Nevada Water Resources Research Institute
Annual Technical Report
FY 2011

Introduction

Research Program Introduction

None.

USGS Award No. G10AP00081 Yerington/Anaconda Mine Site Technical Support

Basic Information

Title:	USGS Award No. G10AP00081 Yerington/Anaconda Mine Site Technical Support
Project Number:	2010NV177S
Start Date:	3/15/2010
End Date:	3/14/2011
Funding Source:	Supplemental
Congressional District:	2
Research Category:	Engineering
Focus Category:	Acid Deposition, Toxic Substances, Groundwater
Descriptors:	
Principal Investigators:	William H Albright

Publications

There are no publications.

USGS Award No. G10AP00081 Yerington/Anaconda Mine Site Technical Support

Problem and research objectives:
Processing of copper ore at the Yerington NV mine site was accomplished by leaching with sulfuric acid. Residual materials, both solid residual ore and process fluids, pose considerable hazard to the local environment. The most likely method for spread of contaminants is through movement of meteoric water through heap leach and drain-down pond facilities and, thus, to groundwater. Hydraulic control at the surface via a final cover is likely a viable option for closure of several of the site features. The purpose of this effort is exploration of the feasibility of a particular solution – a water balance cover - not only at the Yerington site, but throughout the Great Basin.

Methodology:
In this study, we conducted initial evaluation of the available soil resources for use in a water balance cover. Soil resources at the mine are very complex and range from undisturbed sources to mine spoils placed over years of activity. Index properties, primarily particle size distribution, allowed estimates of unsaturated soil properties including soil water storage. The climate of the site was evaluated with a new method described by Albright et al (2010) which compares precipitation to potential evaporation on a monthly basis to determine the required soil water storage for a cover. Required storage was computed for the wettest year on record. A survey of available soils was conducted by the site owner to give a more comprehensive view but, unfortunately, those results were only recently made available and no further analysis has been done.

Principal Findings:
Analyses to date suggest a cover of moderate thickness (~1-1.2 m) and vegetated with local species will likely provide sufficient control of percolation. That thickness allows for plant viability and is economically feasible. Further work will be required to evaluate the effect of the considerable variability in the available soils on expectations of performance.

Information Transfer Activities:
There are no papers to date on this effort.

Measuring Water Use of Tamarisk and Impacts from Biocontrol: Lower Virgin River, NV

Basic Information

Title:	Measuring Water Use of Tamarisk and Impacts from Biocontrol: Lower Virgin River, NV
Project Number:	2011NV178B
Start Date:	3/1/2011
End Date:	2/28/2013
Funding Source:	104B
Congressional District:	
Research Category:	Not Applicable
Focus Category:	Acid Deposition, Ecology, Water Quantity
Descriptors:	
Principal Investigators:	Kumud Acharya

Publications

There are no publications.

Annual Progress Report

Title: **Measuring Water Use of Tamarisk and Impacts from Biocontrol: Lower Virgin River, NV**

PI: Kumud Acharya, DRI
Other Participants: Sachiko Sueki and John Healey, DRI

Problem and Research Objectives

The lower Virgin River is a tributary of the Colorado River System that is a major component of the water budget of the Southwest. The Virgin River flows through the Tri-State area of Arizona, Utah, and Nevada with a mean flow rate of 100 cubic feet per second. The State of Nevada contains 53% of the drainage basin followed by equal shares to Arizona and Utah at 24% and the river's relevance to each state is an important issue as rising population growth results in greater demands on a depleting, limited water supply. To compound the situation, an avaricious water-consuming plant has inundated this region reducing water availability. The invasion of non-native plant species, *Tamarix* (tamarisk, salt cedar), along the lower Virgin River and other river systems has developed riparian communities of mono-specific thickets. In addition to detrimental effects on biodiversity along these corridors, tamarisk commonly occurs in dense thickets. This can result in high evapotranspiration (ET) rates, much of which emanates from relatively shallow groundwater. Extraction of groundwater can reduce stream flow and increase the salinity of soil, leading to less available water, and potentially degrading water quality, for irrigation and potable uses. Traditional eradication efforts such as herbicidal treatment, fire and mechanical removal have either proven too costly or shown to have negative impacts on the native flora which they are intending to restore. Recently, new eradication efforts have shifted towards the use of a biocontrol agent, the saltcedar leaf beetle (*Diorhabda carinulata*), to reduce tamarisk leaf cover along many western water sheds. Defoliation of tamarisk in lieu of *Diorhabda carinulata* infestation has been occurring along the Colorado River and its tributaries since the release of the beetle in 2001. The last few years have seen establishment of large scale populations in Lower Virgin River eventually reaching to Overton arm of the Lake Mead in 2011. The relatively rapid progression of these beetles down the Colorado River basin provides a unique opportunity to directly assess if the beetles are providing any water savings to this water deprived region by measuring the change in ET, while the beetles are actively migrating through tamarisk groves. The primary goal of the research is to quantify ET prior to and following episodic herbivory by the leaf beetle, calculate the difference between ET prior to and following herbivory which may contribute to a net savings of water along the Virgin River, and monitor stream flow and daily groundwater oscillations from groundwater wells maintaining by Desert Research Institute, Southern Nevada Water Authority, and Virgin Valley Water District.

Methodology

The study so far has focused on collecting the field data at the research that was established by funding from the U.S. Bureau of Reclamation (Technical Services Center, Denver) along the alluvial-filled valley of the lower Virgin River. The site consists of a groundwater monitoring well and the equipment necessary to utilize the classic Eddy Covariance technique to determine atmospheric fluxes and to obtain accurate estimates of ET. Eddy Covariance set up includes a 3D sonic anemometer (model CSAT3) mounted one meter above the canopy, an open-path infrared gas analyzer (model CS7500) mounted one meter above the canopy, a REBS net radiometer (model Q7.1), two soil heat flux plates (model HFP01SC), two soil thermocouple probes (model TCAV-L), two soil water reflectometers (model CS616), and a combination air temperature/relative humidity probe (model HMP45C-L). Data is stored on a datalogger (model CR5000) equipped with a 1 Gb memory card. Data is monthly collected by visiting the site and swapping the full memory card with an empty one. Additionally, real-time data is checked with a lap-top pc to ensure appropriate sensor operation. Fluxes are later calculated offline and corrected using EdiRE (University of Edinburgh, 2003). This technique is used on all data and allows for the following corrections: despiking and low pass filtering, sonic temperature path correction, sonic flow distortion, rotating velocity signals, sonic temperature density correction, highpass filtering signals, frequency response corrections, sonic temperature correction and density corrections. All corrections are made to the 10-Hz data (time interval of 0.1 second) prior to calculating 30-minute averages. Fluxes are then calculated using the averaged data. In the groundwater monitoring well, diurnal groundwater fluctuations are recorded every minute using a pressure transducer installed in a shallow piezometer (5.08 cm diameter). Data from the transducer will be downloaded to a computer during each site visit.

Principle Findings and Significance

This project continues data collection from previously funded project (see above). The previous project ended in spring 2011 and the current project started immediately after that. To compare ET difference before and after arrival of the beetles, the data previously collected in 2010 will be used as the beetles arrived at the field site in the summer of 2011. The results presented here are preliminary, complete data of pre- and post-beetles' arrival will be analyzed and presented at the end of the project cycle

Preliminary examination of data indicates that defoliation caused by beetles' herbivory reduced the ET rates resulting in less phreatophytic ground water consumption. The beetles had migrated into the Eddy covariance site and began their defoliation of tamarisks in June 2011. Figure 1 shows the comparison of ground water level over the time period of June to August during 2010 (before beetles' arrival) and 2011 (after beetles' arrival). The smaller oscillations imprinted on the larger oscillations represent diurnal fluctuations in the water table due to phreatophytic groundwater consumption. Peaks and valleys roughly correspond to daily times of 0600 and 1600 hours, respectively (clearly visible in Figure 2 of a week-long time frame). The period between 6/24/2011 (A) to 8/16/2011 (A') of 2011 plot clearly shows the reduced magnitude (dampening) of the diurnal fluctuations. The ET data is currently being analyzed. However, the initial observation of the data shows a significant drop in ET rates after the defoliations (verbal communication, R. Jasoni, Desert Research Institute) which corresponds to the nearly non-existent diurnal fluctuations in the water level data.

Also, preliminary review of the water level data appears to show that new growth recurs within weeks of initial defoliation. Figure 2 shows diurnal fluctuations of the water table at the Virgin River site for one week period in September 2010 and 2011. The magnitude of the fluctuations is very similar from year to year over the same period. This implies that tamarisk recovered from the defoliation caused by the beetles and resumed their normal pattern of water consumption as seen by the recurrence of diurnal fluctuations common to areas of active plant growth. In fact the defoliation in August appears to result in growth of leaves continuing later into the season thus causing water level fluctuations to continue beyond the preceding year's growth period.

Information Transfer Activities

Results obtained so far are preliminary and have not been presented yet. However, when the data collection and analysis is complete, they will be presented to a technical conference.

Student/other Support

The project currently provides partial support to a postdoctoral researcher (Sachiko Sueki) for data analysis and an Assistant Research Scientist (John Healey) for field data collection.

Publications

The result will be published in peer-reviewed journals when all data have been collected and analyzed.

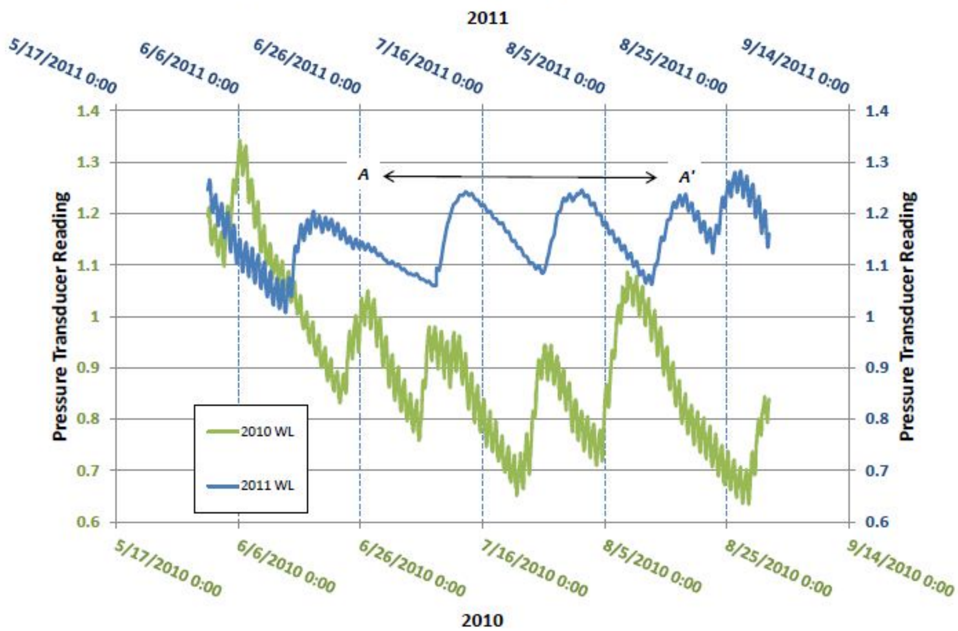

Figure 1. Defoliation of Tamarisk as seen in water level record. Note the diminishing diurnal fluctuations represent by A to A'.

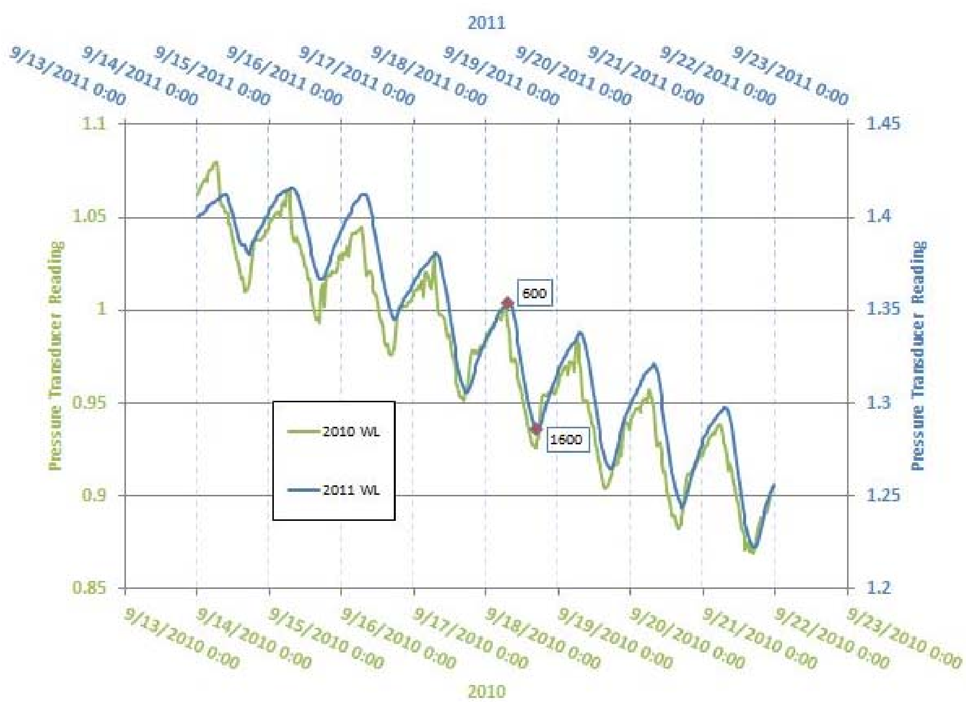

Figure 2. One-week water level record demonstrating similar magnitude of diurnal fluctuations pre and post defoliation and subsequent new growth.

Assessment of Resiliency of Las Vegas Water System Under Climatic and Non-Climatic Stressors

Basic Information

Title:	Assessment of Resiliency of Las Vegas Water System Under Climatic and Non-Climatic Stressors
Project Number:	2011NV179B
Start Date:	3/1/2011
End Date:	2/28/2013
Funding Source:	104B
Congressional District:	
Research Category:	Climate and Hydrologic Processes
Focus Category:	Water Use, Water Supply, Management and Planning
Descriptors:	
Principal Investigators:	Mahesh Gautam, Kumud Acharya

Publications

There are no publications.

Annual Progress Report

Title: **Assessment of resiliency of Las Vegas water system under climatic and non-climatic stressors**

PIs: Mahesh R. Gautam and Kumud Acharya, DRI
Graduate Students: Srijana Dawadi and Peng Jiang, University of Nevada Las Vegas

Problem and Research Objectives

Until recently the Las Vegas Metropolitan represented one of the highest growing regions in the U.S. The Las Vegas Valley (LVV) obtains 90% of its water supply from the Colorado River while remaining 10% is from ground water. Residential water demand accounts for the highest water use in this region (SNWA, 2008), and although semi-arid in climatic setting, the LVV has among highest water consumption per capita in the southwestern United States. Recent frequent droughts and possibility of cutback due to climate change on water supply from the Colorado River have raised importance of demand side management (DSM). Implementation of demand side management measures can act as a new source of water.

Demand management has been practiced extensively in the LVV for the last decade. Water conservation efforts have reduced consumption from 1191 liters per capita per day (lpcd) in 2000 to 930 lpcd in 2010 (SNWA, 2009) despite increase in population, as shown in Figure 1. Still, Las Vegas has the highest per capita consumption compared to Tucson, and Albuquerque, the cities with similar climate. This leaves potential for further conservation of water in the LVV.

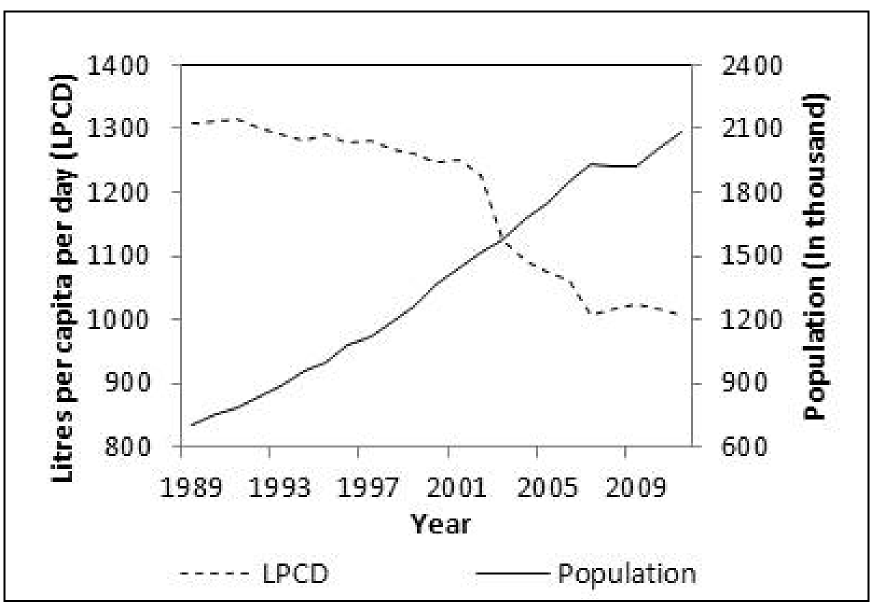

Figure 1. Water Consumption and population growth in the Las Vegas Valley from 1989 to 2010

With this motivation, this project analyzes the effect of population growth and changing climatic conditions on water demand in the LVV. In particular, the project aims to assess role of demand management, analyze portfolio of available water sources and vulnerability of the water supply system in the LVV. For this, the current study assesses potential of demand management of each city (within LVV) in detail by making use of available conservation and water demand data from various local agencies and contribute towards analyzing potential imbalances in demand and supply under population growth and climate change impact. A system dynamics model is being developed and applied to test various management strategies related to water conservation. The study will help develop local expertise, increase agency-academia interaction, and support students and young researchers. Results from the study will be published in peer reviewed journals and communicated to local stakeholders including general public. A major emphasis of the study is to contribute towards public education on the importance of water conservation through findings of the study. Additionally, data and results of the present study will be used to develop competitive proposals to further enhance our understanding in other critical areas of water management under climate change.

Methodology

As part of understanding demand and supply imbalances, first a system dynamics model (SD) model for water demand prediction was developed using STELLA software. System dynamics is a dynamic simulation model created by the causal influence of feedback loops and time delays. The user friendly interface of the system dynamics software is considered to be conducive to communication with stakeholders. Above all, understanding and dynamically simulating the changing behavior of water resources system can provide scientific basis for developing demand management strategies.

Water demand sector in the SD model was developed for residential customers in three different cities: the City of Las Vegas and Unincorporated areas in the Clark County, the City of Henderson, and the City of North Las Vegas. End use method was used for projecting water demand in all three cities. Indoor and outdoor demands were modeled separately. Water savings obtained with each appliance was estimated by subtracting the efficient use by water smart appliances from non-efficient use by non-conserving appliances. Outdoor water use was divided into landscape water use and water use by swimming pools. Landscape consists of both turf land and water smart landscape.

The landscape water demand was calculated by multiplying the average lawn size per household and water used per square meter for lawn irrigation. Water savings was obtained by converting turf grass into water smart landscape. Swimming pools water demand was calculated by multiplying the average pool area and depth with the water required per unit volume along with the water lost from uncovered pools due to evaporation. The frequency of water change in swimming pools was considered once a year. Use of cover in swimming pool is considered to save water loss due to evaporation. Likewise, pool cover saves on average about 2034 liters per square meters of water per year which would otherwise be lost (SNWA, 2009).

The effect of climate change was incorporated in the model by using ordinary least square regression equation obtained between monthly water demand, and climate variables including monthly average temperature and precipitation. The effect of change in both climate variables (temperature and precipitation) was considered. Temperature positively correlates the outdoor water demand, while precipitation is expected to negatively correlate.

<u>Principle Findings and Significance</u>

The study is currently ongoing due to a late start (delay in funding) and only a completed part is reported in this report.

Effectiveness of DSM measures

Turf conversion to water smart landscape started in year 1996 and progressed through years until today. Irrigation clock rebate started in year 1998 and ended in 2006.

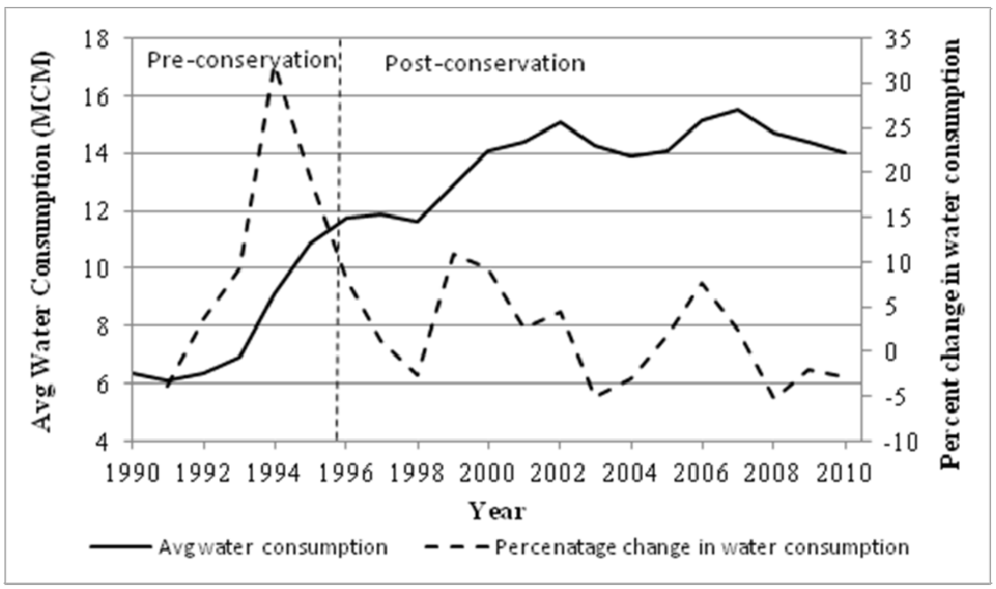

Figure 2. Average monthly water consumption and percentage change in water consumption in the Las Vegas Valley Water District

Effectiveness of DSM measures in the LVV can be clearly seen from the Figure 2, which shows the average single family residential water consumption from years 1990 to 2010; this duration is divided into pre- and post conservation period. Pre-conservation years start from 1990 and lasts till 1995, while post conservation runs from 1996 to 2010.

Water Demand Assessment

A city-wide spatial water demand has been successfully calibrated with calibration runs from 2003 to 2010. The calibrated model is used to run future simulations from 2013 to 2035. Future simulations are run for different scenarios of population growth and different demand side management measures. Two scenarios of population growth considered in the study are, (1) status quo population growth, and (2) only 50% of the projected growth. In status quo population growth scenario, it considered to increase in consistent with the growth rate projected by the Center for Business and Economic Research (CBER), and no further conservation potential was considered. Second scenario of population growth considers that the growth rate is only 50% of the rate projected by the CBER. This is consistent with recent reduction in the population growth rate in the LVV. Conservation scenario considered that houses built after 2013 will be built as water smart and will conserve water both indoor and outdoor.

Calibration of historic water usage for single family residential (SFR) customers was made for the city of Las Vegas from 2003 to 2010 based on observed water usage obtained from the Las Vegas Valley Water District (Figure 3). Root Mean Square Error (RMSE) and mean absolute error (MAE) of about 1.5 Million Cubic Meters (MCM) and 1.2 MCM were obtained between observed and simulated water demand for SFR customers. Because of lack of data availability and other problems in actual historical water usage for North Las Vegas and Henderson, we used an average percentage of water usage in the LVV to derive monthly water usage time series for these two cities. Figure 4 and 5 respectively show a comparison of simulated and observed monthly water usage data for North Las Vegas and Henderson for the duration of 2003 to 2010. RMS error between observed and simulated water demand in in North Las Vegas and Henderson was 0.44 MCM and 0.27 MCM, respectively. Similarly, MAE for Henderson and North Las Vegas were 0.21 MCM and 0.37 MCM, respectively.

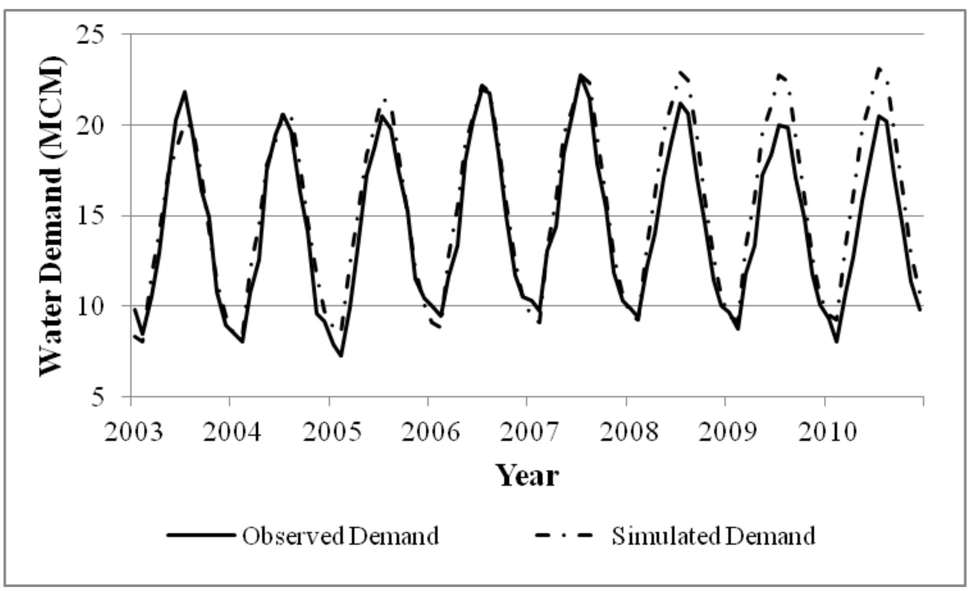

Figure 3. Comparison of historical and simulated water demand in the City of Las Vegas for duration of 2003 to 2010

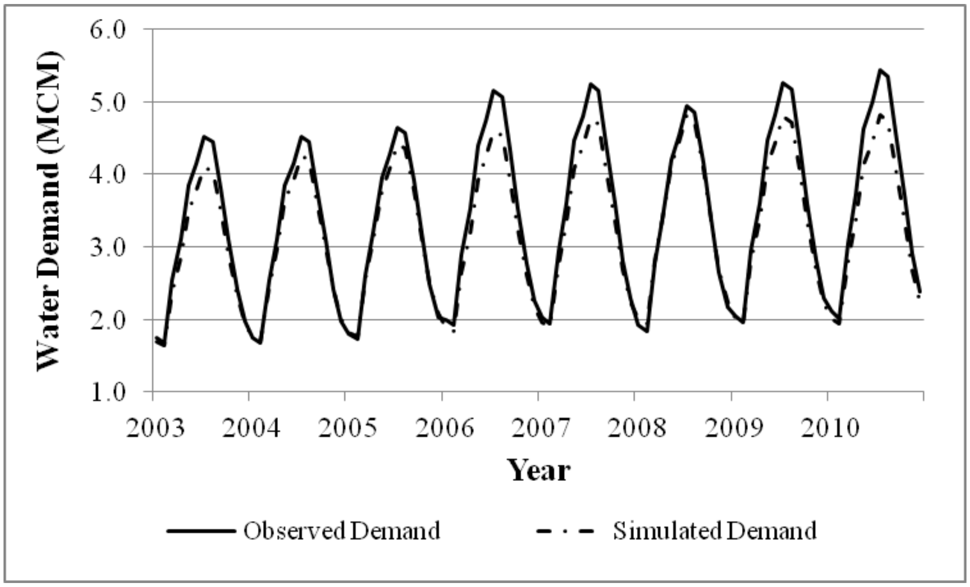

Figure 4. Comparison of historical and simulated water demand in the City of Henderson for duration of 2003 to 2010

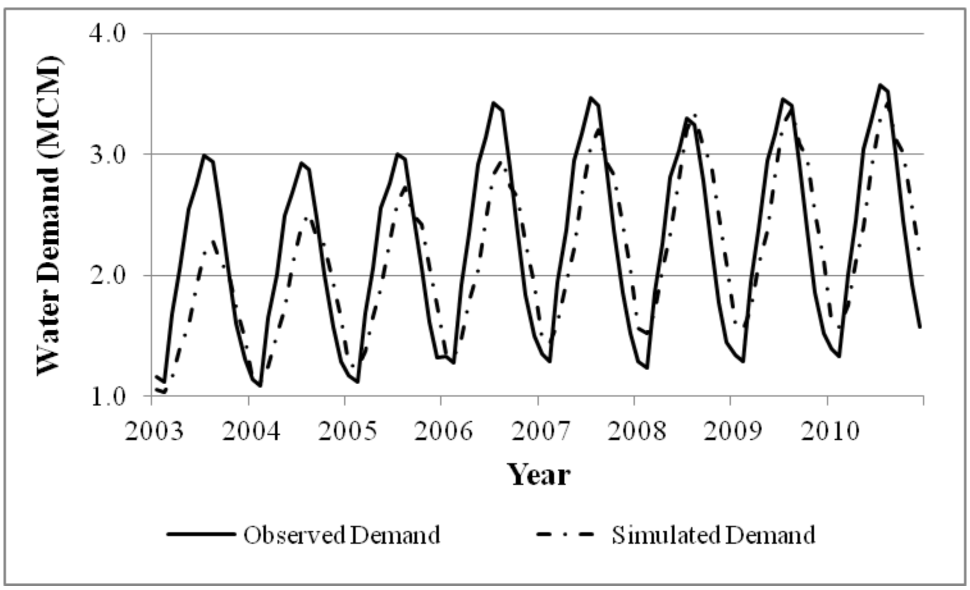

Figure 5. Comparison of historical and simulated water demand in the City of North Las Vegas for duration of 2003 to 2010

Simulation under two growth scenarios

The SD model was run for future simulation for the duration of 2013 to 2035. As described in the modeling approach, future simulations were run for different scenarios of population growth and water conservation measures, as well as climatic conditions (ongoing). For future simulations, results are presented for all residential customers in the LVV. Results for different scenarios are listed below:

a. Base case: In this scenario, population in each city grows as predicted by the CBER, and no further DSM measures are considered for water conservation; similarly there is no change in the climatic conditions. Water demand for residential customers in the cities of Las Vegas, North Las Vegas, and Henderson reached 390.4 MCM, 104.6 MCM, and 88.9 MCM respectively, a total of 583.9 MCM for residential customers in the LVV.
b. Conservation scenario: In conservation scenario, three DSM measures were considered: indoor conservation, landscape conversion, and using swimming pool covers. Each scenario was used with base case population growth rate and only 50% of the population growth. Additionally, retrofitting 50% of the existing houses were also considered. A list of all conservation policies for base case population growth scenario and only 50% of the projected growth scenarios are presented in the Table 1. Water demand in 2035 for all three cities is shown along with percentage savings for each DSM measure. Percentage savings were obtained by comparing water demand data obtained in conservation scenario with that obtained in base case scenario.

Principle Findings

Our simulation results showed that landscape conversion was found to be more effective compared to indoor conversion. Indoor conservation has not been extensively practiced in any of these three cities as credit is obtained with more water used indoor, through return flow credit policy. Total percentage savings for indoor conservation, landscape conversion, and combination of all DSM measures were 4.4%, 13.3%, and 17.8%, respectively. Similarly, water demand in 2035 for all the cities for different population growth rates and different DSM measures along with 50% retrofit of the existing houses are shown in the Table 1. With 50% growth in population from the projected growth rate, combination of DSM measure resulted in water demand of 278.4 MCM, 63.4 MCM, and 58.7 MCM in city of Las Vegas, North Las Vegas, and Henderson, respectively.

Collaboration with Stakeholders and Research Result Dissemination

The project was conducted with support from and collaboration with the Southern Nevada Water Authority (SNWA). Due to late start of the project, this research is still continuing and the results have yet to be presented to a workshop or symposium. However, series of presentations are aimed in the future at various local and regional conferences this year. The PIs, staff and the graduate student plan to attend AGU fall meeting and present a poster. A manuscript is currently being written for potential submission to a peer reviewed journal.

Student Support

The project partially supported a post-doctoral researcher and two graduate students (Peng Jiang from the Department of Geoscience, and Srijana Dawadi from the

Department of Civil and Environmental Engineering, University of Nevada Las Vegas). The project will contribute to a thesis chapter of Peng Jiang's Ph.D. dissertation.

Publications

A manuscript is currently being written to be submitted to a peer review journal paper in the near future.

Table 1. Water demand in 2035 using different demand side management measures

S.N	DSM Measures	Water Demand (MCM)				% Savings
		Las Vegas	North Las Vegas	Henderson	Total	
Base Case Population Growth						
1	Indoor conservation	376.4	96.8	84.9	558.1	4.4
2	Landscape conversion	350.8	80.9	74.4	506.1	13.3
3	Combination	336.7	73.0	70.4	480.1	17.8
Base Case Population Growth With 50% Retrofit						
4	Indoor conservation	365.6	95.0	83.0	543.5	6.9
5	Landscape conversion	303.3	73.1	64.6	441.1	24.5
6	Combination	278.4	63.4	58.7	400.5	31.4
Population growth only 50% of the projected growth						
7	Indoor conservation	317.2	68.1	68.4	453.8	22.3
8	Landscape conversion	309.7	61.6	64.1	435.3	25.4
9	Combination	305.5	58.3	62.4	426.2	27.0
Population Growth only 50% of the Projected Growth with 50% Retrofit						
10	Indoor conservation	306.4	66.3	66.5	439.2	24.8
11	Landscape conversion	262.7	53.8	54.3	370.7	36.5
12	Combination	247.6	48.7	50.7	347.1	40.6

Effects of Regional Climate Change on Snowpack in Northern Nevada: Research and Education

Basic Information

Title:	Effects of Regional Climate Change on Snowpack in Northern Nevada: Research and Education
Project Number:	2011NV180B
Start Date:	3/1/2011
End Date:	2/28/2013
Funding Source:	104B
Congressional District:	NV02
Research Category:	Climate and Hydrologic Processes
Focus Category:	Climatological Processes, Hydrology, Water Supply
Descriptors:	None
Principal Investigators:	Rina Schumer, Anna Knust

Publications

There are no publications.

2012 NIWR Project Update
Effects of regional climate change on snowpack in northern Nevada: Research and education

Rina Schumer Division of Hydrologic Sciences, Desert Research Institute, Reno, NV

Problem and Research Objectives

Hal Klieforth, a former Desert Research Institute meteorologist, began measuring monthly precipitation and snow water equivalent at 29 sites between Spooner Summit and Henness Pass Junction (Figure 1) in the mid 1960s. Until recently, the majority of these data only existed as hard copies located in Mr. Klieforth's personal office in Bishop, CA. This dataset is unique in its temporal and spatial resolution; measurements were recorded after nearly every storm at sites spanning elevations of 1,400 to 2,590 masl over approximately 24 linear kilometers. The goals of this project are to 1) complete digitization and QA/QC of the Klieforth data set and 1) analyze the spatio-temporal statistics of precipitation and SWE from the newly compiled dataset combined with observations recorded by other sources (e.g. Snotel and USGS stream gage sites).

Methods

Digitization and QA/QC of this dataset is labor intensive and requires consultation with data collectors. Statistical analyses include non-parametric trend analyses, snowpack centroid analyses, and correlation analysis between datasets.

Principal findings and significance

- Total precipitation has remained constant at the study sites over the study period. The fraction of precipitation that fell as snow (as represented by snow water equivalent measurements) decreased over the study period. This could be significant if associated with a long term climate trend. Specifically:

    - total precipitation in the eastern Sierra Nevada has not changed since the 1960s;
    - the fraction of precipitation as snow has decreased since the 1960s; this fraction is dependent upon elevation; and
    - occurrence of early spring melt-out dates began in the 1990s.

- Comparison of SWE trends for 1960-1990's with Western Regional Climate Center (WRCC) freezing level tracker indicates that this period may be a falling limb of a long term cycle, rather than a new trend, as our initial analysis suggests. This hypothesis is being analyzed in conjunction with Kelly Redmond, regional Climatologist.

Information Transfer Activities

Voepel, H.E.. R. Schumer, D. P. Boyle; A. Knust; J. Ashby; H. Klieforth,. Changes in Eastern Sierra Nevada precipitation related to climate change. AGU Fall Meeting. San Francisco.

Student Support

This grant is funding the Master's research of Tracey Backes. Hal Voepel, a PhD student received a few months of funding for data preparation statistical analysis.

Quantifying the Impact of Hyporheic Exchange on In-Stream Water Quality in the Truckee River, NV

Basic Information

Title:	Quantifying the Impact of Hyporheic Exchange on In-Stream Water Quality in the Truckee River, NV
Project Number:	2011NV181B
Start Date:	3/1/2011
End Date:	2/28/2013
Funding Source:	104B
Congressional District:	NV02
Research Category:	Climate and Hydrologic Processes
Focus Category:	Hydrology, Models, Water Quality
Descriptors:	None
Principal Investigators:	John J. Warwick

Publications

There are no publications.

2012 NIWR Project Update
Quantifying the Impact of Hyporheic Exchange on In-Stream Water Quality in the Truckee River, NV

Rina Schumer Division of Hydrologic Sciences, Desert Research Institute, Reno, NV
Zachary Johnson (Doctoral Student), Desert Research Institute, Reno, NV

Problem and Research Objectives

Hyporheic exchange, the mixing of surface water (SW) and groundwater (GW) beneath and adjacent to streams, can have a significant effect on water quality and aquatic habitat (Gooseff et al., 2006). In this zone, stream water residence times are increased which has a large effect on the fate and transport of solutes (Gooseff et al., 2003). Perhaps the most important function for the Truckee River is the removal of nitrogen through denitrification from the system as periphyton growth in the Truckee River is primarily nitrogen limited (Green, 2002). If hyporheic exchange is increased through current restoration efforts, total periphyton biomass should decrease and the minimum nighttime DO concentrations in the river should increase. Understanding the fluctuations of DO in this system are particularly important for the threatened and endangered habitat of the Lahontan cutthroat trout (threatened species) and cui-ui (endangered species) that historically made spawning runs from Pyramid Lake to the Truckee River (US Fish and Wildlife Service 1992, 1995).

Although the physics of hyporheic exchange are well understood, characterization of exchange over long reaches is difficult. For this reason, most hyporheic exchange studies have focused on relatively short reaches ranging from 300 m to 3.5 km (Gooseff et al., 2003; Jones et al., 2008). The proposed reach length on the Truckee River is approximately 56.5 km, stretching between Derby and Marble Bluff Dams. Apart from the challenges posed by the relatively large reach length, few studies have specifically focused on hyporheic exchange in the Truckee River even along short stretches (Knust and Warwick, 2009). We propose to add hyporheic exchange to an existing model which was previously modified for the Truckee River.

Restoration efforts along the Truckee River plan to return the river to more natural conditions including the addition of stream meanders and pool-riffle sequences. Despite the fact that these projects are known to increase hyporheic exchange (Sawyer and Cardenas, 2009), the magnitude of influence towards in-stream water quality does not appear to have been addressed in previous studies. We will use knowledge gained about the hyporheic processes in the Truckee River and the factors controlling them to quantify the relative impact of these restoration efforts on the in-stream water quality.

Specific research objectives for Year 1 were a dye tracer test in geomorphically distinct sections of the Truckee River to assess differences in hyporheic exchange and to develop a framework for including hyporheic exchange in the river water quality model WASP.

Methods

In Year 1, we conducted a dye tracer experiment to estimate the stream storage coefficient (α), the storage zone cross-sectional area (As), dispersion (D), the first-order decay coefficient for the stream (λ), and travel times between measurement points. We injected Rhodamine WT, a conservative dye, to allow for complete mixing across the stream above our model area. Real-time dye concentrations were monitored at our three points with field fluorometers. Water samples were also collected for more detailed laboratory measurements. Principal findings are below. This year, we also developed the concept for introducing hyporheic exchange into the WASP water quality model. This coding is in progress.

Principal findings and significance

The unusually late and large 2011 snowpack resulted in high Truckee River flows into September. Principal findings from the field study are

- there is significantly more mass loss in the channel reach with higher sinuosity
- no significant power-law tailing was observed in either reach. We suspect that flow rates may have been too high to observe significant hyporheic exchange in the river. As a result, surface storage dominated over hyporheic storage
- longitudinal hyporheic storage dominated lateral hyporheic storage suggesting that water quality modelling should emphasize sub-channel exchange.

Information Transfer Activities

Johnson, Z.C.; Schumer, R.; Warwick, J.J.; McKay, A.; 2011. Hyporheic exchange in geomorphically distinct sections of the Truckee River, NV AGU Fall Meeting. San Francisco.

This work is currently in progress and does not yet have any publications.

Student Support

This grant is funding the PhD research of Zachary Johnson.

Information Transfer Program Introduction

None.

USGS Summer Intern Program

None.

Student Support					
Category	Section 104 Base Grant	Section 104 NCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	2	0	0	0	2
Masters	1	0	0	0	1
Ph.D.	2	0	0	0	2
Post-Doc.	3	0	0	0	3
Total	8	0	0	0	8

Notable Awards and Achievements