Lake Mead Ecosystem Monitoring Workgroup

Date: August 23, 2012
Location: SNWA, Molasky Corporate Center
Suite 700, Colorado River Room #2
100 City Parkway, Las Vegas NV 89106

Participants

Kumud Acharya (DRI), **Achyut Adhikari** (DRI), **Becky Blasius** (Reclamation), **Doug Drury** (CCWRD), **Dan Fischer** (Las Vegas), **Debora Herndon** (NDOW), ***Janet Kirsch** (Reclamation), **Dana La Rance** (Henderson), ***Maria Lopez** (MWD), **Jennell Miller** (UNLV), ***Randy Pahl** (NDEP), **Craig Palmer** (UNLV), ***Reynaldo Patiño** (USGS), **Peggy Roefer** (SNWA), ***Michael Rosen** (USGS), **Roslyn Ryan** (SNWA), **Scott Schiefer** (Las Vegas), **Seth Shanahan** (SNWA), ***Bill Taylor** (MWD), **Todd Tietjen** (SNWA), **Warren Turkett** (SNWA), **Kent Turner** (NPS), **Ron Veley** (USGS), ***Doyle Wilson** (Lake Havasu), **David Wong** (UNLV), and **Xiaoping Zhou** (SNWA).
* via conference call.

Action Items

- Next meeting: **December 05, 2012 • 1:00 pm • SNWA Molasky Corporate Center, Colorado River Room-2**. **PLEASE NOTE CHANGE OF DATE**

Summary

1. Welcome, Introductions, and Other Business (Kent Turner, NPS)

Kent opened the meeting and participants introduced themselves. The agenda, which was developed and circulated prior to the meeting and is represented in the headings below, was reviewed.

Brief update by Todd Tietjen (SNWA)

Strong thermal stratification of Lake Mead has now occurred (30°C at the surface); although, it took longer to develop this year than in past years. In the past couple of weeks, some *microcystis* has been observed in samples from the back of Las Vegas Bay. This finding is unremarkable; SNWA monitors the species because it has the potential to be toxin forming under the right conditions. Some changes in algae were noted for Lake Mohave where, for several weeks, excessive accumulations of *Cladophora* (filamentous algae) occurred on the SNWA water intake and everything at Willow Beach was covered. Next week, Todd will accompany Jessie Rinella (NPS) to take nutrient/chlorophyll samples from Lake Mohave starting at Willow Beach and sampling every 5 miles plus at all high-use coves. There is no indication that phosphorus is coming from Lake Mead. This activity is intended to provide a snapshot of Lake Mohave and is unlikely to pinpoint a nutrient

point source. It is possible that quagga mussels have changed the distribution of nutrients to benefit algae; but other causes for the algal growth are also plausible.

Comment: High algal growth has occurred near Willow Beach for several years due to the clear water conditions and abundant sun. Nevertheless, the present growth seems to be higher since Big Bend Water District is having to clean their intake structure every two weeks. Central Arizona Project (CAP) has also experienced issues with aquatic plant growth and the disposal of it. Tons of plant material is removed monthly from the boom that protects their intake.

Quagga Mussel Announcement

At the 8/15/2012 Interagency Quagga Mussel meeting, a new Minimal Monitoring Plan for Quagga Mussels was distributed for final review. The plan includes substrate, veliger, and juvenile/adult monitoring. Its purpose is to ensure that the most critical or "core" aspects of data collection begun by I-MAP are continued despite the extremely limited funding environment of the current times. As the group moves into the future, it will take collective resources to fund continued quagga mussel efforts. The Bureau of Reclamation has agreed to fund the juvenile/adult sample analyses by UNLV for transects from two sites selected on Lake Mead and two on Lake Mohave through 2013. NPS will collect the samples (via dive and PONAR). This effort will also look at benthic invertebrates. Veliger monitoring funded by SNWA and others will also continue.

Michael Rosen noted that a USGS/NPS collaborative grant will fund PONAR grabs from two or three locations over the next couple of years for invertebrates, including quagga mussel. The USGS/NPS project should be coordinated with the Reclamation-funded work mentioned above to prevent duplication of effort.

2. Topic Presentations:

USGS STUDIES—LAKE MEAD WATER QUALITY MONTORING

Ronald J. Veley, USGS

See presentation file: Veley_LaMEM_2012-08-23.pdf

Ron provided an overview of USGS water-quality monitoring collection efforts past and present in the Lake Mead ecosystem. Data are collected in cooperation with Federal, State, and local entities to provide insight into the physical and chemical processes that affect Lake Mead water quality.

Data Collection

See presentation file for a map of the water quality monitoring stations (not all are currently active) and screenshots of the web interface. Data are available at http://maps.waterdata.usgs.gov/mapper/index.html.

Following are past and present USGS water-quality-data-collection stations located within the Lake Mead ecosystem:

Colorado River Station	Located above Diamond Creek at Peach Springs, AZ, this station is currently a USGS discharge-gaging station. Water-quality data were also collected in cooperation with SNWA at this station.
Muddy and Virgin River Stations	USGS cooperated with SNWA and NPS for approximately three years to collect water-quality data at these stations (water years 2008-2010).
Lake Mead Stations	Data-collection stations were located in shallow water (<20 m) at Las Vegas Bay and Overton Arm, and in deep water (>20 m) near Sentinel Island and at Virgin and Temple Basins during water years 2005-2009. The stations were operated in cooperation with the NPS and SNWA. Currently, two USGS stations are active at Lake Mead: (1) a meteorological weather station near Sentinel Island operated in cooperation with Clark County Water Reclamation District (CCWRD) and (2) a water-quality monitoring station (>20 m), located in the thalweg of the Colorado River near the entrance to Black Canyon, Boulder Basin. Data from the Lake Mead stations are available online at http://nevada.usgs.gov/water/lmqw/map.htm.
Lower Colorado Stations	USGS operates a discharge-gaging station below Hoover Dam that also collects water-quality samples quarterly.

Boulder Basin Monitoring Station

The Boulder Basin Monitoring Station collects data every 5 m starting 1 m below the surface to depths of 111 m (10 m from bottom). The near continuous, depth-dependent, water-quality data collected include water temperature, specific conductance, dissolved oxygen, pH, and turbidity. Profiles are taken every six hours starting after midnight daily. Each day, the profile of the previous day is accessible online (along with all historical data associated with the site). See PowerPoint for sample graphs generated from 8/21/2012 data.

Ron presented a series of graphs (see PowerPoint) showing the averaged monthly temperature profiles (July 2011 – July 2012). NOTE: graphs are based on provisional data. Stratification is apparent from July through October. In November and December, a shape change is obvious in the graph (note the line becoming more vertical). The nearly vertical line is clearly obvious in February and March at approximately 12°C. The process of annual temperature change repeats starting in April. The Boulder Basin monitoring station, a cooperative effort between USGS and SNWA, is on course to continue monitoring through the end of September 2013.

Question: Have you ever thought of studying gradients from the bottom up (rather than dropping the sondes down from a platform)?

Response: Yes, bottom-up sampling is possible; it is usually used in discreet sampling. Typically, USGS works in a down-stream-ordering numeric system when establishing surface-water stations. When the Lake Mead stations were initially established, the project managers followed this format when setting up the top-to-bottom format of the data collected at these sites.

Question: Do you know when you hit bottom?

Response: The sondes do have depth sensors. We also use our boat's depth sensors (sounding equipment) and Reclamation's lake-level data to monitor how close we get to the bottom. If needed, we can change the last depth collected to avoid hitting the bottom using remote, telemetric access to the equipment from the office.

Comment: The scoping process has begun for the Environmental Impact Statement (EIS) on the operations of Glen Canyon Dam to meet requirements of Grand Canyon Protection Act and Law of the River for operations. One alternative is looking at ways to modify temperatures to enhance humpback chub at the Little Colorado River. The new temperatures considered in the alternative future do not drastically differ from the existing temperatures; however, the change would involve structural temperature control devices at the dam (this is all undecided as of yet). Members of the LaMEM Workgroup noted they would be interested in seeing how such changes would impact the flows and limnology of Lake Mead, and the group would be interested in using ELCOM-CAEDYM to model various scenarios.

Comment: We should request that a temperature recorder be re-installed at Diamond Creek. Kent Turner anticipates making this request in future discussions, if appropriate.

Response: NPS Lake Mead NRA will request that device (in the future). It was also noted that Diamond Creek temperature data are on the web, but not beyond September 30, 2007. Provisional temperature data may be available offline.

LAKE MEAD AND LAS VEGAS WASH WATER QUALITY MONTORING

Scott Schiefer (City of Las Vegas) and Dana La Rance (City of Henderson)

See presentation files: Schiefer_LaMEM_2012-08-23.pptx and La Rance_LaMEM_2012-08-23.pptx

Scott Schiefer and Dana La Rance gave a joint presentation on the Lake Mead and Las Vegas Wash sampling programs carried out by the City of Las Vegas, City of Henderson, and the Clark County Water Reclamation District.

Purpose of water quality sampling: To satisfy Permit Condition I.A.21 of the Nevada Division of Environmental Protection (NDEP) National Pollution Discharge Elimination System (NPDES) permits for the Las Vegas Valley require dischargers to monitor the ambient water quality of Lake Mead and the Las Vegas Wash. The current permit requires the dischargers to submit a sampling plan by November 1 for the following year to the NDEP for approval. The sampling plan contains details on the Las Vegas Wash and Lake Mead water-quality sampling standards.

Lake Mead Water Quality Monitoring

Reporting

All Lake Mead data generated through this program is submitted to the state each quarter. The permit also requires submission of an annual report prepared according to NDEP guidelines. The **2011 Annual Report** has recently been completed and is available upon request. The data can also be accessed from the Lower Colorado River Water Quality Database.

Sampling

See PowerPoint for map of monitoring sites.

For a copy of the current sampling plan, e-mail Scott at sschiefer@lasvegasnevada.gov. The current permit specifies that seven sites are to be sampled weekly to monthly depending on location and season. All seven sites are accessed via boat. Four sites are located within Las Vegas Bay in the middle of the Colorado River channel. Ranging 3.5 miles to 1.2 miles from the confluence of Las Vegas Wash and Lake Mead, they are marked via GPS readings on a regular basis. Below is an overview of parameters studied; for a complete list, please reference the current sampling plan.

Physical Parameters	A Hydrolab DataSonde is used to monitor pH, dissolved oxygen, temperature, and conductivity profiles as specified in the sampling plan. Secchi depth, light transmittance, and general weather conditions are also monitored.
Other Chemical Parameters, Nutrients, and Bacteria	Discrete samples are collected at three depths within the water column: (1) epilimnion—integrated 0-5 m sample; (2) metalimnion—at thermocline when present or halfway between the surface and hypolimnion when not present; and (3) hypolimnion. The samples are analyzed by Clark County Water Reclamation District. Results are sent to the City of Las Vegas where they are formatted for storage in the database and used to create various reports.
Zooplankton	The current sampling plan also specifies that a zooplankton tow will be collected and microscopically analyzed in regulatory samples. Zooplankton are collected using an 80-micron, Wisconsin-style plankton net. Sampling is performed to within 1 m of the bottom or a maximum of 40 m. The enumeration procedure has remained consistent for the last 20 years providing a large dataset to assess how changes (e.g., veligers and treatment-plant improvements) have affected zooplankton populations. Next year's analyses may include quagga mussel veliger counts.

Scott noted that winds up to 25 mph create a significant challenge to sampling. Because most of the stations are too deep for anchoring, a "sea anchor" (a large, underwater, parachute-like device) must be used to maintain position.

Selected Results

See PowerPoint for graphs.

Total phosphorus daily average (LWLVB1.2): This is the closest permit site to the confluence of Las Vegas Wash and Lake Mead. The trend, over the last five years, is only very slightly positive.

Chlorophyll-a (Chl-a): Located in Las Vegas Bay, LWLVB1.85, is the primary site that the permit specifies for chl-a compliance. The data show expected summer peaks, but unlike the phosphorus data, the chl-a trend is slightly downward. Quagga mussels are being considered as a potential explanation for the gradual decrease in the chlorophyll concentration at this site; colonization started slowly in Las Vegas Bay, but recently has increased. Site CR350.0SE0.55 (Boulder Basin in the Colorado River channel) is not influenced by the Las Vegas Wash and, therefore, is monitored as a comparison site. Here, the chl-a concentration decrease is more dramatic, possibly correlating with the quicker development of quagga mussel populations that occurred in this location.

Zooplankton: In Las Vegas Bay at LWLVB1.85, Cladocerans, copepods, and rotifers do not appear to have decreased significantly between 2007 and 2012. In contrast, at CR346.4 (in Boulder Basin), zooplankton numbers do appear to have decreased since 2005 and since the 2007 onset of quagga mussels; nonetheless, zooplankton numbers are stable at this site and do not appear to be declining further.

Secchi Depth: Many factors can affect the water clarity of a lake. Several major changes to Lake Mead have occurred over the last couple of years including fluctuating lake levels, the establishment of the quagga population, and a new treatment plant, all of which have potential to impact water clarity. However, even at site LWLVB1.85 (less than 2 miles from the Wash), the unchanged Secchi values demonstrate Lake Mead's assimilation capacity. At site CR350.0SE0.55 (Boulder Basin), a low nutrient load and corresponding excellent water clarity is evidenced in its Secchi values. Initially, fears were expressed that quagga mussels could clear up the water column further and cause problems with macro plant growth as seen in other parts of the country. So far, this has not been an issue in Boulder Basin in part due to the lack of nutrients available for growth.

Question: What are the P values in your data analyses…are the trends real?

Response: There are a lot of data; the trends are likely significant. The long-term trends for chlorophyll and phosphorus have ridiculously bad R^2 values. However, the lines are significant in that the numbers are significantly different from zero. The old version of the LAKEWATCH system tried to remove variation due to seasonality, but this did not provide for more meaningful interpretation in terms of R^2 or P values.

Comment: Consider compiling all the data from the months within each season, then look at the P values in comparisons of seasons.

Las Vegas Wash Sampling and Analysis

Las Vegas Wash and Tributaries Overview

See PowerPoint for map.

The Las Vegas Wash is the only major outlet for the Las Vegas hydrographic basin and the entire 1,600-square-mile Las Vegas valley. All stormwater flows, urban runoff, shallow groundwater seepage, and about 140 million gallons per day of treated effluent from the City of Las Vegas, Clark County Sanitation District, and City of Henderson flows through the Las Vegas Wash to Lake Mead. Approximately 80 percent of the water in the Wash comes from the water treatment plants.

Wastewater Treatment in the Las Vegas Valley

As mentioned above in the Lake Mead portion, the Nevada Division of Environmental Protection (NDEP) issues and reviews National Pollutant Discharge Elimination System (NPDES). Permits for Clark County Water Reclamation District (CCWRD); City of Las Vegas; City of Henderson; and City of North Las Vegas are valid for five years. The "208 Plan" is an area-wide, waste-treatment-management plan authorized under section 208 of the federal Clean Water Act. It develops a comprehensive program for the treatment of wastewater and for controlling water pollution from all point and non-point sources in the geographic area. In accordance with the 208 Plan and their respective discharge permits, dischargers collect and analyze samples from Las Vegas Wash, Las Vegas Bay, and Lake Mead. Data collected are used to assess compliance with water-quality standards; maintain and water-quality model; and assess water quality trends. Data are uploaded to the Lower Colorado River Regional Water Quality Database.

In the 1990s, the City of Las Vegas took over monitoring that was previously conducted by the UNLV Limnological Research Center. In 1994, the City of Henderson began to discharge to the Las Vegas Wash and, in turn, to contribute to the monitoring requirements. In 1995, the City of Henderson began sampling the Las Vegas Wash in an effort that continues to this day.

Sampling Locations

See PowerPoint for maps, descriptions, photo, and permit requirements dictating sampling frequency.

LW 11.5 (LW11.5)	Las Vegas Wash just upstream of where Sloan Channel meets Las Vegas Wash. This is upstream where the City of North Las Vegas discharge enters the Las Vegas Wash (via the Sloan Channel). The purpose of this station is to determine the water quality of the Las Vegas Wash prior to discharges from any of the four wastewater-treatment plants. This is the newest location.
LW 10.75 (LW11.1)	Las Vegas Wash between the confluence of Las Vegas Wash and Flamingo Wash, and the City of Las Vegas Water Pollution Control Facility discharge. This station is also downstream of the confluence of the Sloan Channel and the Las Vegas Wash.
LW 8.85 (LW8.85)	Las Vegas Wash downstream of where the City of Las Vegas and Clark County Water Reclamation District discharge enters the Wash.

LW 6.05 (LW5.55)	Las Vegas Wash near Telephone Line Road, downstream of where the City of Henderson Water Reclamation Facility discharge enters the Las Vegas Wash. The purpose of this station is to determine compliance for the upper Las Vegas Wash reach.
LW 3.7 (LW 3.1)	Las Vegas Wash before the sedimentation basin for Lake Las Vegas.
LW 0.55 (LW0.9)	Las Vegas Wash at Northshore Road – egress of pipe under Lake Las Vegas.

() actual name of site that corresponds to database.

Sampling Method Highlights and Results

See PowerPoint for graphs.

Field measurements for pH, temperature, dissolved oxygen, and specific conductance are collected with a Hydrolab MiniSonde®5. Graphs with data from each of the six sampling locations were shown.

Microbiological and laboratory physical measurements are completed for Total Dissolved Solids, Total Suspended Solids, turbidity, fecal coliform, and *E. coli* as required by the permit. The City of Henderson also collects data for sulfate, chloride, and total coliform. Graphs with data from each of the six sampling locations were shown.

Nutrients analyses are completed for total phosphorus as P; dissolved ortho-phosphorus as P; Ammonia as N; Total Kjeldahl Nitrogen (TKN) as N; Nitrite as N; and Nitrate as N. Graphs with data from each of the six sampling locations were shown. Phosphorus concentrations are low; new, more sensitive detection methods are being developed, which will be able to show even lower phosphorus levels in future sampling. Dana noted that ammonia and TKN concentrations are also quite low in the Wash.

Toxic parameters are also studied, including total metals, pesticides, volatiles, semi-volatiles, and additional various compounds. Samples are collected for these parameters twice per year. See PowerPoint for the list of Priority Pollutants plus additional compounds; everything crossed out is not observed. Testing for most of these parameters is done at external labs (sub-contracts). Graphs of 2011 fluoride data from each of the six sampling locations were shown. In 2011, metals were also analyzed by Clark County; graphs of metals concentrations at sampling site LW0.55 were presented.

Question: You mentioned you measure turbidity in the lab**.** Why not measure it in the field?

Response: I believe there were issues with calibrating the instrument to measure turbidity; in addition, the water levels in the Wash increase the difficulty of measuring turbidity in the field. The City of Las Vegas also analyzes turbidity in the lab. All analyses are conducted the same day as collection. It was noted that it is a good observation that field measurements and laboratory measurements for turbidity can provide different results based on the nature of how sediments settle out.

SELENIUM MASS BALANCE IN THE LAS VEGAS WASH USING FIELD DATA AND MATHEMATICAL MODELING

Kumud Acharya,Ph.D., Desert Research Institute (DRI)

See presentation file: Acharya_LaMEM_2012-05-24.pdf

Kumud discussed a selenium modeling study, which has been a collaborative effort between DRI and SNWA.

Project Background (Presented Previously)

The Las Vegas Wash and its tributaries contain elevated levels of selenium and other metalloids. With increasing wetland areas, there is a growing concern over bioaccumulation of these trace elements. Selenium is an essential element at lower concentrations, but toxic at higher concentrations. Because the total selenium loading into Lake Mead has exceeded 1,500 lb/year, SNWA has been regularly monitoring for selenium in Las Vegas Wash waters, its tributaries, and surrounding wetlands, and it has established a baseline dataset. With increasing ecosystem service improvements in the Las Vegas Wash over the last decade, there has also been a significant increase of wetland acreage and growing concern over bioaccumulation of selenium and its possible impact in aquatic habitat. The benefits of using wetlands to remove a wide range of metalloids/metals such as selenium have long been recognized; however, very few studies have explored the mass balance of selenium in wetland ecosystems. This project developed a process-based mathematical model of selenium fate and transport to show selenium distribution in the water, sediment, and plant matter associated with the Las Vegas Wash and its tributaries. The model is based on a system-wide mass-balance calculation that takes into account chemical, biological, and physical processes.

Objectives

(1) Create a **selenium database** that includes data for major components (water, sediment, and plants) from Las Vegas Wash and its tributaries.
(2) Develop a **selenium mass balance model** using the system-dynamics approach to determine where the selenium is coming from and where it is going, trying to incorporate as many processes (e.g., sedimentation, uptake by plants, volatilizations, etc.) as possible. It was noted that there are some unknowns (e.g., impact of seepage) that limit the model; but that the resulting model can be refined and enhanced in the future as more data are collected.

Step 1 – Design model concept, define boundary area, and develop model framework.

Concept: Selenium speciation and transport pathways in a wetland ecosystem.

See PowerPoint for graphical concept map and framework.

Basically, the system includes water, sediment, and plants – and selenium moves among these three major "storage units," for which input/output and inflow/outflow must be considered.

Boundary Area: Las Vegas Wash.

See PowerPoint for maps (satellite imagery) with the physical boundaries of and selenium input sources into each Box are indicated.

For the model, the entire Las Vegas Wash is separated into five consecutive compartments (also referred to as "Boxes"); the areas within each Box have similar attributes, and Boxes differ from one another in their characteristics (e.g., Box 1 is the driest, whereas Box 3 contains the most vegetation). Each Box is modeled separately as one unit with output that feeds into the next Box in a complex process. The model does not extend beyond the vegetated area flanking the wash.

Step 2 – Estimate selenium mass along major pathways and develop selenium database for modeling.

See PowerPoint for an overview of estimating of selenium in water, sediment, and plant matter.

Additional notes about model components and pathways:

- **Selenium** – there are several speciations of selenium; but the project currently only considers selenium as a single element.
- **Water** – Most selenium is in the water. Discharge data for tributaries and mainstream Las Vegas Wash came from USGS and SNWA. Selenium concentration in the water was provided by SNWA and NDEP. See PowerPoint for equation.
- **Plants** – There are three dominant plant forms in the Wash: cattails, bulrush, common reeds. These macrophytes uptake different concentrations of selenium and have different transpiration rates; they volatilize selenium at different rates (based upon the literature), which the model considers. Reliable coefficients were determined to estimate selenium loss via volatilization. Channel polygons were measured using Arc GIS and field study (plant cover, frequency, density, and aboveground biomass) from selected polygons, with extrapolation to the remaining polygons.
- **Sediment** – The model takes into account the top 6 inches of sediment. Sediment was estimated using selenium mass in seepage water, and considered to be in a state of equilibrium. The Fetter Equation (see PowerPoint) was used to analyze sediment transport.
- **Seasonality** – The model currently takes into account monthly inflow of water and transpiration.

Step 3 – Conduct STELLA model run for the compartments (Boxes) and calibrate model.

See PowerPoint for:

- *Box 1 model calibration data for Box 1 (2006-2008)*
- *Graphs of flow volume (2006-2010) for Boxes 1-4.*
- *Selenium mass and distribution for Boxes 1-4.*
- *The present scenario of selenium storage by different plants contacted within Boxes 1-4.*

Step 4 – Carry out model simulations and complete final report.

Brief Observations and Findings

See PowerPoint for a series of slides summarizing selenium mass balance and distribution for Boxes 1-4 (2006-2008).

Overall, selenium input (total load in lbs) decreased between 2006 to 2008. For each box, note the variation between years. Other considerations to keep in mind include the following: Box 1 is strongly influenced by groundwater discharge. As one moves towards Boxes 2 and 3, the dynamics change quite a bit. There is much more water (more tributary contribution) and more selenium in Box 2. Nearly 97 percent of selenium in Box 2 selenium is in the water; plant matter accounts for very little because hardly any plants exist in Box 2. Box 3 has much more vegetative coverage; it is where the Wetlands Park is located. Less vegetation occurs in Box 4, which has more selenium in the water.

Ongoing Effort – Next Steps and Various Scenarios

The next step will be to manipulate a variety of parameters such as selenium concentrations, the number of plants, and the locations of plants. Other parameters (e.g., phosphorus) can also be added to model.

- Scenarios will be developed assuming variable flow and selenium concentration from existing sources for all compartments.
- Scenarios will be based on ongoing and future management activities (e.g., wetlands area increase/decreased after completion of the Wetlands Park, bank stabilization activities, and associated revegetation plan).

Question: Are you going to remove the plants or just crop them? If you remove the plants, there is the potential to mobilize sediment (and selenium).

Response: This decision rests with resource managers.

FATHEAD MINNOW STUDY AT CLARK COUNTY WATER RECLAMATION DISTRICT (CCWRD) – Parts 1 and 2

Douglas D. Drury, Ph.D., CCWRD and Reynaldo Patiño, Ph.D., USGS

See presentation files: Drury_LaMEM_2012-08-23.pdf and Patino_LaMEM_2012-08-23.pdf

Doug Drury and Reynaldo Patiño gave a joint presentation on the fathead minnow study at Clark County Water Reclamation District (CCWRD).

PART 1 – Wastewater Treatment and Analyses

Doug provided an overview on a portion of a fathead minnow study that occurred between 12/2008 and 3/2011 at the Clark County Water Reclamation District (CCWRD). The presentation focused on

analyses of trace organic compounds and their removal from wastewater. CCWRD priorities for this removal are to (1) protect razorback sucker spawning areas in Las Vegas Bay; (2) protect drinking water intakes downstream of discharges; and (3) provide background information for development of a consensus on future NPDES permit requirements.

Project Background

This study was originally initiated as part of the U.S. Fish and Wildlife Service's biological opinion on the impact of the Systems Conveyance and Operations Program (SCOP) on endangered razorback sucker; fathead minnow served as the surrogate species. Because SCOP has been terminated, the biological opinion is no longer needed. However, the study was completed and the final report is in preparation. The basic research questions underlying this project were: (1) Can wastewater effluent over a long period have a negative impact on fathead minnow growth? and (2) Will wastewater purified with a combined ozone/membrane ultrafiltration (UF) system reduce adverse impacts if any?

For the project, CCWRD proposed a combined ozone/membrane UF system as the best wastewater treatment alternative and built the pilot facility, which it also used for other purposes; it characterized ways to improve the system; and it is conducting ongoing research on contaminants of concern. Other project participants (whose roles are described within the PowerPoint) included U.S. Fish and Wildlife Service, U.S. Geological Survey, Southern Nevada Water Authority, City of Henderson, City of Las Vegas, and City of North Las Vegas.

Analyses

See PowerPoint for plots prepared for selected trace organic compounds.

Most of the trace organic compound analyses for this study were conducted by SNWA. Analyses were completed for steroid hormones; endocrine disrupting compounds; a variety of pharmaceutical compounds; personal care products; flame retardants; and pesticides/herbicides. Treatment plant influent, plant effluent, and ozone-treated, membrane-filtered effluent were sampled and maximum, median, and minimum concentrations were determined for each compound.

Findings

- Biological Nutrient Removal (BNR) treatment with membrane ultrafiltration and ozone disinfection significantly lowers the concentrations of trace organics and removes virtually all of the estrogenicity.
- Ozonation decreases variability, decreases trace organic concentrations, and increases the percentage of non-detects.
- Grab samples for trace organics yield highly variable results. Future study designs should take into account the intermittent nature and peak discharges of trace organics and should consider daily composites to find trace organics present.

Comment: Consider the use of fluorescent (optical) sensors to measure gross organic matter.

Question: It seems that you're looking at 96 percent vs. 98 percent removal…if you're already getting such a great removal rate, is the extra 2 percent removal worth it?

Response: We feel that the multiple barrier system is worthwhile and especially important in the removal of viruses. In addition to the reduction of estrogenic compounds, the system can also remove virtually 100 percent of the enteric viruses that we are capable of monitoring.

PART 2 – Fish Treatment Studies

Reynaldo provided the second part of the fathead minnow study, which included the fish treatment portion. Please note that all data presented today are preliminary and are subject to revision.

Study Objectives

1. Examine the impacts of CCWRD wastewater effluent on fathead minnow (a surrogate for Lake Mead's endangered razorback sucker).
2. Compare the impacts of exposure to wastewater that has been treated by different methods: (A) tertiary-treatment effluent, which is sand filtration/UV irradiation or (B) membrane ultrafiltration combined with ozonation.

Research Design Overview

See PowerPoint for laboratory set-up and photo of an experimental unit.

The overall study featured short-term (21-day) adult exposures and multigenerational exposures, which spanned naïve larvae to F1 juveniles. Embedded within the multigenerational trials were 21-day assessments conducted similarly to those of the short-term trials. The multi-generational trials comprised three phases as follows:

- Phase 1: naïve hatchlings (F_0) exposed through adulthood (6 months)
- Phase 2: at 6 months, applied 21-day assay format (2 males + 4 females per tank)
- Phase 3: raised F1 hatchlings for 40 days

In the 21-day exposure experimental design, each replicate included two males and four females per tank, with four tanks per treatment. Five trials were conducted. Exposure media included diluted wastewater effluents (see A and B, above); a control consisting of dechlorinated tap water (Trials 1 and 2) and deionized/reconsitituted tap water (Trials 3-5); and a positive control which included xenoestrogen. Endpoints included the following: mortality, gonadal histology, nuptial tubercles, blood vitellogenin levels, spawning/egg production, and F1 hatching/growth. Reynaldo noted that spawning/egg production served as a population-performance measure. Therefore, any mortality in a replicate would eliminate the replicate from consideration. At least two of the four available replicates from a given treatment were needed for statistical consideration.

Preliminary Results

See PowerPoint for details of individual trials and graphs.

Short-term (21-day trials): Trial 3 results indicated that standard tertiary-treated water had no effect on fathead minnow reproductive output (even when the trial was extended to 38 days). Trials 4 and 5 did yield results for statistical assessment of reproductive output due to treatment-unrelated mortality. No other differences in any of the other measured outputs occurred, except concerning vitellogenin: a slight reduction in vitellogenin levels was observed in Trial-5 males exposed to the ultrafiltered/ozonated effluent compared to standard tertiary-treated effluent. Additional note: The full experimental design was applied only to trials 4 and 5, where deionized/reconstituted tap water was used as the control. The first two trials used dechlorinated tap water, which led to poor reproductive performance; the third trial was a test of the new control water, which was successful.

Multi-generational Trials: Both effluent types caused concentration-dependent mortality of naïve (F0) larvae during first month but not at later times. Both effluent types had concentration-dependent effects on vitellogenin levels in females.

Preliminary Combined Summary

Endocrine/Reproductive Endpoints

- Lifetime exposure to both wastewater effluent types affected vitellogenin levels in adult female fathead minnow.
- However, reproductive development and reproduction were unaffected by either 21-day or lifetime exposures.

Standard Toxicity Endpoints

- Continuous exposure to both wastewater effluent types affected survival of naïve larval fathead minnow at 30 days but not at later times.
- Trans-generational exposure to undiluted (100 percent) standard tertiary-treated effluent caused reduced hatching rates in F1 embryos.

ENDOCRINE DISRUPTING COMPOUND STUDIES IN THE LAKE MEAD AQUATIC ECOSYSTEM

Michael R. Rosen, Ph.D., USGS

See presentation file: Rosen_LaMEM_2012-08-23.pdf

Michael provided an overview and highlighted key results of studies focused on endocrine disrupting compounds (EDCs) at Lake Mead NRA. It was noted that all results presented (except those that have already been published) are preliminary and subject to revision.

This work included the EDC effort funded by Round-6 SNPLMA, which concludes in December 2012. All fieldwork and analyses have been completed; 14 total publications (journal articles and USGS publications) have resulted from SNPLMA Round 5 and 6 efforts with several in press or still in preparation (see PowerPoint for a list of the most recent publications). Michael noted that studies conducted through a 3-year USGS-NPS collaborative grant funded by USGS will also conclude this year in September. The collaborative work looked at population dynamics and endocrine disruption and provided for additional investigation related to previous intersex findings in fish at Willow Beach. Analyses of these projects have been completed and their interpretation is underway; project results should be ready for discussion next year. Michael acknowledged the USGS, NPS, SNWA, USFWS, UNR, UNLV, DRI personnel and others (a large team) that have contributed to these efforts.

SEDIMENT STUDIES

Sediment Flux Experiment in Las Vegas Bay Using Semi-permeable Membrane Sampling Devices (SPMD) and Polar Organic Chemical Integrative Samplers (POCIS).

See PowerPoint for sampler diagram and graphs of PAH concentrations buried in sediment (by depth ranges), estimated estradiol equivalents (by depth ranges), and mass of a variety of compounds sampled by depth range.

This project was designed to assess whether sediments were a source or sink of organic compounds. SPMDs and POCIS are usually suspended in water. For this project, custom sediment sampling probes were assembled by attaching hollow, perforated stakes containing POCIS and SPMD (three each) to platforms, which were then positioned at the sediment/water interface such that the samplers were buried in the sediment at depths of 0-10, 10-20, and 20-30 cm. In another portion of the study, SPMDs and POCIS were suspended from a water-quality-monitoring station in Las Vegas Bay at a series of different depths (including lake bottom) to determine a vertical gradient of organic compounds in the water column.

<u>Sediment Flux Findings Overview:</u>

The greatest concentration of organic compounds analyzed were detected at sediment depths of 0-10 cm. Many compounds were not detected at all at 20-30 cm depths. Note that the sampler is detecting compounds present in the water (pore-fluid) around the sediment particles, not in the sediment itself. The findings can be interpreted in different ways. One possibility is that at depths of 20-30 cm, contaminants have all been bound to sediment and are no longer present in pore fluid; whereas, at shallower sediment depths, they are not bound and can flux with the water column.

Three New (2007) Sediment Cores from Las Vegas Bay

See PowerPoint for graph showing 2007 core depths adjusted for 1998 ^{137}Cs activity.

Michael noted that a publication describing this work has been completed and is currently under review. In 2007, three new shallow sediment cores (approximately 70 cm deep) were taken from the Inner, Mid, and Outer portion of Las Vegas Bay. These cores were collected to add to findings from a project on sediment-deposition rates and organic compounds in bottom sediment that collected cores from four sites in 1998. The intent was to analyze chemical gradients from near shore to

deeper locations within Las Vegas Bay (i.e., looking for consistency or variations in the different profiles); Core 4 is nearest the Wash and Core 6 is the furthest from the Wash. Very little sediment (only 7 or 8 cm) has accumulated past 1998; and, the new cores did not penetrate pre-reservoir sediments. Sedimentation rate was lowest in Core 6. Age dating of core sediments was done by analysis of ^{137}Cs content, but Core 4, nearest the delta, was not deep enough to detect the Cs peak and so could not be aged in the same way. Two of the new cores could be well correlated to the 1998 cores in terms of age.

Flame retardants (polybrominated diphenyl ethers; PBDEs) in the Sediment Cores:

See PowerPoint for histograms of all PBDEs and plots of PBDEs in Las Vegas Bay sediment cores.

PBDEs are a group of brominated flame-retardant chemicals that have been used in a variety of manufactured products such as fabrics, plasticizers, foam products (shipping materials), etc., for decades. Detections of total PBDEs were found at higher concentrations in the upper 10 – 15 cm of the 1998 and 2007 (up to 65 ng/g) cores and declining to non-detection in the lower parts of the oldest cores. The formulation of PBDEs has changed over time to reduce toxicity; three types are present within the Lake Mead core sediments: penta-BDE (newest, lightest), octa-BDE, and deca-BDE (oldest, heaviest). The change in formulation over time is evident in the cores.

PBDE concentrations decline from the Inner Las Vegas Bay to the Outer Bay, suggesting that the source is the Las Vegas Wash. PBDEs are found in greater concentrations at the top of the cores and decrease at lower levels within the core.

Other Compounds Present in the Sediment Cores:

See PowerPoint for graphs of galaxolide and selenium concentrations within each core by date.

Galaxolide: The polycyclic musk fragrance, galaxolide, used in personal care products was present with concentrations higher at the top of the core, with highest levels detected within Core 2. Galaxolide concentrations are lower in cores taken further out in the Bay.

Selenium: Cores were analyzed for the metalloid selenium due to interest in how it affects fish health. Core 6, furthest from the wash showed the highest selenium concentrations pre-1980, which then declined around 1980. During this time, a lot of effort was made to control run-off from the BMI Site; so, the reduction in the one core may be related, although it is curious that the phenomenon is only seen in the core furthest from the Wash. The other cores and upper part of Core 6 all have show approximately the same concentration of selenium (~1µg/g).

FISH STUDIES

Overall E2/KT Ratios in Common Carp

See PowerPoint for a graph of E2/KT ratios by location and date.

The 17β-estradiol-to-11-ketotestosterone (E2/KT) ratio is a metric of reproductive health and condition; lower E2/KT ratios are expected in healthy male fish. E2 and KT levels were measured in fish sampled in 2007 and 2008 from Las Vegas Wash, Las Vegas Bay, Overton Arm, and Willow

Beach. E2/KT ratios are generally lower in Overton Arm (control site) compared to the other sites, except Willow Beach. Ratios are highest at Las Vegas Wash.

2007 Sperm Counts

See PowerPoint for a graph of sperm count per mL milt by location.

Sperm counts were completed for male fish sampled from Las Vegas Bay, Las Vegas Wash, Willow Beach and Overton Arm. The lowest counts were observed in individuals from Las Vegas Wash and the highest were found in Overton Arm (which was the control site) samples. Las Vegas Bay results were slightly higher than those of Las Vegas Wash, and Willow Beach results were similar to those from Overton Arm.

2007 Testicular Histopathology

See PowerPoint for a photo of Willow Beach carp testes and a photomicrograph of a testicular cross-section.

This project was intended to add more information and insight to a previous Regional USGS study that revealed reproductive abnormalities in fish sampled from a site near Willow Beach in Lake Mohave.

1. Three of five Willow Beach common carp males analyzed from the November 2007 sample batch had testicular tumors, some were possibly pre-cancerous seminomas, others were possibly malignant tumors.
2. The gender of one Willow Beach fish could not be reliably identified by macroscopic inspection of gonads. This intersex fish was histologically identified as a female with undeveloped ovaries containing spermatocytes (male germ cells).

Endocrine Disruption in Common Carp

<u>Summary of field-based studies on common carp:</u>

The reproductive and endocrine condition of male carp in Lake Mead NRA differed among sampling sites and can be classified from higher to lower as follows: Overton Arm > Las Vegas Bay > Las Vegas Wash > Willow Beach. Especially notable observations were: (1) the weak seasonality in the reproductive physiology of male fish from Las Vegas Wash and Willow Beach and (2) the poor condition of fish from Willow Beach including the incidence of gonadal tumors and other reproductive organ anomalies.

<u>Currently ongoing analyses include:</u>

- Levels of chemical contaminants in fish tissues and their association with biomarker differences among sites; and
- Levels of non-chemical environmental factors, such as seasonal profiles of water temperature, and their association with biomarker differences among sites.

Metals in Common Carp

See PowerPoint for a canonical correlation scatterplot of biological traits vs. total metal concentrations.

Metals were studied in fish sampled during March 2008 at Las Vegas Wash, Lake Mead's Las Vegas Bay and Overton Arm, and Willow Beach. Nearly one quarter of the variance in the biological traits observed was explained by the variance in the metal composition of the fish: Ag, As, Ba, Hg, Pb, Se, and Zn appeared to be the most important.

E2 and KT Levels and E2/KT Ratios in Largemouth Bass

See PowerPoint for bar graphs of KT concentration, E2 concentration, and the E2/KT Ratio comparing Overton Arm and Las Vegas Bay largemouth bass from two different sampling events.

During July 2007 and March 2008, adult male largemouth bass were collected at two sites within Lake Mead: Las Vegas Bay and Overton Arm. Plasma levels of estradiol-17β (E2) and 11-ketotestosterone (KT) were determined at the E2/KT ratio calculated. Chemical data are not yet available. Differences were most pronounced in fish sampled just prior to the spawning period (March 2008). Relatively low KT levels and high E2/KT ratios were observed in the Las Vegas Bay males, which is a finding consistent with the reduced health and reproductive condition also observed in fish at Las Vegas Bay. The results for largemouth bass are consistent with findings for common carp, which had been studied in more detail (shown above).

New Projects

A new USGS-NPS collaborative grant study has been approved for funding and will begin in 2013; the project -- to be led by Mike Moran (USGS) -- will assess how EDCs move through the food web. The previous efforts have looked at fish, water, and sediment; the new project will cover the food web, including phytoplankton, zooplankton, invertebrates, forage fish, to see if there is a cumulative effect or biomagnification of EDCs in Lake Mead or whether fish are simply obtaining EDCs through the water. The project will also look at whether quagga mussels have any impact on the movement of EDCs. Sampling is anticipated to begin in the spring. Note that Michael has a new role with the USGS as a Regional Water Quality Specialist, a role with greater advisory and review focus and limited research time.

Question: How can you describe the levels of metals observed in fish tissue; can you classify them as high, moderate, or low?

Response: Michael did not have the results with him, so a detailed response could not be given at this time. Overall, by Reynaldo's recollection, the concentrations were present within ranges reported for other places and were not found at exceptionally high levels; however, the concentrations of a few metals were higher than expected and appeared to correlate with poor physiology.

Question: From your core results, it seems that EDCs are not present below 30 cm mark. Did you take into account degradation?

Response: It was difficult to make sure the samplers were properly inserted into the sediment and situated correctly. Water flux was not measured because it would require the additional and difficult installation of flux meters. The SPMD/POCIS data from the water column showed higher concentrations at lower levels than in the upper levels. There is potential for flux to occur. We did consider degradation; some of these compounds analyzed could degrade.

Question: For your Willow Beach investigations, have you looked at dam operations (e.g., wastewater treatment or leaking transformers) over the years as a possible source of contaminants?

Response: There are limited sources of contaminants to consider at Willow Beach. One is the hatchery. SMPDs and POCIS were installed at five locations: 2 upstream, 2 downstream, embedded in the sediment, and at the benthic level. All of them have been analyzed. Based on some of the initial results, it is less likely than previously thought that the source is the hatchery. There are no upstream sources other than the dam. We did not see a lot of compounds that would be expected from wastewater treatment. Leaking transformers are a possibility but we don't have a clear answer yet. Natural possibilities are also being considered; for example, the water is cold and fish do not reproduce well at low temperatures or maybe the issues are simply related to age.

End of Presentations

3. Announcements, Assignments, Next Meeting Date Reminder

Announcement: The USGS Circular Report (A Synthesis of Aquatic Science for Management of Lakes Mead and Mohave) is almost complete; in manuscript form, it is 300+ pages, double-spaced with figures. It has been under development for 2-3 years, written by 25 authors, reviewed by numerous people, and undergone revisions. It is moving toward the approval stage. Final approval is anticipated for December 31, 2012. Following completion, a public presentation is planned; the report will be available online and printed copies will also be produced.

Suggestion pertaining to the next meeting: Consider holding the LaMEM Workgroup meeting on the same day as the Interagency Quagga Mussel Meeting for the convenience of the many members that attend both meetings.

The group discussed and decided to **re-schedule** the 11/15/2012 LaMEM Workgroup for 12/05/2012 as suggested.