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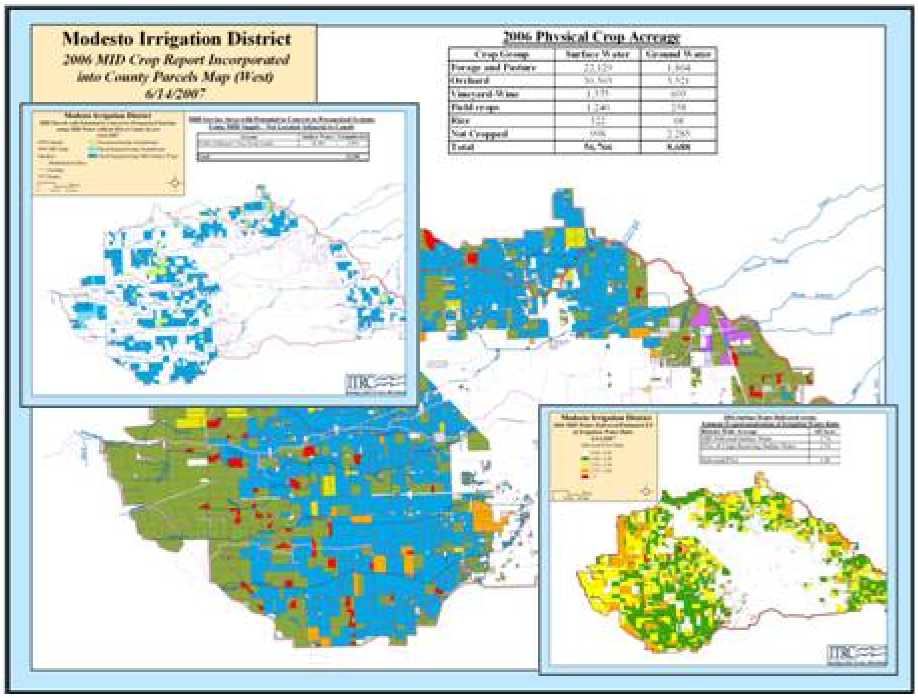
Comprehensive Water Resources Management Plan

Executive Summary of the Phase 1 – Draft Report



Technical Report

Modesto Irrigation District

February 2008

IRRIGATION TRAINING AND RESEARCH CENTER

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Irrigation Training and Research Center
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EXECUTIVE SUMMARY

Modesto Irrigation District initiated Phase 1 of the *Comprehensive Water Resources Management Plan* (CWRMP) in March of 2007. The CWRMP is designed as a multiple-phase effort to occur over three years (2007-2009). The Irrigation Training and Research Center (ITRC) at California Polytechnic State University, San Luis Obispo and the URS Corporation were responsible for separate elements of the CWRMP, with ITRC working on issues primarily related to district-level water management. A draft technical report presenting the main findings and observations of ITRC's portion of Phase 1 was submitted to Modesto ID in November 2007. A copy of the full report is available on a special download section of ITRC's website at the following address: http://www.itrc.org/MID/index.htm.

Phase 1 focused on data development and characterization of the existing physical infrastructure of the canal system and pipelines, and water operations. This information will be used to develop conceptual solutions for system enhancements in Phase 2 and, eventually, detailed engineering recommendations and management plans in Phase 3.

The reader will notice the Phase 1 Report briefly summarizes numerous details. Many aspects of the physical infrastructure and canal operations procedures are discussed in detail to better understand the opportunities for improvements and potential constraints. ITRC did not assign any priorities or costs to the issues identified in the field visits and interviews. No specific recommendations are being offered at this time, except for some ideas about minor issues noticed in the field, which in some cases are already being addressed by the district. Strategic concepts and detailed engineering solutions will be provided in the next phases.

Phase 1 Report Highlights

Major elements of the Phase 1 Report by ITRC include:

- A summary of findings about the design, function, constraints, and water management in Modesto ID
- Detailed operational characterization of the Main Canal and all laterals
- Field characterization maps in GIS highlighting the locations and areas of fields that in the future may convert to pressurized irrigation systems with district surface water
- Information from interviews with Irrigation Supervisors, ditchtenders, and SCADA/IT staff
- Updated GIS maps for groundwater pumping characterizations of electrical energy usage as well as water quality impacts due to salinity, nitrate and boron
- Existing and future issues with the design and implementation of SCADA and automation systems

The purpose of the Phase 1 Report was to consolidate what we have learned so far about Modesto ID and prepare for the next steps in the CWRMP.

The Phase 1 Report was completed through a series of site visits to Modesto ID, and extensive interviews conducted with water managers and operations staff. ITRC has visited the entire canal system, pumping plants, measurement structures, and other key facilities in the district. We have also interviewed the irrigation supervisors and ditchtenders from all 7 divisions, along with staff involved with the SCADA/IT systems.

A series of special GIS maps were created by ITRC to illustrate certain interesting characteristics about surface and groundwater use within the district. For example, the GIS maps help explain how energy use and water quality are influenced by groundwater pumping in the district, particularly from the network of drainage wells. GIS maps were also developed to characterize fields according to various criteria in order to help illustrate how and where future actions may be prioritized. As more information is analyzed the GIS maps of the district will be updated.

The information contained in the Phase 1 Report is summarized here under the following topics:

- *Characterization of the Canal System*
- *Irrigation Water Management*
- *Field Characterization*
- *Groundwater Pumping Characterization*
- *SCADA & Automated Control Systems*

Characterization of the Canal System

Modesto ID operates a complex network of canals, control structures, pumping plants, and pipelines in close cooperation with private landowners to deliver irrigation water to approximately 58,000 acres of irrigated lands. Water is supplied by the district to direct turnouts on the canals/laterals to adjacent fields, delivered to groups of irrigators organized into Improvement Districts, or served via privately-owned pipelines. The physical infrastructure owned and operated by the district is in good shape, although some of the computer automated control and monitoring features are outdated or obsolete.

In many respects the district has been innovative compared to other irrigation districts in California; <u>however, significant upgrades to the canal system will be required to provide the service needed in the future to meet changing customer needs</u>.

Within Modesto ID, current operational strategies and procedures are characterized by the following points:

a) The district has already invested in an extensive SCADA network so Water Operations staff can change set-points at the start of the Lower Modesto Main Canal and lateral headings. In addition, the SCADA system controls the automatic operation of a series of pumps that provide supplemental water supplies for the Main Canal and Lateral 5. Some spill sites are also remotely monitored. However, supervisors and operators do not have real-time access to the SCADA system via the Internet for mobile access devices.

b) The Irrigation Supervisor (1 person on duty) is responsible for the operation of the Lower Modesto Main Canal and the lateral headings (all automated flow control points). Ditchtenders (1 person each for 7 divisions) operate lateral canals, including the turnouts to private pipelines and improvement districts, and “weekender” deliveries that occur on Saturdays and Sundays.

c) Water orders are taken and arranged by ditchtenders, who maintain records of water delivery timings and amounts. Ditchtenders total the water orders in their division and coordinate with the Irrigation Supervisor to schedule flows at the start of their individual laterals for the next day.

d) In addition to the 13 automated pumps sequenced by the SCADA system based on set-points entered by the Irrigation Supervisor, there are a number of deep well pumps (approximately 4-5 cfs each) and drainage pumps (3-4 cfs each) that are manually operated by the ditchtenders. In most cases there are preferred pumps that are operated continuously throughout the water season.

e) There are no buffer reservoirs on laterals in the system used for operational purposes.

f) Water quality concerns in the San Joaquin River are changing how the district can dispose of drainage water.

g) The canal system serves to convey and dispose of storm water from the City of Modesto and surrounding developed areas. Most winter flood flows are diverted through Lateral 6 and the Lateral 3-4-5 system. The amount of storm drainage handled by Lateral 6 has been steadily increasing. The district avoids diverting winter flows into Lateral 7.

h) The water quality of some wells pumping into the distribution system is poor and the resulting elevated salt loads should be minimized.

i) There is a wide range in the size of areas served by improvement districts and private pipelines. A "small" delivery for a drip/sprinkler system may only be a few cfs, but flood deliveries are 10-15 cfs. A large pipeline turnout may be supplied with 30-40 cfs, which is run all the time and rotated among individual landowners.

j) Water operations staff spend a considerable amount of time filling out various types of paperwork to record and organize information about flows in the system on a daily basis. The paper records from the strip charts (Stevens Recorders) serve as the 'official' records, even though in some cases the same information is being logged by the SCADA system. The recorders have served the district well in the past, but upgrading the measurement recording devices (with reliable SCADA instrumentation) at key points such as Skittone Weir and the Lateral 3 and Lateral 5 spills would benefit operations.

k) The existing automatic control scheme is based on older 'Littleman' type logic that originated with electro-mechanical controllers. This type of control has been reliable but is generally too slow to respond to the type of flexible canal operations that will need to occur in the future.

l) The district has tried two different types of manufactured automated gates – Armtec and Rubicon – without the success that was originally hoped for. There were a variety of mechanical and electronic problems. Some of the problems were probably due to critical *details* (e.g., entrance conditions) that were initially overlooked by the manufacturers or unknown by district staff. Even though district staff have spent considerable time and effort to remedy the problems, our impression is that the existing issues can be alleviated as part of an overall automation plan that would upgrade the existing SCADA system with modern, field-proven equipment and technology. A few ideas are discussed in this report, but the details will have to be worked out as part of later phases in the Master Plan.

m) There is an extensive network of long-crested weirs in the Main Canal and lateral canals. The canal system is characterized by upstream water level control. The weirs are long enough to provide good water level control under current operational demands in the system. Because of the long-crested weirs ditchtenders do not have to make adjustments to board settings at the check structures. In fact, because of the large number of check structures in the lateral canals, it would be impossible for the existing number of staff to operate a 'typical' system of weir board structures without the long-crested weirs.

n) Growers or irrigators may operate their turnouts, with prior permission from ditchtenders. Later, the ditchtender will personally visit every turnout taking water in order to measure the delivery flow rate and confirm the starting time.

o) There are capacity constraints in areas in the system where the canals operate at less than maximum capacity. At peak times of the season operators are not able to deliver irrigation water when growers would like it without making them wait for several days. The general rule is that water orders are taken care of within 3 days of when a customer contacts the ditchtender.

p) There are several bottlenecks in the canal system, particularly where laterals cross Hart Road and Highway 99. District staff also have to stay on top of cleaning trash from the steel grates; properly designed floating booms would help this problem.

q) There is a significant amount of spill from the lateral canals, which is understandable for several reasons: there is no mechanism for buffering the ± flow discrepancies in the system; the long travel time from the Modesto Reservoir; growers' preference for not irrigating at night; the ditchtenders' efforts to respond to tight irrigation schedules; and some uncertainties in flows at key points. In addition, ditchtenders are shuttling flows among a large number of water users who take water on fairly short notice and then turn it back into the system temporarily while the next user is getting set up to take his/her turn.

r) The staff are experienced with the system and many operations staff have been at the district for many years (10, 20, 30 yrs). For example, ditchtenders have known their customers (farmers and irrigators) long enough to anticipate trends in water use in specific areas within their division.

s) Handling deliveries to the large number of "weekenders" or small ranchettes is a major hassle for ditchtenders. However, giving these small customers more control over opening and closing their own delivery gates would be very risky because the large delivery flow rates can easily mess up the rest of the lateral.

Irrigation Water Management

ITRC conducted a series of interviews with the Irrigation Engineering Manager, the Irrigation Manager, Irrigation Supervisors, and the ditchtenders from all 7 divisions. The interviews covered topics including: canal operations; condition of physical infrastructure; water ordering and scheduling procedures; staff roles; bottlenecks and capacity constraints; operational flow capacities; water travel times; and staff recommendations for system improvements. The interviews usually lasted several hours with each person. Site visits to various places in the district were made to follow up on information obtained in the interviews.

During the interviews ITRC engineers and Modesto ID staff reviewed large scale GIS maps, water records, logbooks, and other misc. information. ITRC transmitted technical memorandums summarizing each interview to the district and reviewed them together to address any clarifications or omissions.

These interviews provide a comprehensive view of the system that has not been captured in previous reports or studies of the district. The focus was on finding out how the system really works from the people who know best. This type of detailed knowledge is valuable for the formulation of engineering projects and the updating of operational practices.

Field Characterization

One of the major challenges for the CWRMP is formulating solutions for Modesto ID to provide reliable and flexible service for growers who want to use pressurized irrigation methods (micro-spray and drip irrigation) and are currently supplied by the old and deteriorating concrete pipeline system. There are over 5,000 fields in the current service area of approximately 58,000 irrigated acres (within a total service area of 108,000 acres in the district). There are over 100 miles of old concrete pipelines in the district. To better understand the scope and priorities for potential upgrades to the private pipelines and those in Improvement Districts, ITRC created a series of *Field Characterization* maps.

The purpose of developing field characterization maps was to determine how many fields (and their acreage) have the potential to convert to pressurized irrigation using district-supplied water. In addition, it was possible to characterize these potential fields based on whether or not they are located in Improvement Districts or served by private pipelines.

Table 1. Field characterization of Modesto Irrigation District

Category		Water Supply	Total Acreage (Acres)	% of Total Irrigated Acreage**
Non-Dairy		On-Farm Gravity Irrigation Supplied by the District or All Groundwater		
	a	Adjacent to Canal	15,800	28%
	b	***Not Adjacent*** to Canal in Improvement District	13,700	24%
	c	***Not Adjacent*** to Canal supplied by Private Pipeline	8,400	15%
Dairy	d	Crop fields owned by Dairy	8,500	15%
	e	Area of Dairy Facilities (buildings, enclosures, etc.)	1,200	---
Planned Urban Development	f	Fields that are presently supplied with district water but will be developed in the medium-term future	5,500	10%

**The total percentage does not sum to 100% because some fields may be in more than a single category. For example, some dairy-owned fields are located next to district laterals.

As indicated in **Table 1**, there are 15,800 acres located next to Modesto ID canals and laterals (*Category a*) that presumably could have their existing turnouts modified or be served by new direct turnouts *without* having to upgrade the old concrete pipeline system. This category of fields would probably be the easiest and least expensive for conversion to pressurized irrigation.

In *Category b,* there are 13,700 acres of fields within Improvement Districts that meet the following conditions. These are the fields which as a group may be considered as the next priority area for upgrading the concrete pipeline delivery system:

- Flood irrigated with district water/groundwater or pressurized irrigated with groundwater
- Located in an Improvement District
- Not planned for medium-term urban development
- Not situated next to an existing canal or lateral

In *Category c,* there are 8,400 acres of fields that meet the above conditions, but which are served by private pipelines. Because there are multiple users being supplied by a common delivery pipeline and no legally enforceable mechanism or organization for upgrading the pipeline, this would probably be the most difficult area to address for pressurized irrigation. Of course, there may be specific instances in each of the categories that are more or less difficult depending on local circumstances.

An example of a Field Characterization map is shown in **Figure 1** (refer to the full report for additional maps). This particular map shows fields in Improvement Districts that have the potential to convert to pressurized irrigation systems, but are not located adjacent to canals (*Category b* above). It is critical to identify where these "islands" are so that this knowledge can be appropriately integrated into the planning of future system-level improvements.

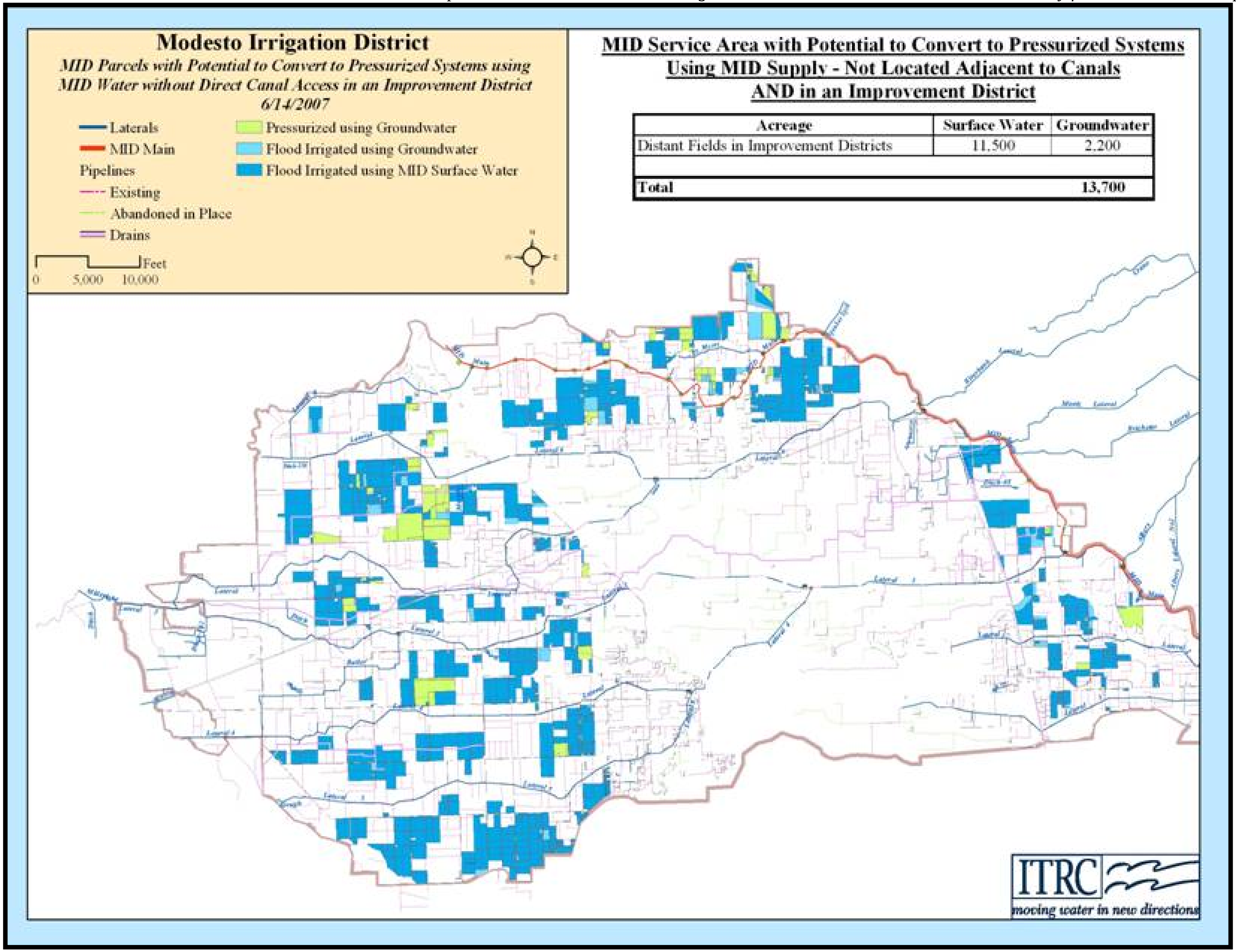

Figure 1. Fields with potential to convert to pressurized irrigation using district supply <u>that are not adjacent to canals and in Improvement Districts</u>

Groundwater Pumping Characterization

Groundwater management is a critical part of the overall future water management in Modesto ID. Using readily available information, ITRC developed a series of GIS maps to characterize the current impacts of groundwater pumping.

The groundwater pumping maps indicate the following (refer to the full report):

- The wells with the highest annual energy usage (approximately 10) are drainage wells pumping supplemental water into Laterals 3, 4 and 7, and two automated deep wells (#241, #242) pumping into the Lower Modesto Main Canal and Dr. Moore Lateral.
- There are a number of deep wells that use more than 150 kWh per acre-foot for pumping and they are spread throughout the district.
- In terms of volume, some pumped wells supply up to 30% of the total downstream deliveries. These wells provide 20-30% of total downstream deliveries and are located near the ends of Laterals 3, 4 and 7, in addition to the deep well pumping into the Dr. Moore Lateral.
- Drainage wells in the western portion of the service area have relatively low salinity (less than 1 dS/m), but they account for the largest amount of pumping. When this pumped drainage water is blended with district canal water the combined EC of water delivered to fields is still above 0.5 dS/m in places near the ends of Laterals 3 and 7, and the Butler Ditch.
- It appears that nitrate concentrations from drainage wells are high enough that they could potentially cause problems with fruit maturity. Of course, the precise effect would depend on the final concentrations in the blended delivery water at the turnout, the time of year, sensitivity of the particular variety, etc. These wells with relatively high nitrate concentrations are generally located to the north and west of the Modesto urbanized area. Particular laterals that have at least several wells with these high nitrate concentrations include the Main Canal and Laterals 3, 4, 5, 6, 7 and 8 (or, in other words, all of the major laterals).
- Many wells in the district may exceed the California Drinking Water Standard of 10 mg/L. However, no detailed water quality analyses or new tests were conducted as part of this study.
- Boron concentrations of the pumped groundwater are generally within normal levels for irrigation water; however, there are several deep wells, particularly along the middle portion of the Lower Modesto Main Canal, with relatively high concentrations above 1 mg/L.

SCADA & Automated Control Systems

SCADA (Supervisory Control and Data Acquisition) is a system that allows an operator at a master facility to monitor and control processes that are distributed among various remote sites. Modesto ID has utilized a district-wide SCADA system for remote monitoring and control of key points such as the Modesto Reservoir, various measurement sites in the Main Canal, lateral headgates, and some operational spill locations. Limitations of the present system are related to constraints for future expansion of the radio network to add new sites, slow response times of automated gates, lack of remote access for operators, and incomplete coverage of district and non-district facilities.

SCADA systems are key parts of irrigation district modernization programs and provide many benefits in terms of operations, record-keeping, safety, troubleshooting, and service to customers. Comprehensive planning for future upgrades to the Water Operations SCADA systems will be done in later phases of the CWRMP because it is an integral part of the detailed planning system modernization enhancements. At this point, ITRC has organized information about the main features of the existing hardware and software in terms of performance and configuration.

Meeting the district's long-term water management objectives will likely require new infrastructure projects like re-regulation reservoirs with automated pumps and additional automated canal control structures, along with enhancements to the existing automated lateral headings and pumps. As a rough estimate for planning purposes, it is possible that up to 100 new RTUs (Remote Terminal Units) could be installed in the district within 5-15 years, depending on what strategies are adopted as part of the CWRMP. Given that the district may also want to integrate data or alarms from some of the existing RTUs owned by the City of Modesto and others, the size of the district's SCADA system could actually double.

Modesto ID's current SCADA system can be characterized by the following key points (refer to the full report for an extensive list):

- The Water Operations SCADA system is part of a larger, complex district-wide SCADA network operated and maintained by the Electric Department and the Information Technology Division.
- There are over 100 RTUs (Remote Terminal Units) in the water and power parts of the district, with 28 of those at sites in the canal system or at groundwater pumps.
- There are three primary screens for the Water Operations HMI: 1) Overview, 2) Monitor, and 3) Control, plus other screens for alarms, trending, individual site details, and others.
- The SCADA system is based on a centralized control configuration. All the computations for gate movements of the automated flow control sites are done on computers at the Control Center. This is in contrast to a distributed control system where a PLC (programmable logic controller) located at the field site monitors connected sensors and does computations in real-time to modulate a gate. Modern automation systems that are implemented in almost all water districts utilize distributed control for a variety of reasons, particularly because the control system is functionally independent of the communications network in case of polling delays or failures.
- The district has built a robust, complex communications system that includes microwave relays, licensed radios, fiber-optic network, and spread spectrum radios. Because the district operates a large network of power generation facilities and sub-stations, communications (polling) has to be reliable, fast, and separate from other networks that would likely be down in case of a local or regional emergency, such as lease lines or cell networks.
- The communications network is the major issue that would have to be addressed regarding the potential for future expansion. Basically, the radio communications network is maxed out. There are potential technology options to be analyzed further for optimizing radio communications, such as mesh networking (routing data through nodes via multiple hops), the DNP3 protocol, IP radios, WiMAX, etc. Each option or combination of options has a significant cost associated with integration to the existing HMI and computer network systems. Developing plans for upgrading the radio network(s) would have to be a major focus of SCADA expansion. In contrast, the overall HMI (Human Machine Interface) and database network can be characterized as about half-full. When the HMI system was being developed, the capability for future expansion was built in.
- The Water Operations SCADA system is maintained by staff from the IT Division, mainly by a single technical supervisor who does maintenance, calibration, troubleshooting, replaces components, etc. If Water Operations staff notice a problem with the SCADA system they notify the technical supervisor. He spends approximately 10% of his time each week on irrigation-related activities. There are two other field technicians who handle the O&M of the overall SCADA system. The district used to employ four technicians for these tasks and has been trying to recruit a new operations technician. The district also employs a full-time communications engineer. In general, the staff who handle SCADA-related activities are very busy with existing issues.

- There is no up-to-date inventory of the hardware and equipment installed in the SCADA system. The district is working to compile a current inventory of 2-way radio equipment in preparation for upgrading the 2-way radio system in the future.
- Security is a major issue at all SCADA sites. Theft and vandalism are serious problems. Even though there are intrusion alarms, lighting, etc., the district still has problems with people breaking in to steal wiring or equipment. This is particularly a problem at the electrical sub-stations. The district will install real-time video camera systems to help with security at a few sub-stations in the near future.
- Each SCADA site is polled every 10 seconds, except for solar sites, which are polled approximately every minute. Polling speed times are based on the centralized nature of the system. For example, 10 seconds is enough time for a certain amount of water to be added to or subtracted from a canal, but the polling time is much more significant for electrical operations. By comparison, the automated control systems that ITRC does the specifications and programming for in other irrigation districts using distributed control (where the PLC does the actual control computations) are typically polled once per minute.

SCADA projects are often highly visible efforts and they always require a substantial investment of staff and resources. Implementation of a SCADA system is very complex and there are many technical options and technology choices. In fact, there are too many details to write every single one down in specifications. In addition, the technology is changing very rapidly. In later phases of the CWRMP, Modesto ID will have to determine how much the new SCADA system development or upgrades/enhancements will be done in-house. For example, perhaps some of the HMI programming should be done by the district's IT staff, who already have extensive experience with the OpenView software and computer systems. However, it will still be necessary to hire a special contractor, called an integrator, who specializes in SCADA systems. It is critical that the integrator selected to work with the district in the future have previous experience with applications in water districts, which means there is currently a relatively small number of firms to select from.

The SCADA planning process at Modesto ID is different from most water districts who undertake modernization programs because the district has already made substantial investments in a district-wide SCADA system, software development, communications networks, etc. The development of the existing SCADA system by the Electric Department has been driven to-date by the needs of electric power generation and distribution facilities, although the Control Center at the headquarters office also provides 24/7 monitoring, remote control, emergency alarming, dispatching, etc. for centralized automation of a number of lateral headings and other key facilities.

Because any new SCADA sites for the Water Department will have to be integrated with at least some of the existing hardware/software platforms, even if some of the hardware/software is different than what is used in the Electric Department, compatibility is a key consideration. In terms of future integration, we see three major issues for further discussion and analysis (for a start):

1. <u>Compatibility</u>: including the implementation of ISaGRAF control code with both the existing RTU hardware and with the OpenView HMI software (e.g., DNP3 protocol, data management, etc.).
2. <u>Communications</u>: options for the expansion of the radio communications network (radio bottlenecks), wireless for mobile SCADA units, voice over IP, IP/Ethernet, mesh radio networking, etc.
3. <u>Ownership & Maintenance</u>: level of staff resources and roles/responsibilities that are appropriate in the future. Installation vs. ongoing maintenance, changes to organizational structures, etc.

Other short-term considerations for the SCADA system include:

1. One of the key ways of improving water management in the district is giving operations staff the ability to make real-time decisions about control of water in their area of responsibility, based on access to real-time information on inflows, spill, reservoir levels, etc. At present this function is mainly handled by the Irrigation Supervisor(s). However, if significant modifications are made to the system including inter-ties between laterals or re-regulating reservoirs, the roles of staff in the real-time operation of the system may evolve. Certainly the details of such organization changes have to be considered and worked out.
2. To achieve the type of real-time control described in item #1 above, mobile laptops or tablets should have full access to the Water Operations HMI system including the ability to change targets, see trending graphs, and receive alarm notifications. The specific configuration on an individual's laptop would vary depending on their area of responsibility. For example, the mobile SCADA unit for an operator in Division 4 would not need to be able to change targets at the Modesto Reservoir.
3. To evaluate potential issues with implementing ISaGRAF and learn more about integration of the types of hardware/software described above, the district may want to consider having ITRC work with staff to overhaul one of the existing automated gates (e.g., the Armtec gate in Lateral 4) using a new PLC, ITRC's control code, new sensors (as needed), etc.