A WEB-BASED IRRIGATION WATER USE TRACKING SYSTEM

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ABSTRACT

Across the 13 irrigation districts in the province of Alberta, there is no direct volumetric financial charge attached to water diversions and consumption. Individual water users pay specific and fixed annual rates per unit of irrigation area defined within their respective assessment rolls, regardless of the actual volume of usage. However, as water is becoming a more stressed resource, with increasing competition for limited supplies by a diversity of users, and with greater public call for more accountability on the part of water users, it is becoming increasingly understood that some form of volumetric accountability is warranted.

As virtually none of the 10,000-plus water delivery turnouts have any metering facilities whatsoever, it has been necessary to develop some alternative form of water use tracking to compile reasonable records of individual diversions. Even though these volumes of diversion are not currently tied to water use charges, many of the districts have implemented limits on deliveries to individual land parcels. A *Water Use Module (WUM)* software package has been developed that tracks water use based on the duration of water deliveries to each irrigation system in each field and the respective capacity of each of those systems. This package has recently been up-dated to take advantage of opportunities to interface with the Internet for more real-time, more accurate and more comprehensive irrigation information reporting.

INTRODUCTION AND BACKGROUND

Irrigation In Alberta

There are 13 organized autonomous irrigation districts in Alberta, collectively supplying water to approximately 1.325 million acres (536,000 ha) of assessed irrigation land in the southern region of the province. In addition, there are approximately 285,000 acres (115,000 ha) of land irrigated across the province through what are referred to as privately licensed and individual water user-

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developed irrigation projects. Irrigation districts are particularly characterized by their extensive infrastructure and their operating under provincial legislation known as the *Irrigation Districts Act* and under water License authority through the province's *Water Act.*

Each of the districts has its own somewhat unique history of development, but, in general, they have been in existence for nearly one hundred years or more. Typically, each district, under the authority of its water License(s), has a volumetric limit available to deliver through its respective works to the farm delivery gates of its water users. The latter pay for this supply, to their water user-owned district through annual rates that are levied against each "acre to be irrigated" on the district's assessment roll. Annual water rates have not and are not levied on the basis of the amount of water used. Although, there is a license limit on the amount of water that can theoretically be diverted to each district and subsequently delivered to the farm gate, water users have not, in the past, been subjected to much in the way of restrictions.

However, the irrigated area in Alberta has now matured to the level where double the area is now aggressively being irrigated than was the case 25 to 30 years ago. In addition, the impact of consecutive drought conditions in recent years, combined with the expanded intensive irrigation development, has resulted in situations of limited water supplies and a need, at some times, to impose rationing. In some irrigation districts, where rationing has not been immediately necessary, there has been a recognition that delivery limits needed to be imposed to encourage a greater ethic towards water conservation. As none of the more than 13,000 farm deliveries operated within the 13 irrigation districts have any physical water metering facilities installed, it has been necessary to derive some other "proxy" measurement system to quantify water use at the farm level.

IRRIGATION INFRASTRUCTURE INVENTORY

At the same time as the need to better quantify and control individual irrigator's water use was emerging, a major study to evaluate the opportunities for future irrigation growth in Alberta (Irrigation Water Management Study Committee 2002) was just concluding. This was a significant partnership collaboration between the Irrigation Branch of Alberta's department of Agriculture, Food and Rural Development (AAFRD) and the 13 irrigation districts in the province. As a major component of this water management study, a complete inventory of all irrigation district infrastructure and associated on-farm irrigation operations was developed within a GIS application. This was required in support of the detailed water management modeling carried out through the Irrigation Demand Model (IDM) (USCID/EWRI 2002). Each year, in consort with the irrigation districts, this spatial and attribute database is up-dated to reflect current system configurations, water delivery and application components, as well as field-by-field crop inventories.

Linking Conveyance Networks and Delivery Components

Two different data acquisition and warehousing systems were developed. The system that warehouses all of the district conveyance infrastructure data, including information on each farm delivery turnout, is referred to as the Irrigation District Infrastructure Information System (IDIIS). It contains a wide variety of descriptors concerning irrigation district conveyance and drainage works as well as significant major structures. Further descriptive information and a graphic representation of the IDIIS application are outlined in an associated paper, in these proceedings, discussing an infrastructure management system (Chinn et al 2005).

The second data management application, which captures all of the relevant on-farm information, is referred to as the *District Data Information Tool (DDIT)* and is the mechanism through which district operations staff inventory all on-farm system and crop information each year (AAFRD 2002). Each established on-farm system (e.g. center pivot sprinkler, surface irrigated field, etc.) is inventoried and linked to a specifically identified turnout delivery. Therefore, whether it is for IDM modeling purposes, for example, or for other water use accounting purposes, each on-farm system is "tied" to the conveyance network at some distinct point.

The DDIT application was developed in Microsoft Visual Basic, providing a straightforward user-interface, with Microsoft Access used for backend data storage.

ACCOUNTING FOR WATER USE

Within the DDIT software package, a *Water Use Module(WUM)* was also developed, enabling district operators to track irrigation water deliveries throughout any given district or portion thereof. The premise for this tracking was based on three identified on-farm system parameters, namely:

- Type of on-farm system (e.g. center pivot and side-roll sprinklers, etc.) and the flow rate or turnout delivery rate required for each type of system (e.g. gpm);
- Area irrigated by each system (e.g. acres); and
- Time of water use / water delivery (e.g. hours, days, etc.)

Therefore, to arrive at the amount of water used by a system during a given time period, the following equation is simply applied.

$$V = Q \times T \times 0.0042 \qquad (1)$$

where: V = volume of water diverted through a given turnout (acre-feet)
Q = flow rate through on-farm irrigation system (gallons/minute)
T = time period of water diversion (days)

The accuracy of applying Equation 1 to quantify water use is directly dependent on the accuracy of the system flow rate and the precision of recording actual diversion time. As is the case where any “proxy” system is being used, some assumptions or default information are relied upon. For example, default system flow rates, for southern Alberta conditions, were identified as a standard reference, on a per irrigated unit area, and are listed in Table 1.

Table 1. Default capacities for southern Alberta on-farm irrigation systems.

Type of On-Farm System (HP = High Pressure) (LP = Low Pressure)	**Default Flow Rate* (gpm/ac)**	**Type of On-Farm System**	**Default Flow Rate* (gpm/ac)**
Sprinkler – Solid Set	8.66	Gravity – Undeveloped	9.95
Sprinkler – Hand-Move	8.98	Gravity – Developed	15.35
Sprinkler – Side-Roll	7.15	Gravity – Auto Control	17.25
Sprinkler – Ctr. Pivot (HP)	6.86	Sprinkler – Volume Gun	8.66
Sprinkler – Ctr. Pivot (LP)	6.35	Sprinkler – Traveller	8.66
Sprinkler – C. Piv. Cor. (HP)	7.06	Micro – Spray – Sprinkler	5.45
Sprinkler. – C. Piv. Cor. (LP)	6.48	Micro – Spray – Trickle	4.49
Sprinkler – Linear (HP)	6.86		
Sprinkler – Linear (LP)	6.41		

* These flow rate values are typical for the higher heat unit and longer growing season regions. Default flow rate values for other regions can be moderately reduced.

Because of the prior on-farm system data collected and held within the DDIT database, all that is required to be entered into the WUM to calculate the water use is the date and time of water “turn-on” and the date and time of water “turn-off”. All other calculation factors are accessible through the DDIT database. This includes such information and variable particulars as:

- Type of system
- A system I.D. number (established by DDIT)
- Area irrigated by the system
- Default system flow capacity
- Land location of the system
- Name of the system owner / water user
- Turnout number (from IDIIS database) from which deliveries are made
- Type of crop grown under the system
- Water supervisor block

Where it is claimed or determined that the default system capacity is incorrect, a revised value can easily be inserted to overwrite the default value. The updated value will then always be referenced for all future water deliveries.

Water Use Information Reporting

A typical selectable water use report is depicted in Table 2. Pre-designed query reports can provide viewing or printouts of similar format information, based on selections according to the water user name, turnout or conveyance lateral identification, water allocation balance, water supervisor block or water deliveries in progress.

Table 2. A sample water use report for a single system during a single season.

BLOCK Name: Albion Ridge				**Water User Name:** Sun Dried Farms			
Land Location: NW-1-2-3-W4				**System Type:** SPLC		**Area:** 159.30 ac	
Date On	**Time On**	**Date Off**	**Time Off**	**Flow Rate (gpm)**	**Divert Time (Days)**	**Volume Delivered (ac-ft)**	**Water Use (ac-ft/ac)**
Jun-20-03	12:00pm	Jun-23-03	4:15pm	1,010	4.17	18.62	0.11
Jul-2-03	8:30am	Jul-12-03	9:00am	1,010	11.02	49.18	0.31
Jul-17-03	9:45am	Jul-23-03	8:30 am	1,010	6.95	31.01	0.20
Jul-28-03	12:00pm	Aug-2-03	7:00pm	1,010	6.29	28.08	0.18
Sep-15-03	11:15am	Sep-20-03	12:00pm	1,010	5.03	22.45	0.14
TOTAL for System					**33.46**	**149.33**	**0.93**

One of the most useful tools for output reporting that is available to a water supervisor for any given block is a listing of the current water deliveries in progress, indicating the location and flow rate of each of those deliveries. This additional information provides the water manager with a more comprehensive grasp, at any selected time, of how much water is moving through the system. When combined with pending water turn-on and turn-off orders, the block water supervisor can be more efficient and more effective in diverting appropriate volumes of water into various reaches of the conveyance network.

Managing for Rationed Allocations

As indicated previously, one of the main drivers for the use of this system has been the need to limit water delivery volumes at the farm gate, either due to shortages in supply or through conservation initiatives. Under rationing, for example, it may be determined that there is only sufficient water available for a given irrigation season in the amount equivalent to 12 inches per irrigated acre delivered at the farm gate. In order to track water use at each and every turnout, to ensure compliance with the restricted allocation, the DDIT/WUM application will track the number of days that water is diverted to any given system and provide notification as allocations are being fully consumed.

Once again, by the database knowledge of each system's capacity and irrigated area, it can be pre-determined as to the total number of days of delivery it would take to fully divert the rationed allocation volume. This can be derived according to Equation 2.

$$T = 18.857 \times D \times A / Q \qquad (2)$$

where: T = allocated time of delivery (days)
D = rationed allocation depth (inches)
A = area being irrigated through the diversion (acres)
Q = *average* rate of flow or system capacity (U.S. gpm)

Therefore, for an irrigation system with an application capacity of 900 gpm and covering 132 acres, it would take 33 days of operation to use the full 12-inch allocation. The WUM provides information reports to list any and all in-field systems that are within a specified balance of the stipulated allocation, thereby notifying the water supervisor as to when and where season cut-offs may be pending.

WATER USE DATA COLLECTION AND COMPILATION

Stand-Alone Computer Assistance

The DDIT application was originally designed to operate on independent computer systems, resident with each local irrigation block water supervisor ("ditch-rider"). Throughout the irrigation season, the water supervisor inventoried all on-farm systems and associated crops, recording the information in whatever form was available and practical at the time. At the end of each day or two, the water supervisor entered the data for his/her block area into the DDIT module installed on his/her home computer system. At the end of the year, summary reports of farm operation details were provided to the irrigation district central office, on a block-by-block basis, and individual block databases merged to provide overall district statistical reporting.

Web-Enabled DDIT

In the evolution of the DDIT and WUM applications, several irrigation districts expressed the desire to have near real-time access to the field information being collected. In particular, the immediacy of on-farm system and associated water use information was expected to be valuable in assisting water operations managers to develop better control of water distribution practices for more efficient water storage and conveyance.

Some water supervisors collected the required information in a manual fashion and then, within a day or two, entered the information into his/her home computer up-dating that block-specific database only. Other supervisors collected and entered the data "on-the-go", carrying laptop computers with them in their work vehicles as they made the daily rounds of their respective irrigation blocks. However, there was still no central district database consolidation until all block databases were merged at season's end.

As a result, a revised application, called Web-DDIT was created. It provided a browser-based tool that allowed access to a centralized database resident on the district's web-server. The DDIT software and WUM application were modified so that all required field data could be collected and made available, via the Internet.

Typically, the inventory of on-farm systems would not change too significantly from one year to the next. However, with the ability to up-date any changes early in the irrigation season and have them up-loaded to the main district server, it became practical then to invoke the water use tracking system in a more rigorous fashion.

With the field information being up-dated more often and routinely on the main district server, the Internet connection also provides an opportunity to allow individual water users to access their water consumption information on a regular basis throughout each irrigation season. This is helpful, for example, where delivery limits are in force, allowing each water user to be completely aware of where his/her operation is at with respect to water allocation used and water allocation remaining.

Evolving to the Cellular Phone Adaptation

As is so often the case, as a new information system becomes more and more accepted, and its application is seen to be more and more useful, the expectations for convenience in its use tend to increase as well. Laptops, were often carried along daily with the water supervisor, were certainly seen to expedite the data acquisition process. Otherwise, written notations of daily collected data were transferred electronically each evening. However, the routine of making nightly up-date submissions over rural communication lines that were very slow, did not enhance the water supervisor's enthusiasm for the process. In addition, these units were not necessarily conducive to the rigors of the heat, dust and light of field duty.

As diverse information-sharing technologies become more and more available, the potential for better and more immediate data sharing becomes possible. Such has been the case with the recent availability of web-enabled cellular communication capabilities. As a result, some irrigation districts have implemented the latest version of the WUM whereby a water supervisor can submit the "turn-on" and "turn-off" dates and times almost instantaneously with the time that the action in the field takes place. Each on-farm system, inventoried within the DDIT database, has a unique identifying system number. At such time as a water delivery is commenced, or terminated, the water supervisor, through a WAP- enabled (Wireless Application Protocol) cellular telephone, simply needs to access the district's web-server and enter the system number of the system being delivered to and selects "turn-on" or "turn-off", depending upon the current operational situation. The delivery rate can also be over-ridden via the cellular connection, if applicable. That is all that is required as the date and time are automatically encoded at the time of data transfer from the cellular unit. This has proved to truly reduce operator workload and provide much better reliability in district management receiving near-real-time information on water operations and how they may affect water management decision-making.

A QUESTION OF ACCURACY

As the WUM application was a proxy measurement system, it was questioned as to how reliable the information was, particularly with regard to its accuracy. Regardless of the sophistication of the data capture and submission techniques, the system was still operating under quantifiers that relied on certain assumptions. Where there was some dispute over the assumed capacity of any given system, that could be verified through direct Doppler or sonic flow measurement devices that most districts had on hand for such situations**.** However, there are several other variables that can, if not correctly quantified, affect the degree of accuracy between the calculated consumption and the actual use. These are:

- System capacity variability;
- Discrepancy between recorded and actually-irrigated area;
- Actual diversion time affected by system shut-downs, etc.; and
- Water supervisor's diligence at recording exact "on: and "off" times.

Any variance from the true values for any of the above could have some degree of effect on the accuracy of the calculated diversion amount. Nonetheless, any loss of accuracy must also be compared to what could be reasonably expected to be achieved with conventional flow measurement equipment.

A Field Test Comparison

In order to determine the relative accuracy of using WUM for tracking water use, a monitoring project was established in the field where actual metered diversions could be compared with the calculated volumes derived through the WUM application.

A conventional conveyance lateral, within the Lethbridge Northern Irrigation District (LNID), was selected for the comparative monitoring evaluation. The

LNID was one of the earliest users of the WUM and are progressing as one of the irrigation districts leading in the adoption of this format of water use tracking. There were 13 different irrigation systems (seven center pivot sprinklers and six side-roll systems) diverting from this supply lateral. Each turnout was equipped with an in-line McCrometer impeller meter, installed at such a location downstream of the turnout and up-stream of the irrigation system so as to satisfy the hydraulic flow guidelines as much as possible. These types of meters had been used by AAFRD on a number of research projects and were found to be quite accurate and reliable. Each meter was also equipped with a datalogger that recorded the date and time of flow as well as the rate of flow and accumulated flow-through. The conventional mechanical meter with a totalizer was installed as well and served as a check against the datalogger readings.

Over the course of three irrigation seasons (2001, 2002, 2003) the actual diverted flows were tracked through the metering equipment. At the same time, the WUM records, as submitted by the local water supervisor for the block, were compiled for later comparative analyses.

Figure 2 illustrates the comparative results from the 2001 irrigation season, one of the highest demand years. The type of system monitored is indicated as well.

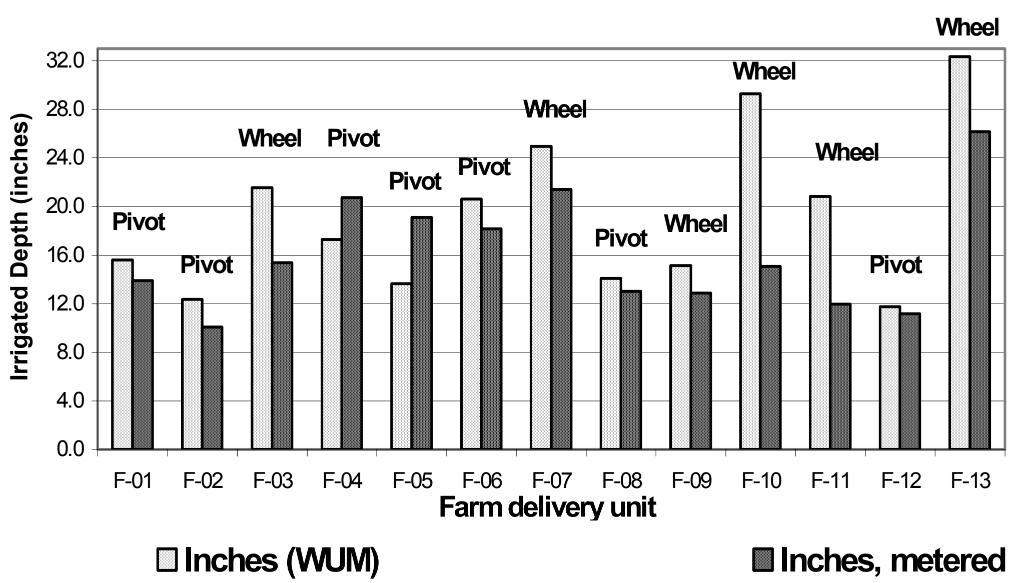

Figure 2. A comparison of metered vs. WUM measurements, by system type

<u>A Discussion of the Results</u>. It was determined that there were some small discrepancies between the assumed system capacity and what was actually confirmed through testing with a more precise sonic meter. It was also found that the actual irrigated area under some systems was slightly different than that which was recorded on the assessment rolls. However, the major factor influencing the variance between the WUM determinations and the metered logs was in the actual

time of diversion. The water supervisor tended to not be too specific in his record-keeping as to exactly what time in the day water was actually turned on or off. Similarly, if a system was turned-off during the delivery period, through, for example, an automatic shut-down due to a pivot operational problem, that "water-off" period was not recorded by the water supervisor but was, however, tracked through the meter datalogger. This yielded a trend where the WUM record generally indicated a higher (23.8%) water use than was actually metered.

CONCLUSIONS

The concept of using the WUM application appears to be feasible for southern Alberta irrigation operations. This has been borne out by the successes in its application achieved in critical water rationing years. In comparison to the estimated $20 to $25 million investment that would be required to incorporate physical metering facilities, the WUM is a good first step, at least, in tracking irrigation water use.

On-going follow-up field research, supplemented by simple flow-switch time clocks, has shown that where the time-linked water deliveries are more precisely recorded and on-farm system capacities are better quantified, reasonable measurement accuracies are attainable. With due diligence in acquiring the correct field data, with a convenient and reliable system of data entry, and with timely entry of correct data by local water supervisors, it is expected that the accuracy of the WUM water use determinations can be within ± 10% or less. Relative to conventional metering systems that usually require considerable on-going maintenance, this level of accuracy may be reasonable and practical.

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