important for the quality of water in Lake Mead and the Colorado River. For example, the present nitrate-dominated effluent in the Wash might benefit from at least partial denitrification in the wetlands (Smith et al., 2000; Bachand and Horne, 2000), particularly under low flow conditions. Studies of trace metals uptake and of the ability for wetlands to mitigate fecal bacteria and contaminants of emerging concern would be of great value, since these are issues increasingly in the public eye.

In addition to the possible treatment effects of these wetlands, they provide valuable waterfowl and wildlife habitat in what is otherwise a harsh and extremely arid environment, and excellent opportunities for outdoor recreational activities for the large human population in the Valley. Investigation of the effects of water quality in the Wash on these important habitat resources should continue. Selenium and perchlorate concentrations in the Wash, for example, may affect bird and amphibian development. Development of wetland areas in the Wash could attract amphibians to locations with high perchlorate levels. Variable tolerance to perchlorate may also limit some amphibians while allowing others to flourish. Additionally, as the Wash corridor becomes more appealing as a site for outdoor recreation, understanding the risks to people who may choose to make contact with the water in the Wash will be necessary. Data from investigations such as these will be important for evaluating potential impacts on the wetlands when changes in water quality and quantity occur.

There was local interest in determining whether or not the lowest mainstream station sampled during monitoring, station LW0.9 at Northshore Road, adequately represents the quality of water that reaches Lake Mead when the lake's elevation is as low as it has been for the last several years. For instance, in 2010 when Lake Mead's elevation hit 1,086.3 feet msl, its lowest elevation since Lake Powell was filling in 1966, the station at LW0.9 was probably three miles or more from Lake Mead, and not the 0.55 mile indicated by its station code. Having the Wash water meander throughout a 3-mile-long delta could have changed some of its parameters before reaching Lake Mead at Las Vegas Bay. The TSS is probably the most likely parameter to change, since the sediment load carried by the flow of the Wash would increase as it wound through the delta. The flow could also intercept saline springs that would change the chemical nature of the water reaching Lake Mead via the Wash. Adding another sampling station downstream of LW0.9 is an option to explore, but access to the Wash below that site can be difficult during low water conditions. Reclamation will collect some samples from this stretch in 2013, accessing the Wash from the abandoned Las Vegas Marina road and launch ramp. Safety of access is paramount, as the wet silt that typically comprises the delta can behave like quicksand.

Prior to construction of the CNLVWRF, the intent was to send most of its effluent to reuse projects in the North Las Vegas area. Whether or not they currently have a customer base for this plan, the facility continued to discharge some, if not all, of their treated wastewater into the Wash through the Sloan Channel throughout 2012. However, a planning effort is presently underway to pipe discharges from the CNLVWRF to the Wash, where the flow will reach the Wash at about station LW11.1. This is in response to complaints from residents who border the Sloan Channel and from Clark County, which has disputed use of the Sloan Channel for this discharge since the treatment plant began discharging in 2011. Because all other Valley treatment plant discharges are monitored on our quarterly schedule, monitoring of the CNLVWRF discharge before it intersects the Wash will be added when it is completed.

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Frequently Used Acronyms and Abbreviations

BMI	Black Mountain Industrial, a.k.a. Basic Magnesium Incorporated
CCWRD	Clark County Water Reclamation District
cfs	cubic feet per second
CHWTP	City of Henderson Wastewater Treatment Plant
CIN	combined inorganic nitrogen (aqueous ammonia, nitrate, and nitrite)
CLVWPCF	City of Las Vegas Water Pollution Control Facility
cms	cubic meters per second
CNLVWRF	City of North Las Vegas Water Reclamation Facility
FBR	fluidized bed reactor
ICP/MS	inductively coupled plasma mass spectrometer
LCRL	Lower Colorado Regional Laboratory; Reclamation, Boulder City, NV
LVVWD	Las Vegas Valley Water District
MDL	method detection limit
µg/L	micrograms per liter, or parts per billion (for scale, 1 second in ~32 years)
mg/L	milligrams per liter, or parts per million (~1 second in 11.5 days)
MGD	million gallons per day
NDEP	Nevada Division of Environmental Protection
NERT	Nevada Environmental Response Trust
ng/L	nanograms per liter, or parts per trillion (~3 seconds in 100,000 years)
ppm	parts per million, or milligrams per liter (mg/L), $1x10^{-6}$
ppb	parts per billion, or micrograms per liter (µg/L), $1x10^{-9}$
ppt	parts per trillion, or nanograms per liter (ng/L), $1x10^{-12}$
PQL	practical quantitation limit (same as reporting limit)
Reclamation	Bureau of Reclamation
RL	reporting limit
SCOP	Systems Conveyance and Operations Program
SFL	Sierra Foothill Laboratory; Contractor, Jackson, California
SNWA	Southern Nevada Water Authority
SNWS	Southern Nevada Water System
TDS	total dissolved solids
TSS	total suspended solids
USDA	United States Department of Agriculture
USGS	United States Geological Survey
Valley	Las Vegas Valley
Wash	Las Vegas Wash
WPCF	water pollution control facility

Glossary of Terms

Artesian conditions/artesian aquifer: Groundwater in aquifers confined between layers of poorly permeable rock may be under positive pressure that is significant enough to push the water through a drilled well or an opening in the rock to an elevation greater than the aquifer itself. When such water reaches the surface of the ground, it becomes a flowing artesian well or spring.

Caliche: (kəˈlēchē/) Caliche is a sedimentary rock, a hardened natural cement of calcium carbonate binding other materials such as gravel, sand, clay, and silt. Caliche is generally light-colored, but can range from white to light pink to reddish-brown, depending on the impurities present. It generally occurs on or near the surface, but can be found in deeper subsoil deposits, as well. Layers vary from a few inches to feet thick, and multiple layers can exist in a single location. Caliche occurs worldwide, generally in arid or semiarid regions, including in central and western Australia, in the Kalahari Desert, in the High Plains of the western USA, in the Sonoran Desert, and in Eastern Saudi Arabia Al-Hasa. Caliche is also known as **hardpan**, **calcrete**, ***kankar*** (in India), or **duricrust**. The term *caliche* is Spanish and is originally from the Latin *calx*, meaning lime.

Electrical or Specific Conductivity: Measure of the ability of dissolved electrolytes in water to conduct electricity. Measurements are temperature-dependent, which is corrected-for in specific conductance.

Eutrophic: An ecological condition used to describe a lake with a high level of primary productivity, resulting from a high nutrient content. These lakes are subject to excessive algal blooms, resulting in poor water quality.

Hydrograph: A graph of the water level or rate of flow of a body of water as a function of time, showing seasonal changes.

Macrophytes: Rooted vegetation that occurs along shorelines and in shallow littoral (near-shore) areas of any water body.

N:P Ratio: Relative measure of the nitrogen and phosphorus available to algae.

Nutrient loading: Discharging of nutrients from the watershed into a receiving waterbody

Orographic: Of or pertaining to the position and form of mountains.

Piezometric head: A measurement of water pressure inside an aquifer.

Tectonic: Of or relating to the structure of the Earth’s crust and the large-scale processes that take place within it

Total Dissolved Solids (TDS): The dry weight of dissolved substances or residue, such as salts and minerals, in water that remain after evaporating a measured quantity of water to dryness.

Turbidity: A measure of the degree to which light is scattered by suspended particulate material and soluble colored compounds in water. It provides an estimate of the muddiness or cloudiness of the water due to clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, plankton, and microscopic organisms.

Xeriscape: Landscaping and gardening in ways that reduce or eliminate the need for supplemental water from irrigation.

Appendix A
A Chronology of Southern Nevada Water Supply and Las Vegas Wash Conditions

The Las Vegas Wash (Wash) drains the Las Vegas Valley (Valley) by capturing a series of tributaries and conveying their flows to Lake Mead. Before domestic use of Lake Mead water in the Valley, the Wash was a generally barren, sandy channel that contained discharge only during brief periods of major storm runoff. As communities in the Valley grew, increasing amounts of wastewater were discharged to the Wash until the flow became perennial. Return flows to the Wash now include effluent from four municipal wastewater treatment plants, industrial cooling water, pumped groundwater from casino dewatering facilities, stormwater and urban irrigation runoff, as well as natural flows. Aspects of growth and water and wastewater management in the Valley that affect the quantity and quality of flow in the Wash include the following.

- Community development and population growth
- Colorado River water pumped from Lake Mead
- Groundwater pumped from the Valley for municipal and industrial use, as well as for dewatering of casino basement structures
- Wastewater quantities generated in the Valley
- Wastewater treatment received
- Amount of wastewater reused in the Valley
- Wetlands acreage in the Wash
- Channel erosion in the Wash
- Urban runoff from the Valley
- Stormwater runoff from the Valley
- Stormwater management in the Valley

Events and time-related conditions regarding the Wash that may be of interest are listed in the following chronology, based on data from SNWA in 2006, updated thereafter.

Chronology

- 1905: Land and Water Company supplies spring water to local people.
- 1913: 3,000 people reside in Clark County.
- 1920's: Population grew to 5,000.
- 1922: Colorado River Compact signed.
- 1928: Boulder Canyon Project authorized construction of Hoover Dam and allocated 300,000 acre-feet of Colorado River water per year to Nevada.
- 1930's: Great Depression. Hoover Dam put southern Nevada on the map.
- 1935: Hoover Dam completed.
- 1940: Groundwater use approximately 20,000 AFY—water managers grow concerned about limited supplies.
- 1941: Basic Magnesium Inc. (BMI) constructed in Henderson to supply materials for war effort and pipeline from Lake Mead was built for use by the plant. Flow returned via the Wash.
- 1946: City of North Las Vegas incorporated.
- 1947: Las Vegas Valley Water District (LVVWD) was formed and became the first municipal water purveyor for Las Vegas and unincorporated Clark County.
- 1950: Southern Nevada population grew to 40,000. Groundwater use was approximately 35,000 AFY and BMI used 15,000 AFY of Colorado River water.
- 1950's: First delivery of Colorado River water to serve residences and businesses.
- 1953: City of Henderson incorporated. Wastewater treatment plant built and effluent discharged to the Wash.
- 1954: Clark County Sanitation District created.
- 1957: City of Las Vegas wastewater treatment plant built, effluent discharged to the Wash.
- 1960: Population of the Valley reached 120,000.
- 1964: The U.S. Supreme Court decree in *Arizona vs. California* confirmed Nevada's allocation of 300,000 acre-feet of Colorado River water.
- 1967: Southern Nevada Water System construction began.
- 1970: Population of the Valley reached 263,000.
- 1971: First stage of Southern Nevada Water System (SNWS) completed, which would provide maximum of 200 MGD.
- 1971: Plans to expand the SNWS to 400 MGD were anticipated to meet the needs of a forecasted year 2000 population of 585,000.
- 1982: The SNWS system expansion was completed; however, the forecasted 2000 population projection was surpassed by 30 percent. Concerns that the region would reach its limits of Colorado River apportionment sooner than projected were becoming reality.
- 1988: May 4, just before noon. The Pacific Engineering Production Company, or PEPCON, plant exploded in Henderson, NV, liberating about 4,500 tons of ammonium perchlorate stored in barrels onsite into the air and soil surrounding the explosion.

- 1989: Due to the uncertainties created by the profound population growth, the LVVWD filed 148 applications for the available water in the counties of Clark, Lincoln, Nye and White Pine.
- 1990: Population in the Valley reached 750,000 with year 2000 population forecasted at one million residents. A comprehensive analysis of water resources and facilities indicated the need for water conservation.
- 1991: The Southern Nevada Water Authority (SNWA) was created with the following seven water and wastewater agencies:
    - Big Bend Water District
    - Boulder City
    - City of Henderson
    - City of Las Vegas
    - City of North Las Vegas
    - Clark County Water Reclamation District
    - Las Vegas Valley Water District
- 1994: SNWA began an integrated resource planning process to identify programs that would help Southern Nevada meet future water demands.
- 1996: Planning process was begun to expand the treatment capacity of the SNWS to 480 MGD by 1997, 600 MGD by 1999, 750 MGD by 2002, and 900 MGD by 2007.
- 1997: A partnership of Las Vegas Valley wastewater dischargers commissioned the Wastewater Needs Assessment Study to identify alternative methods to accommodate wastewater flows from the Valley.
- 1997: Perchlorate is found in Colorado River water pumped from Lake Havasu by Metropolitan Water District of Southern California (MWD); its source is traced to the Las Vegas Wash, and to the BMI site in Henderson.
- 1998: Increasing flows from unprecedented growth in the Valley created problems with down cutting and bank erosion in the Wash. The Las Vegas Wash Coordination Committee (LVWCC) was created to develop a long-term management plan that would protect and enhance the Wash and surrounding wetlands.
- 1999: A July rainstorm caused a peak flow of 18,000 cubic feet per second in the Wash downstream of Henderson, the highest flow in the Wash for more than 40 years.
- 1999: The wetlands along the Wash had reportedly dwindled to less than 200 acres from 2,000 acres in the early 1970s.
- 1999: The Las Vegas Wash Coordination Committee released a draft comprehensive management plan for the Wash, which called for the construction of erosion control structures and the establishment of off-stream areas.
- 1999: The Kerr McGee Chemical Company began efforts to intercept perchlorate-contaminated groundwater adjacent to the Wash.
- 1999: The Colorado River Basin began to experience drought conditions.
- 2000: Construction of the Pabco Road weir begins; dewatering contributes to spike in perchlorate concentrations in Lake Mead.

- 2001: The Secretary of the Interior signed a Record of Decision (ROD) on the Final Environmental Impact Statement (FEIS) for Colorado River Interim Guidelines for Surplus Conditions, in January.
- 2001: The Kerr McGee Chemical Company completed a slurry wall to prevent perchlorate-contaminated groundwater from leaving its property, and was operating 22 wells to extract contaminated groundwater.
- 2002: At Athens Road, between the Wash and the Kerr McGee property, eight wells began regular operation to extract perchlorate-contaminated groundwater.
- 2002: Recorded as the worst drought year to date.
- 2002: Nevada placed the lower reach of the Wash on its 303(d) list for impairments to aquatic life propagation (excluding fish) due to Total Suspended Solids (TSS).
- 2002: A Notice of Intent to prepare an EIS for the SCOP project was published in the Federal Register, in July. The proposed project involved conveyance of most of the treated wastewater from the Valley into Lake Mead by pipeline for underwater discharge.
- 2002: City of Las Vegas Wastewater Treatment Plant began treating effluent for P removal year-round.
- 2003: SNWA adopted an aggressive drought response plan.
- 2004: Nevada removed the lower reach of the Wash from its 303(d) list because of a decline in TSS concentrations attributable to construction of erosion control structures and restoration of wetlands.
- 2004: Clark County wastewater treatment facilities began optimizing P removal from their effluents.
- 2004: Tronox (formerly Kerr McGee) began utilizing a fluidized bed reactor system to remove perchlorate more efficiently.
- 2005: Clark County wastewater treatment facilities began tertiary addition of alum for even better P removal from their discharges.
- 2005: The Secretary of the Interior initiated a planning process to develop Lower Basin shortage guidelines and management options for the operation of Lakes Powell and Mead.
- 2006: As of June, the Las Vegas Wash Restoration Project had constructed 9 erosion control weirs, stabilized over 21,000 linear feet of stream bank, and restored 33 acres of wetlands.
- 2006: Seven Basin States present a proposal to the Secretary regarding interim operations to minimize shortages, along with a package of other actions to improve water availability in the Colorado River Basin.
- 2007: Reclamation and the National Park Service each issued a ROD on the FEIS for the proposed SCOP project, in July.
- 2007: SNWA, Arizona Department of Water Resources, and the Colorado River Commission agreed to share the annual shortages within the Lower Basin up to a total volume of 500,000 AFY in the U.S., based on water surface elevation of Lake Mead.

- 2007: The Secretary of the Interior signed a ROD on the FEIS for Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operation for Lake Powell and Lake Mead (Shortage Guidelines), in December. In general, the Shortage Guidelines provide that water allocations to Nevada and Arizona will be reduced in years when Lake Mead's content is projected to be at or below elevation 1075 feet on January 1.
- 2008: A nationwide mortgage crisis left Las Vegas ranking in the top tier of cities with the greatest number of housing foreclosures. An estimated 10,396 residents left the Valley between July 1, 2007 and July 1, 2008.
- 2008: The average flow in the Wash fell to the lowest level since 2004, dropping approximately 10 cfs below the 2007 average rate.
- 2009: Average flow in the Wash remained at the 2008 rate, estimated at 285 cfs at the USGS gage at LW0.55, immediately downstream from the Northshore Road bridge. This is approximately 184 million gallons of discharge per day.
- 2009: The estimated TDS load carried by the Wash fell to the lowest level since 2002.
- 2009: The Clean Water Coalition put their Systems Conveyance and Operations Program (SCOP) on hold. Two-thirds of the $880 million funding was to come from new hookups, but new residential and commercial development nearly came to a halt, due to the economic downturn of the last two years.
- 2011: In June, the City of North Las Vegas began discharging approximately 17 MGD (approximately 26 cfs, 0.74 cms) of treated wastewater to the Wash through the Sloan channel. They did not receive express permission to do so from Clark County, which owns and operates the Sloan channel for flood control. The effect this discharge will have on the quality of water in the Wash depends on the degree of treatment the effluent receives at the plant. The City's webpage states that "The Water Reclamation Facility (WRF) is a state-of-the-art facility using submerged membrane bioreactor technology to produce extremely clear reclaimable water. When placed on line, the WRF was the largest plant of its kind in North America and one of the largest in the world. Advanced nutrient removal is used for the removal of phosphorous and nitrogen before discharging the highly treated wastewater to the Sloan Channel. For the phosphorus removal the WRF will use either enhanced biological phosphorus removal or chemical phosphorus precipitation. A modified Ludzack-Ettinger process for pre-denitrification is used for nitrogen removal. The end result of this treatment process is a facility that discharges reclaimed water with parameters at or below the laboratory detection limits for most constituents of concern." For more information, see the CNLV webpage: (http://www.cityofnorthlasvegas.com/Departments/Utilities/WRF.shtm)
- 2011: The Clean Water Coalition was disbanded as of June 30, putting an end to the System Conveyance Operations Program (SCOP).
- 2011: At the end of the year, the City of North Las Vegas and Clark County remain engaged in a lawsuit over the right to discharge treated effluent into the Sloan Channel.
- 2012: In October, unemployment in the Las Vegas Valley fell to its lowest level in three years, to 11.1 percent in the Valley, down from 13.6 percent in 2011.

- 2012: In November, Clark County and the City of North Las Vegas settled their lawsuit. Under terms of the agreement, North Las Vegas will transfer $8 million to the county to design and build a pipeline that follows the path of the Sloan Channel. The county will spend another $7 million, bringing the total cost to $15 million. The city will repay the county the $7 million with a portion of its quarter-cent sales tax distributed by the Southern Nevada Water Authority over the next 10 years.

Appendix B
2012 Las Vegas Wash Data

This appendix contains tables displaying the 2012 quarterly Las Vegas Wash laboratory and field data. These data were used to report the water quality and overall condition in the Las Vegas Wash.

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Table B-1. 2012 Quarterly Las Vegas Wash field measurements and laboratory TDS by ROE.

Site Code and Description	Sample Date	Temperature, °C	Specific Conductivity, µS/cm	pH	Dissolved Oxygen, mg/L	Total Dissolved Solids, mg/L (ROE)
LW11.5 Mainstream Wash Above Sloan Channel Confluence	3/14/2012	12.7	3706	8.07	9.41	3244
	6/12/2012	19.0	3725	8.17	8.70	3206
	9/11/2012	23.6	3044	8.24	7.94	2598
	12/11/2012	7.25	3416	8.33	11.1	3056
	Average	15.6	3473	8.20	9.30	3026
	stdev	7.15	319.2		1.37	296.7
	Minimum	7.25	3044	8.07	7.94	2598
	Maximum	23.6	3725	8.33	11.1	3244
LW11.1 Mainstream Wash Below Vegas Valley Drive	3/14/2012	14.1	1966	8.02	9.20	1768
	6/12/2012	21.6	1798	8.63	14.0	1192
	9/11/2012	25.5	1782	9.01	17.9	1596
	12/11/2012	10.3	1838	8.72	12.5	1345
	Average	17.9	1846	8.68	13.4	1475
	stdev	6.92	83.5		3.60	256.6
	Minimum	10.3	1782	8.02	9.20	1192
	Maximum	25.5	1966	9.01	17.9	1768
LWC10.6 City of Las Vegas WWTP Effluent Discharge Channel	3/14/2012	21.3	1700	7.15	7.53	1103
	6/12/2012	27.4	1509	7.01	6.24	973.0
	9/11/2012	30.1	1447	7.14	6.21	949.0
	12/11/2012	23.2	1636	6.99	7.23	1100
	Average	25.5	1573	7.08	6.80	1031
	stdev	4.01	115.6		0.68	81.72
	Minimum	21.3	1447	6.99	6.21	949.0
	Maximum	30.1	1700	7.15	7.53	1103
LW9.3 Mainstream Wash Above Clark County Discharges	3/14/2012	18.9	2063	7.51	7.96	1418
	6/12/2012	25.0	1981	7.55	6.50	1368
	9/11/2012	30.0	1735	7.52	6.82	1170
	12/11/2012	20.6	1882	7.36	8.29	1340
	Average	23.6	1915	7.52	7.39	1324
	stdev	4.95	141.2		0.87	107.6
	Minimum	18.9	1735	7.36	6.50	1170
	Maximum	30.0	2063	7.55	8.29	1418
LWC9.0 Clark County Advanced Water Treatment Plant Discharge Channel	3/14/2012	23.0	1754	7.18	6.91	1139
	6/12/2012	28.0	1624	7.19	6.04	1045
	9/11/2012	30.7	1612	7.17	6.36	1062
	12/11/2012	24.2	1651	7.09	6.91	1121
	Average	26.5	1660	7.18	6.56	1092
	stdev	3.54	64.3		0.43	45.31
	Minimum	23.0	1612	7.09	6.04	1045
	Maximum	30.7	1754	7.19	6.91	1139

*because pH is a log function, the median of pH values is used instead of the average

Table B-1, continued. 2012 Quarterly Las Vegas Wash field measurements and laboratory TDS by ROE.

Site Code and Description	Sample Date	Temperature, °C	Specific Conductivity, µS/cm	pH	Dissolved Oxygen, mg/L	Total Dissolved Solids, mg/L (ROE)
LWC9.0_1 Clark County Central Plant Discharge Channel	3/14/2012	23.6	1739	7.08	6.71	1130
	6/12/2012	28.4	1612	7.17	6.22	1041
	9/11/2012	30.6	1621	7.14	6.11	1065
	12/11/2012	24.9	1650	6.99	6.89	1112
	Average	26.9	1655	7.11	6.48	1087
	stdev	3.23	57.8		0.38	41.13
	Minimum	23.6	1612	6.99	6.11	1041
	Maximum	30.6	1739	7.17	6.89	1130
LW8.85 Mainstream Wash at USGS Gage Below County Discharge Confluence	3/14/2012	21.5	1859	7.31	7.24	1243
	6/12/2012	27.0	1716	7.35	6.43	1127
	9/11/2012	29.7	1724	7.34	6.46	1167
	12/11/2012	22.6	1759	7.24	7.46	1207
	Average	25.2	1765	7.33	6.90	1186
	stdev	3.81	65.8		0.53	50.11
	Minimum	21.5	1716	7.24	6.43	1127
	Maximum	29.7	1859	7.35	7.46	1243
LWC Well PC-97 Groundwater Monitoring Well Near Pabco Road	3/15/2012	20.3	3419	7.25	0.82	2470
	6/12/2012	24.0	3694	7.23	4.62	2654
	9/12/2012	22.8	3716	7.03	0.13	2356
	12/11/2012	20.5	3950	7.29	3.35	2900
	Average	21.9	3695	7.24	2.23	2595
	stdev	1.78	217.3		2.11	237.5
	Minimum	20.3	3419	7.03	0.13	2356
	Maximum	24.0	3950	7.29	4.62	2900
LWC6.1_2 Pittman Bypass Discharge (formerly Alpha Ditch)	3/14/2012	20.0	2582	8.48	8.77	1686
	6/12/2012	27.9	1696	7.48	7.16	1163
	9/12/2012	30.3	2671	8.21	6.85	1590
	12/11/2012	20.7	974	8.21	8.40	662.0
	Average	24.7	1981	8.21	7.80	1275
	stdev	5.15	802.3		0.93	467.8
	Minimum	20.0	974	7.48	6.85	662.0
	Maximum	30.3	2671	8.48	8.77	1686
LWC6.1_1 City of Henderson WWTP Effluent Discharge Channel	3/14/2012	22.6	1718	7.30	7.66	1107
	6/12/2012	27.9	1698	7.50	7.11	1083
	9/12/2012	30.0	1792	7.19	6.90	1162
	12/11/2012	23.7	1783	7.22	7.85	1172
	Average	26.0	1748	7.26	7.38	1131
	stdev	3.50	46.8		0.45	42.90
	Minimum	22.6	1698	7.19	6.90	1083
	Maximum	30.0	1792	7.50	7.85	1172

*because pH is a log function, the median of pH values is used instead of the average

Table B-1, continued. 2012 Quarterly Las Vegas Wash field measurements and laboratory TDS by ROE.

Site Code and Description	Sample Date	Temperature, °C	Specific Conductivity, µS/cm	pH	Dissolved Oxygen, mg/L	Total Dissolved Solids, mg/L (ROE)
LW6.05 Mainstream Wash at Pabco Road Erosion Control Weir	3/14/2012	21.9	2111	8.50	9.41	1442
	6/12/2012	28.7	1937	8.43	8.16	1313
	9/11/2012	29.6	1962	8.11	7.34	1363
	12/11/2012	21.2	2026	8.15	8.97	1446
	Average	25.4	2009	8.29	8.47	1391
	stdev	4.42	77.5		0.91	64.53
	Minimum	21.2	1937	8.11	7.34	1313
	Maximum	29.6	2111	8.50	9.41	1446
LW5.5 Mainstream Wash Upstream from Historic Lateral Crossing	3/14/2012	22.0	2146	8.46	10.09	1452
	6/12/2012	28.9	1980	8.47	9.05	1327
	9/11/2012	29.5	2019	8.05	7.22	1420
	12/11/2012	21.8	1990	7.96	8.43	1402
	Average	25.5	2034	8.26	8.70	1400
	stdev	4.21	76.4		1.20	53.03
	Minimum	21.8	1980	7.96	7.22	1327
	Maximum	29.5	2146	8.47	10.1	1452
LW3.4 Mainstream Wash Below Rainbow Gardens Weir	3/14/2012	21.1	2280	8.52	9.00	1556
	6/12/2012	28.5	2145	8.77	8.02	1432
	9/11/2012	28.0	2144	8.28	7.41	1518
	12/11/2012	19.4	2173	8.20	8.68	1564
	Average	24.2	2186	8.40	8.28	1518
	stdev	4.66	64.4		0.71	60.43
	Minimum	19.4	2144	8.20	7.41	1432
	Maximum	28.5	2280	8.77	9.00	1564
LW0.9 Mainstream Wash Below Lake Las Vegas Dam	3/14/2012	21.3	2303	8.59	8.78	1568
	6/12/2012	28.7	2153	8.81	7.67	1454
	9/11/2012	26.0	2311	8.21	7.85	1626
	12/11/2012	19.4	2198	8.26	9.02	1562
	Average	23.8	2241	8.43	8.33	1553
	stdev	4.28	78.0		0.67	71.73
	Minimum	19.4	2153	8.21	7.67	1454
	Maximum	28.7	2311	8.81	9.02	1626
LWC0.9 Seep in Spring Box about 3 m North of LW0.9	3/14/2012	16.1	3312	7.49	1.11	2724
	6/12/2012	16.7	3368	7.54	1.13	2754
	9/11/2012	16.8	3377	7.46	0.13	2846
	12/11/2012	16.4	3540	7.37	0.09	2984
	Average	16.5	3399	7.48	0.62	2827
	stdev	0.31	98.2		0.58	116.8
	Minimum	16.1	3312	7.37	0.09	2724
	Maximum	16.8	3540	7.54	1.13	2984

*because pH is a log function, the median of pH values is used instead of the average

Table B-2. 2012 Quarterly Las Vegas Wash nutrient results, with average, maximum, and minimum values.

Station Code and Description	Sample Date	Laboratory Name	NH_3 as N, mg/L	NO_3/NO_2 as N, mg/L	Ortho-PO_4 as P, mg/L	Total-PO_4 as P, mg/L
LW11.5 Mainstream Wash Above Sloan Channel Confluence	3/14/2012	SFL	0.011	3.80	0.0046	0.014
	6/12/2012	SFL	0.073	3.10	0.0080	0.019
	9/11/2012	SFL	0.046	3.50	0.0047	0.026
	12/11/2012	SFL	0.007	4.80	0.0054	0.012
		Average	0.034	3.80	0.0057	0.018
		stdev	0.031	0.73	0.0016	0.006
		Minimum	0.007	3.10	0.0046	0.012
		Maximum	0.073	4.80	0.0080	0.026
LW11.1 Mainstream Wash Below Vegas Valley Drive	3/14/2012	SFL	< 0.005	2.90	0.0024	0.021
	6/12/2012	SFL	0.008	2.30	0.0068	0.036
	9/11/2012	SFL	0.023	2.10	0.0247	0.068
	12/11/2012	SFL	< 0.005	3.70	0.0069	0.033
		Average	0.016	2.75	0.0102	0.040
		stdev	0.011	0.72	0.0099	0.020
		Minimum	0.008	2.10	0.0024	0.021
		Maximum	0.023	3.70	0.0247	0.068
LWC10.6 City of Las Vegas WWTP Effluent Discharge Channel	3/14/2012	SFL	0.579	20.0	0.1400	0.270
	6/12/2012	SFL	0.036	22.0	0.1970	0.300
	9/11/2012	SFL	0.017	20.0	0.2720	0.290
	12/11/2012	SFL	0.015	19.0	0.0865	0.140
		Average	0.162	20.3	0.1739	0.250
		stdev	0.278	1.26	0.0795	0.074
		Minimum	0.015	19.0	0.0865	0.140
		Maximum	0.579	22.0	0.2720	0.300
LW9.3 Mainstream Wash Above Clark County Discharges	3/14/2012	SFL	0.454	13.0	0.0959	0.180
	6/12/2012	SFL	0.110	13.0	0.1180	0.160
	9/11/2012	SFL	0.089	14.0	0.2060	0.270
	12/11/2012	SFL	0.017	15.0	0.0699	0.110
		Average	0.168	13.8	0.1225	0.180
		stdev	0.195	0.96	0.0591	0.067
		Minimum	0.017	13.0	0.0699	0.110
		Maximum	0.454	15.0	0.2060	0.270
LWC9.0 Clark County Advanced Water Treatment Plant Discharge Channel	3/14/2012	SFL	0.019	16.0	0.0148	0.043
	6/12/2012	SFL	0.039	14.0	0.0250	0.050
	9/11/2012	SFL	0.012	12.0	0.0229	0.049
	12/11/2012	SFL	0.007	12.0	0.0216	0.055
		Average	0.019	13.5	0.0211	0.049
		stdev	0.014	1.91	0.0044	0.005
		Minimum	0.007	12.0	0.0148	0.043
		Maximum	0.039	16.0	0.0250	0.055

Table B-2, continued. 2012 Quarterly Las Vegas Wash nutrient results, with average, maximum, and minimum values.

Station Code and Description	Sample Date	Laboratory Name	NH_3 as N, mg/L	NO_3 as N, mg/L	Ortho-PO_4 as P, mg/L	Total-PO_4 as P, mg/L
LWC9.0_1 Clark County Central Plant Discharge Channel	3/14/2012	SFL	< 0.005	15.0	0.0113	0.046
	6/12/2012	SFL	0.033	12.0	0.0149	0.048
	9/11/2012	SFL	0.010	11.0	0.0265	0.066
	12/11/2012	SFL	0.009	11.0	0.0132	0.048
		Average	0.017	12.3	0.0165	0.052
		stdev	0.014	1.89	0.0068	0.009
		Minimum	0.009	11.0	0.0113	0.046
		Maximum	0.033	15.0	0.0265	0.066
LW8.85 Mainstream Wash at USGS Gage Below County Discharge Confluence	3/14/2012	SFL	0.190	15.0	0.0420	0.086
	6/12/2012	SFL	0.063	14.0	0.0545	0.092
	9/11/2012	SFL	0.046	12.0	0.0665	0.130
	12/11/2012	SFL	0.014	13.0	0.0317	0.071
		Average	0.078	13.5	0.0487	0.095
		stdev	0.077	1.29	0.0151	0.025
		Minimum	0.014	12.0	0.0317	0.071
		Maximum	0.190	15.0	0.0665	0.130
LWC Well PC-97 Groundwater Monitoring Well Near Pabco Road	3/15/2012	SFL	0.200	0.10	0.0422	0.052
	6/12/2012	SFL	0.110	0.56	0.0275	0.058
	9/12/2012	SFL	0.030	< 0.05	0.0097	0.034
	12/11/2012	SFL	0.038	1.70	0.0475	0.070
		Average	0.095	0.79	0.0317	0.054
		stdev	0.079	0.83	0.0170	0.015
		Minimum	0.030	0.10	0.0097	0.034
		Maximum	0.200	1.70	0.0475	0.070
LWC6.1_2 Pttman Bypass Discharge (formerly Alpha Ditch)	3/14/2012	SFL	< 0.005	0.55	0.0130	0.036
	6/12/2012	SFL	< 0.005	0.49	0.0250	0.034
	9/12/2012	SFL	0.022	1.10	0.0224	0.033
	12/11/2012	SFL	< 0.005	1.70	0.0068	0.012
		Average	0.022	0.96	0.0168	0.0288
		stdev	#DIV/0!	0.56	0.0084	0.0112
		Minimum	0.022	0.49	0.0068	0.0120
		Maximum	0.022	1.70	0.0250	0.0360
LWC6.1_1 City of Henderson WWTP Effluent Discharge Channel	3/14/2012	SFL	13.000	13.0	0.0141	0.049
	6/12/2012	SFL	0.008	14.0	0.0957	0.160
	9/12/2012	SFL	0.010	16.0	0.0343	0.100
	12/11/2012	SFL	0.012	12.0	0.0432	0.130
		Average	3.258	13.8	0.0468	0.110
		stdev	6.495	1.71	0.0348	0.047
		Minimum	0.008	12.0	0.0141	0.049
		Maximum	13.000	16.0	0.0957	0.160

Table B-2, continued. 2012 Quarterly Las Vegas Wash nutrient results, with average, maximum, and minimum values.

Station Code and Description	Sample Date	Laboratory Name	NH_3 as N, mg/L	NO_3 as N, mg/L	Ortho-PO_4 as P, mg/L	Total-PO_4 as P, mg/L
LW6.05 Mainstream Wash at Pabco Road Erosion Control Weir	3/14/2012	SFL	0.047	13.0	0.0385	0.093
	6/12/2012	SFL	0.019	13.0	0.0511	0.100
	9/11/2012	SFL	0.037	12.0	0.0785	0.370
	12/11/2012	SFL	0.010	13.0	0.0353	0.076
		Average	0.028	12.8	0.0509	0.160
		stdev	0.017	0.50	0.0197	0.141
		Minimum	0.010	12.0	0.0353	0.076
		Maximum	0.047	13.0	0.0785	0.370
LW5.5 Mainstream Wash Upstream of Historic Lateral Crossing Site	3/14/2012	SFL	0.041	13.0	0.0366	0.088
	6/12/2012	SFL	0.014	13.0	0.0517	0.100
	9/11/2012	SFL	0.041	12.0	0.0758	0.310
	12/11/2012	SFL	0.010	12.0	0.0391	0.086
		Average	0.026	12.5	0.0508	0.146
		stdev	0.017	0.58	0.0179	0.110
		Minimum	0.010	12.0	0.0366	0.086
		Maximum	0.041	13.0	0.0758	0.310
LW3.4 Mainstream Wash Below Rainbow Gardens Weir	3/14/2012	SFL	0.007	13.0	0.0297	0.070
	6/12/2012	SFL	0.007	12.0	0.0472	0.084
	9/11/2012	SFL	0.019	12.0	0.0735	0.180
	12/11/2012	SFL	0.010	12.0	0.0437	0.085
		Average	0.011	12.3	0.0485	0.105
		stdev	0.006	0.50	0.0183	0.051
		Minimum	0.007	12.0	0.0297	0.070
		Maximum	0.019	13.0	0.0735	0.180
LW0.9 Mainstream Wash Below Lake Las Vegas Dam	3/14/2012	SFL	< 0.005	13.0	0.0295	0.072
	6/12/2012	SFL	0.007	12.0	0.0455	0.085
	9/11/2012	SFL	0.360	9.60	0.0774	0.150
	12/11/2012	SFL	0.010	12.0	0.0475	0.084
		Average	0.125	11.7	0.0500	0.098
		stdev	0.203	1.45	0.0200	0.035
		Minimum	0.007	9.60	0.0295	0.072
		Maximum	0.360	13.0	0.0774	0.150
LWC0.9 Seep in Spring Box about 3 m North of LW0.9	3/14/2012	SFL	0.049	0.16	0.0191	0.038
	6/12/2012	SFL	0.051	0.17	0.0184	0.020
	9/11/2012	SFL	0.057	0.25	0.0125	0.014
	12/11/2012	SFL	< 0.034	0.22	0.0132	0.012
		Average	0.048	0.20	0.0158	0.021
		stdev	0.010	0.04	0.0034	0.012
		Minimum	0.034	0.16	0.0125	0.012
		Maximum	0.057	0.25	0.0191	0.038

Table B-3. 2012 Quarterly Las Vegas Wash cation and anion results, with average, maximum, and minimum values.

Station Code and Description	Sample Date	Laboratory Name	Na, mg/L	K, mg/L	Ca, mg/L	Mg, mg/L	Alkalinity as $CaCO_3$, mg/L	Cl, mg/L	SO_4, mg/L	SiO_2, mg/L	F, mg/L
LW11.5 Mainstream Wash Above Sloan Channel Confluence	3/14/2012	LCRL	273	35.2	288	223	213	284	1660	30	0.39
	6/12/2012	LCRL	267	37.8	291	210	214	296	1680	27	0.46
	9/11/2012	LCRL	211	25.3	302	183	192	280	1240	35	0.50
	12/11/2012	LCRL	257	29.0	295	210	217	267	1540	34	0.46
		Average	252	31.8	294	207	209	282	1530	32	0.45
		stdev	28.1	5.71	6.14	16.8	11.2	12.0	203.0	3.7	0.05
		Minimum	211	25.3	288	183	192	267	1240	27	0.39
		Maximum	273	37.8	302	223	217	296	1680	35	0.50
LW11.1 Mainstream Wash Below Vegas Valley Drive	3/14/2012	LCRL	236	22.0	146	106	186	255	742	21	0.88
	6/12/2012	LCRL	209	16.6	85.1	52.6	166	251	392	20	0.96
	9/11/2012	LCRL	219	19.0	141	89.7	164	246	666	22	0.89
	12/11/2012	LCRL	232	18.7	110	76.4	161	221	486	23	0.89
		Average	224	19.1	121	81.2	169	243	572	22	0.91
		stdev	12.4	2.22	28.5	22.6	11.2	15.3	161	1.3	0.04
		Minimum	209	16.6	85.1	52.6	161	221	392	20	0.88
		Maximum	236	22.0	146	106	186	255	742	23	0.96
LWC10.6 City of Las Vegas WWTP Effluent Discharge Channel	3/14/2012	LCRL	197	18.7	87.2	36.3	109	224	304	12	0.61
	6/12/2012	LCRL	157	18.0	78.1	40.1	110	190	284	14	0.44
	9/11/2012	LCRL	140	16.1	74.4	41.2	123	184	259	16	0.49
	12/11/2012	LCRL	84.6	49.2	97.5	59.7	107	221	313	12	0.70
		Average	145	25.5	84.3	44.3	112	205	290	14	0.56
		stdev	46.6	15.8	10.3	10.5	7.14	20.7	24.0	1.9	0.12
		Minimum	84.6	16.1	74.4	36.3	107	184	259	12	0.44
		Maximum	197	49.2	97.5	59.7	123	224	313	16	0.70
LW9.3 Mainstream Wash Above Clark County Discharges	3/14/2012	LCRL	216	20.3	119	65.2	138	249	540	17	0.73
	6/12/2012	LCRL	187	20.4	112	69.2	142	224	537	19	0.60
	9/11/2012	LCRL	166	18.0	104	56.9	136	201	398	18	0.64
	12/11/2012	LCRL	202	18.3	103	59.3	126	225	464	17	0.74
		Average	193	19.2	109	62.6	135	225	485	18	0.68
		stdev	21.4	1.27	7.46	5.59	7.03	19.6	67.7	1.0	0.07
		Minimum	166	18.0	103	56.9	126	201	398	17	0.60
		Maximum	216	20.4	119	69.2	142	249	540	19	0.74

Table B-3, continued. 2012 Quarterly Las Vegas Wash cation and anion results, with average, maximum, and minimum values.

Station Code and Description	Sample Date	Laboratory Name	Na, mg/L	K, mg/L	Ca, mg/L	Mg, mg/L	Alkalinity as $CaCO_3$, mg/L	Cl, mg/L	SO_4, mg/L	SiO_2, mg/L	F, mg/L
LWC9.0 Clark County Advanced Water Treatment Plant Discharge Channel	3/14/2012	LCRL	189	18.1	103	37.7	115	230	330	12	0.62
	6/12/2012	LCRL	171	17.8	95	36.4	126	212	313	12	0.64
	9/11/2012	LCRL	170	17.9	103	38.9	141	211	328	14	0.74
	12/11/2012	LCRL	192	17.8	103	41.1	123	225	339	13	0.73
		Average	181	17.9	101	38.5	126	220	328	13	0.68
		stdev	11.6	0.14	4.00	1.98	11.0	9.47	10.8	1.0	0.06
		Minimum	170	17.8	95.0	36.4	115	211	313	12	0.62
		Maximum	192	18.1	103	41.1	141	230	339	14	0.74
LWC9.0_1 Clark County Central Plant Discharge Channel	3/14/2012	LCRL	188	18.2	101	37.3	113	226	328	12	0.62
	6/12/2012	LCRL	167	17.9	94.2	36.6	126	214	319	12	0.67
	9/11/2012	LCRL	174	17.9	103	39.1	135	213	333	14	0.72
	12/11/2012	LCRL	182	17.1	97.1	39.5	122	223	340	13	0.71
		Average	178	17.8	98.8	38.1	124	219	330	13	0.68
		stdev	9.2	0.46	3.92	1.38	9.14	6.48	8.83	1.0	0.05
		Minimum	167	17.1	94.2	36.6	113	213	319	12	0.62
		Maximum	188	18.2	103	39.5	135	226	340	14	0.72
LW8.85 Mainstream Wash at USGS Gage Below County Discharge Confluence	3/14/2012	LCRL	201	18.8	107	46.4	124	232	388	14	0.67
	6/12/2012	LCRL	177	18.5	98.8	45.7	126	217	370	14	0.62
	9/11/2012	LCRL	179	18.3	111	49.8	144	214	395	16	0.75
	12/11/2012	LCRL	197	18.1	108	50.1	124	227	395	15	0.74
		Average	189	18.4	106	48.0	129	223	387	15	0.70
		stdev	12.3	0.28	5.20	2.28	9.50	8.43	11.8	1.0	0.06
		Minimum	177	18.1	98.8	45.7	124	214	370	14	0.62
		Maximum	201	18.8	111	50.1	144	232	395	16	0.75
LWC Well PC-97 Groundwater Monitoring Well Near Pabco Road	3/15/2012	LCRL	423	19.5	200	70.8	208	540	833	37	1.07
	6/12/2012	LCRL	500	21.2	228	83.1	206	602	969	74	1.34
	9/12/2012	LCRL	408	18.9	212	76.0	189	512	816	66	1.00
	12/11/2012	LCRL	494	21.2	250	98.2	192	630	1040	75	1.27
		Average	456	20.2	222	82.0	199	571	915	63	1.17
		stdev	47.5	1.16	21.6	11.9	9.57	54.4	108	18	0.16
		Minimum	408	18.9	200	70.8	189	512	816	37	1.00
		Maximum	500	21.2	250	98.2	208	630	1040	75	1.34

Table B-3, continued. 2012 Quarterly Las Vegas Wash cation and anion results, with average, maximum, and minimum values.

Station Code and Description	Sample Date	Laboratory Name	Na, mg/L	K, mg/L	Ca, mg/L	Mg, mg/L	Alkalinity as $CaCO_3$, mg/L	Cl, mg/L	SO_4, mg/L	SiO_2, mg/L	F, mg/L
LWC6.1_2 Pttman Bypass Discharge (formerly Alpha Ditch)	3/14/2012	LCRL	404	6.57	69.3	21.2	142	521	237	7.1	0.29
	6/12/2012	LCRL	279	6.08	69.6	24.6	142	369	250	7.4	0.33
	9/12/2012	LCRL	472	8.44	67.9	21.6	157	628	264	8.5	0.44
	12/11/2012	LCRL	93.7	5.46	76.8	27.4	124	90.4	229	7.9	0.32
		Average	312	6.64	70.9	23.7	141	402	245	7.7	0.34
		stdev	166	1.28	4.00	2.89	13.6	233	15.3	0.6	0.07
		Minimum	93.7	5.46	67.9	21.2	124	90.4	229	7.1	0.29
		Maximum	472	8.44	76.8	27.4	157	628	264	8.5	0.44
LWC6.1_1 City of Henderson WWTP Effluent Discharge Channel	3/14/2012	LCRL	199	18.4	96	29.0	117	252	308	10	0.57
	6/12/2012	LCRL	198	18.6	91.0	29.9	126	245	302	10	0.84
	9/12/2012	LCRL	218	19.0	100	31.2	104	277	331	12	0.72
	12/11/2012	LCRL	236	20.1	97.5	34.5	118	274	328	10	0.64
		Average	213	19.0	96.1	31.1	116	262	317	10	0.69
		stdev	18.0	0.75	3.78	2.42	9.25	15.9	14.4	1.0	0.12
		Minimum	198	18.4	91.0	29.0	104	245	302	10	0.57
		Maximum	236	20.1	100	34.5	126	277	331	12	0.84
LW6.05 Mainstream Wash at Pabco Road Erosion Control Weir	3/14/2012	LCRL	226	20.8	131	59.3	126	271	529	16	0.72
	6/12/2012	LCRL	190	20.4	120	56.7	134	241	466	16	0.63
	9/11/2012	LCRL	197	20.6	133	61.3	144	241	496	18	0.78
	12/11/2012	LCRL	228	20.9	136	67.5	130	256	521	18	0.79
		Average	210	20.7	130	61.2	134	252	503	17	0.73
		stdev	19.5	0.22	7.20	4.59	7.83	14.4	28.4	1.2	0.07
		Minimum	190	20.4	120	56.7	126	241	466	16	0.63
		Maximum	228	20.9	136	67.5	144	271	529	18	0.79
LW5.5 Mainstream Wash Upstream of Historic Lateral Crossing Site	3/14/2012	LCRL	222	20.2	127	56.2	133	286	509	14	0.70
	6/12/2012	LCRL	202	20.0	118	55.2	134	259	463	16	0.71
	9/11/2012	LCRL	203	20.2	132	59.4	146	261	484	20	0.79
	12/11/2012	LCRL	231	20.2	129	61.9	127	261	489	17	0.76
		Average	215	20.1	126	58.2	135	267	486	17	0.74
		stdev	14.3	0.11	6.24	3.05	7.89	12.9	18.9	2.5	0.04
		Minimum	202	20.0	118	55.2	127	259	463	14	0.70
		Maximum	231	20.2	132	61.9	146	286	509	20	0.79

Table B-3, continued. 2012 Quarterly Las Vegas Wash cation and anion results, with average, maximum, and minimum values.

Station Code and Description	Sample Date	Laboratory Name	Na, mg/L	K, mg/L	Ca, mg/L	Mg, mg/L	Alkalinity as $CaCO_3$, mg/L	Cl, mg/L	SO_4, mg/L	SiO_2, mg/L	F, mg/L
LW3.4 Mainstream Wash Below Rainbow Gardens Weir	3/14/2012	LCRL	238	21.2	137	59.3	133	312	553	14	0.71
	6/12/2012	LCRL	218	21.3	127	58.2	134	291	533	14	0.72
	9/11/2012	LCRL	228	22.0	140	62.5	141	300	546	22	0.81
	12/11/2012	LCRL	257	22.0	149	70.6	138	292	557	19	0.81
		Average	235	21.6	138	62.7	137	299	547	17	0.76
		stdev	16.6	0.41	9.26	5.62	3.89	9.7	10.5	3.9	0.06
		Minimum	218	21.2	127	58.2	133	291	533	14	0.71
		Maximum	257	22.0	149	70.6	141	312	557	22	0.81
LW0.9 Mainstream Wash Below Lake Las Vegas Dam	3/14/2012	LCRL	244	23.4	139	60.0	132	318	562	14	0.77
	6/12/2012	LCRL	219	21.9	129	59.3	133	291	543	14	0.63
	9/11/2012	LCRL	252	22.8	156	64.5	142	320	610	24	0.77
	12/11/2012	LCRL	255	22.1	150	71.2	140	291	559	19	0.80
		Average	243	22.5	143	63.8	137	305	569	18	0.74
		stdev	16.3	0.69	12.1	5.49	5.03	16.1	28.9	4.8	0.08
		Minimum	219	21.9	129	59.3	132	291	543	14	0.63
		Maximum	255	23.4	156	71.2	142	320	610	24	0.80
LWC0.9 Seep in Spring Box about 3 m North of LW0.9	3/14/2012	LCRL	249	26.0	410	79.6	124	371	1320	28	0.85
	6/12/2012	LCRL	260	27.5	409	79.8	134	371	1400	36	0.91
	9/11/2012	LCRL	271	29.7	442	85.8	128	393	1340	47	1.04
	12/11/2012	LCRL	295	30.2	458	104	134	383	1450	37	1.00
		Average	269	28.4	430	87.3	130	380	1378	37	0.95
		stdev	19.7	1.97	24.4	11.5	5.07	11	59.1	7.8	0.09
		Minimum	249	26.0	409	79.6	124	371	1320	28	0.85
		Maximum	295	30.2	458	104	134	393	1450	47	1.04

Table B-4. 2012 Quarterly Las Vegas Wash total suspended solids, selenium and perchlorate results, with average, maximum, and minimum values.

Station Code and Description	Sample Date	Laboratory Name	Total Se, µg/L	ClO_4^-, µg/L	TSS, mg/L
LW11.5 Mainstream Wash Above Sloan Channel Confluence	3/14/2012	SFL	15	7.20	2.0
	6/12/2012	SFL	15	7.60	3.0
	9/11/2012	SFL	9.7	8.00	11
	12/11/2012	SFL	13	9.10	2.8
		Average	13	7.98	4.7
		stdev	2.5	0.82	4.2
		Minimum	10	7.20	2.0
		Maximum	15	9.10	11
LW11.1 Mainstream Wash Below Vegas Valley Drive	3/14/2012	SFL	2.2	1.10	< 1.0
	6/12/2012	SFL	3.1	1.50	2.6
	9/11/2012	SFL	3.1	2.20	3.6
	12/11/2012	SFL	3.7	2.40	2.4
		Average	3.0	1.80	2.9
		stdev	0.6	0.61	0.6
		Minimum	2.2	1.10	2.4
		Maximum	3.7	2.40	3.6
LWC10.6 City of Las Vegas WWTP Effluent Discharge Channel	3/14/2012	SFL	1.6		8.8
	6/12/2012	SFL	1.9		< 1.0
	9/11/2012	SFL	1.3		< 1.0
	12/11/2012	SFL	1.6		1.0
		Average	1.6		4.9
		stdev	0.2		5.5
		Minimum	1.3		1.0
		Maximum	1.9		8.8
LW9.3 Mainstream Wash Above Clark County Discharges	3/14/2012	SFL	3.3		1.8
	6/12/2012	SFL	4.0		8.0
	9/11/2012	SFL	2.6		29
	12/11/2012	SFL	2.8		7.4
		Average	3.2		12
		stdev	0.6		12
		Minimum	2.6		1.8
		Maximum	4.0		29
LWC9.0 Clark County Advanced Water Treatment Plant Discharge Channel	3/14/2012	SFL	1.4		< 1.0
	6/12/2012	SFL	1.5		< 1.0
	9/11/2012	SFL	1.1		< 1.0
	12/11/2012	SFL	1.2		< 1.0
		Average	1.3		#DIV/0!
		stdev	0.2		#DIV/0!
		Minimum	1.1		< 1.0
		Maximum	1.5		< 1.0

Table B-4, continued. 2012 Quarterly Las Vegas Wash total suspended solids, selenium and perchlorate results, with average, maximum, and minimum values.

Station Code and Description	Sample Date	Laboratory Name	Total Se, µg/L	ClO_4^-, µg/L	TSS, mg/L
LWC9.0_1 Clark County Central Plant Discharge Channel	3/14/2012	SFL	1.6		< 1.0
	6/12/2012	SFL	1.7		< 1.0
	9/11/2012	SFL	1.1		< 1.0
	12/11/2012	SFL	1.2		< 1.0
		Average	1.4		#DIV/0!
		stdev	0.3		0.0
		Minimum	1.1		< 1.0
		Maximum	1.7		< 1.0
LW8.85 Mainstream Wash at USGS Gage Below County Discharge Confluence	3/14/2012	SFL	2.0		1.2
	6/12/2012	SFL	2.2		3.4
	9/11/2012	SFL	1.7		13
	12/11/2012	SFL	1.8		4.0
		Average	1.9		5.4
		stdev	0.2		5.2
		Minimum	1.7		1.2
		Maximum	2.2		13
LWC Well PC-97 Groundwater Monitoring Well Near Pabco Road	3/15/2012	SFL	0.9	560.0	5.4
	6/12/2012	SFL	1.5	2000	2.2
	9/12/2012	SFL	0.4 j	87.00	37
	12/11/2012	SFL	1.0	3900	8.0
		Average	0.9	1637	13
		stdev	0.5	1714	16
		Minimum	0.4	87.00	2.2
		Maximum	1.5	3900	37
LWC6.1_2 Pttman Bypass Discharge (formerly Alpha Ditch)	3/14/2012	SFL	1.9		< 1.0
	6/12/2012	SFL	1.9		1.4
	9/12/2012	SFL	1.4		4.2
	12/11/2012	SFL	1.8		< 1.0
		Average	1.8		2.8
		stdev	0.2		2.0
		Minimum	1.4		< 1.0
		Maximum	1.9		4.2
LWC6.1_1 City of Henderson WWTP Effluent Discharge Channel	3/14/2012	SFL	1.2		< 1.0
	6/12/2012	SFL	1.5		1.4
	9/12/2012	SFL	1.2		1.2
	12/11/2012	SFL	1.2		1.4
		Average	1.3		1.3
		stdev	0.1		0.1
		Minimum	1.2		1.2
		Maximum	1.5		1.4

j = value that is above the method detection limit, but below the reporting limit for this analyte

Table B-4, continued. 2012 Quarterly Las Vegas Wash total suspended solids, selenium and perchlorate results, with average, maximum, and minimum values.

Station Code and Description	Sample Date	Laboratory Name	Total Se, µg/L	ClO_4^-, µg/L	TSS, mg/L
LW6.05 Mainstream Wash at Pabco Road Erosion Control Weir	3/14/2012	SFL	2.9	12.0	11
	6/12/2012	SFL	2.8	12.0	14
	9/11/2012	SFL	2.4	14.0	69
	12/11/2012	SFL	2.7	20.0	7.6
		Average	2.7	14.5	25
		stdev	0.2	3.79	29
		Minimum	2.4	12.0	7.6
		Maximum	2.9	20.0	69
LW5.5 Mainstream Wash Upstream of Historic Lateral Crossing Site	3/14/2012	SFL	2.8	11.0	11
	6/12/2012	SFL	2.8	13.0	18
	9/11/2012	SFL	2.4	16.0	61
	12/11/2012	SFL	2.3	19.0	14
		Average	2.6	14.8	26
		stdev	0.3	3.50	24
		Minimum	2.3	11.0	11
		Maximum	2.8	19.0	61
LW3.4 Mainstream Wash Below Rainbow Gardens Weir	3/14/2012	SFL	3.1	47.0	10
	6/12/2012	SFL	3.2	77.0	11
	9/11/2012	SFL	2.3	62.0	118
	12/11/2012	SFL	2.5	52.0	15
		Average	2.8	59.5	38
		stdev	0.4	13.2	53
		Minimum	2.3	47.0	9.6
		Maximum	3.2	77.0	118
LW0.9 Mainstream Wash Below Lake Las Vegas Dam	3/14/2012	SFL	2.8	47.0	12
	6/12/2012	SFL	3.1	78.0	13
	9/11/2012	SFL	1.8	49.0	45
	12/11/2012	SFL	2.9	52.0	23
		Average	2.7	56.5	23
		stdev	0.6	14.5	15
		Minimum	1.8	47.0	12
		Maximum	3.1	78.0	45
LWC0.9 Seep in Spring Box about 3 m North of LW0.9	3/14/2012	SFL	< 0.5	1.30	6.2
	6/12/2012	SFL	< 0.5	0.88	< 1.0
	9/11/2012	SFL	0.2 j	2.10	1.6
	12/11/2012	SFL	< 0.5	1.50	< 1.0
		Average	0.2 j	1.45	3.9
		stdev	#DIV/0!	0.51	3.3
		Minimum	0.2 j	0.88	1.6
		Maximum	0.2 j	2.10	6.2

j = value that is above the method detection limit, but below the reporting limit for this analyte

Table B-5: 2012 Quarterly Las Vegas Wash ambient conditions with average, maximum, and minimum values.

Site Code and Description	Sample Date	Time Sampled	Air Temperature °C	Wind Speed mph	Notes
LW11.5 Mainstream Wash Above Vegas Valley Drive	3/14/2012	0815	17.4	0.0	Sunny, high clouds. Flow low/normal, 1" deep at apron edge, covers 30% of channel width.
	6/12/2012	0740	28.1	0.0	Water turbid, almost black, smells anaerobic. Algae at sample point reddish. Usually green.
	9/11/2012	0918	29.3	5.8	*Wind E-SE. Turbidity sensor not functional. Usual flow, more than usually turbid.
	12/11/2012	0830	11.2	0.0	Overcast. S bank severely eroded. Flow low/normal, about 1" deep at apron edge.
	Average		21.5	1.5	*100-year flood hit the Valley mid-afternoon. Flamingo Wash gage jumped from 50 cfs to
	stdev		8.7	2.9	6,430 at 1430; flow peaked at 9,270 cfs at 1600.
	Minimum		11.2	0.0	
	Maximum		29.3	5.8	
LW11.1 Mainstream Wash Below Vegas Valley Drive	3/14/2012	0738	17.5	2.8	Wind SE, partly cloudy. Flow fills channel at bridge. Very stinky, large algal matts, gnats.
	6/12/2012	0713	27.9	1.3	Wind NE. Normal to low flow in channel. Algae cleaned out since last sampling event.
	9/11/2012	0835	28.0	5.5	Construction just downsteam. E side of channel graded. Solar array construction adjacent, E.
	12/11/2012	0900	8.8	1.0	Lots of foam on surface. Severe erosion at downstream apron edge.
	Average		20.6	2.7	
	stdev		9.3	2.1	
	Minimum		8.8	1.0	
	Maximum		28.0	5.5	
LWC 10.6 City of Las Vegas WWTP Effluent Discharge Channel	3/14/2012	0648	17.0	2.0	Water from spigot very gray. Flushed well, stringy black organic matter came out. Cleared.
	6/12/2012	0640	23.1	2.5	Wind NE. Usual sampling spigot is dry. Sampled the outfall from housing underground.
	9/11/2012	0800	30.1	1.0	Wind S-SE. Collected sample from outfall underground. Spigot dry. Construction adjacent.
	12/11/2012	0715	10.3	0.0	Overcast. Sample tap dry, dipped sample from large concrete outfall structure.
	Average		20.1	1.4	
	stdev		8.5	1.1	
	Minimum		10.3	0.0	
	Maximum		30.1	2.5	
LW9.3 Mainstream Wash Above Clark County Discharges	3/14/2012	0940	24.5	3.1	Bottom rocky, no plants.
	6/12/2012	0858	31.1	0.0	Normal flows, clear water, no odor.
	9/11/2012	1115	24.3	3.6	Flow higher than normal. Very turbid. Black, stormy sky to N-NW over Spring Mountains.
	12/11/2012	1050	21.0	1.5	Flow appears normal, flecks of foam on surface.
	Average		25.2	2.1	
	stdev		4.2	1.6	
	Minimum		21.0	0.0	
	Maximum		31.1	3.6	

Table B-5, continued: 2012 Quarterly Las Vegas Wash ambient conditions with average, maximum, and minimum values.

Site Code and Description	Sample Date	Time Sampled	Air Temperature °C	Wind Speed, mph	Notes
LWC 9.0 Clark County Advanced Water Treatment Plant Discharge Channel	3/14/2012	0920	22.0	4.7	None.
	6/12/2012	0838	29.8	0.0	Good flow, no odors, slight foam, which is typical.
	9/11/2012	1050	34.9	4.9	E-SE wind. High flow today, about 2' higher than normal. Terrible sewage odors.
	12/11/2012	1030	15.5	0.0	Lots of foam, more than usual.
	Average		25.6	2.4	
	stdev		8.5	2.8	
	Minimum		15.5	0.0	
	Maximum		34.9	4.9	
LWC9.0_1 Clark County Central Plant Discharge Channel	3/14/2012	1015	23.0	2.8	Water seems deeper than normal, flow a little stronger.
	6/12/2012	0910	31.2	0.0	Turbidity reading erratic, good flow, appears slightly higher than usual.
	9/11/2012	1141	30.7	5.0	E-SE wind. Flow higher than normal here, too. Clarity good, as usual. Black clouds N-NW.
	12/11/2012	1115	15.3	1.7	E wind, flow appears a bit higher than usual.
	Average		25.1	2.4	
	stdev		7.5	2.1	
	Minimum		15.3	0.0	
	Maximum		31.2	5.0	
LW8.85 Mainstream Wash at USGS Gage Below County Discharge Confluence	3/14/2012	0850	24.0	1.8	Good flow, water looks greenish. White heron in dry brushy area to East of Wash.
	6/12/2012	0814	27.9	0.0	Normal flow. Usual rock shelf causing deep hole in right bank.
	9/11/2012	1000	27.5	6.0	E-SE wind, flow seems high today. Storms heading this direction but still distant.
	12/11/2012	0930	9.5	0.7	Usual flow, no morphology change apparent from the September flood.
	Average		22.2	2.1	
	stdev		8.7	2.7	
	Minimum		9.5	0.0	
	Maximum		27.9	6.0	
LWC Well PC-97 Groundwater Monitoring Well Near Pabco Road	3/15/2012	1140	26.3	3.4	Used Manta 2 for well. No turbidity sensor.
	6/12/2012	1126	35.3	0.6	Water sample had a few floating particles and appeared slightly turbid.
	9/12/2012	0930	27.0	0.0	**Sample smells of sulfur, pretty sandy. Yesterday's flood filled well head with sand.
	12/11/2012	1430			No connection to multiprobe. Access to site by vehicle not possible, long hike to truck.
	Average		29.5	1.3	**Skipped this site to try to beat storm flow on mainstream Wash on 9/11/12.
	stdev		5.0	1.8	
	Minimum		26.3	0.0	
	Maximum		35.3	3.4	

Table B-5, continued: 2012 Quarterly Las Vegas Wash ambient conditions with average, maximum, and minimum values.

Site Code and Description	Sample Date	Time Sampled	Air Temperature, °C	Wind Speed, mph	Notes
LWC6.1_2 Pittman Bypass Discharge (formerly Alpha Ditch)	3/14/2012	1230	25.6	0.8	Head-sized boulders cover bottom, black algae and tan stringy algae over all.
	6/12/2012	1205	37.1	0.0	Flow good, slightly turbid. Most of algal growth on rocks has disappeared.
	9/12/2012	1010	31.8	0.0	**Sampled next day, after flood. Humidity high, clear blue sky.
	12/11/2012	1310	19.3	0.3	The usual stringy black algae on rocks in channel is gone. Lots of small fish.
	Average		28.5	0.3	**Skipped this site to try to beat storm flow on mainstream Wash on 9/11/12.
	stdev		7.7	0.4	
	Minimum		19.3	0.0	
	Maximum		37.1	0.8	
LWC6.1_1 City of Henderson WWTP Effluent Discharge Channel	3/14/2012	1245	22.6	1.5	Head-sized boulders cover bottom, covered with black and green algae. Lots of fish.
	6/12/2012	1155	37.4	0.6	Bee swarm near water. Normal flow, many fish eating bright green algae off rocks.
	9/12/2012	1025	30.0	0.0	**Sampled next day, after flood. See note above.
	12/11/2012	1325	21.0	1.0	None.
	Average		27.7	0.8	
	stdev		7.5	0.6	
	Minimum		21.0	0.0	
	Maximum		37.4	1.5	
LW6.05 Mainstream Wash at Pabco Road Erosion Control Weir	3/14/2012	1300	27.5	4.9	All vegetation has been cleared downstream of the weir.
	6/12/2012	1230	36.9	0.7	Good flow, slightly turbid. Most algal growth on rocks has disappeared.
	9/11/2012	1245	30.4	4.2	Wind S-SE. Very turbid flow, about 1' higher than normal flow at this site.
	12/11/2012	1245	17.1	0.3	Access via Pabco Rd blocked. 'Normal' flow and turbidity, nice gravel bar downstream.
	Average		28.0	2.5	
	stdev		8.2	2.4	
	Minimum		17.1	0.3	
	Maximum		36.9	4.9	
LW5.5 Mainstream Wash Upstream from Historic Lateral Crossing	3/14/2012	1330	27.7	6.1	High overcast.
	6/12/2012	1257	37.2	0.0	More turbid than upstream, swift flow.
	9/11/2012	1310	30.7	4.8	Wind S-SE. Very turbid. Flow only slightly higher than normal. Looks like storm at Strip.
	12/11/2012	1500	16.2	2.2	S wind. Road to platform now deep gravel bar, impassable. Good stream flow, turbid.
	Average		28.0	3.3	
	stdev		8.8	2.7	
	Minimum		16.2	0.0	
	Maximum		37.2	6.1	

Table B-5 continued: 2012 Quarterly Las Vegas Wash ambient conditions with average, maximum, and minimum values.

Site Code and Description	Sample Date	Time Sampled	Air Temperature °C	Wind Speed, mph	Notes
LW3.4 Mainstream Wash Below Rainbow Gardens Weir	3/14/2012	1410	27.4	3.9	Wind S/SW. Lots of foam on surface, at toe of weir and downstream.
	6/12/2012	1332	35.1	0.6	Slight increase in EC here. Turbidity appears less than at LW5.5, light foam in channel.
	9/11/2012	1330	26.2	11.1	Wind E-NE. Very turbid. Lightning approaching area. Did not linger.
	12/11/2012	1525	17.3	3.9	N-NE wind. Surface very foamy, more than normal, but water appears less turbid.
	Average		26.5	4.9	
	stdev		7.3	4.4	
	Minimum		17.3	0.6	
	Maximum		35.1	11.1	
LW0.9 Mainstream Wash Below Lake Las Vegas Dam	3/14/2012	1515	29.7	3.0	No notes.
	6/12/2012	1412	35.5	0.9	Slight sewage odor, swift water, slightly turbid.
	9/11/2012	1415	22.6	21.0	***Winds erratic, strong gusts. Flow seems a bit high, very turbid with strong sulfur smell.
	12/11/2012	1605	14.1	0.0	Lots of gnats. Sun has dropped behind the dam.
	Average		25.5	6.2	***USGS flow gage at 1415 indicated 325 cfs, which is not that unusual for this site. The
	stdev		9.2	9.9	highest flow recorded at this site was at 1945, at 6,810 cfs.
	Minimum		14.1	0.0	
	Maximum		35.5	21.0	
LWC0.9 Seep in Spring Box about 3 m North of LW0.9	3/14/2012	1450	29.7	3.0	Gage height 7.37. Sunny, high clouds.
	6/12/2012	1419	37.1	0.6	Very clear water, mat of algae at entry way. Gage height approximately 7.3.
	9/11/2012	1420	22.6	21.0	Rain starting to fall. Flow in spring box seems higher than normal, maybe 1.5-2 cfs.
	12/11/2012	1615	13.6	1.2	Flow 'normal', estimate 1 cfs, did not note gage height.
	Average		25.8	6.5	
	stdev		10.0	9.8	
	Minimum		13.6	0.6	
	Maximum		37.1	21.0	

Appendix C
An Approximation of the Las Vegas Valley's Net Salt Contribution to the Colorado River via Las Vegas Wash

This appendix contains an approximation of the differential between tons of salt in water pumped from Lake Mead for municipal and industrial uses in the Las Vegas Valley and the tons of salt discharged to the lake via Las Vegas Wash. Data are provided in both tabular and graphical formats.

The salt load discharged to Lake Mead by the Wash contributes to the salinity of the Colorado River, and is thus of interest under the Colorado River Basin Salinity Control Program. Based on salt load analyses (the concentration of dissolved solids per unit of volume multiplied by the volume) beginning in the 1960s, Congress authorized construction of facilities to reduce salt concentrations in the Colorado River by passing the 1974 Colorado River Basin Salinity Control Act, Title II (Public Law 93-320). Subsequent studies led to construction of the Pittman Bypass pipeline to carry treated wastewater from Basic Magnesium, Inc. (BMI, now known variously as Basic Water Company. and the Black Mountain Industrial complex) back to the Wash. Pre-construction calculations estimated the pipeline would reduce salt load from the Wash to Lake Mead by 3,200 tons per year by isolating this return water from contact with saline groundwater. Studies showed that other Wash projects formerly proposed to reduce the salt load more significantly were not feasible and none were constructed.

Most of the volume of water discharged into Lake Mead via the Wash is return flow from water originally pumped from Lake Mead for municipal and industrial use. Consequently, most of the salt discharged by Las Vegas Wash is offset by the salt contained in the pumped water. It is important to note that, when the salinity in Lake Mead decreases as it has the last several years, the salt load discharged at LW0.9 will also decrease. Figure C-1 presents a comparison of the estimated tonnage of salt contained in the water pumped from Lake Mead to the Las Vegas Valley with the estimated tonnage of salt returned to Lake Mead through the Wash.

To estimate the salt load in water diverted from Lake Mead to the Valley, the annual average total dissolved solids (TDS) concentration of water pumped at the Saddle Island intake to the Alfred Merritt Smith Water Treatment Facility (AMS) was applied to the total volume of water diverted from Lake Mead at AMS and at the two water systems that supply water to the Las Vegas Valley: the Southern Nevada Water System (SNWS); and the BMI system. Calculations for the salt load discharged to Lake Mead via the Wash are based on quarterly analysis of TDS in the surface flow of the Wash at LW0.9 (Northshore Road).

On average, comparison of the salt load discharged by the Wash with the salt load pumped from Lake Mead indicates that during the years from 2000 to 2012 collectively, approximately 86 percent of the salt load in the Wash originated from Lake Mead. Approximately 90 percent of water used in the Valley comes from Lake Mead, with the other 10 percent coming from groundwater wells. The values presented in Figure C-1 should be viewed as approximations, recognizing the water quality sampling intervals in the Wash (quarterly) and the use of average annual TDS concentrations of water pumped at Saddle Island.

Table C-1. Comparison of estimated salt load discharged by Las Vegas Wash with estimated salt load diverted to Las Vegas Valley from Lake Mead for the years 2000 through 2012.

Year	Annual Salt Load Discharged to Lake Mead via Las Vegas Wash (Tons)	Annual Salt Load Diverted to Las Vegas Valley at Saddle Island (Tons)	Apparent Net Salt Load Contribution to Lake Mead from Las Vegas Valley (Tons)	Total Annual Precipitation (Inches)
2000	406,522	364,289	42,232	3.47
2001	386,649	372,906	13,743	3.94
2002	392,192	393,492	-1,299	1.44
2003	462,098	393,667	68,431	6.86
2004	485,281	388,067	97,214	7.76
2005	593,511	422,611	170,900	7.37
2006	537,813	456,693	81,120	1.69
2007	495,216	440,198	55,018	2.73
2008	462,932	407,210	55,722	2.64
2009	447,070	377,993	69,077	1.59
2010	444,206	360,305	83,901	5.90
2011	460,796	346,237	114,560	2.34
2012	418,856	335,082	83,774	5.31

Conversion used: 1 ton of salt per acre foot of water = 735 mg/L total dissolved solids

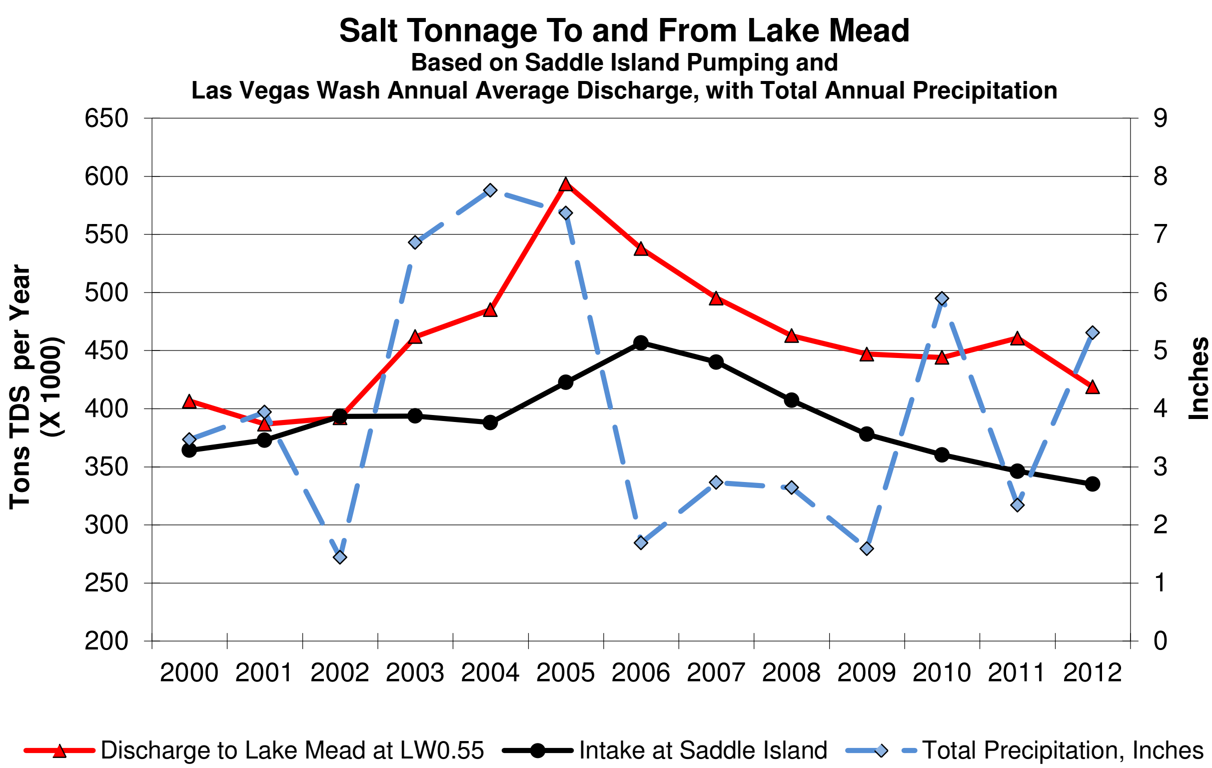

Figure C-1. Comparison of salt tonnage diverted from Lake Mead and discharged to Lake Mead via Las Vegas Wash, 2000 through 2012.

Appendix D
Las Vegas Valley Population Estimates

This appendix presents Clark County/Las Vegas Valley Population Estimates and Growth Rates from 1990 to 2011.

Clark County / Las Vegas Valley Average Population and Growth Rates 1990 - 2011

	Clark County				Las Vegas Valley Urban Area				
Year	Population		Added Population	*Growth Rate*	Population		Added Population	*Growth Rate*	*Share of County Population*
1990	797,142			-	764,464			-	95.90%
1991	829,839		32,697	4.10%	794,622		30,158	3.94%	95.76%
1992	870,692		40,853	4.92%	834,446		39,824	5.01%	95.84%
1993	919,388		48,696	5.59%	880,716		46,270	5.54%	95.79%
1994	986,152		66,764	7.26%	945,620		64,904	7.37%	95.89%
1995	1,040,688		54,536	5.53%	998,254		52,634	5.57%	95.92%
1996	1,119,708		79,020	7.59%	1,074,362		76,108	7.62%	95.95%
1997	1,170,113		50,405	4.50%	1,123,932		49,570	4.61%	96.05%
1998	1,246,193		76,080	6.50%	1,195,376		71,444	6.36%	95.92%
1999	1,321,319		75,126	6.03%	1,266,680		71,304	5.96%	95.86%
2000	1,428,690	*	107,371	8.13%	1,366,916	*	100,236	7.91%	95.68%
2001	1,498,279	*	69,589	4.87%	1,445,791	*	78,875	5.77%	96.50%
2002	1,578,332	*	80,053	5.34%	1,522,117	*	76,326	5.28%	96.44%
2003	1,641,529	*	63,197	4.00%	1,583,172	*	61,055	4.01%	96.44%
2004	1,747,025	*	105,496	6.43%	1,685,197	*	102,025	6.44%	96.46%
2005	1,815,700	*	68,675	3.93%	1,752,240	*	67,043	3.98%	96.50%
2006	1,925,654 ■		109,954	6.06%	1,860,495 ■		108,255	6.18%	96.62%
2007	1,996,542	*	70,888	3.68%	1,925,261	*	64,766	3.48%	96.43%
2008	1,986,146	*	-10,396	-0.52%	1,916,436	*	-8,825	-0.46%	96.49%
2009	2,006,347	*	20,201	1.02%	1,936,324	*	19,888	1.04%	96.51%
2010	2,036,358	*	30,011	1.50%	1,965,950	*	29,626	1.53%	96.54%
2011	1,966,630	*	-69,728	-3.42%	1,901,103	*	-64,847	-3.30%	96.67%
Average			**55,690**	**4.43%**			**54,126**	**4.47%**	**96.20%**

Sources: Clark County Department of Comprehensive Planning, SNRPC Consensus Population Estimate.

Note: Local annual estimates as of July 1 resident population based on housing methods.

* Southern Nevada Regional Planning Coalition Consensus Population Estimate began in 2000.

■2006 based on revised data.

Clark County, Nevada 2012 Population Estimates							PLACE	POPULATION
August 3, 2012 (Roll Close)								
	HOUSING TYPE							
PLACE / COMMUNITY	Single Family	Duplex 3/4-Plex	Mobile Home	Apart-ments	Town-homes	Condo-miniums	Group Quarters	TOTAL POPULATION
CLARK COUNTY	1,233,440	47,455	57,944	389,183	97,225	161,974	21,433	**2,008,654**
Cities	742,916	30,835	17,155	195,346	53,154	73,722	7,212	**1,120,341**
Unincorporated Areas	490,524	16,620	40,789	193,837	44,071	88,252	14,221	**888,314**
LAS VEGAS VALLEY URBAN AREA	1,203,952	46,599	48,663	383,132	92,034	156,200	14,568	**1,945,149**
Cities	725,107	30,092	13,713	193,096	48,875	69,925	6,731	**1,087,540**
Unincorporated Areas	478,845	16,507	34,950	190,035	43,159	86,275	7,837	**857,609**
OUTLYING AREAS	29,488	855	9,281	6,052	5,191	5,774	6,865	**63,505**
Cities	17,809	743	3,442	2,250	4,279	3,797	481	**32,801**
Unincorporated Areas	11,679	113	5,839	3,802	912	1,977	6,384	**30,705**
CITIES								
Boulder City	9,310	535	2,939	894	818	979	426	**15,901**
Henderson	186,948	1,301	3,912	42,745	15,804	16,930	1,603	**269,243**
Las Vegas	369,523	17,609	7,306	122,984	26,270	46,865	3,737	**594,294**
Mesquite	8,499	208	503	1,356	3,462	2,818	55	**16,900**
North Las Vegas	168,637	11,183	2,495	27,368	6,801	6,129	1,391	**224,003**
UNINCORPORATED AREAS IN THE LAS VEGAS VALLEY								
Enterprise	123,928	10	371	19,423	6,780	13,823	0	**164,335**
Lone Mountain	15,374	8	203	0	0	0	0	**15,585**
Nellis AFB	0	0	0	0	0	0	6,105	**6,105**
Paradise	75,609	4,067	5,604	63,158	13,941	23,199	826	**186,405**
Sloan	35	0	81	0	0	0	0	**116**
Spring Valley	101,084	2,218	3,477	37,766	9,311	32,008	707	**186,571**
Summerlin South	20,597	0	0	3,139	1,235	517	0	**25,487**
Sunrise Manor	108,861	9,125	21,443	42,816	5,759	10,312	20	**198,336**
Whitney	23,292	93	1,344	8,592	3,521	2,418	0	**39,260**
Winchester	6,710	933	2,346	15,141	2,612	3,998	179	**31,918**
Urban "County Islands"	3,356	55	81	0	0	0	0	**3,492**
UNINCORPORATED OUTLYING AREAS[1]								
Blue Diamond	444	0	69	14	0	0	0	**527**
Bunkerville	871	13	210	0	0	0	0	**1,094**
Cal-Nev-Ari	38	0	113	0	0	0	0	**151**
Corn Creek	15	0	38	0	0	0	0	**54**
Fort Mojave Reservation	0	0	0	0	0	0	385	**385**
Goodsprings	114	7	84	0	0	0	0	**204**
Indian Springs	210	0	993	0	0	0	0	**1,203**
Jean	0	0	0	0	0	0	160	**160**
Laughlin	2,552	0	2	3,066	912	1,959	0	**8,490**
Lower Kyle Canyon Road	142	0	51	0	0	0	0	**193**
Moapa / Moapa Reservation	663	48	385	0	0	0	320	**1,416**
Moapa Valley - Logandale	2,529	6	536	0	0	0	0	**3,071**
Moapa Valley - Overton	2,130	40	1,371	222	0	0	0	**3,763**
Moapa Valley - Remainder	96	0	0	0	0	0	0	**96**
Mountain Springs	98	0	0	0	0	0	0	**98**
Mt. Charleston	534	0	0	0	0	18	100	**652**
Nelson	15	0	17	0	0	0	0	**31**
Primm	0	0	148	476	0	0	0	**624**
Red Rock[2]	112	0	8	0	0	0	0	**120**
Sandy Valley	863	0	1,032	0	0	0	0	**1,896**
Searchlight	75	0	301	23	0	0	0	**399**
Spring Mountains[3]	107	0	13	0	0	0	0	**120**
Other Outlying Areas[4]	70	0	469	0	0	0	5,419	**5,958**

Clark County Department of Comprehensive Planning

Source: Southern Nevada Consensus Population Estimate, July 2012

(run date:12/17/2012)

[1] Figures may be different than previous years due to changes in community boundaries.

[2] Includes all areas served by the Red Rock Citizens Advisory Council (Calico Basin, W. Blue Diamond Road) except the townsite of Blue Diamond.

[3] Includes Cold Creek, Lee Canyon and other areas in the Spring Mountains, but not Mountain Springs or the town of Mt. Charleston.

[4] Includes Las Vegas Paiute Tribal Lands, Boulder Basin, Cottonwood Cove, Coyote Springs, Las Vegas Wash, & other outlying areas.

Appendix E
Precipitation and Storm Events in the Las Vegas Valley

In some circles, Las Vegas is as famous for its spectacular "monsoon" season flooding as it is for its slogan, "What Happens in Vegas, Stays in Vegas." Examples of intense rainfall in the Las Vegas Valley are plentiful, but the July 8, 1999 storm is a particularly good example of high intensity rainfall over a short time frame. During the event, much of the Las Vegas valley had rainfall

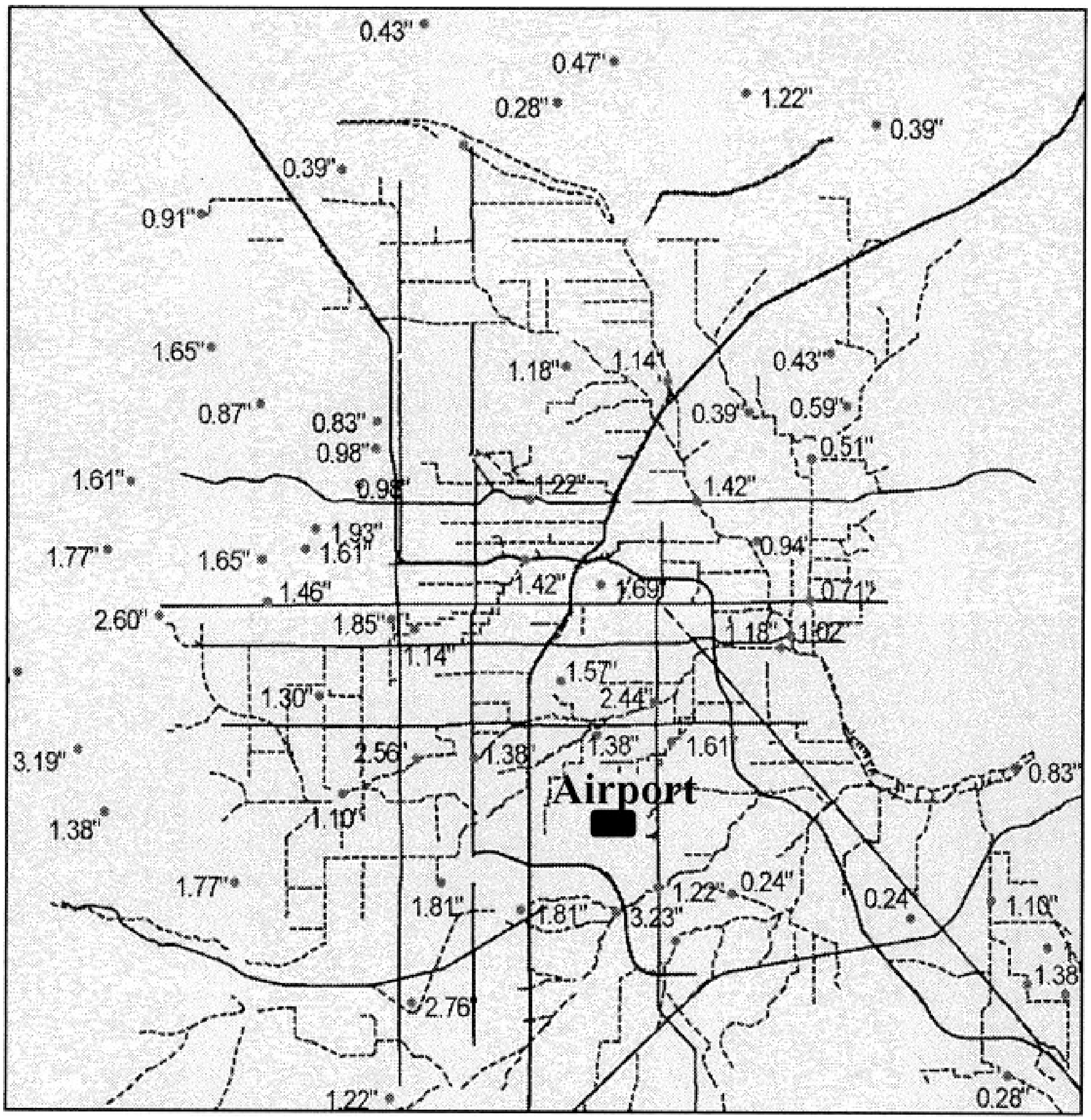

Figure E-1. Rainfall amounts (inches) in the Las Vegas metropolitan area on 8 Jul 1999 from Haro et al. (1999). Airport is the McCarran International Airport amounts (Figure E-1) of 35%-70% of the average annual precipitation (about 4 inches, or 100 mm) during a brief period of 60-90 min. According to Haro et al. (1999), "Severe flash flood storms that occurred in Las Vegas, Nevada, on 8 July 1999, were unusual for the semiarid southwest United States because of their extreme intensity and the morning occurrence of heavy convective rainfall. …the floods caused over $20,000,000 in property damage and took two lives. The Office of the Governor issued a Declaration of Emergency for the area and requested assistance from the Federal Emergency Management Agency on 15 July. President Clinton declared the city a disaster area on 19 July." Many specific details about the meteorology of this event and its impacts are available in a National Weather Service, Western Region, Technical Attachment by Haro et al. (1999).

The July 8, 1999 storm was focused on areas north and west of McCarran, downstream of existing infrastructure (detention basins and flood channels). The vulnerability of major flooding on the Wash downstream of existing detention facilities was recognized in 1997 as a regional risk and led to the construction of the Cheyenne Peaking Basin, located immediately downstream of the confluence of the Main Reach, Western Tributary, and Central Basin subwatersheds. Significant work was performed beginning in 1997 to better define the 100-year flow rate of the Wash above the Pecos/Lake Mead Boulevard intersection in North Las Vegas. The 100-year peak discharge was determined to be greater than 12,000 cfs, well above the capacity of existing downstream infrastructure. Therefore the CCRFCD 1996 Master Plan Update was amended to include the construction of the Cheyenne Peaking Basin in North Las Vegas. The peaking basin functioned to retain flow above 8,500 cfs because of downstream flow constrictions at bridge crossings over the Wash, and to minimize scour along the Wash below the Flamingo Wash confluence.

Additional information regarding the July 1999 storm event is described by Li et al (2003) in *A Numerical Investigation of Storm Structure and Evolution during the July 1999 Las Vegas Flash Flood,* Stachelski and Pierce (2009) *Record Flash Flood of July 8, 1999: Ten Year Anniversary,* and Sutko (1999) *Rainfall Event Report, July 8, 1999*.

Appendix F
Perchlorate in the Las Vegas Wash: History and Present Remedy

The BMI complex is located in Henderson, Nevada, situated for the most part east and just west of Highway 93/95 and bounded on its south end by Lake Mead Drive. The Wash lies north of the BMI complex. A brief history of the inception of the complex reports that a 5,000-acre parcel in the empty desert SE of Las Vegas, NV, was deeded by the government in 1941to become the largest producer of magnesium in the world. At the time known as Basic Magnesium, Incorporated, the production of this 'miracle metal' at the Henderson plant was critical to the World War II effort and employed 14,000 people until about 1947.

The site today is 450 acres total, and is the historic home of two manufacturing plants that produced ammonium perchlorate for the Department of Defense (DOD) and for the National Aeronautics and Space Administration (NASA) beginning in the 1950s. According to Sellers et al. (2007), one plant was owned by Kerr McGee (which changed its name to Tronox in 2005) and the other by Pacific Engineering and Production Company of Nevada (PEPCON). The two plants were 1.5 miles apart, and together they produced all of the perchlorate needed by NASA and DOD at that time to fuel their rockets and missiles. From 1951 to 1976, wastewaters from perchlorate production were evaporated in unlined ponds along the Eastern perimeter of the complex. Production of perchlorate continued until 1998 at the Tronox plant, but due to an oversight in 1988, welding slag ignited at the PEPCON facility and the plant exploded, along with its 8.5 million pounds of stored ammonium perchlorate. Much of this perchlorate was distributed throughout the BMI complex by the explosion, and in 1997, perchlorate was found in groundwater in the vicinity of the Wash.

Today, it is known that three groundwater plumes carry perchlorate toward the Wash in Paleolithic stream channels (Todd Croft, NDEP, personal communication, 2009). One plume originates at the Tronox plant, another from the PEPCON explosion site, and the third from unlined process water evaporation ponds located Southeast of the Wash that were used by both Tronox and PEPCON. The plumes coming from the BMI complex contain a combined estimated total of 21.5 million pounds of perchlorate (Sellers et al., 2007).

The plumes enter the Wash in the area between stations LW8.85 and LW3.4, which includes the site of the groundwater seep/surface flow capture sump at LWC6.3 and a groundwater well designated LWC Well PC-97. The sump at LWC6.3 consists of an underground concrete dam and stilling well that were used to trap near-surface groundwater so it could be pumped to the fluidized bed reactor (FBR) for perchlorate removal. In 2010, perchlorate concentrations in samples from the stilling well were quite variable and subject to precipitation, evaporation, and other atmospheric effects. During the March sampling event that year, 900 µg/L of perchlorate were measured in the sample. During the June 2010 sampling event, the water pulled from the stilling well was jet black, smelled strongly of hydrogen sulfide (anaerobic decomposition, perhaps), and contained very high levels of ammonia but less than 2 µg/L of perchlorate. Since the water level in June was quite low, in addition to being black, the decision was made to sample one of the nearby Tronox monitoring wells for all future events instead. LWC Well PC-97 replaced LWC6.3, since it is the monitoring well located closest to the stilling well, about 85 m south and east of LWC6.3. Sampling from the groundwater well should mitigate most of the variation in chemistry due to exposure to the atmosphere, as seen at LWC6.3, and should not react to precipitation and drought effects as readily. Samples collected from LWC Well PC-97 are truly groundwater and may provide a better understanding of trends in the quality of shallow groundwater in this area over time.

Although Tronox filed for bankruptcy in 2009, the company continues its manufacturing operations at the BMI complex through a lease from the NDEP. Through a settlement agreement dated February 14, 2011, NDEP was appointed owner and trustee over the lands and groundwater extraction treatment system (GWETS)[3] within the BMI complex that were previously owned by Tronox (http://ndep.nv.gov/bmi/index.htm). This area is now referred to as the Nevada Environmental Response Trust Site, or NERT. Cleanup efforts on the NERT site are effectively dropping concentrations of perchlorate measured in the Wash through operation of a groundwater treatment facility in place since June 2004. The FBR system provides biological treatment to about 1,000 gallons per minute of perchlorate-contaminated shallow groundwater pumped from this area, which is then discharged to the Wash under a National Pollution Discharge Elimination System (NPDES) permit.

Documents obtained at the above website show that 535,023 pounds (242,682 kg) of perchlorate were removed from the NERT site between July 2010 and June 2011, and that concentrations of perchlorate in the FBR discharge are less than the laboratory's sample quantitation limit that varied from 0.0025 to 0.0005 µg/L. The discharge reaches the Wash just above the Pabco Weir and station LW6.05, which is located on the downstream side of the Pabco Weir. Perchlorate remediation of the area east of Pabco Road, the section of the BMI complex where the unlined ponds were located, was completed at the end of 2010. To accomplish this, approximately 2.2 million cubic yards of soil were removed and placed into a specially-designed offsite landfill in Henderson. Once all tests show that remediation of the 2,200-acre site mitigation is complete, this area located in the heart of Henderson will become a mixed-use development containing 15,000 homes, shopping complexes, and several neighborhood parks.

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3 GWETS refers to all components of the groundwater extraction and treatment systems owned and operated by the Nevada Environmental Response Trust (NERT), whether located on-site or off-site. This includes well fields and the groundwater capture sump located near the Wash at Pabco Road.