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WATER CONSERVATION: SAVINGS DETERMINATION IN NEAR REAL-TIME

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ABSTRACT

The Imperial Irrigation District (IID) and the Metropolitan Water District of Southern California (MWD) entered into a pioneering water transfer agreement in 1988. MWD was to finance water conservation programs in the IID in return for the transfer of the conserved water volume each year for 35 years. The agreement required that the water conserved be verified.

This paper describes the information system module that determines water savings from a variety of system and on-farm conservation projects in near real-time. The system integrates data from Supervisory Control and Data Acquisition Systems (SCADA), data loggers, CIMIS, agricultural delivery data and volume pumped by tailwater return systems with distribution system configuration and project information.

Colorado River system operating conventions require that the volume of water conserved by IID and made available for transfer to MWD be projected prior to the start of each Calendar Year. In line with the Water Conservation Agreement, the Water Conservation Measurement Committee (WCMC) established the convention of using the verified water savings from the proceeding Water Year

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(October through September) for the projected savings for the upcoming Calendar Year[8]. The verified savings are computed using data and algorithms stored in the Conservation Projections Module of the Water Information System (WIS) of the IID under the direction of the Conservation Verification Consultants (CVC) and the WCMC.

BACKGROUND

The IID and MWD agreed to a pioneering water transfer agreement in December 1988 (Agreement). MWD financed an IID water *Conservation Program* (Program) in return for the transfer of the conserved water volume each year for 35 years. Because the Agreement had the potential to impact other water users, the water conserved must be verified. Dimmitt (1998) provides details about Program organization and Projects implemented.

The WCMC engaged the CVC to verify water conserved and prepare water *Conservation Projections*. *Conservation Projections* are defined as the estimated Project Net Conservation Savings forecast for the upcoming calendar year. A set of precisely defined terms supporting verification of the conserved water is used throughout this document. These terms are in italics.

Colorado River System conventions require that water available for transfer from IID to MWD must be projected prior to the start of the Calendar Year. Thus, each year, the CVC computes *Conservation Projections* based on the just completed water year. In December, the WCMC reviews and adopts *Conservation Projections* for the upcoming year. After approval, a final report detailing the *Conservation Projections* is produced.

Over a period of years, the CVC developed conservation verification strategies (Burns, et. al., 2000) and algorithms for each Project. During that time, the need for an accessible historical database became apparent. This historical database came on line January 1, 1996 as IID's Water Information System (WIS). Data is transferred to the WIS from IID's SCADA and business computer systems and other sources for historical warehousing (Thoreson, et al., 1999). All data is quality controlled prior to use in the verification algorithms (Archer, et al., 1999).

This paper describes the WIS *Conservation Projections* module that integrates the stored data and computes the *Conservation Projections*. The module outputs are discussed; followed by discussion of required data, design concepts, and a summary.

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[8] According to this convention, the cumulative actual conserved volume lags the projected volume by one year, with the maximum difference between the two values limited to the difference between consecutive years. There is no cumulative error between the projected and actual conservation savings.

OUTPUTS

The *Conservation Projections* (CP) Module integrates data from five WIS modules to compute and store the Program's annual *Conservation Projections*. The five data modules are WIS SCADA (SC), Easylogger (EZ), Delivery Detail (DD), Tailwater Return Systems (TRS) and CIMIS Weather (CW) (Figure 1). The CP Module includes a report summarizing each Project's annual *Conservation Projection* and associated details. The report can be viewed on screen, printed and bound with introductory text for the Program's annual report.

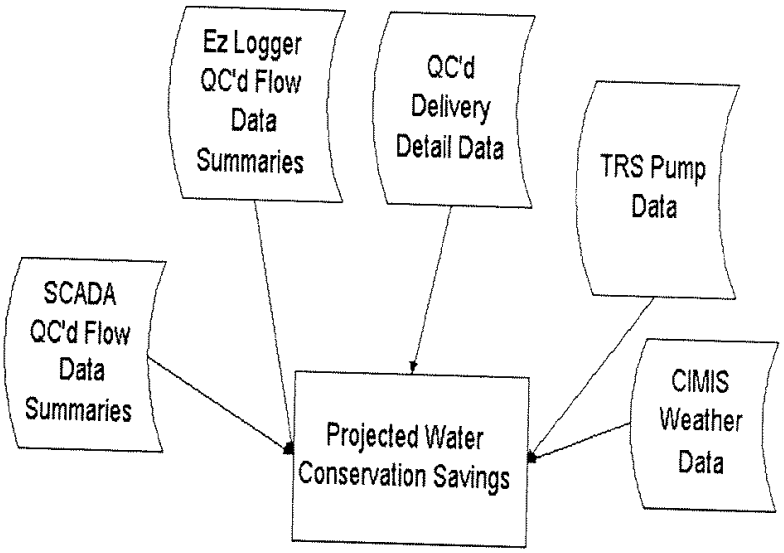

Figure 1. Required data for *Conservation Projections*.

In addition to the Program's annual report, the Module produces mid-year estimates from January through September, which are based on data from the most recent 12-month period. These procedures allow month-to-month tracking of changes in conserved water. The module stores the *Conservation Projections* for all years. Historical reports can be run for any desired five-year period.

In November of each year, a draft *Conservation Projections* is prepared by the CVC for review by the WCMC. After review by the WCMC and incorporation of any adjustments required by the WCMC, the final *Conservation Projections* report is published in January. The report consists of a summary table showing the Project-by-Project *Conservations Projection* (Table 1) and pages for each Project (Table 2).

Table 1. Projected water conservation savings.

Projected Water Conservation Savings
in Acre-Feet
* Historical Verified Savings

Proj.	Project Name	HVS* 1998	HVS* 1999	HVS* 2000	HVS* 2001	HVS* 2002
1	Robert F. Carter (Trifolium) Reservoir	4,470	4,110	4,100	4,090	3,200
2	South Alamo Canal Lining, Phase I	510	510	510	510	510
3	Plum-Oasis (Lateral) Interceptor	6,650	9,000	9,390	8,550	8,340
4	Bernard Galleano (Z) Reservoir	5,230	4,470	4,530	4,510	4,570
5	South Alamo Canal Lining, Phase II	900	900	900	900	900
7	Lateral Canal Lining	24,250	24,250	24,250	24,250	24,250
8	Trifolium Interceptor	14,700	14,560	16,300	15,020	14,480
9	12-Hour Delivery	22,290	21,750	21,730	21,390	20,740
10	Vail Supply Canal Lining	10	10	10	10	10
11	Rositas Supply Canal Lining	130	130	130	130	130
12	Non-Leak Gates	630	630	630	630	630
14	Irrigation Water Management	510	280	110	110	110
15	System Automation	13,490	14,600	14,000	14,390	14,250
16	Westside Main Canal Lining, North	260	260	260	260	260
17	Mulberry-D (Modified East Lowline) Interceptor	8,460	8,500	8,540	8,220	8,030
18	Additional Irrigation Water Management	4,670	4,540	4,070	3,910	4,530
	Total	107,160	108,500	109,460	106,880	104,940

Project 6 (Sperber Reservoir Outlet) and Project 13 (Tailwater Assessment) were included in the original Water Conservation Agreement.
Project 6 was dropped from the IID/MWD Program by the Program Coordinating Committee because savings were found to be insufficient.
Project 13 was replaced by Projects 17 and 18 in the Approval Agreement.

Table 2. Project 9 - 12-hour delivery.

* Historical Verified Savings

	HVS* 1998	HVS* 1999	HVS* 2000	HVS* 2001	HVS* 2002
Reduced Farm Delivery (12-HD)(1)	23,913	23,625	23,807	22,949	22,373
Induced Lateral Spillage (12-HD)(3)					
Induced Main Canal Spillage (12-HD)(6)	0	0	0	0	0
	1,625	1,879	2,073	1,556	1,635
	22,290	21,750	21,730	21,390	20,740

(Rounded to the nearest ten acre-feet)

REQUIRED DATA

The data required from other modules can be classified as constant, infrequently changing and time-series data. Constant data relates the water delivery gate to structural aspects of the water delivery system. This data changes when construction alters the structural aspects of the water delivery system. Delivery gate attributes identify the spillage site and intercepted area each delivery gate is related to. These attributes must be specified when a new delivery gate is added. Infrequently changing data relates to water saving, on-farm water application and handling systems sponsored as part of the IID/MWD water *Conservation Program*. These systems may exist at other gates, but are included here only if they were sponsored by, or installed as a direct result, of the IID/MWD program.

DESIGN CONCEPTS

The *Conservation Projections* Module presents the *Conservation Projections* in terms of *Conservation* and *Consequential Effect Elements. Conservation Elements* are reductions in water uses or losses due to the effects of a conservation Project. *Consequential Effect Elements* are increases in water uses or losses due to the effects of a conservation Project. *Conservation* and *Consequential Effect Elements* computational details are described in detail in Verification Summary Reports. Each project's *Net Conservation Savings* is the difference between the totals of its *Conservation Elements* and its *Consequential Effect Elements.*

Conservation and *Consequential Effect Elements* are sub-divided into "sub-elements." Sub-elements are annual values that cannot be further subdivided. Elements and sub-elements are classified as *Fixed* or *Time-dependent* elements. *Fixed* elements are *Conservation* or *Consequential Effect Elements* that do not change with respect to time or change sufficiently slowly that they can be held constant for periods of five years or more. *Time-dependent* elements are *Conservation* and *Consequential Effect Elements* that change over time and therefore must be recomputed for preparation of each conservation projection.

The sub-elements often are flow measurements from specific locations. However, they can also represent classes developed for computing the reduction of a targeted flow path. Elements with sub-elements require detail pages as part of the *Conservation Projections* report.

Five steps occur in the data processing to compute the *Conservation Projections*:

1. Programs process those elements requiring integration of data from more than one module placing the results in summary tables.
2. The current values of the *Fixed* elements are stored in a holding table.
3. The *Time-dependent* elements are collected and stored in a holding table.

4. The values in the holding table are used to compute each project's *Conservation Projection*, which is initially stored in a holding table.
5. Following approval by the WCMC, the elements and *Conservation Projections* are moved from the holding tables to a table containing the time series of Historical Verified Savings (HVS).

Required Processing

Two types of processing are required before data from the WIS modules can be used to determine a *Conservation* or *Consequential Effects Element*. For elements based on deliveries to farms, the deliveries with conservation potential must be selected based on established criteria and summarized. Three independent programs conduct this processing. Elements requiring synthesis of the without project *Spillage* integrate delivery and spillage information in a "*Spillage* a Analysis." Six programs integrate the delivery and *Spillage* data to compute the values required for three *Conservation* and one *Consequential Effects Element.*

The *Spillage* Analysis relates *Spillage* in IID to the delivery flexibility provided to growers. This analysis provides an adjustment to historical *Spillage* for current levels of delivery flexibility and also estimates the incremental *Spillage* caused by program-sponsored delivery flexibility. The *Spillage* Analysis computes estimates of the *spillage* volume that would have occurred absent delivery flexibility.

The *Spillage* Analysis consists of a pre-*spillage* analysis/draft projections data review and the *Spillage* Analysis procedures. The pre-*spillage*/draft projections data review (Table 3) is a report that allows for a final quality control review and, if necessary, data corrections prior to the *Spillage* Analysis.

Fixed Elements

Fixed elements are not based on time series data. Although these elements are expected to change infrequently, their values could change due to changes in IID's distribution system or operations. Therefore, provision has been made for these elements to change if necessary. The value of the *Fixed* elements is stored in a table in the CP Module. This table contains a history of the value of the *Fixed* elements if they have changed, but uses only the current value for the determination of *Conservation Projections*. Upon completion of pre-processing, a program collects all current *fixed* element values and places them in a holding table for use in either the draft projections or mid-year estimate report.

Table 3. Pre-spillage analysis/draft projections data review

PRE-SPILLAGE ANALYSIS/DRAFT PROJECTIONS
WATER YEAR 2001
(10/01/2000 to 09/30/2001)
DATA REVIEW
SUMMARY

Proj No	Element Description	No. Sites	1997	1998	1999	2000	2001
1	Continuing Main Canal Spillage	1	140	147	154	148	**1,059**
3	Introduced Interceptor Canal Spillage	1	1,216	1,475	1,135	1,184	1,246
3	Continuing Lateral Spillage	9	364	198	197	333	**207**
4	Continuing Main Canal	1	2	71	2	10	**4**
8	Introduced Interceptor Canal Spillage	1		1,033	663	267	**87**
8	Continuing Lateral and Main Canal Spillage	10		4,335	1,939	2,224	2,304
17	Continuing Lateral and Main Canal Spillage	12	2,222	3,064	3,028	2,980	2,919
	1. Verification Lateral Base Spillage Sites	11	11,405	12,171	10,904	10,615	10,325
	2. Additional Verification-Quality Spillage Sites	7	2,731	3,663	3,195	2,828	2,886
	3. Additional Spillage Sites	11	10,038	8,114	9,058	7,731	8,869

Note: All spillage values in Acre-Feet.
Bold values are either new maximums, new minimums, or greater than 10% different than the previous year.

Prepared by: WIS/IID

Time-dependent Elements

Time-dependent elements, in contrast to *Fixed* elements, are based on time series data collected and stored on the WIS. Thus, the values of these elements change each year. Some of these elements use available WIS data that needs little or no additional processing. Others require processing of available WIS data to synthesis the without project condition (Burns, et. al 2000). After processing is complete, a program computes all *Time-dependent* element values. These values are placed in the same holding table as the *Fixed* elements for use in either the draft projections or mid-year estimate report.

Conservation Projection

Once the elements have been stored in the holding table, a procedure computes Project *Conservation Projections*. These values are stored in a holding table for use in the draft projections report or mid-year estimate report.

Historical Verified Savings

Following WCMC adoption of the draft projections, the *Conservation Projections* and all the elements for the upcoming year's final projections are moved from the holding tables to the final time-series table containing the Historical Verified Savings (HVS).

Algorithm Revisions

Certain changes in the calculation of these values can be easily done, however, it was neither possible to plan for nor predict all changes. Changes in the sites required and the constants used in algorithms can be made with ease. However, changes in the algorithms themselves require changes in the processing and procedures within the CP module. Elements can be added or made inactive, however any processing required to compute the value of an added element will need to be developed. The value of *Fixed* elements can be modified by making the current element inactive and adding a new record for the element.

Time-dependent elements vary according to the collected time-series data. Some of these elements use complicated algorithms to calculate the *Conservation* or *Consequential Effect Element*. Considerable effort was spent to design flexibility into the application computing these algorithms and also to maintain a history. For simple elements, such as volume measurement totals, if a site changes, the current site is marked as inactive and the new site is added as an active record.

SUMMARY

An information system application has been developed that integrates near real-time quality-controlled flow, delivery and weather data for computation of *Conservation Projections*. A report detailing water conservation achieved by various projects over a 12-month period can be printed providing mid-year estimates of and draft and final *Conservation Projections* for the upcoming year. This report provides access to monthly mid-year estimates of what the next year's *Conservation Projections* might be.

Key requirements in the design of the information system application were:

1. *Conservation Projections* and details available at the "push of a button,"
2. Maintain a history of all inputs and computations,
3. Allow month-to-month tracking of projections,
4. Allow a draft projections report for review and, if necessary, adjustments prior to finalizing the projections, and
5. All input data and final projections must pass rigorous quality control.

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