

## **USING GIS TO MONITOR WATER USE COMPLIANCE**

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### **ABSTRACT**

Irrigation districts are responsible for a wide variety of issues including but not limited to water distribution, water management, regulation of water rights, and collecting assessments. The Lake Chelan Reclamation District irrigation system is owned by the U.S. Bureau of Reclamation and operated by the District. The contract between the District and the USBR limits the application of irrigation water to lands classified as irrigable. The nature of the topography together with the delivery of pressurized water to high value crops has led to both inadvertent and advertent use of irrigation water outside of the classified areas. The high value of the water involved has required the District to use the best technologies available to evaluate the cumulative impact of water use outside of the classified areas.

This paper will describe how GIS is being used as an evaluation tool to quantify and manage the aerial imagery, GPS information, irrigable boundaries, the extent of irrigation and other database properties associated with the land use. One unique aspect of the project is merging and sharing the database information from the District's billing and water management software platforms with GIS so that maintenance of customer information is done only one time in only one location. Automated systems are planned to analyze and evaluate changes in the aerial images over time so that managers can evaluate changes in water use patterns when permanent crops are upgraded and replanted. The results of the analysis will be the basis of a reclassification survey by the USBR to bring the lands back into compliance with the contract provisions.

### **INTRODUCTION**

The Lake Chelan Reclamation District (LCRD) was formed in 1920 as an irrigation district. The system was challenged with years of drought, forest fires, floods and severe winters that threatened the viability of the district. In the early 1970's, the U.S. Bureau of Reclamation (USBR) entered into a contract with the District to construct a modern irrigation system for the district by pumping directly out of Lake Chelan. The District repays the construction obligations and operates the system for the USBR. The contract specifies that the District must supply irrigation water only to lands classified as irrigable or under special contract.

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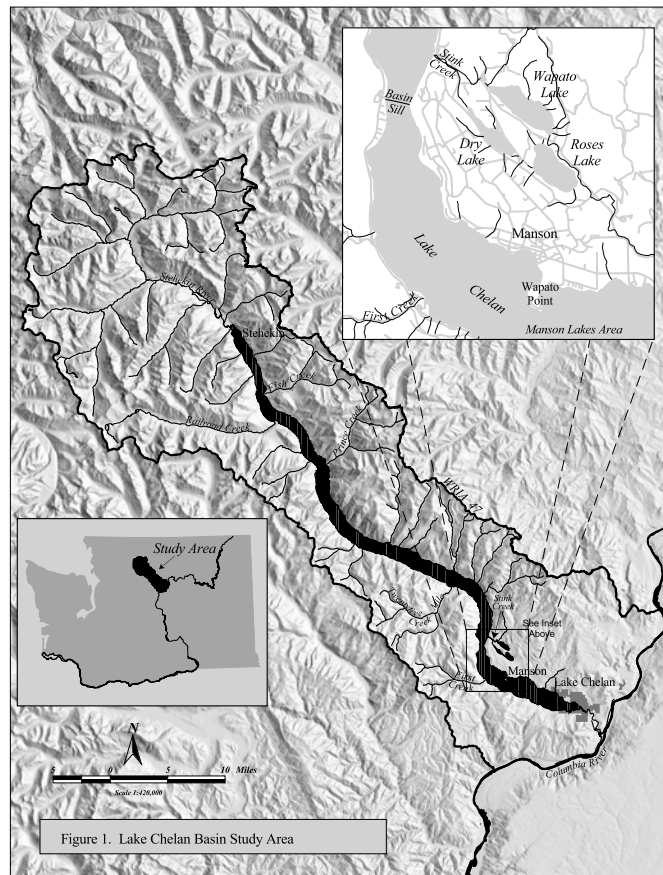


Figure 1. Lake Chelan Basic Study Area

## IRRIGATION SYSTEM AND CLASSIFICATION PROCESS

### **System Design and Layout**

The USBR began planning for a new irrigation system for the District back in the late 1950's. The concept of irrigable lands was used to identify agricultural property that had long-term commercial viability within a logical service area.

**Topography:** The Lake Chelan Reclamation District is in a mountainous region on the east slopes of the Cascade Mountain range. The USBR system identified a service area that extended from 1100 feet mean sea level (MSL) to over 2400 feet MSL that would be served by 12 different pressure zones. The system was designed to provide irrigation water under pressure to all farms with a minimum 30 psi at the high point.

**Allotment:** The typical crops grown in north central Washington are fruit trees and vines. These crops require an average of 3 acre-feet per acre of supplemental

irrigation water to raise a productive crop. The USBR system was designed to provide at least 6.9 gallon per minute per acre to meet daily evapotranspiration requirements of these crops during peak demand.

Delivery: The District operates the system as an on-demand, limited rate system. The farmer may turn their water on and off as needed and is asked only to stay within the maximum instantaneous delivery rate dictated by the system based upon acres assigned to the turnout, overall capacity and demand. The use of flow meters, pressure reducing valves and regulating reservoirs provides the growers with outstanding flexibility of service.

### **Land Classification**

The USBR classifies land in the District as irrigable classes 1, 2 or 3 or as non-irrigable class 6. The lands classified as irrigable have the elevation, slope, soil type and profile to productively grow crops.

Elevation: The USBR system was designed to serve 12 different pressure zones with at least 30 psi at the high point. This criteria was established when overhead impact sprinklers were the most commonly used on-farm irrigation system in local orchards. The high point was established based upon an allowable friction loss in the grower's mainline and instantaneous flows to serve impact sprinklers. The current use of micro and drip sprinklers at low pressures has expanded the grower's potential service area using turnouts based upon the original criteria.

Slope: Irrigable classifications were based upon slopes not exceeding 15%. Classification maps were drawn with topographic information of limited detail and accuracy. The advent and wide-spread popularity of the four-wheel drive orchard tractor made farming slopes steeper than 15% much easier and safer. Land leveling for high value crops also became popular.

Soils: Smaller trees in the orchard setting have proportionally shallow root stock and need less soil depth than in the original criteria. Wet areas that were thought to be non-irrigable have been drained and conditioned making them suitable for cultivation.

### **Development and Replants**

As growers developed the new lands added to the project in the 1970's and 1980's and as old orchards were torn out and replanted, the growers were looking for horticultural situations that were easiest and most profitable to farm. Many land classifications done by the USBR were done without "field truthing" the topography and soil types leaving the grower to plant orchards where the land was truly arable and where the orchards produced the best crop.

## MONITORING WATER USE COMPLIANCE

As the proceeding sections briefly describe, the changes that have occurred over time have allowed growers to both advertently and inadvertently use water outside of the lands classified by the USBR as irrigable. The high value crops make land values increase and limited water an increasingly valuable commodity. The modulating topography and odd-shaped properties make visual observation of crop patterns difficult to evaluate and impossible to quantify without a survey. The Lake Chelan Reclamation District is required to regulate the use of irrigation water to stay within the contractual terms of the USBR contract and the state water rights. Geographic information systems allow the Lake Chelan Reclamation District to look at the overall contractual acreage as well as the compliance of the individual grower.

### **Electronic Mapping and Imagery**

AutoCAD® software is used to map parcels, land use and facilities within the Lake Chelan Reclamation District. Orthorectified aerial photos of the lands within the LCRD can be viewed and overlaid with mapped features. Specific features can also be identified by operational personnel with a global positioning system (GPS) and added to the AutoCAD layering system.

Base Maps: Experience has taught the District that electronic mapping and imagery must be done on the proper coordinate system, with very good base information, and to a high degree of accuracy. Assessments and allotments are based upon the number of irrigable acres within each parcel. Every subdivision and boundary line adjustment potentially impacts the assessment of each parcel.

The District began the exercise of mapping parcels into AutoCAD using their actual legal descriptions overlaid on the original USBR plats. The original USBR plats unfortunately contained inaccurate data that was poorly coordinated and constructed. Translating the data to 1983 North American Datum (NAD 83) proved that mistakes were made in the earlier plats. This was verified when the maps were overlaid onto the high quality orthorectified aerial photos. The inaccuracies were not at a consistent offset or scaling factor and rubber sheeting the maps would only distort the metes and bounds descriptions of each parcel.

GPS Control Points: The translation of data into NAD 83 required the establishment of known control points as points of reference. District personnel used global positioning systems (GPS) to identify and reference over 4,000 property and plat monuments that could be verified with the high resolution aerial photography. Parcels and plats could then be repositioned and apportioned within NAD 83 to meet accuracy requirements. Physical land use is then digitized within the parcel off of the aerial images. Land classification is digitized off of the USBR classification maps onto specific AutoCAD layers. Other distribution

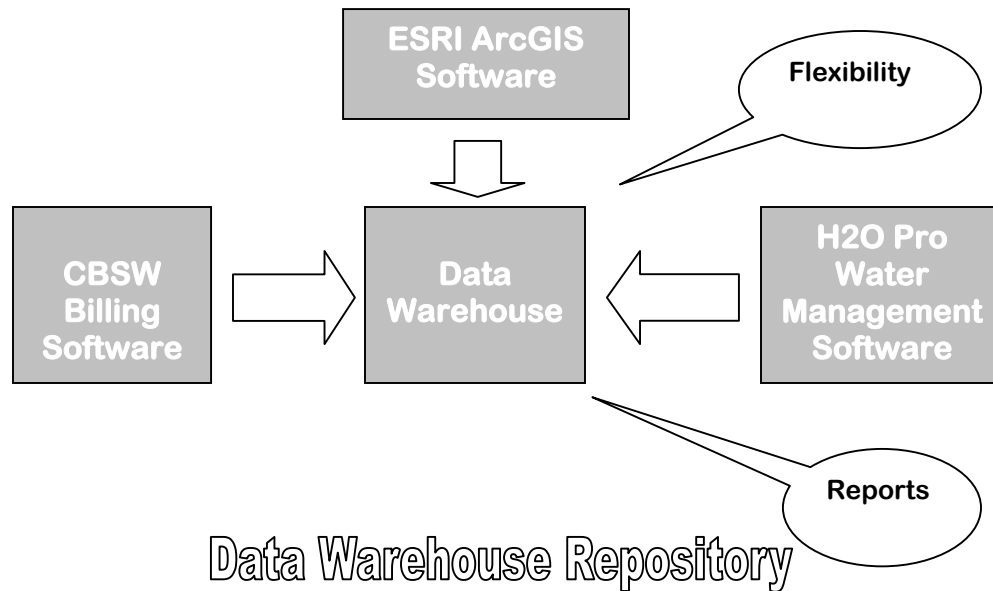
system elements including turnouts and lateral locations were also positioned with GPS.

### **Integration of Platforms**

All AutoCAD drawing layers are being imported into the geographic information system (GIS) used by LCRD. The maps are converted to elements within ArcGIS® by ESRI software. The only attributes imported to GIS at this time are parcel number and irrigation turnout number together with the land use and other physical features represented by closed polylines in the appropriate AutoCAD layer. This process is currently underway in the District and represents the current status of the project.

Electronic Data: The Lake Chelan Reclamation District has worked closely with Easy Reader International through its program H2O Pro® and Continental Utility Solutions through its program Continental Irrigation Billing System for Windows® (CBSW) to develop a new billing and water management software platform. H2O Pro is a robust program designed for irrigation districts that develops a relational database between irrigation water use, crop types and facilities management. CBSW is a relational database that can track multiple services provided by irrigation districts together with several customer information features to meet billing needs. LCRD hired these companies to develop a data warehouse repository for a single common database that works with both programs. The data warehouse program provides periodic exchanges and synchronization of data between H2O Pro and CBSW to coordinate the various functions.

H2O Pro handles all water use issues associated with meters and meter reading functions. This is done by utilizing handheld scanners and bar codes that identify both meter and turnout information in the field. H2O Pro will manage quality control of new meter readings that are entered into the system and allows the operators to read the meters at daily intervals if needed. H2O Pro also provides the internal calculations to determine if water use is within established allotments, or if not, where usage lies within tiered excess rate structures. The program allows for multiple meters that are shared and averaged for one or multiple customers. Water use reports can be generated by customer, crop type, lateral or system for any queried time period. The water use by billing category is then exported to CBSW where bills are generated by service type.



CBSW coordinates customer information, turnout identification and parcel identification together with the same attributes identified in ArcGIS. This customer and facility data is then exported to H2O Pro for its use in developing customer water use reports. The data warehouse is used to coordinate the timing and quality control of the data being synchronized between the three applications.

Populating the GIS Database: Most GIS systems have standalone databases that run independently of other customer information systems. The GIS system must therefore be independently updated and maintained. As described above, CBSW has considerable capabilities to provide customer information. This includes the actual number of acres assessed and allotted to each parcel and customer. The goal in the future is for the data warehouse to allow the database information generated and maintained in the billing software to be exported and populate the GIS database. The cross reference will be the parcel and turnout number that were attributed in the GIS conversion. Queries can then be developed in GIS to compare assessed versus planted acres to be reported both on the District-wide level as well as the ownership or parcel level. The resulting high quality maps can then be used by the USBR as a basis for a reclassification survey. It is anticipated that a reclassification survey will be done soon after the GIS is fully populated with current data and then periodically in small areas thereafter as the need arises.

### **FUTURE INTEGRATION NEEDS**

Within the next year, the Lake Chelan Reclamation District will be integrating the platforms together for an overall compliance report. The compliance report will

be a snapshot in time back to when the most current orthorectified aerial photography was done in 2001. Unless aerial photography can be taken every year, none of the land use changes that have occurred since the aerial photography will be reflected in the reports.

Several irrigation districts in Oregon have been using satellite imagery as a cheaper alternative to expensive orthorectified aerial images. The satellite imagery is cheaper to obtain but does not have the resolution or accuracy of the aerial images. It is proposed that the District will obtain satellite imagery on an annual basis to supplement orthorectified photography obtained every 5 to 7 years. ArcGIS can be queried to analyze and identify only changes between the aerial photos and the satellite imagery. If the changes identified in the satellite imagery are a compliance concern, GPS technology can be used to “field truth” the extent and location of the change in land use and make up for the lesser accuracy of the satellite image.

The data warehouse can also be used to synchronize the database between future upgrades of the billing, water management and GIS products described. Subtle changes in the warehouse may be needed to describe where the data is coming from and going to within the upgraded standalone products, but if open architecture remains in vogue, the future of this idea remains positive. The data warehouse is much easier to customize and upgrade than it would be to customize each individual standalone platform.

## CONCLUSIONS

Water use compliance is an important issue within irrigation districts in the arid west as more interest groups compete for these limited resources. Water law, endangered species, clean water act provisions, third party impacts and contractual obligations are just a few of the competing factions interested in assuring that present uses of water are efficient and effective. At the Lake Chelan Reclamation District, GIS will be used to advance our understanding of water use and efficiency and document the same. The integration of various software platforms allows the customer information to be updated, queried, compared and maintained within one single database. This makes data management more efficient and useful.