ESTABLISHMENT OF AN AUTOMATIC WATER QUALITY SURVEILLANCE PROGRAM

by

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The impact any action may have upon the environment is a consideration that is receiving more interest and study than ever before. The protection and enhancement of the environment is a matter of self preservation. In order to make perceptive determinations concerning this vital matter, the decision maker must have certain essential facts available to him. The quality of the water that will be released from a hydraulic structure is one of these essential facts.

In an attempt to obtain information about the effect existing prototypes in the Mobile District have on water quality, an Automatic Water Quality Surveillance Program was developed. The basic component of this program is the continuous water quality monitor. Basically, as used here, a water quality monitor continuously analyzes water for certain parameters producing an electrical signal proportional to the parametric value and displays and/or records the results in an intelligible manner. An example is to measure the water temperature with a thermistor, display the findings on a dial in degrees centigrade and record the values on a strip chart.

The purpose of this paper is to provide a general overview of the establishment of a surveillance program utilizing water quality monitors and enumerate some of the pitfalls. Technical discussions of individual components of the monitor system will be avoided.

No prudent man would think of planning a water-related project of significant magnitude without some assurance that the quality of the water associated with the project would be satisfactory for his needs. Furthermore this prudent man would not accept this assurance unless it could be proven reliable by recourse to adequate data. (1)

The needs and demands for data on the effect of water resource projects are continually increasing. A tremendous amount of information is needed and must be supplied posthaste. The Automatic Water Quality Surveillance Program will collect a large amount of data in a relatively short time and is an effort to alleviate some of this demand.

The data collected will serve many purposes. First, basic data will be obtained to document water quality conditions. The water quality of the release waters from existing projects will then be available for analyses of the effect of flow patterns. In some instances,

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modification of operating procedures may optimize water quality without sacrificing or interfering with other project purposes.

Diurnal variations, such as the photosynthetic effect on dissolved oxygen, as well as long-range seasonal cycles, such as stratification and overturn in lakes, can be observed. More often than not, variations in water quality go unobserved until extreme conditions make them apparent. Often maximum or minimum values are missed if surveillance is not on a continuous basis. The actual cause of an undesirable situation may be lost or masked with other variables due to the absence of timely data (2). Early warnings of impending dangers to the aquatic environment will permit remedial action before a catastrophe, such as a large fish kill, takes place. The data obtained will supplement field investigations and data from other agencies. Also, they can be made available to others to aid in their studies and promote the overall "state of the art" in the field of water quality and water resources.

Analysis and evaluation of the data will permit utilization and provide verification for predictive techniques. Also new design criteria may be developed which could revolutionalize the design of hydraulic structures for water quality improvement.

With these worthy and maybe somewhat grandiose objectives in mind, how can they be accomplished in a practical manner? It was decided that continuous water quality monitors provided the best method available, supplemented by field investigations. Ten projects were selected for installation of monitors. The projects, location and type of discharge are presented in the following tabulation:

MONITOR SITES

Project	Stream	Type Discharge
Allatoona Dam	Etowah River	Turbine[a], Gated Spillway
Buford Dam	Chattahoochee River	Turbine[a], Flood Control Sluice
Walter F. George L & D	Chattahoochee River	Turbine[b], Gated Spillway, Lock
Columbia L & D	Chattahoochee River	Gated Spillway, Lock
Jim Woodruff L & D	Apalachicola River	Turbine[c], Gated Spillway, Lock
Bankhead L & D	Black Warrior River	Turbine[b], Gated Spillway, Lock
Warrior L & D	Black Warrior River	Gated Spillway, Lock
Demopolis L & D	Tombigbee River	Fixed-Crest Spillway, Lock
Coffeeville L & D	Tombigbee River	Gated Spillway, Lock
Okatibbee Dam	Okatibbee Creek	Sluice[d]

[a] Peaking hydropower generation with a small base-load service unit.
[b] Peaking hydropower generation.
[c] Primarily base-load hydropower generation with slight diurnal variation.
[d] Includes low flow releases for water quality enhancement.

The table indicates the diversity of the type projects being observed. The sites for the individual monitors were selected to obtain a sample representative of all the combinations of discharges which might be encountered.

The specific parameters to be measured were selected to achieve the most pertinent information possible, with the most reliability.(3)(4) Five parameters were selected: temperature, dissolved oxygen (D.O.), pH, specific conductivity and turbidity. These are the most frequently analyzed water quality parameters with the exception of turbidity which ranks sixth behind dissolved solids.(5) These parameters, independently and collectively, define many aspects of the quality of the water. With slight modifications the number of parameters being measured can be increased to a total of eight.

Several options were considered in selecting the time interval for measuring each parameter and method for recording the data. Flexibility was added to the system by providing four separate time intervals, 15 minutes, 1 hour, 2 hours and 12 hours, any of which can be utilized by simply turning a switch. A paper tape punch was chosen for data recording because of its capability of directly interfacing with automatic data processing techniques.

At each site the monitor consists of two elements, a remote station and a central station, which are connected by a telephone line. The remote station includes a monitor house, the analyzer or sensor portion of the monitor, a submersible pump and the necessary plumbing and electrical appurtenances. The eight-foot-square prefabricated monitor houses are either slab-on-grade or elevated structures depending on local flood conditions. The highest is elevated about 15 feet above the ground. Each house is equipped with lighting and thermostatically controlled electric heaters and exhaust fans. The pump supplies the monitor with river water which flows by each sensor in parallel and then is returned to the river by a drain line.

The sensors or probes continuously produce a voltage proportional to parametric value and the value is displayed in conventional units, such as mg/l or $^{\circ}$F., on an individual panel meter. A modulator at the remote translates the voltage to a frequency which can be transmitted to the central where it is converted back to a voltage.

The central stations are located in either the reservoir manager's office or the lock control station of each project where they can be readily observed on a frequent basis. The central includes a digital display of all parameters, digital voltmeter, digital date-time clock, paper tape punch unit, and electronic circuitry. This unit interrogates the remote unit at the selected time interval and receives the data on each parameter in a prescribed sequence. The data received update the digital displays and are punched on the paper tape together with the date-time series. A manual scan is also available for intermediate updates. The punch unit may be inhibited if the data are not to be recorded.

A computer program has been developed to reduce the data to a more interpretable form. If the 15-minute time interval is utilized, there are 96 readings of each of the five parameters each day. The program statistically analyzes the data on a daily basis and determines the maximum and minimum value for each parameter, the first time it occurred and the number of times this value was repeated. The mean value and standard deviation are also calculated. The temperature values are presented in both degrees, centigrade and Fahrenheit, along with the percent saturation of the dissolved oxygen. The number of times the D.O. was less than 4, 3, 2 and 1 mg/l, respectively, is also presented so the relative quality of the water and its impact on the aquatic environment can be rapidly discerned. The raw data are retained for future analyses.

The information derived from the computer program is only as good as the input data. The water quality monitors must be in calibration and functioning properly if the data obtained are to have any validity. Erroneous data can lead to erroneous decisions. It is inevitable that the system is going to be out of service occasionally. Principal causes for loss of data include probe failures, power outages, pump failures, vandalism, electronic failures and breakdowns in the telemetry. A continuous water quality data collection system was operated for six years in Maryland by the USGS and an average data recovery rate of 83 percent was reported.(6) Others indicate a 70 to 80 percent recovery rate.(7)

To minimize the loss of data an operation and maintenance procedure was incorporated to provide a systematic checkout of the monitors. The monitor sites are for the most part remotely located from the Mobile District Office. This precludes personnel from that office performing the routine checkouts, so personnel from the field offices are utilized. Generally, these people are not familiar with chemical analysis or electronic equipment, and the procedures have been simplifed as much as possible.

The standardized procedure includes daily checks at the central and weekly checks at the remote. The daily checks consist of reading and recording the data from the digital display three times daily; checking and resetting the clock as required; and insuring the punch unit has an adequate supply of tape and is functioning properly.

The weekly checkout of the remote station involves cleaning of the sample chamber, examining all sensors, adding of electrolyte to the D.O. and pH probes as necessary and a calibration check of three parameters. The temperature is tested with a mercury thermometer. Dissolved oxygen concentration is determined utilizing a modification of the standard winkler method which employs premeasured reagent powder pillows. Titration is accomplished with an eyedropper; the number of drops added to reach an endpoint represents the concentration of dissolved oxygen.(8) The pH is tested with a colormetric slide comparator.(9) Although these are not precise analytical methods, they produce reasonable precision, accuracy and incorporate "cookbook" type procedures which can be performed by relatively inexperienced personnel.

Comparison of values at the remote and the central provides verification of telemetry system. The values obtained from the test, the panel meters at the remotes and the digital display at the central are recorded on a checkout sheet. The values are then compared with a table of significant differences to determine if any difference between the test value and the panel meter is significant. If a significant difference is indicated, the test is rerun to verify the values obtained. When verified, a significant difference demonstrates the need for recalibration. The checkout sheet and daily logs are submitted to the District Office weekly. In addition, any malfunctions of the system or significant differences are to be reported by telephone for "trouble shooting" instructions. The field personnel are also responsible for maintenance on the physical facilities and accessories.

Personnel from the District Office make a scheduled visit to each site about every six weeks. A thorough inspection of the facilities is made and sensors and sample chamber are serviced. All parameters are tested utilizing more precise methods. For example, the dissolved oxygen is determined by the standard winkler method (10) and the pH is measured electrometrically. Calibration is performed as necessary. Also these visits present an opportunity to resupply chemicals and supplies to the field and to evaluate the effectiveness of their weekly checkouts and routine maintenance. Additional instructions can be given to the field personnel and it is expected that additional responsibility will be assigned as they become more familiar with the system and gain confidence in their performance.

Maintenance visits by the manufacturer are scheduled on a three-month interval. During these visits the units will be completely checked out and serviced. The manufacturer is also on call to provide field repair service on an established reimbursable basis. Because of the modular construction, individual components may be returned to the factory for repair, thus saving the cost of a service call.

Most of the problems encountered with the support accessories are not exotic but, nevertheless, put the system out of commission. The submersible pumps have been a continuous source of trouble. In all fairness, the pumps were adapted to perform a function other than their designed function. The pump was selected because of its positive displacement characteristics — considered important in preventing a change in the dissolved oxygen content of the water. Tests of the dissolved oxygen in the river and the sample chamber have indicated that, with these pumps, no change in dissolved oxygen takes place. Failures have been encountered in the pump motors, rotors and stators, starter capacitors and other components. Others have also documented problems with this type pump.(4)(6)(11)(12) Another type pump is currently under trial, but its operating characteristics and effect on the dissolved oxygen content have not yet been completely evaluated. Preliminary results are encouraging and this type pump shows promise.

Difficulties have also occurred due to vandalism and fences are being installed to protect the installations. Power outages represent the most prevalent electrical type failure; however, a transformer did burn out at one site and a truck ripped down a telemetry line at another site.

Slime growth in the sample chamber and on the probes has been troublesome at some sites. The slime growth definitely affects the sensitivity of the dissolved oxygen and pH probes, and can cause erroneous readings. The plating of the probes with iron and manganese deposits has been observed at one site and acid had to be employed to dissolve the coating. After being unattended for several weeks, a large population of Asiatic Clam (Corbicula) became established in flow chambers at still another location. The largest of the clams was about one-half inch in diameter. The larval stage, veliger, enters the system through the pump and grows to adulthood in the sample chamber. (13) This rather unique problem can be controlled by proper and timely cleaning techniques and chlorine (bleach) can be used if the problem persists.

The specifications, under which the monitors are purchased, include a provision to help assure that a properly functioning system is obtained. This provision establishes a four-week acceptance period following installation and is in addition to normal manufacturer's warranties. The monitor and all components of the system must operate without malfunction for the entire test period and calibration must remain within specified tolerances. Any failure constitutes a necessity to restart the test period. Under this arrangement, the manufacturer is fully aware of his responsibility to provide a workable system and the retention of payment encourages him to retain an active interest in the equipment.

When properly functioning, the Automatic Water Quality Surveillance Program will be well worth the efforts expended in establishing and maintaining it. Several additional installations are in various stages of planning or construction within the District and the experience gained thus far will be helpful in avoiding many pitfalls. The program is not a panacea but will go a long way toward satisfying the urgent demand for data to support decisions involving water quality considerations in water resources development.

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