RECLAMATION
Managing Water in the West
Oct- Dec 2008

Science & Technology Highlights

Contents

page

U.S. Department of the Interior
Bureau of Reclamation
Science and Technology

Improving Infrastructure Reliability

Developing affordable SCADA systems. Supervisory Control and Data Acquisition (SCADA) systems allow Reclamation managers to monitor Reclamation equipment on a real time basis—providing up to the minute information on water and power operations. SCADA systems allow Reclamation staff to monitor the internal state of the water delivery or power system, to pinpoint equipment problems before damage occurs, and to improve the efficiency of water and power operations. If every measurement and control point in Reclamation's water delivery systems were tied into a SCADA system, the efficiency of water delivery and use could be improved, and costs of operations reduced Yet the vast majority of such points are operated manually because the high cost of installing SCADA systems has only been justified for the most critical components.. Every SCADA application is a little different, so each requires expensive custom design and engineering.

Reclamation's Ephrata Field Office has developed a SCADA system that uses affordable, general purpose, off- the-shelf components and thereby greatly lowered the costs for the SCADA system. Moreover, this system has been certified as secure through Reclamation's security programs. The Science and Technology (S&T) Program is now making such affordable SCADA systems available for the rest of Reclamation by generalizing this system. This "generic" system will greatly expanded the number of points where SCADA implementation is feasible.

To date, the research project has procured lab space and equipment for a separate testing server, and developed a program to translate the source code for cross referencing and indices to generate the documentation. This detailed documentation is vital to allow Reclamation staff to adapt the software code to their situations and maintain the code. This program will be a standardized way to generate the commented appendix even though several software coding languages will be used. Next, the researchers will develop general definitions and provide a system to ensure that the separate components (e.g., remote terminal unit, central server, and human-machine interface [HMI]) interact effectively. By concentrating on using as much open source software as possible (e.g. MySQL for the central server and FXRuby for the HMI) we will be able to ensure Reclamation has the affordable SCADA technology needed to protect our infrastructure. Alan Schrom (509-754-0242)

Improving Decision Support

Predicting changes in river characteristics to improve river management. Characteristics of river reaches can be altered by natural or managed events such as shifts in climate pattern, invasive vegetation, changes in water depletions, bank stabilization efforts, and construction of cross channel diversions. Predictions of a river's response to these events can aid managers in selecting actions beneficial to future operations and river ecosystems.

The S&T Program is developing a new tool to aid river managers in planning future actions. At Reclamation's Technical Service Center in Denver, the Sedimentation and River Hydraulics Group is teaming with the San Joaquin River Recovery Program and the Platte River Recovery Implementation Program to develop a conceptual model that predicts general changes in river pattern and form. For example, an increase in canal returns or the establishment of invasive vegetation can narrow and deepen a reach of river or cause a transition from a braided to a meandering river pattern. This model is based on the premise that general adjustments in river pattern and form can be predicted by assessing flow, sediment, and other physical river elements.

Model development is based on a review of existing literature and data and on some analysis of new data. New findings (e.g., sediment loads in the Rio Grande River, and vegetation and flow interactions in the San Joaquin River and the Platte River) will be combined with findings on other key elements from literature on rivers in Hungary, New Zealand, Australia, Canada, and the United States. This broad base of development and test information will improve robustness and applicability of the model for managers of rivers throughout the west.

Invasive vegetation stabilizing the Platte River bank

While most element information comes from existing studies, vegetation impacts on bank stability are one of the least quantified of the model elements. Currently, impacts of invasive vegetation are being incorporated based on studies from the San Joaquin River and from the Platte River Recovery Implementation Program. Like many other rivers, the San Joaquin River and the Platte River have been infested with non-native species that increase the stability of the bank and displace natural systems of cottonwood and willow thus altering characteristics of the river. As a preliminary step to incorporating vegetation information into this conceptual model, we assessed river form change on the Platte River and will present information at the 2009 World Environmental & Water Resources Congress in May. Lisa Fotherby (303-445-2476)

Using light detection and ranging (LiDAR) technology to protect our heritage. The National Historic Preservation Act (Section 110) and other legislation requires Federal agencies to protect and manage the cultural resources under their jurisdiction. The S&T Program is using LiDAR to help fulfill these obligations.

LiDAR is a remote sensing system that collects topographic data, and works in a way similar to radar, but using laser light rather than electromagnetic waves. LiDAR can provide highly detailed three-dimensional imagery of cultural resources, such as rock art and archaeological features. Archaeologists can use these data to document the base-line condition of these resources at a very fine scale.

Threshing Machine Canyon, Kansas

The rock art (petroglyphs and pictograph panels) at Cedar Bluff Reservoir in Kansas, date from the mid-19th Century and is subject to natural erosion and vandalism. This location, a National Register of Historic Places eligible site, was an important stopping point for westward traveling settlers and military regiments in the field. Individuals used the sandstone to carve and paint their names, dates, and regimental affiliation.

Reclamation's Nebraska-Kansas Area Office, Mid-Pacific Region's Remote Sensing and Survey Group, and the Land Resources Office in Policy and Program Services are using LiDAR to document this historic era rock art and pinpoint panels that need intervention to retard erosion or reduce vandalism. During the 1st quarter of 2009, the Nebraska-Kansas Area Office summarized the first year of field work and data collection (May 2008). Fieldwork and data collection will continue in May 2009.

Hill and rock inscriptions at Threshing Canyon.

Applying LiDAR technology should create significant cost savings over tradition rock art recording methods as well as provide data which will be used in resource protection and preservation. Thomas R. Lincoln (303- 445-3311)

American Falls Archaeological District, Idaho

Reclamation will also be using LiDAR to protect the public's heritage assets on Reclamation land in the American Falls Archaeological District in eastern Idaho. The District, which is listed on the National Register of Historic Places, contains important archaeological sites that represent the entire span of human occupation in southern Idaho, beginning more than 15,000 years ago. But severe erosion is compromising their integrity.

Using LiDAR to create finely detailed records of the entire area will greatly aid the agency in identifying patterns and rates of erosion and support management actions to mitigate these problems. Jenny Huang (208-383-2257)

Trails made by off-road vehicles scar the landscape within the American Falls Archaeological District are one of the leading contributors to the erosion problem, prompting LiDAR investigations.

Using helium balloons to map changing river topography after dam removal. Following dam removal, downstream river conditions change rapidly, and Reclamation needs to quickly document these changing conditions. Three-dimensional (3D) mapping allows for the measurement of all visible features, expediting field data acquisition and analyses for many disciplines including geology, biology, construction, sedimentation, river hydrology and geotechnical engineering.

The S&T Program is researching ways to use readily available digital cameras to create 3D ground surface maps. Reclamation has used digital cameras to map the structural geology of large vertical rock faces commonly studied at concrete dam sites. This 3D photogrammetry technique has been proven to be highly successful and economical at numerous damsites and has become the tool of choice for mapping steep rock surfaces. We first used this technique at the Chiloquin Damsite, where the old dam was recently removed. We are now applying these techniques and associated mapping software to map river channels, using a

These low level aerial photographs are used in an ongoing study of sediment erosion and debris management.

We are also using the remote controlled cameras to study the stability and habitat value of engineered log jams on the Middle Fork John Day River. The data produce gridded terrain models and topography accurate to a few inches. This topography can be used to determine the location and size of the key pieces within an engineered log jam without having to spend extensive time surveying the structure. For more information on engineered log jams, contact Kendra Russell (303-445-2552).

View of an engineered log jam in the Middle Fork John Day River as seen from a helium balloon about 120 feet above the ground.

For these remote photographs, a Nikon D300 camera is attached to an 8-foot diameter helium balloon. Pan and tilt camera movements are remotely controlled using a control unit designed for flying small airplanes and helicopters. The image from the camera is transmitted to a receiver on the ground so the operator can view through the camera lens. The camera is triggered remotely from the ground at specific overlapping intervals to obtain accurate terrain models, using ADAM Technology software. The images can be exported to other graphical information systems.

D300 Nikon Camera mounted to frame with pan and tilt servo motors to control orientation. Live images are viewed on the ground to help aim and trigger the camera remotely. Pan rotates 360 degrees and tilt rotates from horizontal to straight down. This allows accurate full 3D modeling.

Helium Balloon to carry digital camera is tethered during surveying of engineered log jams. Balloon can carry approximately 12 pounds. Testing of a wing prototype will occur this spring.

Wireless Ground control transmitter to control camera pan, tilt, and trigger mechanism. Screen allows operator to view directly through the Nikon lens for more accurate photographs.

Ongoing research is being focused on improving the battery life of the air-born servo-controls to permit four hour balloon flights. Further refinements are expected to lead to a robust aerial balloon system that can meet a wide variety of Reclamation imaging needs. Pete Shaffner (303-947-3153)

Making it easier to use HydroGeoSphere for complex hydrologic modeling. HydroGeoSphere (HGS) is a computer model Reclamation managers use to help effectively manage water resources and protect complex ecosystems. The model can analyze irrigation systems, wells, and tile drains in one dimension, surface water flow and solute migration in two dimensions, and variably saturated subsurface water in three-dimensions. As it is highly sophisticated and can simulate a large number of physical processes, HGS requires a complex set of inputs, including grid geometry, material properties, and boundary conditions. Furthermore, HGS is a research code, and new model capabilities and features are continuously developed, tested, and added. As a result, a traditional graphical user interface would be costly and expensive to maintain.

Research in 2008 found that integration of HGS with the US Army Corps of Engineer's Groundwater Modeling System (GMS) is possible. GMS is a modeling program for every phase of a groundwater simulation including site characterization, model development, calibration, post-processing, and visualization.

Integrating HGS into GMS would make its sophisticated analytic tools more functional and available to a broad group of existing GMS users. This S&T project proposes to begin the database design for storing HGS model input and output and integrating this with the GMS.

GMS makes building models and viewing results very easy and intuitive using MicroSoft Windows. Integration will allow users to easily access and analyze HGS data. The GMS interface also integrates geologic data, including cross-section delineation either automatically from boreholes or as defined by the user. GMS allows the user to manually define cross-sections between boreholes and to build a 3D mesh that conforms to the cross section profiles.

This S&T project will design a relational database schema for storing HGS model input and output to:

- Simplify interface development, allowing for boundary conditions and material properties to be edited using a generic spreadsheet-like format external or internal to GMS
- Support hydrologic database models under development and stewardship by Federal, State, local, educational and private organizations

The HGS components proposed as part of the database design process include:

- Mesh geometry – 2D and 3D unstructured finite element mesh
- Multi-dimensional arrays – scalar and vector data associated with the meshes
- Boundary conditions – parameters associated with the mesh nodes, faces, and edges
- Time series data – lists of date/time data pairs for both model input and output
- Material properties – properties of the materials involved in the simulation
- Other data – model run options, time step definitions, file paths, field observations, etc.

The mesh geometry and multi-dimensional array data associated with HGS will be converted to the Hierarchical Data Format (HDF5) and eXtensible Model Data Format (XMDF). This will help the integrated model's performance in file input/output efficiency by converting ASCII files into binary files—increasing readability and decreasing the overall file size.

The mesh geometry and multi-dimensional array data associated with HGS will be converted to the Hierarchical Data Format (HDF5) and eXtensible Model Data Format (XMDF). This will help the integrated model's performance in file input/output efficiency by converting ASCII files into binary files—increasing readability and decreasing the overall file size. The relational databases will store modeling information in the form of related tables for boundary conditions, time series, and material properties

The benefits of a relational database include:

- HGS is a complex model with a variety of input options – this will standardize the input, provide a spreadsheet-like interface to define and edit the input data, minimize the learning curve for new users and reduce the implementation costs in GMS.

- HGS is research code and continually being modified. New options for boundary conditions and material properties can be added as the code evolves allowing for support within GMS without significant changes to the GMS code. This will reduce long-term maintenance costs for the GMS-HGS interface and allow HGS to continue to develop as a research tool.

- Importing HGS into ArcGIS for pre- and post-processing and analysis will simplify the learning curve for integration of geospatial data into HGS and reduce the number of software packages current users need to learn to do pre- and post-processing of HGS input/output data.

The design is deliberately structured so that the HGS model data will be stored in a format that is compatible with ArcHydro Groundwater (AHGW). AHGW is an extension to ArcHydro for storing groundwater data, including boreholes, cross sections, 3D geology models, wells (both monitoring and pumping wells), time series, and aquifer boundaries. It also includes a Simulation Feature Dataset for storing groundwater simulation models. AHGW is a popular and widely used data model and toolset for storing surface water data in ArcGIS. AHGW includes features for representing watershed boundaries, river networks, lakes and reservoirs, stream gage data, river cross sections, and time series. Lorri Peltz-Lewis (916-978-5271)

Using electromagnetic surveys and image processing software to map wetland water flows. Managing the water quality in wetlands can be very difficult if wetland managers do not have data on plant water requirements, water quality parameters (e.g., salt import and export), and water use, and thus cannot develop accurate water budgets needed to effectively analyze management alternatives. Refuge managers are reluctant to change the way they apply water to and drain water from wetlands unless the consequences of these actions are known. They need decision tools to map changes in the extent and locations of the most desirable wetland moist soil plants. Annual comparisons of the extent and location of wetland vegetation would provide the direct evidence wetland managers need to help correlate vegetation responses to wetland management actions once all the other biological and climatological factors have been accounted for. Unfortunately, up until now, it has been impossible to construct accurate vegetation maps for wetlands, even with the aid of high resolution aerial photography.

To address these problems, we are engaged in a multi-cooperator study – part-funded by the S&T Program – to develop a set of analytical tools that utilize data from newly installed flow and water quality monitoring stations. State-of-the-art sensor network technology (YSI-EcoNet) and reporting software (Aquatic Informatics-Aquarius) perform real-time quality assurance on the data and provide powerful data visualization features. Remote sensing techniques (e.g., wetland soil salinity magnetic surveys using electromagnetic surveys and image processing software) improve discrimination and quantification of important wetland moist soil plant associations that comprise wetland waterfowl habitat. In these areas, desirable moist soil plants such as swamp timothy, watergrass and smartweed grow in association with other plants – making quantification extremely difficult using typical remote sensing techniques. The research undertaken focuses on the 140,000 acres of wetlands in the San Joaquin Basin where we have tested these technologies for the purpose of evaluating and improving wetland best management practices..

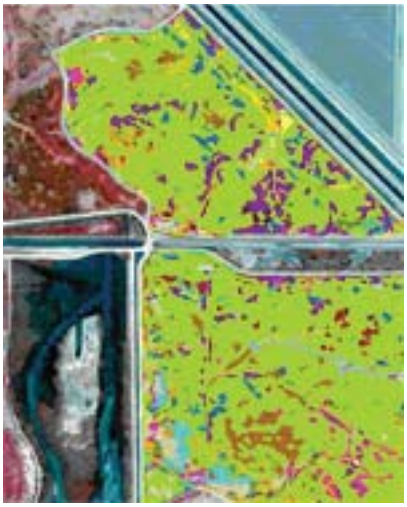
Aquarius software allows the data to be evaluated continuously and matched using a suite of signal processing algorithms to help provide quality assurance. This software has been recommended for adoption by other Reclamation monitoring programs that rely on continuous sensors.

Wetland plants grow in association with other plants that favor similar moisture regimes, germinate under the same temperatures and have similar tolerance to salinity. To identify these plants, we use e-Cognition software for multi-spectral image processing to develop segmented polygons based on previously determined spectral signatures for the major wetland moist soil plant associations.

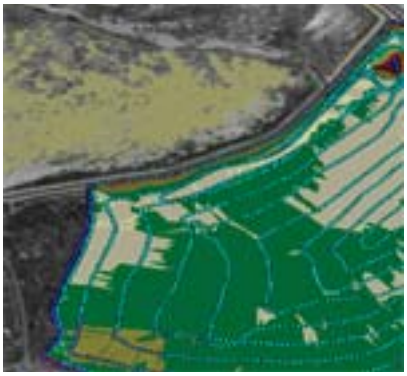
We computed the volume of each pond by mapping the pond bathymetry using an ATV custom fitted with a Trimble GPS receiver for accurate geodetic surveying.

Improving salt management in wetland ponds through better water management requires continual updating of estimates of the salt load contained within each pond and eventual scheduling of these loads with the assimilative capacity of the San Joaquin River. Residual salt load can be calculated using the stage-area relationship (which estimates pond evaporation and emergent plant evapotranspiration and thence residual salt load). To determine this relationship, we developed a triangulated irregular network (TIN) using ARCGIS software to create a three dimensional rendering of the pond bathmetry up to the height of the surrounding berm. Resulting stage-area and stage-volume graphs provide the wetted surface area and pond volume for any pond stage reading. The stage-volume relationship allows an estimate to be made of residual salt load based on inflow and outflow monitoring of electrical conductivity.

The techniques deployed and developed as part of this Science and Technology Program project can be applied to seasonal wetlands throughout the western United States. As discharges from agriculture and managed wetlands come under increased regulatory scrunity, these technologies will be of great value in providing accurate, timely information in support of improved salinity management practices while helping to protect the long-term sustainability of the wetland resource. Tracy Slavin (916-978-5202)



Use of high resolution multispectral to map wetland moist soil plant species abundance (by wetland associations) in the Gadwall Unit of the Los Banos Wildlife Management Area. The light green shaded areas show swamp timothy in the wetlands.



Pond bathmetry survey of Ducky Strike north pond.

Improving Water Delivery Reliability

Measuring iron bacteria for more effective agricultural drain cleaning schedules. Iron reducing bacteria are very common in the western United States, often growing in agricultural drains where they can create a sufficient biomass to plug the drain. Irrigation districts use brushes or high pressure water jets to clean the bacterial film from these drains and restore their capacity. Cleaning schedules are usually arbitrary and thus may not be very efficient.

Core sample collected during drilling.

This S&T study partners with the University of North Dakota, North Dakota State University, and state agencies to analyze the optimal interval for cleaning and enable irrigation districts to determine how often their tile drains need to be cleaned. This can lead to more efficient management, lower maintenance costs, and reduced impacts to downstream water quality.

To determine how quickly the tile drains plug up, wells were placed on each side of a tile drain to measure conductivity. The rate of travel between the wells was measured using a tracer solution that was detected using a conductivity test. The slower the tracer travels between wells, indicates more plugging is occurring. At the Oakes study site, we initiated three of these tracer tests. The tracer tests involved injecting a chloride tracer in a well installed perpendicular to the tile drainage line and measuring the increase in conductivity in another well close to the drainage line. The increase in conductivity was logged to determine the transport time of the tracer from one well to the other.

The information from these various analyses will be used as inputs into DRAINMOD, a computer simulation model developed at the Department of Biological & Agricultural Engineering, North Carolina State University, Raleigh, North Carolina. The model predicts the effects of drainage and associated water management practices on water table depths, the soil water regime and crop yields. We are using DRAINMOD to model the tile drainage system at the study site to assist in understanding the entire system and for the interpretation of results. Students traveled to North Carolina State University to receive training with the developers of DRAINMOD. Alison K. Schlag (701-221-1276)

Monitoring the seasonal movements of green sturgeons at Red Bluff Diversion Dam. Monitoring the movements and habitat preferences of green sturgeons (*Acipenser medirostris*) will help Reclamation operate the Red Bluff Diversion Dam (RBDD) in ways that reduce adverse impacts on sturgeon and ensure the continued delivery of water to irrigation districts in Northern California.

As reported in an earlier Research Highlight, Reclamation biologists used acoustic tags to monitor ten green sturgeons in the vicinity of the RBDD. The sturgeons were monitored to document seasonal movements around the dam and to determine if any behavioral patterns could be distinguished. Two distinct post-spawning behaviors were observed: some green sturgeons moved immediately downstream and out of the river system after spawning in June and July, while other individuals held in specific areas for long periods of time prior to migrating downstream. Reclamation biologists found that some individual green sturgeons held within the same specific areas for over 6 months (June to December) prior to moving downstream. Downstream movement occurred when flows in the Sacramento River increased during a storm event on December 25, 2008. However, data from manual tracking and stationary receivers indicates that one of the three tagged green sturgeons only migrated downstream approximately 21 kilometers before stopping again in a known holding area, and as of early February has remained within this specific area for forty days. Richard Corwin (530-528-0512)

A green sturgeon showing spaghetti tag with Reclamation's contact information. Photograph taken by Richard Corwin, Reclamation.

Benefitting Pacific lamprey passage in the Columbia River Basin. Pacific lamprey (*Lampetra tridentata*) are primitive anadromous fish whose once abundant populations in the Columbia River basin have declined substantially in recent years, to the point that they were petitioned for listing under the Endangered Species Act. The lamprey are important in the culture and traditions of Native Americans, and play a vital role in the aquatic and terrestrial ecosystem. Lamprey are much poorer swimmers than salmon and thus have a difficult time using fish ladders designed to pass salmon at major dams in the Columbia River Basin. Lamprey use their sucker-like mouths during migration to attach to substrate and other objects to rest, and cannot handle high velocities in fish passages, nor negotiate sharp 90-degree corners or edges on structures. Upstream migration of adults is also impaired at water diversion structures in tributaries, and downstream migrating juveniles are sometimes entrained into irrigation canals and consequentially the populations suffer high mortality.

Several state, Federal and tribal agencies are engaged in lamprey work, but there is little focus on Reclamation facilities. Reclamation has been requested by various tribes in the Northwest to address the issue of lamprey mortality at its diversion structures. Reclamation will benefit from resolving any lamprey passage issues. If lamprey abundance does not improve, the species could be listed under the Endangered Species Act (Act), requiring Reclamation to consult under the Act on all projects where lamprey occur. Reclamation has agreed to implement several actions for lamprey as part of the 2008 Memorandum of Agreement Fish Accords with several Columbia Basin tribes. But site-specific information is needed to address lamprey passage issues at Reclamation facilities and ensure that the most cost-effective solutions are implemented.

This S&T project focuses initially on the Umatilla and Yakima basins where Reclamation has substantial irrigation projects. In this first year of study, structures where passage problems might exist will be identified as well as the specific nature of the passage problem, and information about the historic abundance and distribution of lamprey will be compiled. This research will involve biologists and managers from State and Federal agencies and Tribes.

Actions taken to benefit Pacific lamprey passage in the Columbia Basin will benefit Reclamation and others by reducing mortality of upstream and downstream migrating lamprey and eventually contribute to restoring an important cultural and ecological resource of the Northwest. Remedies that allow easier or enhanced lamprey passage will be applicable to other basins where adult and juvenile lamprey passage is an issue. Stephen Grabowski (208-378-5030)

Lamprey specimen from USGS.

Improving Water Supply Technologies

Using automated surface irrigation systems for improved water use efficiency. Despite rapid urbanization in the Region, agriculture remains the major water user in the Lower Colorado Region, accounting for more than 80 percent of the total water consumption, almost entirely associated with surface irrigation. Proper decisions on when the flow of water to a field should be cut off must be made based upon the extent of water advance across the field, but this is difficult to gauge at night or with tall, dense crops. Therefore, irrigators compensate by over-irrigating. Automating controls that are now manual could help these systems use water more efficiently.

This S&T project is constructing and operating automation systems on two types of irrigation fields – level basins and graded borders – in cooperation with the Universities of California and Arizona. These automation systems will use "smart" programmable logic controllers. We have completed the initial construction of the systems. We are now solving initial problems with some electronic components prior to attempting automated operation. The next step will be programming the "Smart" controllers and de-bugging of the control software, which is scheduled for March 2009.

Future plans are to incorporate control of the district delivery flow rate and telemetry of the water delivery data to translate the on-farm water savings into overall district water-savings. Mark Niblack (928-343-8253)

Automated farm irrigation system near Yuma, showing control station, motorized gates, and flume.

Control center showing programmable controller, solar charge regulator, and multiple outlet board.

Modeling changes in water quality based upon interactions between reservoirs and sediment-deltas. Sediment deltas form in reservoirs from tributary inflow of sediments and other debris. Deltas serve as sources and sinks of nutrients and biochemical oxygen demand. As deltas grow, the interactions between deltas and reservoir basins become increasingly important. These interactions can result in increased algal growth and poor water quality for municipal and industrial uses. Hydrologic conditions and reservoir operations can change the interactions between deltas and reservoir basins and thereby change the impacts to water quality. The S&T Program is researching ways to discern the different interactions between sediment deltas and reservoir basins, relate these changes to hydrologic conditions and reservoir operations, and develop methods of quantifying the impacts including reservoir modeling.

Reclamation is partnering with Brigham Young University to perform field research on Deer Creek Reservoir in Utah, including: defining and characterizing nutrients in Deer Creek Reservoir through sediment samples, laboratory analyses, and estimates of nutrient content across the sediment delta.

Laboratory analyses is focused on quantifying phosphorus sources in the sediments and mechanisms for phosphorus release from the sediments. Phosphorus was chosen as it is typically associated with algal problems in lakes and reservoirs. This work was compared with similar studies and provides the foundation from which other studies can be carried out.

We will now focus on characterizing the sediment-water interface processes, sediment loading dynamics, reservoir/sediment interactions and dynamics, reservoir conditions, and analyzing the effect of reservoir hydrology and operations. As the data become available, we will use and evaluate a reservoir model to compare the data with model results and determine what actual processes the model does not show and then identify methods to represent these processes. Additionally, we are developing other tools associated with spreadsheets and geographical information systems that can be used in any water quality field work and analyses. These and all other tools will be shared among Reclamation water quality personnel as they become available. (Nick Williams 801-524-3888).

Analyzing sediment samples.