COOPERATIVE EFFORT OF IRRIGATION COMPANIES LEADS TO WATER CONSERVATION

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ABSTRACT

The West Side Combined Canals Salinity Project (Combined Canals) was a multi-million dollar combined irrigation project that met the needs of two irrigation companies and the Ute and Ouray Indian Tribes. The Bureau of Indian Affairs (BIA), the Uintah River Irrigation Company (URIC), and the Ouray Park Irrigation Company (OPIC) had historically competed over the limited Uinta River water supply. A steering committee made up of representatives from these groups met monthly over the past decade to oversee and direct the development of the Combined Canals. The project involved working together to create one large pressurized distribution system, rather than merely laying pipe in the existing alignments of the seven participating canals. A memorandum of understanding was produced that defined operation of the combined system. A Supervisory Control and Data Acquisition (SCADA) system was implemented to allow project participants to monitor water usage and water accounting. Each entity was able to realize an increased water supply, an increase which may have been economically infeasible if implemented as individual projects.

INTRODUCTION

Background

Over a decade ago, an irrigation company in western Uintah County, Utah received funding to pipe their canal. When the irrigation company requested assistance, the Uintah Water Conservancy District (UWCD) realized the potential for other companies to receive similar benefit. The concept of the West Side Combined Canals Salinity Project (Combined Canals) was born. The result was a multi-million dollar combined irrigation project that met the needs of two irrigation companies and the Ute and Ouray Indian Tribes.

The Bureau of Indian Affairs (BIA), the Uintah River Irrigation Company (URIC), and the Ouray Park Irrigation Company (OPIC) had historically competed over the limited Uinta River water supply. Through the implementation of the Combined Canals, these entities realized that by working together thousands of acre feet of water could be conserved. By combining the various canal replacement projects, water conservation was

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achieved at a lower cost. Each entity was able to realize an increased water supply that may have been economically infeasible had they tried to implement an individual project.

Project Description

The final phase of the Combined Canals was put into operation during the irrigation season of 2008. The project delivers water to over 14,000 acres in three distinct areas within western Uintah County. The project, as shown in Figure 1, replaced 46.4 miles of 7 different canals or ditches with a 200-cfs diversion structure from the Uinta River, rehabilitation of the Cottonwood Reservoir outlet works, 8.3 miles of 48-inch diameter HDPE pipe, almost 7 miles of other large (24-inch to 36-inch) diameter pipe, and 21 miles of lateral pipelines. In order to accomplish a project of this magnitude, coordination with several agencies, including the U.S. Bureau of Reclamation, was necessary to obtain funding and establish environmental and ecological benefits.

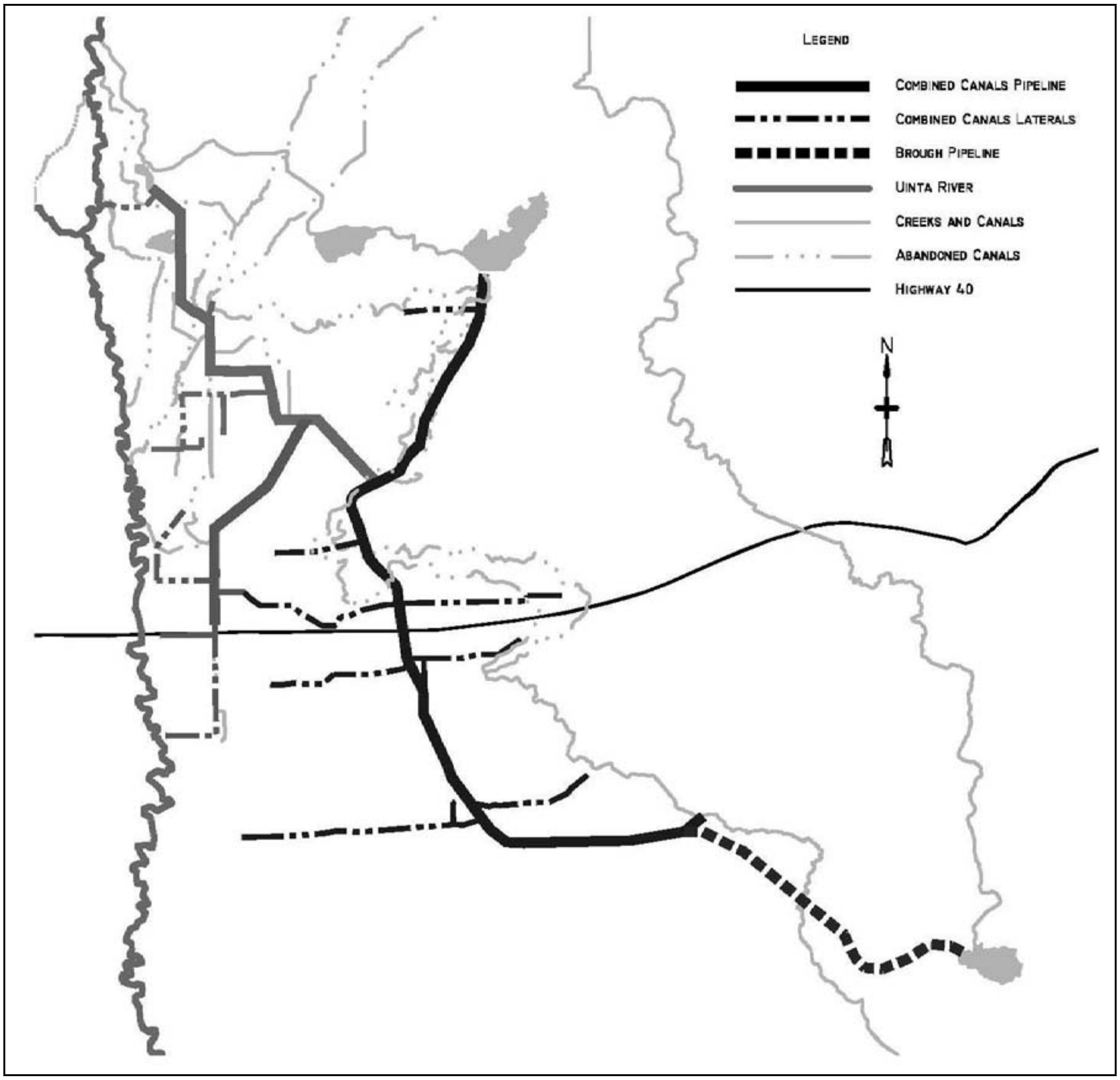

Figure 1. West Side Combined Canals Salinity Project

Purpose

This paper will discuss the significant water savings that are accruing due to the pipeline and operation factors of the project. The water supply is extremely limited in the area and thus the resulting increase of water due to the saved water has significant economic benefits to the irrigators. This paper also discusses the use of the SCADA System in the operation of the Combined Canals System and the significant operation costs that are saved due to the remote operation.

COOPERATIVE EFFORT

Before conception of the Combined Canals, the seven canals were owned and operated separately by two irrigation companies and the Ute and Ouray Indian Tribes. As the water source for all of the canals is the Uinta River, the irrigation companies and Tribes often competed for water. In order for the Combined Canals to be successful, the irrigation companies and Tribes would have to work together to overcome many obstacles, all while achieving a technically innovative and socially acceptable design.

Memorandum of Understanding

The idea of a combined system was innovative because not only water but also water rights and system operation would be commingled. Having historically competed over a limited Uinta River water supply, people were not eager to participate. In order for the Combined Canals to succeed, system operation would need to ensure the honoring of existing water rights. A detailed Memorandum of Understanding (MOU) was negotiated and an extensive Supervisory Control and Data Acquisition (SCADA) system was implemented to allow the project participants to monitor water usage and water accounting.

Key items addressed in the MOU include:

- Honoring of existing water rights,
- Ownership of project facilities,
- Operation of project facilities,
- Storage in Cottonwood Reservoir,
- Operation and maintenance responsibilities by project participant, and
- Roles of steering committee members.

Steering Committee

The Combined Canals would not have been possible without the input from the project participants. One of the first steps of the project planning was to create a steering committee made up of representatives from UWCD, OPIC, URIC, and BIA. This group met monthly over the past decade to oversee and direct the development of the Combined Canals. They compromised and agreed to a memorandum of understanding and other water use agreements that defined the operation of the project. The committee also helped to make critical design choices presented by the engineer.

WATER CONSERVATION

As discussed later in the paper on improved water management, significant amounts of water are being saved by the project. Water is released from storage reservoirs only when it is needed. With a gravity canal system, the travel time of water is measured in hours. Thus, when time is needed to change water sets, the water continues down the ditch and much water is lost. Due to the use of pipelines and the Control system, very little water is lost to operational inefficiencies.

Abandonment of Canals

The Combined Canals resulted in the abandonment of all or part of seven canals. Table 1 lists the canals and the lengths of which have been abandoned.

Table 1. Abandoned Canals

Canal	Abandoned Length (miles)
Moffat	16.4
Ouray Park	13.8
Tabby White	2.5
Harris Ditch	5.9
Military Ditch	2.6
Deep Creek – Lateral 7	2.7
Daniels Ditch	1.0

In addition to the abandonment of the canals, a portion of the Ouray Park Canal was rehabilitated by lining it with a bentonite and geotextile liner.

Table 2. Lined Canal

Canal	Lined Length (miles)
Ouray Park Feeder	1.5

Seepage Loss

The seepage loss that has been conserved through the abandonment of the canals is tabulated in Table 3. The project has resulted in a total of almost 12,000 acre-feet (acft) of conserved water.

Table 3. Estimated Pre-Project Annual Seepage Loss

Canal	Length (miles)	Annual Flow (acft)	Estimated Loss (%/mile)	Estimated Loss per mile (acft/year)	Annual Seepage Loss (acft)
Moffat	16.4	8,330	2.7	227	3,715
Ouray Park Feeder	1.5	30,000		390	585
Ouray Park	13.8	30,000	1.5	453	6,253
Tabby White	2.5	890	7.0		156
Harris Ditch	5.9	890	4.0		210
Military Ditch	2.6	1,490	8.0		310
Deep Creek Lateral 7	2.7	3,270	4.0		353
Daniels Ditch	1.0	600		230	230
TOTAL	**46.4**	**45,470**			**11,812**

(total flow does not double count 30,000 acft for Ouray Park)

Conserved Water

The water supply is in the Combined Canals area is extremely limited. It has been estimated that the irrigators have increased their water supply by more than 25%, as shown in Table 3). Though this still leaves them short of water, the resulting increase of water due to the saved water has significant economic benefits to the irrigators.

USE OF SCADA TECHNOLOGY

The project was planned, designed, and constructed to use the latest in water measurement technology to allow for accurate water accounting. The measurement of water and accounting by user assures that the use of water is within the parameters of the original water rights. The extensive use of meters in an agricultural setting is an innovative but critical part of the success of this project. A SCADA system is usually thought of as just an operational need, but here it was absolutely critical.

While the water accounting is critical to the operation & success of the project, the project also uses the capabilities of SCADA by allowing remote operation at 6 critical points within the system. Due to the remote location of these points, some of which are accessible only by unimproved roads, travel times are measured in hours. Also the elevation difference from the beginning of the project to the last delivery point is over 500 feet over a 14 mile distance as the crow flies.

Why a SCADA system?

The three entities involved in this project have a very long history of mistrust and accusations of water stealing. Some of the accusations may have been well founded but the fact of the matter is that none of them had an accurate way to measure what they or the others were using. Each company had a measurement point from the Uinta River on their individual canal but these were seldom checked due to their remote location. When they were checked, the measurement was often an approximation by the ditch rider of the individual company whose tendency was to underestimate what was actually being taken.

The mistrust between the separate entities also filtered down to the individuals within the irrigation companies. Each individual would accuse those on the ditch upstream of them of taking more than their right. This determination was again an approximation by the ditch rider or by the landowners themselves and was more often than not estimated in their own favor. Because there were almost no actual measurement devices on the system, there was no way to determine who actually had taken more or less than their allotment for the year. This lead to a “take it when you can get it” mentality that turned neighbor against neighbor especially during dry water years.

Due to the mistrust and angst between and within irrigation companies, the three separate but parallel irrigation systems were not functioning efficiently. When the companies with the priority rights were not using all the water they were entitled to under their rights, they would send the water they were not using down the river instead of notifying the company with the next right that they could take more water. This waste of a precious resource was due to the poor management of the resource and a reluctance to communicate between the irrigation companies.

Even on good water years, when there was more than enough water to go around, there was confusion as to who could take the high spring runoff, who could store it and how much each company could use. During years like this the water distribution was a free for all with companies and individuals taking everything they could get without respect to water rights.

Because of the mistrust and inefficient operation of the systems it was determined very early in the design process that a system for accurate water measurement and accounting would be necessary and critical to the success of a combined project in the area. This system would have to be in the control of a neutral third party that had the authority to make the hard decisions during dry water years.

What will a SCADA system do?

The system would have to achieve three main purposes in order for the project to be successful for all entities involved. The system would, first, have to accurately measure the water for all three irrigation companies and for the individual water users, facilitating the efficient use and distribution of the limited water. Secondly, the system must add ease of operation for the ditch rider to cut down on the wasted time driving from one site to another. Third, the information gathered by the system must be made public so that individual water users could see that the water was being distributed fairly. This last purpose would create local accountability, with each water user knowing exactly what their neighbors are using.

From the purposes and needs defined for the system it was obvious that a complex Supervisory Control and Data Acquisition (SCADA) system would be needed. The

SCADA system would have to be composed of measurement devices for accurate water measurement, a series of dataloggers and radios to relay the collected data and a central computer (Host) to gather and display all the data for the irrigation system. The system would also need remote operable valves at critical locations in the water system that could be opened or shut from the Host computer.

Water Accounting

With this system in place, the three main purposes could be achieved. The place of diversion for all three companies water rights were moved to a single diversion at the head of the Ouray Park Canal. The headgate at this diversion was automated but the control of this gate was not connected to the project SCADA system but rather was connected to a system run by the Uinta River Commissioner. He controls all the diversions from the river and is in charge of distributing the water in the river according to water rights of the companies. A large concrete flume was built at the same diversion location to accurately measure the full diversion amount that is to be divided between the three irrigation companies.

From here the water flows down the Ouray Park Canal and into Cottonwood Reservoir. There is only one diversion along the main canal and that feeds into the BIA Inlet pond. This pond acts as a regulating pond for the entire BIA system. Cottonwood Reservoir acts as the regulator for the pipeline that feeds the URIC and OPIC irrigation systems. There is a flume at the Inlet Pond diversion to measure what the BIA is using. There are magmeters at the outlets of the Inlet Pond and Cottonwood Reservoir to measure what is being taken from the reservoirs.

Every lateral from the main pipelines of the system have a magmeter connected to the SCADA system. The data from all of these individual SCADA sites are transmitted to the Host computer. Calculations are programmed into the Host so that at any point in time it displays the current flow reading at each measurement point within the system and also displays the total flow being taken by each irrigation company. This facilitates the correct operation of the system by company water right. The access to the information on the Host computer is limited to the system operators and the Presidents of the individual irrigation companies.

Along each lateral there are meters for each individual turnout. These meters are not connected to the SCADA system but are manually read monthly as a check for the Lateral SCADA meter and also to account for the individual water used. This allows for accurate determination of when one water user on a lateral has used his allotted amount of water and how much another may still have the right to. Using the SCADA system meters as tools, individual and company water accounting can be achieved quite easily.

Operation

In order to make the system operator's job possible within a normal workday several other tools were implemented within the SCADA system. Using the data received from the meters along the pipeline it is possible to diagnose flow problems and check for leaks in the pipeline. Several meters were installed at strategic points in the pipeline with the sole purpose of creating a point of reference or a check on the pipeline. These additional meters have also helped diagnose problems with the SCADA system itself, such as a bad meter or a faulty radio.

In addition to the flow data received by the Host, several other critical system readings are measured and communicated to the Host. The level of the Inlet Pond and Cottonwood Reservoir can also be monitored through the Host Computer. Pressure transducers are installed in each reservoir which are connected to the SCADA system. The elevation data is displayed at the host but more importantly, the Host computer has a system of alarms that will alert the system operator by phone if the reservoir level is too high or too low.

Pressure transducers are installed at strategic locations along the pipeline. Due to the large elevation drop along the length of the pipeline, several pressure reducing valves (PRV's) have been installed to regulate system pressures in the mainline and to the individual laterals. Pressure transducers are installed on the upstream and downstream sides of these PRV's to quickly monitor and report potentially damaging pressure situations. The Host alarms are also set for the pressure in the pipeline so that if there is a pressure surge above the safe operating pressure or if there is a PRV failure, the Host will immediately call the system operator to alert him to the condition. Quick response time by the operator after being alerted by the Host may save thousands in repair costs to the pipeline each year.

There are three critical valves along the pipeline system that can be operated remotely. There are a couple purposes for automating some of the valves along the pipeline. One purpose is to be able to open and close often used valves in remote locations without having to travel to the site each time. This literally saves hours and hours of driving time each day. The second purpose is to be able to respond quickly to open or close a valve when there is a problem with the pipeline system. The three automated valves are located at the beginning and end of the URIC/OPIC pipeline and at the Inlet Pond diversion from the Ouray Park Canal. Although the Host site is available to the company presidents, the only one with authority to open or close these automated valves is the system operator. Individual logins with different access rights have been set up to ensure the consistent operation of the system.

Figure 2. Pressure Reducing Valve Vault

Local Accountability

In order to make the data on the Host computer available to the general public a website was created that shows the current flows to each lateral. Only one person can be logged on to the Host computer at a time and having a login for the general public, even with very restricted access, would often make it unavailable to the system operator when he needed to check the system or operate the automated valves. A website was the obvious solution to this dilemma. The website pulls the data from the Host computer once an hour.

A call-in number has also been set up on the host computer so that those water users in the area that do not have a computer can call by phone and with the proper codes, can hear the current flows to the laterals. In this manner, anyone that wants to know what the flow is anywhere in the system has a way to find out.

Example Problems

Although SCADA systems are becoming quite common among municipal water systems, to find one this complex on a local irrigation system is almost unheard of. There are three specific examples within this system of creative uses of the capabilities of a SCADA system as it applies to irrigation systems.

Inlet Pond Level Control

The Inlet Pond for the BIA system is an approximately 40 acft pond. The average flow in a high water demand year through this pond could possibly reach 30 cfs. The size of this pond for the amount of water that is used from it causes it to drain quite quickly. In the past, there have been several times when the pond has gone dry and the pipeline has partially drained before the ditch rider was aware of the problem. Maintaining a consistent level in this pond manually is almost a full time job in itself.

In order to eliminate this problem, an automated gate was installed on the inlet to this pond at the diversion from the Ouray Park Canal. This gate was programmed to work with the pressure transducer that records the level of the pond. When the level of the pond had dropped a foot from the spillway level the gate on the canal begins to open. It continues to slowly open until the pond is at the spillway. When the pond reaches this level the gate closes to prevent losses over the spillway. This programming can be overridden from the Host. If for some reason the system operator wants to drain the pond, he can manually close the headgate.

Using this automatic level control, the system operator was able to specify the high and low set-points of the pond from the Host and the pond regulates itself. The pond regulated itself the entire summer of 2008 without any losses over the spillway and with no problems with draining the pond.

Figure 3. Inlet Pond Automated Gate

Cottonwood Reservoir Elevation Measurement

In order to get an accurate water level measurement from Cottonwood for the SCADA system there were several options. A conduit and pressure transducer could have been run up and over the dam, down the upstream face of the dam to the bottom of the reservoir. This would have been very costly and time consuming and would have required the approval and regulation of the Utah Division of Dam Safety. A deep stilling well could have been used but would have had the same negative aspects as the conduit with the addition of icing problems in the winter.

It was decided to place a pressure transducer in the pipeline at the downstream toe of the dam. There is a large vault at the toe of the dam that houses the automated valve and meter for the pipeline. There is a SCADA site already installed at this location so adding a pressure transducer reading to the data being sent to the Host was not a problem. The problem is that at this location, the only time that we would get a true elevation reading for the reservoir was when there was no water running through the outlet conduit of the dam into the pipeline. This would only happen at the end of the water year when the reservoir was down to the legal deadpool level.

In order to solve this problem, the pressure in the pipeline had to be used in conjunction with the flow through the pipeline and a headloss calculation in order to get an accurate level reading with flowing water. Using the energy equation with estimated minor losses for the inlet screen and steel pipe, the host is able to calculate an accurate water level. The calculation was monitored throughout the summer and the largest variation from the actual reservoir elevation was 6 inches and the average error was about 3 inches. With 60 feet of elevation difference from top to bottom, that is a very acceptable error. The Host computer simply displays the elevation of the reservoir.

The use of the SCADA data and the correct calculations saved the cost of placing a much more expensive level measurement system. Having the pressure transducer in the vault and attached to the outside of the pipe also protects it from corrosion or silting. It also makes it much easier to remove and replace if necessary making the maintenance of the transducer almost nothing as compared to a transducer on the upstream side of the dam.

Brough Vault Control Valves

The Brough Vault is located at the opposite end of the pipeline as the Cottonwood Vault. The Brough Vault controls the flow of water out the end of the pipeline. This water then discharges back into the Ouray Park Canal and continues south to other OPIC water users and to Pelican Lake. Because this canal serves several water users during the summer, the flow to the canal changes almost daily as the water users turn their irrigation systems off and on. The location of this vault is very remote, being about 20 minutes from any paved road. The only power line in the area is a 500KV line on 100 foot tall towers.

Control valves had to be placed in this vault to maintain pressure in the pipeline upstream and accurately control the flow to the canal at anywhere from 5 to 70cfs, but had to run

on a battery and solar panel system. Running a power line to the area would have been cost prohibitive. With only DC power available, Globe valves were the only good option since they use the water pressure in the system to open and close rather than an outside source of AC power. The globe valves were installed and connected to the SCADA system.
(picture)

The selection and installation of the valves was just the first hurdle to make these valves function properly. Because globe valves use the pipeline pressure to open and close, they will not move if there is no pressure on the pipeline. Because these valves are at the end of the pipeline and at the bottom of a large hill, if they were opened too much they could easily bleed off the pressure and render themselves useless. A system operator would then have to travel to the site and close the butterfly valves in the vault manually in order to build pressure before the globe valves would work again. A series of safeties was programmed into the SCADA system at this site to ensure that the pressure in the system never dropped below 20psi. If the pipeline drops below 20 psi, the SCADA system closes the valve a little at a time automatically until it maintains 20 psi. This safety can be overridden in the vault if the system operator needs to drain the pipeline.

The SCADA system was also programmed with a high pressure safety in case of a failed PRV valve upstream. If the pressure of the system rises above safe levels, the SCADA system automatically opens the valve a little at a time until the safe pressure is maintained. If a high or low pressure situation arises, the Host computer phones the system operator to let him know something is wrong.

During testing of the globe valves, we discovered that when the SCADA system sent the initial signal to open or close the valve, that the valve would quickly open up too far and would have to close back down to reach the desired setpoint. This was especially true when flows of over 40cfs were going through the pipeline. This would cause unstable pressure fluctuations and would have possibly caused water hammer damage to the pipeline. To offset this quick initial opening, a delay was programmed into the SCADA system so that it would send the signal to open for 1 second and then would wait for the valve to equalize for 15 seconds before sending another 1 second open signal if necessary. It continues to send 1 second signals and 15 second delays until the valve is at the desired setpoint.

<u>Problems Summary</u>

In each of these cases, the SCADA system was able to automatically control and operate parts of the irrigation system that would have required a lot of manual operation and time by a system operator to maintain. Add to that the time saved in normal operation of the irrigation system by reducing driving time and minimizing manual system checking and the value of a SCADA system starts to reveal itself. Although a SCADA system requires capital expenditures at the onset of a project, the time and money that it saves on operation and maintenance of a pipeline is well worth it. In this case, an irrigation system that used to have three full time ditch riders can be operated by a single system operator.

SUMMARY

The attitude and willingness of the local irrigators to work together in developing this project has resulted in significant water savings to them. The reduced losses are from two major sources. The first is due to reduced seepage and evapotranspiration by converting from open ditches and canals to pipelines. The second is due to operational savings by having better control of the water. While reliable pre-project measurements are not available, conservative estimates would indicate that over 25% of their water supply are being saved. These water savings are being used towards meeting the shortages which they had before the project.

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