RECLAMATION
Managing Water in the West

Science & Technology Highlights

Contents

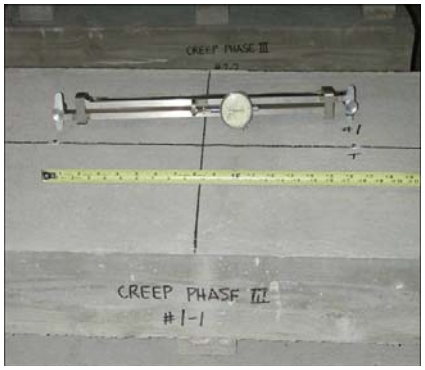
U.S. Department of the Interior
Bureau of Reclamation

Improving Infrastructure Reliability

Preparing the way to successful concrete repairs

Obtaining consistent, long lasting concrete repairs has been a goal of the concrete repair industry for many years. The quality of the surface preparation of the substrate prior to repair will often determine whether a repair project is a success or a failure, and whether or not a repaired structure is durable—regardless of the cost, complexity, and quality of the repair material or even the application method.

To help quantify the performance requirements for surface preparation to achieve long lasting concrete repairs. Reclamation is participating in an international joint research effort on "*Development of Performance Criteria for Surface Preparation of Concrete Substrates prior to Repair and Overlay.*" This research effort, with partners from Canada, Poland, Belgium, and a U.S. firm, is aimed to develop measurable specifics about surface preparation characteristics to obtain a successful concrete repair. The research is:



Two feet by 4 feet by 6-inch wide concrete base slab curing before surface preparation.

- **Developing effective methods to quickly measure surface roughness of concrete.** Currently, the only methods are looking at the concrete or using an ASTM method that only works on horizontal surfaces.

- **Establishing relationships between tensile bond, shear bond, and surface roughness.** Different surface profiles affect tensile and shear bond differently. Understanding and documenting these effects will help determine the most effective method to use for these different surfaces.

- **Evaluating effects of load eccentricity on tensile pull-off tests**. Pull-off tests are the standard method to evaluate bonds; however, very little is known about the impact of load eccentricity on test results.

- **Developing a field test to evaluate optimum moisture condition for the concrete substrate**. There are a variety of methods to measure moisture condition, but little is known about which methods are the most effective.

- **Evaluating the effects of surface carbonation of the concrete on bond**. Testing has shown that concrete surfaces can carbonate relatively quickly after preparation, and carbonation can reduce bond strength.

Performance requirements will be published in a final report, which is scheduled for publishing sometime this fall. Kurt Von Fay (303-445-2399).

Base slabs being prepared using three different surface preparation methods prior to application and bond testing of the overlay materials.

Predicting coating service lives using Electrochemical Impedance Spectroscopy (EIS)

Reclamation uses protective or industrial coatings to control corrosion that can plague hydraulic structures. These coatings help protect the life, safety, operating efficiency, appearance, and economy of these structures. Using the highest performance coating systems will reduce the maintenance and down time of the structure, thus increasing water availability and reducing maintenance costs.

Many coatings degrade or allow water to get through over time. Reclamation needs to be able to determine the lifespan of coatings to select, specify, and schedule for replacement of coatings before corrosion takes place. Coatings technology has vastly changed in the past 20 years due to more stringent VOC regulations, especially in California, and the service life of these new materials is vague. We can not simply wait "x" number of years to determine this lifespan—we need to predict it now. Reclamation needs effective ways to evaluate and select new emerging coating technologies.

We can determine coating life by measuring impedance. The more impedance a coating has, the stronger its corrosion protection is. When the coating is exposed to simulated or real service conditions, its impedance gradually decreases. The rate of decrease depends on how the coating was made and how severe the service conditions are. The rate of decrease can be used to predict the service life of the coating. Measuring this impedance through EIS helps Reclamation determine which coating system will provide the longest protection in a specific environment. EIS is a new technology to evaluate coatings, and provides more quantitative results for corrosion resistance of coatings than conventional evaluations. EIS is a non-destructive, highly sensitive technique that can obtain measurements rapidly and is more accurate than waiting for visible corrosion products to form.

This project demonstrated that EIS is a useful tool for determining the corrosion resistance of coating. It was determined that service life could be predicted on defect-free samples, however it could not determine if blisters would form or if there would be undercutting corrosion in damaged areas. The most valuable information that was obtained is the direct comparison of different coating systems and change of EIS values over time. EIS can also be used in field studies to determine the remaining service life of existing coatings on Reclamation structures.

- This technology works best on barrier type coating systems, such as coal tar epoxy, polyamide epoxy, moisture cured urethanes, polyurethanes, and acrylics. Some findings so far are:

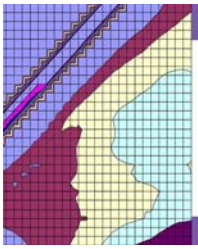
- A polyamide epoxy currently used on many Reclamation projects had fairly minimal change over the course of 3.5 years of water immersion testing.

- Moisture cured urethanes used on radial gates, fixed wheel gates, and other infrastructure for a number of years blistered after 3 years of water immersion.

- A 100 percent solids epoxy coatings had an initially extremely high EIS value as it is very thick. However the coating was withdrawn from the study due to the rate of water absorption and the extent of undercutting corrosion on the scribed panel. Other 100 percent solids coatings are performing better than this particular coating system.

Electrochemical Impedance Spectroscopy Test Cell

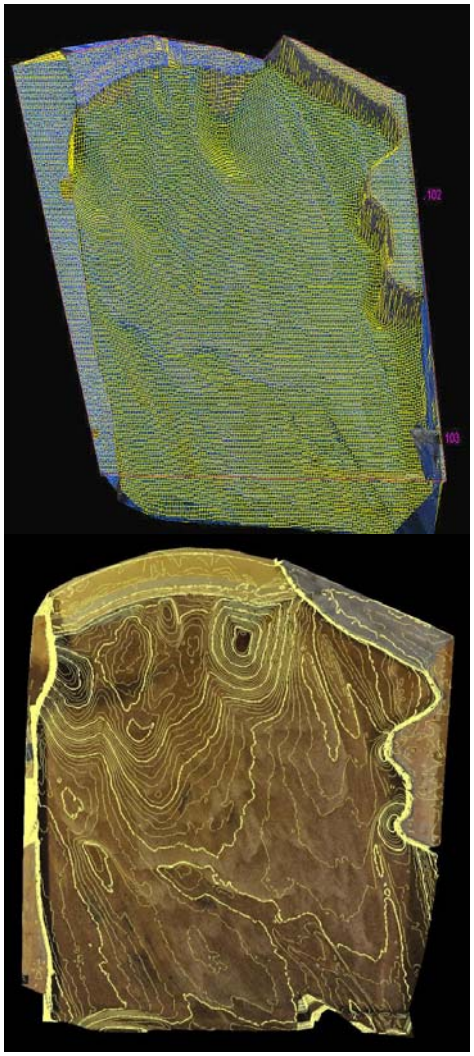
Allen Skaja (303-445-2396)



Improving Decision Support

Getting more data faster with photogrammetry

The photogrammetry research program provides remarkable and fast surveying capabilities for a very wide range of applications. The initial Science and Technology Program research efforts for photogrammetry, led by Pete Shaffner, focused on mapping the geology of steep rock abutments using photographs only. Then research focused on using a helium balloon to obtain detailed photography and contours along stream channels. Now, the recent development allows for very accurate measuring of physical hydraulic models using only photographs and sophisticated software.



Photogrammetry-generated gridded terrain and contours of laboratory Hydraulic model for the Blue River Fish Barrier after 100 year flow event.

Photogrammetry is currently being used for three physical hydraulic models in Reclamation's Hydraulics Laboratory to document topographic elevations in moveable bed models. Once properly set up and calibrated, photogrammetric techniques are faster than typical model data collection techniques and also provide far more data points than can be collected with traditional laboratory methods.

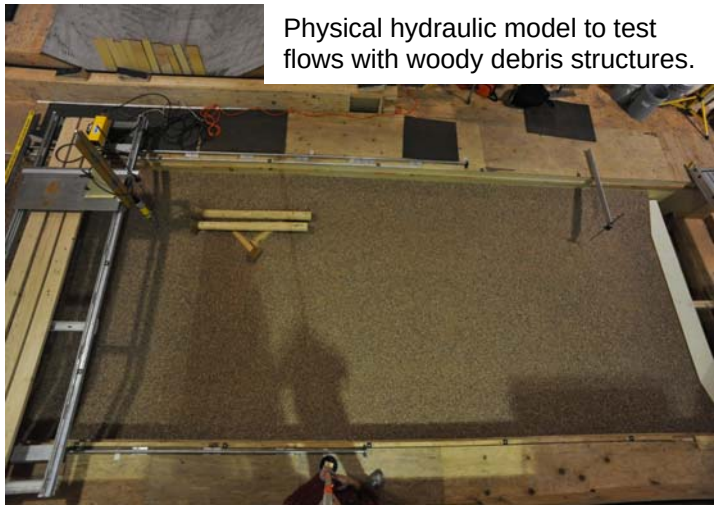
For the current models, a 12 megapixel (MP) Nikon D700 camera with a 14mm lens is mounted on the top of a 12-foot-high range pole to document sediment erosion and deposition after flow scenarios are run. Photographs are processed using ADAM Technology's 3DM CalibCam and 3DM Analyst to identify spatial coordinates, elevations, areas, volumes, contours, and cross sections. Joe Kottenstette has been helping other researchers learn the software and photographic requirements. Photogrammetry is also identifying changes to the bed topography to analyze large woody debris structures in another S&T research project (see the next article).

Blue River Fish Barrier Model
Photogrammetry is being used to examine scour locations and depths downstream of a low head dam in the 1:28-scale model of the Blue River Fish Barrier project in the Hydraulics Laboratory. Data elevations were exported to AutoCAD to provide direction comparisons between the original design and subsequent modifications to the design. Dale Lentz (303-445-2143)

Lower Yellowstone River Project
Photogrammetry is helping researchers examine sediment deposition areas around the diversion intake in the 1:20-scale physical hydraulic model of the Lower Yellowstone River Project. This model includes the headworks, dam, and a stretch of the downstream river channel at Intake Dam in Montana. The model is being used to assess screened headworks for diversion and a rock ramp for pallid surgeon passage. The photogrammetry camera is on an overhead cable to compare photographs of the moveable bed to the fixed bed. . Comparing construction drawings to the actual construction of the model is used as a supplement to surveying for quality control in the model. As modeling continues, it is anticipated that photogrammetry will be used to assist with the rebuilding of the rock ramp by identifying the size and locations of new features on the rock ramp. Kathy Frizell (303-445-2144)

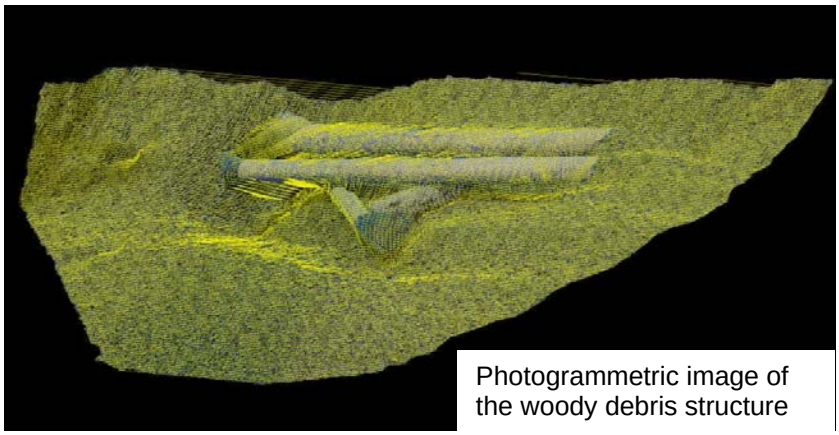
Photogrammetry contact: Pete Shaffner (303-445-3152)

Using photogrammetry to evaluate large woody debris structures in the laboratory



Physical hydraulic model to test flows with woody debris structures.

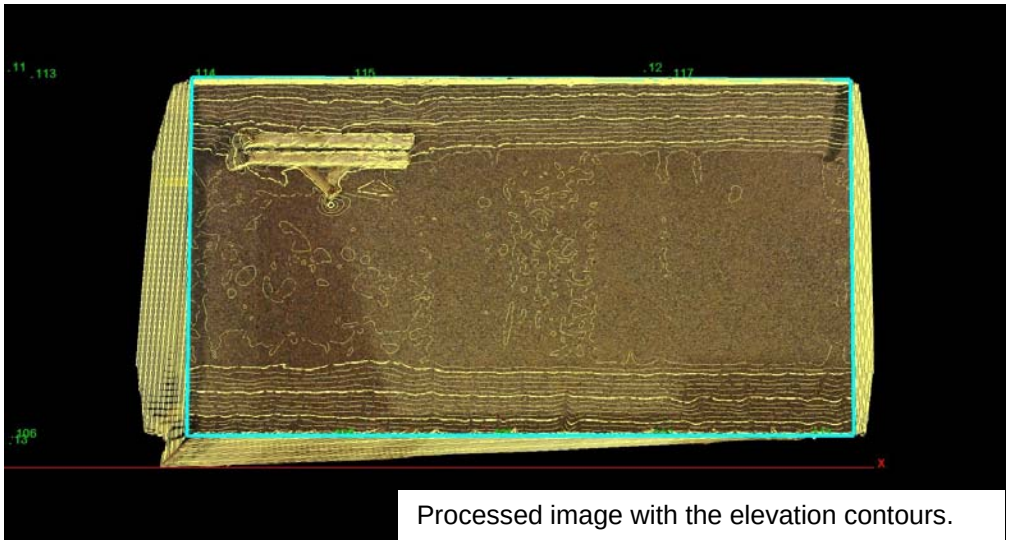
Naturally occurring in-stream large woody debris (LWD) jams, where trees or logs have entered and collected in channels, are found in many streams. These LWD jams form structures with many benefits, including habitat restoration, bank protection, and flow changes. Much of the natural LWD in channels was removed during the 20th century; however, we are now replacing LWDs to obtain these benefits. Current design methods do not provide a complete picture for how different structure configurations affect erosion and deposition occurring in the vicinity of the structure. Information is unavailable for determining the most effective sizing, configuration, placement, and vertical extent of LWD structures to create scour for habitat enhancement.



Photogrammetric image of the woody debris structure

To begin addressing some of these questions, a Froude-scaled physical hydraulic model was constructed in Reclamation's Hydraulics Laboratory in Denver. The moveable bed model consists of a trapezoidal river channel with a gravel material bed. A logjam structure was installed along the bankline, secured to the wall of the model. The log components are fastened to each other, allowing for localized scour and deposition without allowing the structure to move. Various logjam configurations (V-shaped cross structure, perpendicular to the bank, layered, random) and submergence levels (plunging vs. interflow) will be analyzed in the model to determine which configurations produce the best hydraulic performance for scour hole development.

After flow conditions are run, then the physical model bed is analyzed using photogrammetry. A high-resolution camera with a wide angle lens is mounted on the top of a 12-foot-high range pole. Fixed control points are placed at several locations within the image area. Photographs are taking from several viewpoints at the same height. The photographs are processed using Adam Technology 3DM CalibCam and 3DM Analyst. A digital terrain model (DTM) is produced for each set of images showing a dense topographic map of the model area. A digital elevation model (DEM) can be produced at a set interval to identify the spatial coordinates and elevations of erosional and depositional regions. Scour areas, volumes, elevation contours, and cross sections can also be created from the software. Connie Svoboda (303-445-2152)

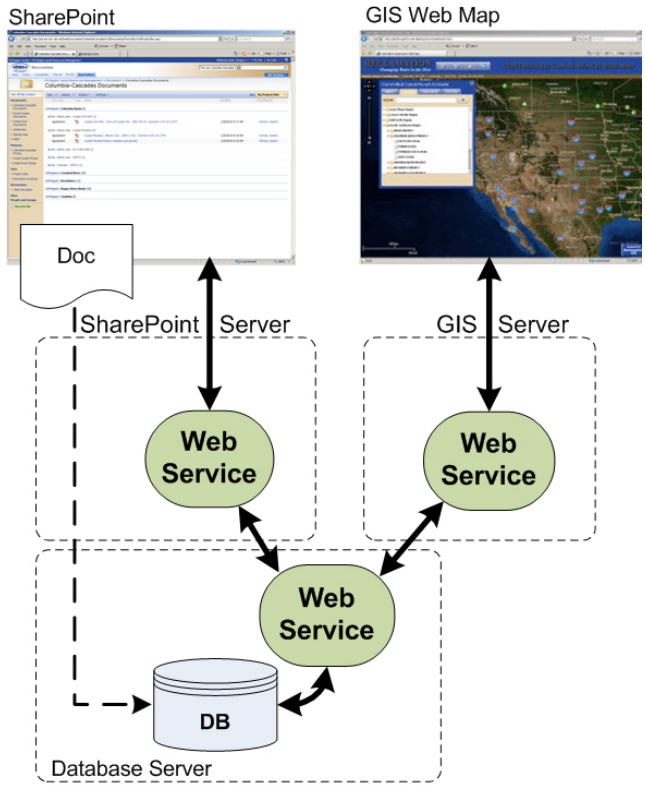


Processed image with the elevation contours.

Finding Reclamation's information—in one place

One of the first questions asked about the lands and facilities Reclamation manages is "Where is it?" Reclamation staff need to quickly access pertinent information based on where something is located. Information about Reclamation's infrastructure needs to be readily available. Having documents, such as condition assessments, site photos, maintenance reports, tied to a map location can help Reclamation staff get the overall picture and get detailed information more quickly and effectively.

Location is a powerful organizing framework that helps find information which is otherwise unrelated. A wealth of information about the lands and facilities that Reclamation manages on the behalf of the American public can be tied to discrete locations and features, such as parcels, dams and canals.



The information infrastructure needed to provide an interactive map to share documents based on location.

Many Reclamation offices are discovering the utility of the collaborative features of SharePoint, in particular, document libraries. Document libraries provide an efficient way to store and share digital information such as deeds, contracts, and agreements associated with lands transactions. Using locations is the key to organizing information on SharePoint systems and other document libraries.

This Science and Technology Program research project is developing an approach to allow Reclamation staff to use an interactive map to link documents to the associated feature (e.g., land parcel or facility). Once linked, the interactive map provides a simple way to retrieve related documents. The link also provides a way to display the map location of the feature(s) associated with a document. To do this, researcers are developing web services interoperations between SharePoint and GIS to store and manage the many-to-many relationships between documents and geospatial features that facilitate user linking functionality. Greg Gault (208-378-5325)

Creating institutional solutions for water conflicts in the Western United States

Water conflicts have always troubled the Western United States By analyzing a large array of conflicts, this Science and Technology Program research project hopes to understand their genesis and develop institutional tools suited to Reclamation water managers to use to help solve them. The Western Water Institutional Solutions research project is a joint effort between Dennis Kubly, Manager of the Upper Colorado Region Adaptive Management Group in the Environmental Resources Division, Douglas Clark of Reclamation's Technical Services Center, and Professor Aaron Wolf in the Department of Geosciences at Oregon State University. This research analyzed a large array of conflictive and cooperative events that Reclamation managers typically face. In subsequent years a manual designed to address the unique needs of our water managers was developed.

During this research, focus group sessions were conducted on the genesis of water conflict in the Western United States in Reclamation area offices. In addition, over 8,000 media events pertaining water conflict were individually scrutinized by a panel of conflict analysts and then each event was assessed a numerical weight on a scale ranging from highly conflictive on one end to highly cooperative on the other. The resulting scaled data set was then regressed against biophysical and social independent variables to produce profiles of environments favorable to water conflict. In addition, case studies were prepared for individual water conflicts to understand their genesis and resolution in detail. These efforts have culminated in a set of teaching modules in a manual entitled "*Sharing Water, Building Relations: Managing and Transforming Water Conflict in the US West."* These modules were tested very successfully in 2008 in the Bismarck and Phoenix Area Offices, and in the Upper Colorado Regional Office. Feedback from the students was outstanding.

Charley Hardes, MTAO surveyor (left), participates in an interactive water conflict management listening exercise with Dr. Aaron Wolf of Oregon State University (right)

Two more trainings in Area Offices were conducted in November and December of 2009, again with exceptional feedback from attendees. During these workshops, held in Billings, Montana and Albuquerque, New Mexico, attendees learned and refined skills for managing conflict. These skills included listening, achieving consensus, and setting up successful public meetings, among others. The workshops commenced with a group brainstorm on *goals* and *ground rules*, two important considerations for a successful stakeholder meeting. They included a mixture of interactive instruction, listening improvement exercises, stakeholder meeting simulations, and group discussions. During one simulation, *Negotiating the Sandus River Basin*, participants arrived at consensus on future water projects through a step-by-step negotiation process. The participatory nature of the workshops allowed attendees to actively engage in activities similar to what they themselves may be responsible for facilitating in the future. Several participants expressed enthusiasm about applying the new knowledge in their jobs, both in the office and out among stakeholder groups.

FY 2010 is the final year of this very successful research effort. Three more training sessions will be conducted. The manual will be updated. A train-the-trainer program will be examined for its feasibility. This research strives to create a permanent water conflict training capability for Reclamation personnel and Reclamation stakeholders. Douglas Clark (303-445-2271)

Managing scientific disputes

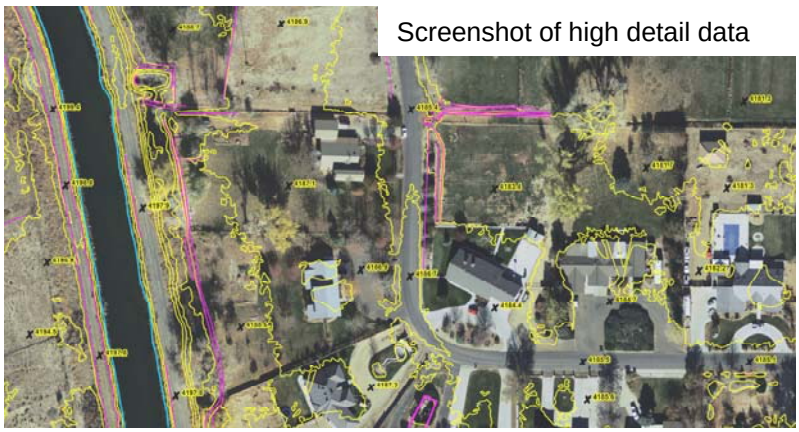
In addition to managing water conflicts discussed in the previous article, ways to manage conflicting or diverging science need to be addressed. Conflicting scientific analyses are often listed as an intractable stumbling block for resolving competing claims to water. Reclamation managers sometimes must make water allocation decisions in situations characterized by conflicting scientific findings. One area manager, for instance, said she wished that endangered fish could 'talk'—that is tell managers exactly how much water they really required. In other words, for example, one scientist may argue that an endangered fish requires X cubic feet per second (cfs) of water flow at a certain phase of its lifecycle and another may argue that it actually requires Y cfs. In such cases what courses of action are open to the manager? This Science and Technology Program research project seeks to understand the genesis and resolution of such disputes over science.

This research effort published a related literature review entitled “Resolving Disputes over Science in Natural Resource Agency Decisionmaking” in February 2010. This review treats such issues as the difficulties in using science to inform decisionmaking, underlying drivers of disputes over the use of science, what the resolution of scientific disputes actually means, and approaches for resolving disputes over the use of science in decisionmaking. The tools that are used are joint fact-finding among stakeholders and scientists, Blue Ribbon panels, conducting new scientific experiments ("more science"), so-called "science courts", adaptive management processes, and collaborative modeling, among others.

This project is a joint effort between Nina Burkardt and Emily Ruell of the USGS Policy Analysis and Science Assistance Branch in Fort Collins and Douglas Clark of Reclamation's Denver Technical Services Center. In FY2010, the researchers will be launching a Reclamation-wide electronic survey to determine how disputes over science are currently managed, and they will also be undertaking one or more in depth case studies to examine lessons learned in these types of disputes. The survey will ask Reclamation scientists, engineers, and managers what techniques they have used and to what effect? Douglas Clark (303-445-2271)

Using customized loss estimation software and high resolution imagery to determine economic consequences of canal breaches

Many of Reclamation's canals are in highly urbanized areas, and canal breaches in these areas can have many economic consequences to residents and businesses. Being able to use a standard method to determine these economic losses would benefit Reclamation and partners in planning for potential events and responding to breaches.



Screenshot of high detail data

The methodology will be able to be applied wherever desired along a canal to determine potential economic losses/consequences. Data availability will drive the process time for a multi-location project. One pre event benefit might include providing information for maintenance and loss mitigation to focus funding on locations with greater economic consequences. The proposed methodology uses software employed by Federal, State, and local emergency/mitigation planners. Modifications that will tailor the loss estimation software to canals include using higher detail data and imagery inputs. To date, researchers have obtained access to high detail data and are working to incorporate this information. Bill Goettlicher (303-445-2275)

Tracking gravel for better habitat management

Dams can impound virtually all the coarse sediment delivered to the dam site from the upstream watershed. As a result, stream reached downstream from dams can become starved of the gravels needed to build the bars and riffles that provide fish spawning beds and hydraulic diversity.

Placing yellow-painted gravel tracers with PIT tags at Grass Valley Creek. California.

Consequently, gravel is increasingly being added to rivers downstream from dams to replenish the local bed material supply and improve aquatic habitats. Despite the growing use of gravel additions in stream management, several important details regarding how best to manage gravel supplies are poorly understood. This Science and Technology Program research project is designed to explore some of the key unknowns surrounding gravel management, including where and how much added gravel is needed to improve habitats at particular locations, how long it will take for new habitats to form, and how long the habitats will last. Answering these questions will help Reclamation restore habitats downstream from its dams while responsibly fulfilling its mission of conserving and delivering water.

Stephen Dickenson, New Albion Geotechnical, Marv Pyles, Oregon State University, and Peter Klingman, Oregon State University collaborated with David Gaeuman, Reclamation's Trinity River Restoration Program to start a multi-year experiment to track the movements of several hundred individual gravel particles using Passive Integrated Transponder (PIT) tags. PIT tags send out radio signals that can be used to find and identify gravel tracers after they have been moved by flood events. This in Grass Valley Creek, a tributary to the Trinity River in Northern California, began in 2007 and is expected to continue through 2012.

Results to date are preliminary, but this project has already yielded some interesting observations for gravel transport in streams. For one, it appears that gravel transport in real streams is controlled by local variations in channel form to a much greater extent than is evident in studies of gravel transport in laboratory flumes. This means that gravel can become locally concentrated to form bars and other habitat features, even though the gravel may have dispersed over a long distance from where it was originally placed in the river. With continued understanding of the control of gravel dispersion and re-concentration, resource managers will be better able to optimize the environmental benefits that can be derived from the scores of gravel augmentation efforts throughout the nation that are underway or being planned. David Gaeuman (530-623-1813)

Using an antenna system to find tagged fish

An endangered Colorado pikeminnow

Reclamation funds and manages several programs concerned with the recovery of endangered fish species. Through these programs fish--both endangered fish as well as other fish in the rivers--are tagged with Passive Integrated Transponder tags (PIT tags) to allow researchers to track their movements and survival. These PIT tags resemble a grain of rice and emit identify the fish using radio frequencies.

Detecting these fish without PIT tags is very difficult and expensive since they must usually be captured using electrofishing or trapping, both of which involve large amounts of personnel and equipment. Additionally, capturing the fish can lead to mortality or changes in behavior. Salmon can often be funneled into small detection areas during their migration patterns and are easier to detect than most other fish species that do not have predictable patterns of movement. A system that allows the detection of fish in the river without capture would be far cheaper and less disruptive to the fish. This project, jointly funded by Reclamation and the San Juan River Recovery Implementation Program, is attempting to develop a floating antenna system that would allow the remote detection of fish that have been PIT tagged. The system is being designed to allow the antenna to float down a river while detecting fish that it passes over. Several contracts have been awarded to equipment manufacturers, as well as Utah State University, to aid Reclamation in the construction of this system. An early prototype of the system was constructed and tested in 2008 and this new project will attempt to construct a fully-functional system that is capable of being deployed and used in rivers of the western U.S.. The new system will build on the results of testing this early system and hopefully lead to better detection. The project is scheduled for completion by October 2010. Mark McKinstry (801-524-3835)

An early prototype of the floating PIT tag detection system.

Improving Water Supply Technologies

Mining water billing data to find The Real Deal: actual water use in irrigated landscapes

Measuring urban water use

Expanding urban populations and increasing urban water crises underscore the need for Reclamation to become actively involved in promoting urban water use efficiency. This Science and Technology Program research project, The Real Deal, mines water district billing data with irrigated landscaped areas for individual users. This research first quantifies landscape water use to determine individual users' capacity to conserve and then statistically quantifies water savings effectiveness of conservation programs.

This research works with Reclamation's Water Conservation Field Services Program (WCFSP) has opened the doors to many of Reclamation's urban water users. The WCFSP acting in partnership with universities, the Extension Service program, and many other state and local partners is ideally positioned to promote more efficient water use by the urban water users.

Irrigated urban landscapes account for 50-70 percent of total yearly water use for these agencies, thus are the prime target for water conservation programs, as they offer rebates, enforce water use ordinances, and encourage low water landscaping.

This project will take three steps to quantify actual irrigated landscape water use to improve conservation program effectiveness:

- Step 1 Determine landscape use. Collect landscape water use from a water billing data set for a water agency by using a custom software program that linearizes water billing data into a manipulate-able format.

- Step 2. Determine the capacity to conserve process. Compare the amount of actual landscape water use for each end user to estimated landscape water needs.

- Step 3.Develop conservation program water saving practices. Use the data from steps one and two to develop an ecologically-based standard of appropriate water use to evaluate effectiveness of actual water conservation programs.

This study will help determine the effectiveness of urban water conservation programs that have been difficult to measure as they are targeted to all end users, and thus may be ineffective with end users who are already efficient. Programs may be ineffective when applied to people who are already conserving water in their irrigated landscapes and simply want validation. Also, actual water savings can be difficult to quantify and to evaluate unless compared to a control population. Frederick Liljegren (801-524-3765)

Determining turf grass water use for more efficient lawns

Study site at the Northern Colorado Water Conservancy District

Urban water crises impact the lives of millions of individuals and can result in dire consequences. In the Western United States, 50-70 percent of the water used in cities and towns is applied to irrigate landscapes. These studies also show that landscape irrigators (professionals and homeowners) are using up to twice as much water as the plants require. This means that potentially a fourth to a third of the water delivered from Reclamation projects to cities and towns is wasted. This Science and Technology project evaluated a methodology to help define the seasonal water needs for a variety of turf grasses, much like work done for agricultural crops grown in the Western United States.

Eight plots were established with different turf grass. Irrigation was closely monitored and no standing water was observed. Divider boards between the plots mitigated any potential runoff from one plot to another. Turf evapotranspiration (ET) on a daily basis was calculated as the residual of the soil water balance.

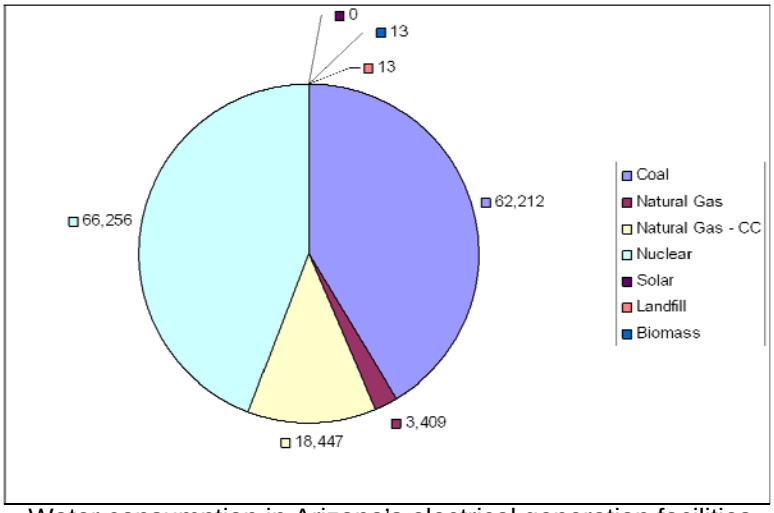
Results showed that several grass mixes offer lower water use for turf installations. Grass mixes instead of single varieties can offer the best characteristics of each grass and so may have an advantage in responding to different conditions. Foothills Mix used 22 percent less water than the Low Grow Mix. Reveille Texas hybrid blue grass used 14 percent less water than the Low Grow Mix. Frederick Liljegren (801-524-3765)

Saving water with more efficient power generation

Most forms of thermo-electric power generation (such as nuclear, coal, and gas) consume large quantities of water as they create steam using water. Growing demand for power using traditional methods means growing water consumption. Finding methods to help thermo-electric power generating plants work more efficiently can save money and –perhaps more importantly—save water. For example, Arizona now uses more than 150,000 acre feet of water for power generation. Conserving even 10 to 20 percent of this water would provide 15,000 to 30,000 acre feet of water which could be used for municipal, industrial, agricultural, or other higher uses. Since Reclamation is a large producer of power and the biggest supplier of water, maximizing the efficient use of both power and water is critical to our mission. This Science and Technology Program research project is exploring opportunities for water conservation through more efficient thermo electric power generation. Reclamation is working with non-governmental organizations and other agencies to examine potential water supplies from reduced water use in thermo electric generation.

This research is underway to inventory the power generation in Arizona as a first step in finding methods of reducing water consumption or obtaining more power for the same water consumption. So far, researchers have appraised existing information and created a basic inventory of generation, gallons used in various generation types, and an estimate of gallons used in Arizona for each type of generation. Figure 1 compares the amounts of water used in various types of electrical generation facilities. The data reflected in this paper are preliminary and subject to revision.

The next steps are to identify inefficiencies in power generation and to examine opportunities for new technologies to reduce water consumption. Examples include dry cooling methods, multi-effect distillation for cleaner water for cooling cycles, and heat reuse to distill water to get more cycles out of the water.
Mitchell Haws
(623-773-6274)



Water consumption in Arizona's electrical generation facilities in acre feet