

USE OF SOPHISTICATED STATE-OF-ART SCADA SYSTEM FOR VERY EFFICIENT AUTOMATED IRRIGATION OPERATIONS ON 22,070 ACRES OF AGROFORESTRY

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ABSTRACT

Along the mighty Columbia River in Eastern Oregon, U.S.A, in an area with less than 8 inches of total annual precipitation, exists the world's largest contiguous drip irrigated tree farm project. This Potlatch Corporation **Western White Poplar Project (WWPP)** uses high level automated technology to produce solid wood on a national and international certified sustainable rate.

The project's 6,000,000 fast-growing desert hardwood trees (*Western White Poplar*) on 17,300 acres are irrigated by a massive and very complex automated water distribution system. Additionally the irrigation system also supplies water to other crops on 4,770 acres under pivot irrigation.

Irrigation pumping energy costs are the major operational cost of tree production on this project; so a very determined effort is made to operate the irrigation system in an efficient and cost effective manner. The **only economical and efficient** way to irrigate this very large and complex project is by the use of an advanced customized Supervisory Control and Data Acquisition (SCADA) system. This State-of-Art SCADA system controls and monitors all pumps, individual fields, sensors and center pivots. This SCADA system makes the WWPP one of the most advanced automated large-scale drip irrigation farm projects in U.S.A., if not in the world. Additionally for the past decade, it has sustained its position as the world leader in large scale drip irrigation efficiency.

INTRODUCTION

In early 1990's near the town of Boardman, Oregon, Potlatch Corporation's "Fiber for the Future" project acquired two very large center pivot-irrigated farms, with a combined total acreage of 22,070 acres, for intensive farming of fast growing Poplar trees (*Western White Poplar*).

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The “Fiber for the Future” project was developed on farmland previously irrigated with center pivots. Gradually over six years, 2,000 to 4,000 acres were converted each year from center pivot to drip irrigation (Figure 1). The converted circular pivot fields were “squared” up to utilize all of the land. At each previous pivot point, a distribution manifold (field) was constructed with valving and automation to serve four, 40 acre or 70 acre blocks. The existing pumping plants and buried pipeline network were also modified to maximize water delivery and operational efficiency. The pivot to drip conversion was discontinued after 17,300 acres and the rest of the pivot acreage was sold.

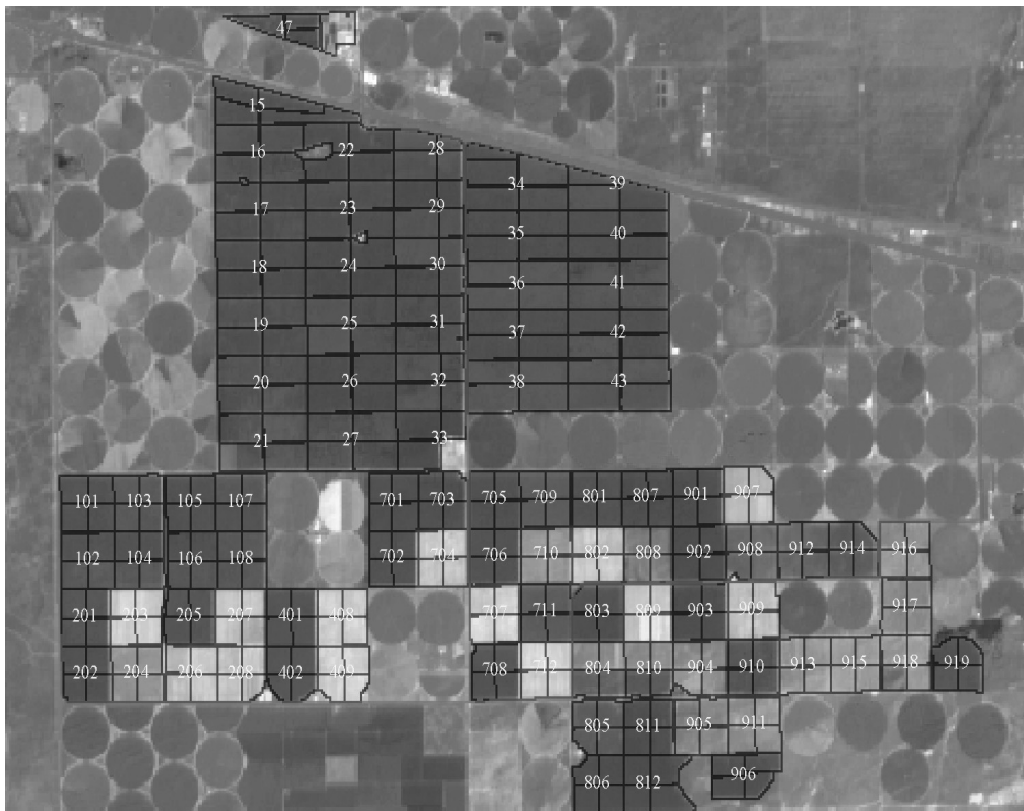


Figure 1: Satellite image of Western White Poplar Project (WWPP) showing both the drip and pivot irrigated lands.

This “Fiber for the Future” farm project was originally designed to provide approximately 25% to 30% of the total chip fiber requirement for the massive Potlatch Pulp & Paperboard operations located at Lewiston, Idaho. By the late 1990’s, opportunities for using the fiber in higher value solid wood products was identified. The project’s management was then moved from pulp-based to saw log management by thinning and pruning younger trees, changing tree clones and spacing, and extending the tree rotation from 7 to 11 years.

The project's overall tree management strategy emphasizes the use of the most efficient water delivery methods via drip irrigation and automation. Together with the use of the highest quality clonal material and the continuous monitoring of crop vigor and health, the project aims to become the lowest cost producer of high quality sustainable saw logs and wood products.

PROJECT FACTS

At its present size of 17,300 acres the project is the world's largest irrigated fiber farm and one of the largest contiguous drip irrigated farms in the world. It is also a world leader in large-scale drip irrigation efficiency.

On this fiber farm, approximately 6,000,000 trees grow on an eleven-year rotation. For disease and other reasons, multiple clones of Poplar trees are used to add genetic diversity. Each clone has its own characteristic needs for water and fertilizer and unique production quality and quantity. These special Poplar trees are known to grow nearly two inches a day during peak growth and have growth rings more than 1.5 inches wide. The trees are harvested at an average sustainable rate of one tree every 16 seconds.

The project's irrigation system has a pumping capacity that exceeds 257,000,000 gallons per day, making its irrigation system among one of the largest in the State of Oregon. At peak flow, nearly 180,000 gallons **per minute** (gpm) are flowing through an irrigation system consisting of 68 major pumps at 13 different pumping stations. Total Horsepower exceeds 30,000 **Horsepower** (Hp) with pump motors ranging in size from 30 Hp to 1,000 Hp. Single pump capacities range from 500 to 32,000 gpm. The pipe network consists of nearly 500 miles of buried pipe ranging in size from 1½ to 72 inches diameter. The drip tube's total length is an astounding 14,300 miles! Finally this large amount of water is fed to the trees through nearly 20,000,000 emitters.

SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEM

This WWPP is so large and complex that it requires a very sophisticated control and monitoring system. The WWPP Supervisory Control and Data Acquisition (SCADA) system controls and monitors all 68 irrigation pumps (Figure 2), 93 manifolds and 46 center pivots. The project's SCADA system consists of two processors and a single computer installed with the latest in **Human Machine Interface** (HMI) software, interacting together with the 153 field processors. All communication to the field processors is done by State-of-Art Spread Spectrum radio telemetry. This SCADA system is designed with the ability to control valve(s) or pump(s) from the SCADA **Operator Interface Terminal** (OIT) at the office and at distances greater than 15 miles. All SCADA actions occur within 2

seconds of operator command, with full control acknowledgement within 5 seconds of command initialization from the OIT.



Figure 2: SCADA system on Western White Poplar Project irrigation canal pump station.

“Stand Alone” SCADA system

Through an elaborate process of decision making and implementation via the SCADA system, the project has attained the level where it can provide a different irrigation regime to each of the 370 blocks and at the same time also apply different irrigation regimes multiple times a day to the individual block. The process manages to do all this complex combination of irrigation regimes while maintaining a hydraulic balance on a huge and very complex irrigation system. No pump changes occur during the duration of an irrigation schedule! This fine-tuning of the hydraulic balance in the irrigation schedule ensures that the system “hums” along with very little human intervention day and night. The only time pump change occurs is when pivot operators’ demand it or when the next irrigation schedule changes. The smooth hydraulic balance also enables the project to operate a massive irrigation system without the need of complex and expensive pump automation programs. This “smooth” operation of the irrigation system is “easy” on the hardware of the system and lessens the burden to the irrigation team members who then only have to interact with the SCADA system when the SCADA system remotely alarms them. This hydraulically smooth operation is what enables the WWPP SCADA system to become a “stand alone” system.

SCADA Answer to the Irrigation Challenges

Survival of these trees on the WWPP is largely dependant on irrigation water. In the semiarid environment during peak evapotranspiration rates, the project's irrigation system cannot adequately provide the trees high daily water consumption. Additionally for some tree clones the timing of irrigation is just as important as the irrigation amount. Growing these trees under these conditions and in sandy soils will cause a detrimental reduction in yields or even death of trees, if there is any cessation of irrigation for more than 15 hours! With all these tough environmental and tree demands, it has forced the project to implement very sophisticated and reliable water management practices. With more than 370 individual blocks, that cycle irrigation as much as four times a day, irrigation scheduling is also a hydraulic nightmare. With the use of a State-of-Art SCADA system, extensive soil moisture monitoring, weather data, crop curves and the use of complex customized and in-house software, has enabled the project to not only adequately irrigate its trees, but do it in such a high level of efficiency that it has made this project a world leader in large scale drip irrigation efficiency. One of the success stories of the project's excellent water management practices is the demonstrated ability to irrigate with such precision that the central 2-foot wide strip between the 10-foot tree rows always remains dry. This level of water application efficiency is unparalleled in such a grand scale anywhere in this world!

There are basically three major irrigation challenges facing this project and its SCADA system:

1) Water deliverance from the source to the trees.

Every irrigation project has its challenges and the challenges faced by this project, especially in water deliverance are not unique except for its very large scale of operation. The projects meet these challenges by spending adequate resources to ensure the delivery of water is not an issue in tree production. Senior water rights, upgrading/changing of existing water deliverance facilities by using the latest and appropriate technology with "good" engineering were the keys. Once the deliverance system was installed, a State-of-Art SCADA system was installed to control and monitor the whole of the irrigation system. This SCADA system provides the ability to "spoon feed" the trees with specific amounts of water and fertilizer.

2) Water management and irrigation scheduling.

In water management and irrigation scheduling, the challenges on this project are huge, ongoing and very complex and require unique solutions that involve collectively the SCADA system and the use of multiple customized and in-house software. These challenges are demanding as they affect the whole economics of operation.

The complexity of water management and irrigation scheduling on this project is a daunting task as the variables are enormous and constraints are extremely restricting. This is where the strength of sophisticated control and monitoring by the SCADA system, allows the very complex operations of irrigation scheduling on each of the individual 370 irrigation blocks.

The SCADA system tackles these daunting tasks of water management and irrigation scheduling by working together with sophisticated and customized **Advanced Hydraulic Balanced Irrigation Scheduling (AHBIS)** software that generates weekly a SCADA operational binary code file with nearly 9,000 individual block irrigation schedules that are hydraulically balanced. This SCADA /AHBIS interaction allows the project to micromanage irrigation scheduling at the individual 40 to 70 acres block level.

3) Water quality.

Maintaining irrigation water quality to avoid plugging 20 million emitters requires the use of both primary and secondary filters, extensive chemical injections and a very closely monitored water quality program utilizing sensors such as automated turbidity meters, pH and chlorine residues sensors. This is where the monitoring and control strength of SCADA system comes into play. Additionally the SCADA system is programmed to do block flushes, flush fills, desilts etc., that mitigates the effect of any silt loading of the drip line and thereby avoid emitter plugging.

SCADA and Pump Energy Efficiencies

With seasonal pumping energy costs in excess of two million dollars, economics dictates that the project maximizes the efficiency of operating its multitude of pumps. The pump motors and pump stations are installed with “near-utility grade” power monitors for monitoring, via SCADA OIT, the “wire to water” efficiency during pump selections and operations. The SCADA system also allows the project to conduct individual or group pump tests in Real-Time for evaluation of present and also predict future pump/motor efficiencies and the corresponding cost of pumping.

SCADA SUMMARY

Potlatch Corporation Western White Poplar Project (WWPP) **Supervisory Control and Data Acquisition (SCADA) System**

This “Stand Alone” WWPP SCADA system controls and monitors:

An irrigation distribution system that consists of 500 miles of buried pipe and 14,300 miles of drip tube with 20,000,000 emitters, capable of carrying a peak water flow of 182,000 gallons per minute generated from 13 different pumping stations located on two independent farm water supply distributions.

WWPP SCADA system control and monitoring area encompasses:

- 17,300 acres of drip irrigated land under Poplar trees.
- 4,770 acres pivot irrigated land under various crops.

Overall the WWPP SCADA system remotely controls and monitors by Radio Telemetry:

- 129 field processors.
- 68 irrigation pumps with a total of 30,000 Hp.
- 93 manifolds with 369 individual irrigated blocks of 40 / 70 acres.
- 110 flow meters.
- 349 pressure transducers.
- 1254 automatic valves.
- 147 fertilizer/chlorine pumps.
- 288 soil moisture sensors.
- 38 electrical power monitoring sensors.
- 113 timers.
- 11 water quality sensors.
- 38 flush counters.
- 101 primary and secondary screen filters.
- 46 center pivots.

These massive Irrigation and SCADA systems are operated and maintained 24/7 by less than 6 full time staff!!

SCADA has allowed enormous irrigation efficiency improvements on the WWPP namely:

1. SCADA allows the sophisticated implementation of the AHBIS program, which optimizes individual block irrigation schedule regimes. This optimization leads to a smooth and steady hydraulic pump station

operation. Therefore no pump changes occur during a particular irrigation schedule regime, eliminating the need of expensive and very complex pump automation programs. It also leads to a steady irrigation canal flow withdrawal rates that assist the irrigation district to run an efficient irrigation canal operation. This overall enhances pumping energy efficiency, decreases irrigation system wear, greatly improves human resource allocations and reduce operational costs.

2. SCADA control and monitoring of **Variable Frequency Drive (VFD)** motors together with Real-Time data of energy usage per unit water pumped, combined with on-line pump testing; all collectively help improve irrigation pumping energy efficiencies.
3. SCADA's ability to monitor extensive Real-Time flow and pressures of pump station and individual blocks enables high irrigation uniformity efficiencies.
4. SCADA's use of sophisticated auto-pump shut-off programs for maintaining system integrity when irrigation system fails. This is combined together with extensive SCADA Real-Time alarm/pager system to remotely alert operators of an irrigation situation that would adversely affect irrigation performance or efficiency.
5. SCADA planned interaction in Real-Time with a **Hydraulic Model Simulation (HMS)**, will enable irrigation operation at operational minimum pressures, leading to an even better pumping energy savings.

CONCLUSION

Potlatch Corporation Western White Poplar Project efforts to mass-produce a tree that has a high evapotranspiration requirements and is sensitive to soil moisture stress, is a challenge in itself. To grow these trees in a desert like environment, in soils with low soil moisture-holding capacity brings additional challenges. All of these irrigation challenges and others were met by the use of latest technology in SCADA and other resources which allowed the project to demonstrate its ability of not only operating the largest drip irrigated project in the world but do it very efficiently and economically.

Using the best available State-of-Art SCADA automation technologies has allowed WWPP to maintain a very high level of efficiency, in its endowers to produce the most efficient and cost competitive high quality "green" wood products with minimum of staff and in a sustainable, safe and environmentally conscientious manner. Additionally this SCADA system has allowed the project to sustain its position as the world leader in large scale drip irrigation efficiency for the past decade.

The WWPP was the first plantation in North America to achieve Forest Stewardship Council Certification and has been recognized as a fully sustainable wood supplier and a well managed plantation.

As a final conclusion, SCADA has enabled the WWPP to utilize efficiently the scarce water and energy resource to grow short rotation Poplar trees at a sustainable rate. These Poplar trees yield more than 18 times the fiber yield of a natural forest; can produce per acre two to three times more ethanol than corn and produce white wood chips that save on strong chemical use in paper production. Additionally these Poplar trees improve habitat and recreational activities, increase plant and animal species and are a superior "carbon sink," with huge capacity to suck up harmful carbon dioxide, a greenhouse gas. Irrigated Agroforestry generates an astonishing local area land surface cooling; by as much as 54 degrees Fahrenheit! It is hoped that this "Green" Agroforestry, a eco-friendly practice, will in an age of federal timber restrictions eventually supply much of the nation's wood and fiber needs and at the same time offer up its numerous other benefits.

ACKNOWLEDGEMENT

Appreciation is extended to the Potlatch Corporation and its Western White Poplar Project Team, whose members devote tireless efforts in seeking higher levels of efficiency in producing a low cost "Desert Wood".

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