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INSTRUMENTATION AND AUTOMATION EXPERIENCES IN WASTEWATER-TREATMENT FACILITIES

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DISCLAIMER

FOREWORD

The Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the prevention, treatment, and management of wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, for the preservation and treatment of public drinking water supplies, and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research; a most vital communications link between the researcher and the user community.

This report describes a nationwide survey of instrumentation and automation experiences collected from visits to fifty wet-and-dry-weather wastewater-treatment facilities. The technical and economic benefits of current monitoring and control practices are considered in the hope that the results will assist design engineers, environmental planners, and regulatory agencies in designing cost-effective instrumentation and automatic control strategies to improve the quality and reliability of wastewater treatment.

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INTRODUCTION

BACKGROUND

Enactment of the Federal Water Pollution Control Act Amendments of 1972 clearly signaled an acceleration of the national commitment to implement a series of corrective measures that will not only prevent further pollution of our water resources but will chart a course for a long-term water-quality-improvement program.[1] Instrumentation and automatic control has the potential for increasing effluent quality, enhancing treatment reliability and reducing the costs of achieving high degrees of purification. Moreover, a review of cost-effective design alternatives should include an examination of appropriate roles for instruments and automatic control devices.

More than most manufacturing processes, municipal wastewater-treatment facilities are continually exposed to changing inputs and ambient conditions. With diurnal and seasonal variations in wastewater flowrates and strengths, municipal plants must operate under widely varying loadings; this situation tends to produce a variable quality effluent. For a typical, 25-MGD, dry-weather treatment plant, the ratio of maximum to minimum flowrate is approximately 1.8, and the corresponding organic loading ratio is about 3[2]. Disturbances such as storm events, oils, grease, organic solvents, or industrial chemical discharges also contribute to upsets commonly experienced in most wastewater-treatment facilities. Combined sewer overflow and stormwater-control technology is being implemented to meet more-stringent water quality standards. These control facilities are also subjected to variable load conditions, and they generate return flows to the central wastewater-treatment plant which, again, cause effluent quality variations. Sludge stabilization and thickening processes, while less sensitive to diurnal and seasonal changes, generate recycle streams which cause load changes in the primary and secondary treatment processes. To minimize the adverse effects of influent variations, treatment plants are often designed conservatively to meet peak loadings, and this incurs higher-than-necessary capital and operating costs.

Based on successful applications of instruments and automatic control devices in other industries, instrumentation of both wet- and dry-weather wastewater-treatment plants offers the following potential advantages:

Improved wastewater-treatment reliability with corresponding decreases in effluent-quality variability

Increased water-quality-management capabilities

Reduced operating and maintenance costs

Smaller equipment and structure sizes because the treatment processes are kept operating at their maximum efficiency.

A recent literature review [3] indicates that the performance of most wastewater-treatment unit operations and processes can be improved through monitoring and control. Yet, on the basis of capital costs allocated to plant construction, [4] the majority of wastewater-treatment facilities provide little instrumentation.

Elements essential to a general instrument or process-control scheme (Figure 1) include the following components:

Measuring or sensing devices

Signal transmitting devices

Indicating elements for data display and inspection of operating conditions

Controllers that implement the selected actions

Final control elements for executing the selected control strategy.

OBJECTIVES

To accumulate information needed for rational decisions governing the type and degree of instrumentation that should be used in wastewater-treatment facilities, the United States Environmental Protection Agency sponsored a comprehensive study of current and potential instrumentation and automation applications in these facilities. As part of this project, a team of engineers surveyed fifty, selected, municipal and industrial wastewater-treatment facilities. These plants utilized a wide array of treatment processes such as pretreatment, primary, secondary, and advanced wastewater treatment. Although the majority of the surveyed facilities were dry-weather or combined-treatment facilities, some stormwater-treatment plants and control centers were also examined. The plant surveys assessed instrument utilization and performance, and estimated special manpower skills, training, and equipment necessary to operate and maintain instrument systems properly. When available, total control-system costs and economic or performance benefits derived were also noted.
The survey efforts concentrated on automatic on-line instruments and computer systems; therefore, laboratory measuring devices (i.e., those requiring a technician to transfer, prepare or condition a sample manually) were excluded from this investigation.

If wastewater-treatment plant automation is to become more widely utilized,

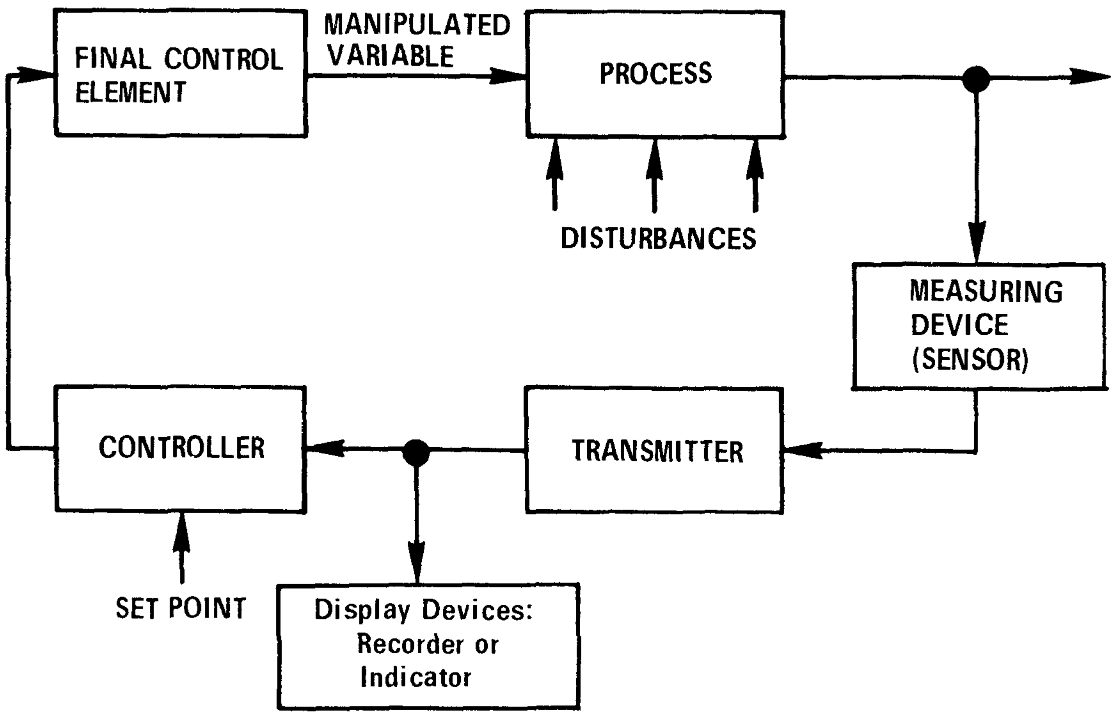


Figure 1. Typical control-system components

comprehensive reports on the successes and shortcomings of observed "field" instruments, automatic control devices, and wastewater-treatment process-control strategies are essential. Such reports will provide guidance to design engineers, municipal planners and regulatory officials; they will also direct future research on equipment development and process-control theory.

A glossary of terms is given in Appendix A.

SECTION II

SUMMARY AND RECOMMENDATIONS

GENERAL

A nationwide survey of fifty wastewater-treatment facilities found that most of these plants use fewer instruments and automatic control devices than closely related, water supply and chemical processing plants. Amassed cost data show that the average secondary treatment plant allocates about 3% of construction costs for installed instruments; water supply and chemical processing plants, however, allocate about 6% and 8% respectively, for installed instruments. Remote satellite, wet-weather treatment plants, which in theory should operate unattended or with a minimal amount of operating man-power, allocated only about 2% for instrumentation and automation. Central, computerized, stormwater-routing and in-line storage systems, however, seemed to employ an adequate amount of instruments and automatic control devices.

An explanation for this smaller utilization of instruments in most wastewater-treatment facilities includes:

- No profit incentive to produce high-quality effluent
- No statutory penalty for poor-quality effluent, plus loosely enforced effluent-discharge standards (or guidelines)
- Lack of commercially available, field-proven instruments that reliably measure important process parameters
- Oversizing of plant capacity: Although this practice is relatively expensive, it permits a more loosely controlled operation
- General lack of familiarity with on-line instrumentation practices and needs.

Regulatory agencies can motivate wastewater-treatment plant authorities to use more process-type analytical instruments by strictly enforcing effluent guidelines and penalizing poor effluent quality. Furthermore, instrument manufacturers and research agencies should demonstrate, under actual field conditions, favorable cost/benefit ratios to stimulate on-line instrument usage. To help assess an instrument's desirability, a uniform easily-practiced record-keeping system is badly needed. Much misunderstanding and confusion could be avoided if design engineers would use standard symbols and standardized instrument drawings. Since instrument purchasing and installation are becoming more complex, consideration should be given to nationwide adoption of new contractual procedures to ensure that the specified instruments and control systems are effective when installed.

Although collection of detailed capital, operating, and maintenance costs for instrumentation was one of the prime survey objectives, only 30% of the surveyed plants had this information. If meaningful equipment life-expectancies, mean time between failures, and operational cost information are available, then the cost-effectiveness of instruments and automatic control devices can be accurately estimated. Clearly such a need exists, and wastewater-treatment facilities should attempt to standardize and improve their record-keeping practices.

MEASURING DEVICES

Unreliable sensors accounted for most of the difficulties experienced with automatic measurement and control of wastewater-treatment processes. Accumulated instrument operating experiences, summarized in Table 1, clearly show that wastewater-treatment instruments require more maintenance than their industrial counterparts. Since most measuring devices in wastewater applications interface directly with raw sewage, mixed liquors or thickened sludge, these devices are subject to continued fouling from solids deposition, slime buildup, and chemical precipitation; accordingly, they need more frequent cleaning and calibration. Poor mechanical reliability, interferences due to extraneous parameters, and lack of established measuring principles are also responsible for the unsatisfactory performance of some analytical sensors.

The distribution of measuring devices (Figure 2) indicates that flow and level devices account for nearly half the instrumentation employed in wastewater-treatment facilities; analytical instruments (e.g., on-line colorimetric instruments) represent approximately one quarter of the instruments observed; position, speed, weight and other mechanical-type measurements add up to another 15%. Based on actual field experiences in the surveyed facilities (Figure 3), the following measuring instruments are commercially available with sufficient reliability for on-line use in wastewater-treatment applications:

> level, flow, temperature, pressure, speed, weight, position, conductivity, rainfall, turbidity, pH, residual chlorine, free chlorine gas, and free flammable gases.

Sludge density meters, sludge blanket level detectors, on-line respirometers, dissolved oxygen probes, and many automatic sampling systems use well-established principles which are suitable for wastewater monitoring and control activities, but some of these require a large amount of maintenance. Such instruments, accordingly, need lower maintenance requirements before they will become widely used.

In spite of the many successful flow-measuring devices observed in treatment plants, accurate and reliable flowrate monitoring for stormwater poses special problems. Highly transient flows, large operating ranges, high concentrations of suspended solids, and frequent collisions with large debris are only some of the obstacles that an acceptable in-sewer flowmeter for stormwater must overcome.

Table 1. INSTRUMENT OPERATING EXPERIENCES

VARIABLE	INSTRUMENT	APPLICATION	TYPICAL COST	TYPICAL MAINTENANCE FRQ/YR.	MH/YR. STP	MH/YR. IND	*** SKILL LEVEL	Mean Time Between Failures	Typical Life Expectancy
LEVEL	Bubbler	Tanks & Wet Wells	$200	12	8	4	1	1-2 yrs.	5-15 yrs.
	d/p Trans.	Digesters & Sludge	700	0.6	5	5	3	1-5 yrs.	5-15 yrs.
	Float & Cable	Tanks & Wet Wells	400	24	60	5	1	0.2-2 yrs.	2-20 yrs.
	Optical	Sludge Blanket	1K	-	-	-	2	0.1-5 yrs.	2-8 yrs.
FLOW	Flume & Weir	Major Flows	2K+	1.4	2	-	3	0.5-5 yrs.	5-30 yrs.
	Venturi, etc.	Air and liquids	800+	4	20	6**	3	2 mo.-5 yrs.	5-30 yrs.
	Propellers	Clean liquids	1K+	7	10	10	4	1 mo.-1 yr.	1-8 yrs.
	Pos. Displace.	Gases	500+	2*	80*	10	4	1 mo.-1 yr.	1-5 yrs.
	Magnetic	Liq. and Sludge	2K+	12	12	8	4	0.5-10 yrs.	5-20 yrs.
DENSITY	Nuclear	Med. & Thick Sludge	5K	48	51	40	3	1-3 yrs.	8 yrs.
	Mechanical	Med. & Thick Sludge	-		Excessive		3	1-6 mos.	2 yrs.
ANALYSIS	pH and ORP	Aqueous Liquids	2K	300	50	29	4	1-4 mos.	0.5-5 yrs.
	Dissolved O_2	Aqueous Liquids	2K	100	60	-	4	1-9 mos.	0.1-5 yrs.
	Res. Chlor.	Aqueous Liquids	5K	365	140	-	4	0.2-1 yr.	4 yrs.
	Turbidity	Fairly Clean Liquid	3K	-	-	-	4	1-6 mos.	4 yrs.
	Conduct.	Aqueous Liquids	1K	200	60	-	3	1-4 mos.	4 yrs.
	Chlorine Gas	Airspace	3K	24	50*	-	4	0.5-1 yr.	8 yrs.
	Explosive Gas	Airspace	3K	12	12+	50	3	0.2-1 yr.	8 yrs.
	COD, TOC	Wastewater	-		Excessive		5	0.1-1 mo.	0.3-1 yr.
MISC.	Temp.	All	300	1*	8*	4	3	0.5-2 yrs.	5 yrs.
	Press.	All	200	5	4	4	3	0.1-5 yrs.	5 yrs.
	Speed	Engines, etc.	-	-	-	-	4	0.6-5 yrs.	5 yrs.
	Weight	Sludge or Cl_2	2K	24*	60*	-	4	0.6-2 yrs.	10 yrs.
	Position	Sluice Gates	1K	18*	30*	-	3	0.1-1 yr.	1 yr.
	Sampling	Liquid Streams	4K	0.5	20	-	2	0.1-1 yr.	4 yrs.
	Rainfall	Storm Waters	500	24*	50*	-	3	1-5 yrs.	12 yrs.
CONTROL	Level	Wells & Basins					3		
	Flow	All Fluids					3		
	Sludge	Sludge Separation					3		
	Air Flow	Aeration					3		
	Dosage	- - -					3		
	Res. Chlorine	Chlorination					4		
	DO	Aeration							

NOTE:

FRQ/YR = Frequency per year

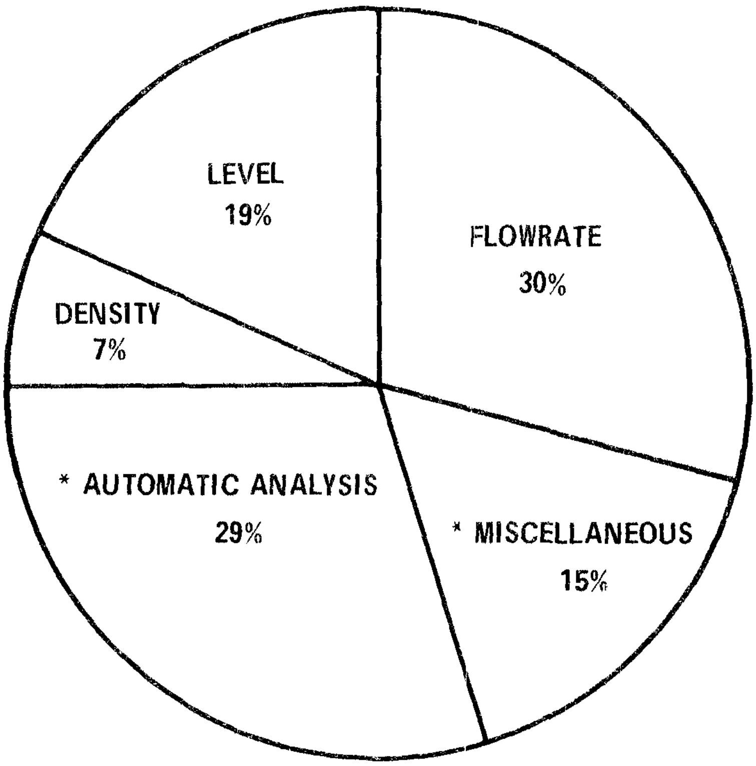
STP = TREATMENT PLANT

IND = INDUSTRIAL

* Estimated

**d/p Converter only

*** Skill levels 1 thru 5 denote the training and qualifications in increasing order of difficulty necessary for properly maintaining the instrument. See Page 92 for detailed definitions.



* NON-LABORATORY PROCESS INSTRUMENTS ONLY

Figure 2. Observed distribution of measuring instruments

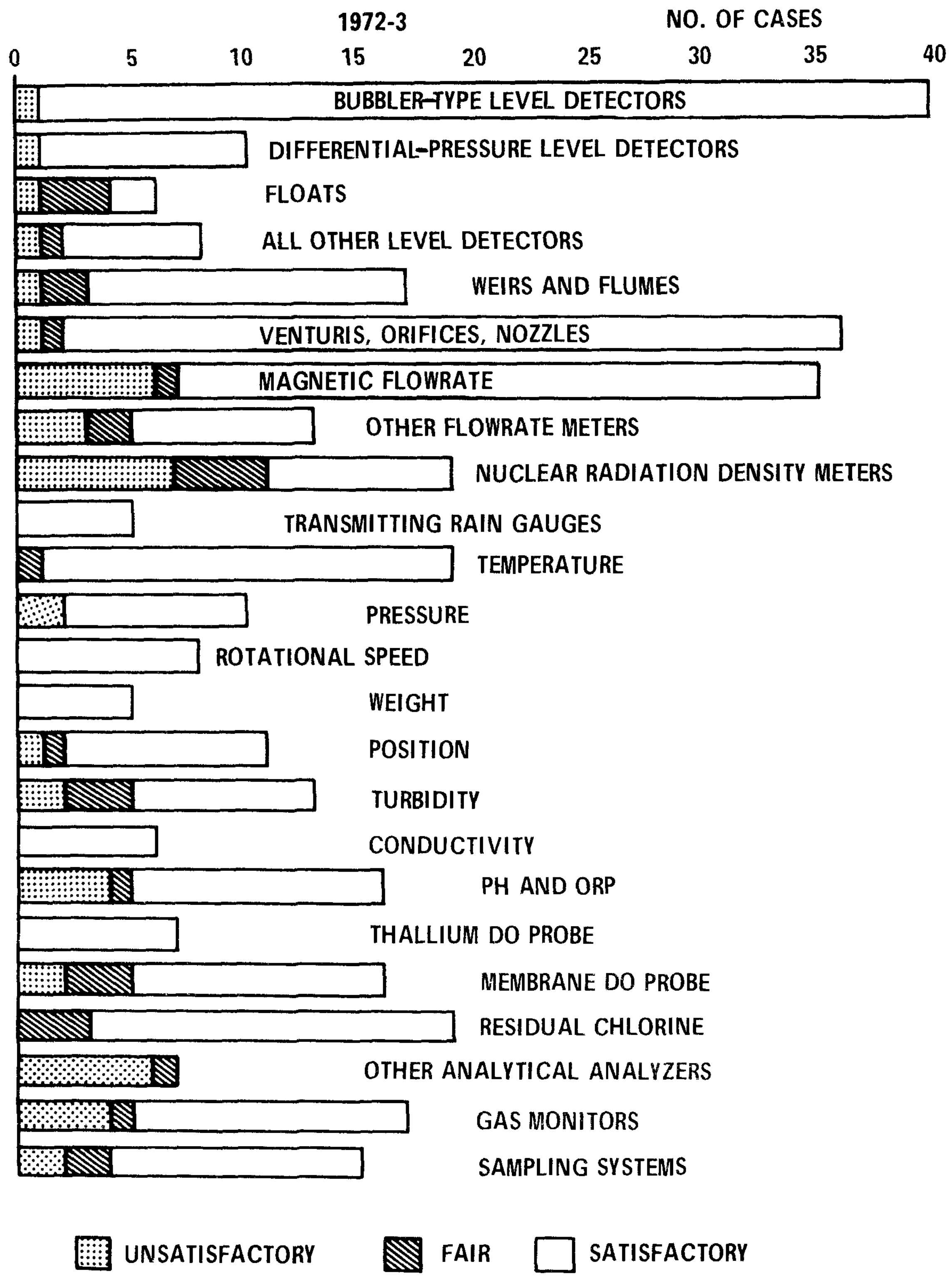


Figure 3. Performance summary of measuring devices in wastewater- treatment facilities

Consequently, a suitable stormwater flow meter needs to be developed for producing the accurate flowrate data required for sewer regulation.

AUTOMATIC CONTROL

As shown in the summary of automatic control devices (Figure 4), most facilities successfully practice automatic liquid-level, liquid-flowrate, and air-flowrate control since fluid regulation is important for proper operation and since satisfactory flow meters are readily available. Presently available, flow-control systems that use established designs are entirely adequate for wastewater-treatment activities.

Automatic process control, however, is only occasionally utilized in wastewater treatment. The nationwide survey, summarized in Figure , found that control systems for flow-ratio chemical addition, feedback residual chlorine, and digester temperature worked well and caused no difficulties. Most plant managers considered these automatic control systems cost-effective since they save energy and chemicals, and improve plant operation. Automatic feedback control systems for dissolved oxygen effectively reduce oxygenation power consumption, but some users reported that these systems required considerable probe maintenance. The turbidity and pH control systems observed in this survey gave unsatisfactory performance because of faulty system design and installation. Some of the most potentially useful process-control parameters (such as substrate concentration, MLVSS, food/microorganism ratio) have not been successfully practiced in wastewater-treatment plants.

The small number of automatic control loops observed in the present plant survey attests to the low level of automation that is characteristic of most wastewater-treatment plants. The survey's observations indicate that lack of sufficiently reliable analytical sensors has impeded process-control efforts. Other commercially available, process-control components (transmitters, display devices, controllers, and final control elements) have proven their ability to provide reliable service in wastewater-treatment plants.

Intensive application of elaborate and novel logic schemes, computers, displays, and recorders will not improve wastewater-treatment effectiveness. Instead, well-documented field-evaluation programs are needed to help ferret-out desirable control systems from the numerous potentially viable ones.

CENTRAL CONTROL

Central control organizes the plant operation in such a manner that all treatment information, important events, and alarms are displayed, indicated and recorded in a centralized location, usually referred to as the control room. In addition, most central facilities practice automatic, or remote manual, actuation of final control elements. The success of central control is assured by the commercial availability of reliable transmitters, displays, indicators, and recording equipment. Virtually all the large successfully surveyed facilities utilized

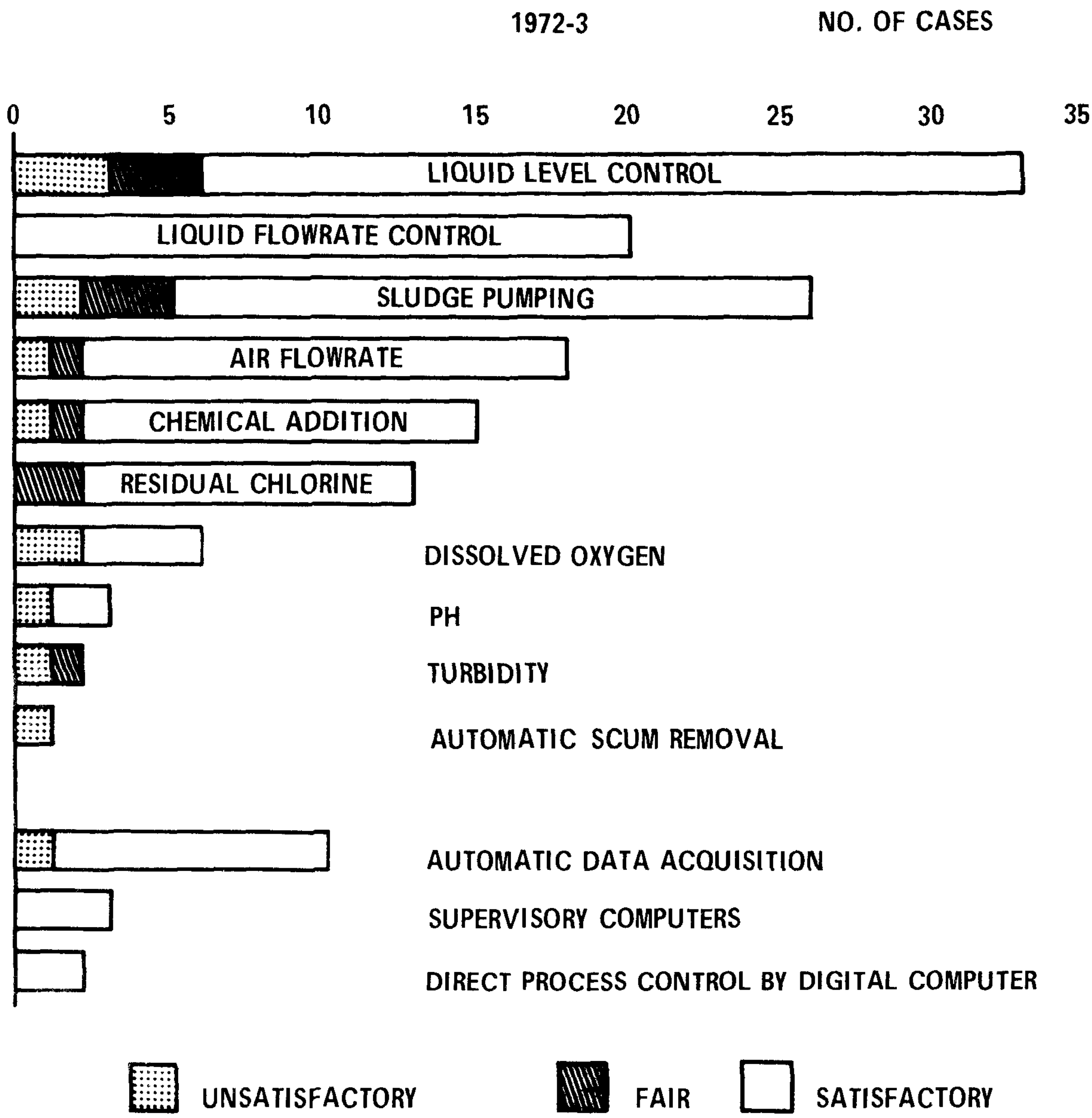


Figure 4. Summary of automatic control experiences in wastewater- treatment facilities

a high degree of centralized control, Since it reduces the number of men required to operate a large treatment plant, centralized control is one of the few forms of instrumentation readily justifiable on an economic basis.

COMPUTERS

Modern data-logging systems accumulate, format, record and display large quantities of data effectively; consequently, most new plants have automatic data-acquisition systems. Approximately twenty percent of the visited facilities used data-logging computers, and ninety percent were satisfied with them.

Although direct digital, and digital supervisory, process-control computers have demonstrated their merits in many industries, they are not well established in dry-weather treatment plants: Only two of the surveyed facilities had process-control computers; on the other hand, three stormwater-control centers used computerized supervisory control, and all of these computer systems worked well.

Computerized supervisory control of large storm and combined sewer systems is cost-effective because the vast number of variables and control points exceeds human computational and decision-making abilities within corrective time limits.

MAINTENANCE

In spite of inadequate amounts of installed instrumentation, wastewater-treatment personnel exhibited a good attitude towards instrumentation, as measured by their willingness to use and maintain those instruments actually present. The survey team found that the treatment plants supplied approximately ninety percent of the maintenance resources needed. Small abandonment rates also attested to their favorable acceptance. Individual plant managers' disposition towards instrumentation, however, ranged from poor to excellent. As a group, satellite stormwater-treatment facilities supplied less-than-adequate maintenance; possibly because of their newness, maintenance of stormwater instruments is not well understood. Since none of these satellite facilities could start up or shut down automatically, it would behoove individuals concerned with stormwater-treatment facilities to direct more attention to development of automatic instruments and devices, as well as to improving the maintenance of existing devices. On the other hand, stormwater-control centers, which typically receive stormwater and combined sewer network information, were well maintained and operated satisfactorily.

Although most plants have reasonably well-qualified instrument-maintenance staffs, any plans for installing sophisticated instruments and automatic control devices must be accompanied by appropriate provisions for upgrading the qualifications of instrument-maintenance personnel.

TRENDS

The survey results show that many instruments provide useful services to enhance a treatment plant's efficiency and operational reliability. Most of these field-proven devices measure and control the important physical variables, such as flowrate and liquid level. A limited number of process analyzers and miscellaneous control devices have also demonstrated their desirability, but some of the most important process parameters (organic loading, for instance) have never been successfully monitored on an automatic basis in wastewater-treatment plants at least not without excessive amounts of maintenance. If treatment-process efficiency and reliability are to improve, suitable measuring devices must be available to permit real-time control. Continuous or semi-continuous monitoring devices must also be available to document compliance with discharge standards. In light of increasingly stringent discharge standards, the potential rewards of process control appear sufficiently large to justify development of the necessary automatic measuring devices.

As a guide for future research and development, the following list of sensors, control loops, software and hardware represents the important needs for wastewater-treatment instrumentation and automation:

Sensors

Rapid, on-line, automatic monitoring devices for organic contaminants

In-situ suspended solids meters for the 500- to 5,000-mg/l range

On-line wet-chemical analyzers for ammonia, total phosphate and total hydrolyzable phosphate

Stormwater flowmeters

Control Loops

Organic load equalization

Food-to-microorganism ratio

Breakpoint chlorination

Phosphate removal

Feed-forward DO control

Computer Hardware and Software

User-oriented language

Uniform data formating and reporting

Standardized input/output requirements

Centralized software library, with program routines useful for wastewater-treatment-plant operation, control, and management

To control treatment processes successfully, the design engineer must have quantitative knowledge about each process' behavior under time-varying loads. Although most treatment processes are well understood in the static sense, the dynamic characteristics are not always known; accordingly, useful models that describe time-varying behavior are needed to advance wastewater-treatment process control.

SECTION III

THE SURVEY

BASIS OF FACILITY SELECTION

To satisfy the previously mentioned survey objectives, 50 treatment facilities were selected for field visits. Selection was based on the variety of instrumentation used, the size and type of treatment processes employed, and plant location. Because of the need for actual field data, only acceptably functioning wastewater-treatment facilities with good record-keeping practices were considered as suitable candidates. Consistent with these criteria, the survey team visited three pilot plants which had gathered a large amount of pertinent experience with full-size control systems. Unfortunately, several new and highly automated plants, such as Bridgeport (Connecticut), Garland (Texas), Wantau (New York) and the stormwater facility at Syracuse (New York), were inappropriate candidates because of insufficient operating data.

Because most of the selected plants employ a higher degree of instrumentation and automation than is usual in wastewater-treatment facilities, some typical treatment plants were also surveyed to establish base-line information. As shown in Table 2, the 50 treatment facilities examined during the nationwide survey utilized a wide array of treatment processes. Geographical locations, summarized in Table 3, are grouped according to USEPA regions.

SURVEY METHODOLOGY

Prior to on-site inspections, the survey engineers attended a two-day orientation session for intensive training in the type of measuring and sensing devices which might be encountered. This training also encompassed the standardizing of all surveying protocol, including the collecting of data and the preparation of reports and drawings. Extensive questionnaire forms (see Figures 5, 6, and 7), detailing background information, instrumentation performance and cost, and control-loop experiences, were prepared in advance.

At the start of each facility visitation, the survey engineer met with the plant management and those persons responsible for instrumentation. Plant histories, design flowrates, and operational characteristics were discussed, with special emphasis placed on the overall benefits or liabilities of the installed instrumentation; this information was documented on the General Survey Questionnaire (Figure 5).

A plant tour, with the facility's instrument engineer (or equivalent) functioning as the guide, permitted the survey engineer to examine the operating instruments and control loops, item-by-item. During the tour,

Table 2. TYPES OF FACILITIES SURVEYED

Type of Facility	Number Visited
Primary treatment plants	9
Secondary treatment plants	25
Tertiary treatment plants	3
Wet-weather treatment facilities	4
Computer data center	5
Industrial waste treatment plants	2
Pilot plants	2

Table 3. REGIONAL LOCATIONS OF PLANTS SURVEYED

EPA Region	Number Visited
1	2
2	4
3	4
4	5
5	16
6	2
8	1
9	10
10	6

Form approved
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GENERAL SURVEY QUESTIONNAIRE

STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address

Responsible Supervisor

Flow Rate Design (Average and Maximum)

Storm Water Collection and Treatment

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)

Performance Data (Individual Unit and Overall)

Year Built — Modifications (Year and Description)

Original Cost — Modification Cost

Instrumentation

Equipment

Panels

Installation and Start up Costs — Original Cost — Total Cost

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total

Computer

Type — Manufacturer — I O Devices

Process Control

Data Logging

Parameter Frequency	Parameter Frequency	Parameter Frequency	Parameter Frequency

Storage

Software Description

Computer Cost — Software Cost — Installation Cost

Central Control

Supervisory Control

Alarm and Safety Systems

Automatic Emergency Program (e g Power Failure)

Maintenance and Calibration

Special Equipment — Down Time

Special Operator Training — Frequency (no mo)

Total In Plant Man Hours Year

Total Cost of Outside Service

Estimate of Over all Benefits of Instrumentation and Automation

Figure 5. General survey questionnaire

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		Comments
Parameter	Manufacturer	Model Number	Equipment Cost	In Plant Maintenance (mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Frequency (no./mo.)	Total Downtime	Downtime Frequency (no./mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	

* Corrosion, fouling, etc.
** Limiters, alarms, ratio relays
*** Local and central

Figure 6. Instrument survey form

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							Comments
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min.)	Manpower (mh/yr)	Utility (kWh/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min./max. (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Down-time (hr/yr)	Downtime Frequency (no./mo.)	

* Control mode – relay, proportional, proportional plus reset, etc.
** Types of controllers – analog (pne., hyd. or elec. media), computer (supervisory, direct digital or set analog)
*** Final control element – pne. valves, variable speed pump, etc.

Figure 7. Process-control-loop survey form

measuring devices were inspected, and pertinent data (manufacturer, model number, maintenance characteristics, accuracy, and application) were recorded on the Instrument Survey Form (Figure 6). In addition, the survey engineer examined control techniques, costs, benefits derived, and operating experiences; these observations were recorded on the Loop and Process Control Survey Form (Figure 7). To coordinate the accumulated information with respect to in-plant applications, instrument diagrams were constructed using standard ISA symbols (see Figure A-2 of Appendix A). These schematics, which ignore parallel duplicate instrumentation, pictorially describe the control instrumentation, strategies, and configurations practiced in the surveyed facilities.

Although instruments utilized in wastewater-treatment works are arrangements of mechanical, pneumatic, electronic, and electrical devices, their performance is undoubtedly affected by human factors, particularly the attitude of plant personnel and the proficiency of the available instrument-maintenance staff. The survey team assessed the capability of each plant's instrument staff on the basis of personal interviews, organizational structure, and the condition of the observed instruments. The available level of skill (see Appendix A) was used to characterize the overall existing capabilities of each facility's instrumentation group; whereas, the desired level of skill represents the degree of instrument-technology proficiency actually required to operate and maintain the facility's instruments and automatic-control systems properly. The attitude of plant personnel toward instrumentation is usually illustrated by the importance attached to maintaining their equipment, by the degree of reliance on monitoring data for plant operation, and by their opinion of the benefits of automation. Attitudes and opinions on instrumentation were paraphrased in the Estimate of Overall Benefits section of the General Survey Questionnaire. Notwithstanding the subjective nature of evaluating human attitudes, the reporting of experienced survey teams produced useful information that has led to greater understanding of the human aspects of instrumentation usage.

This survey, which limited its investigation to on-line process instruments, omitted some routine control systems, such as those supplied with package incinerators, lift stations and pumps, if their success was well-documented in other applications.

SURVEY RESULTS

Survey data from the visited wastewater-treatment facilities were documented on the survey forms (Figures 5, 6, and 7) and instrument diagrams (Appendix C). This information was condensed into a series of tables and figures (see Conclusions and Recommendations) which summarize background, cost, and maintenance data associated with the observed instrumentation.

With these tables and figures the reader can quickly assess the number of instruments observed, find the percent acceptance based on interviews with the plant's instrument staff, and gain an overview of instrument costs and associated maintainance requirements. Those readers interested in studying the instrumentation details of each facility are referred to Appendix C for the complete survey forms and instrument diagrams. A numeric code permits linking the summarized results with the actual survey data in Appendix C. Also, this code preserved the anonymity of the surveyed facilities.

Although collection of detailed operating and maintenance-cost information was one of the prime survey objectives, only a few treatment plants had collected or preserved such data. As a result, the survey placed more emphasis on documenting instrument-operating experience and performance.

SECTION IV

INSTRUMENT COST FACTORS AND USERS' ATTITUDES

INTRODUCTION

Meaningful data on the success and shortcomings of instrumentation employed in wastewater-treatment facilities includes more than a simple statement about the ability of the instrument to function in the observed environment. Applicability of principles, amount of resources committed, and level of skill, motivation and attitude of the operating personnel are also important items in a rational evaluation of an instrument's success or failure. Our discussion begins with an overview of pertinent background data that concentrates mostly on the non-technical aspects, such as economic data and users' attitudes and motivations. Subsequent sections discuss measuring devices, automatic control loops, central control, computers, and skill levels - both applied and required.

OVERVIEW OF MOTIVATION, ECONOMICS, USERS' ATTITUDES AND MAINTENANCE SKILLS

Some reasons for installing instruments are:

They may be essential to operate the plant

They may save money

They may improve the reliability of plant operation

Their usage may be mandated by regulatory agencies

All of these reasons, with the possible exception of regulatory requirements, imply that a user purchases an instrument and maintains it because he hopes to realize a net gain. More simply, he spends to save, to improve, or to comply with regulations. The necessity and cost savings for some additional instruments, namely flowrate and liquid-level measuring devices, are readily apparent. The desirability of other instruments, such as respirometers and total organic carbon analyzers, is relatively unknown. A significant number of successful trial applications usually precedes, frequently by several years, widespread employment of the instrument.

In Tables 4-A, 4-B, and 4-C the surveyed facilities are grouped as primary, secondary, tertiary, stormwater, industrial, control center, or pilot plant. The first items denote background information such as flowrate data, BOD_5 and suspended solids removed, and the year built. Substantiating the reasonableness of these data, a summary of the performance (measured by BOD and suspended solids removals) compares favorably with generally recognized values. For example, in their 1968 survey of municipal wastewater plants, the EPA reported that primary treatment removes 37% of the BOD, secondary treatment removes 81 to 85% of the BOD, and advanced wastewater treatment

Table 4-A. BACKGROUND AND ECONOMIC DATA FOR PRIMARY TREATMENT FACILITIES SURVEYED

Facility Code-Primary	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	A-9	Av.
Design flow (MGD)	24	60	-	100	125	230	-	-	-	
Present average flow (MGD)	24	30	50	88	95	100	330	420	750	
Present average flow, % of design	100	50	-	88	76	48	-	-	-	
BOD removal, %	-	54	25	31	38	30	29	54	48	38
Solids removal, %	-	76	55	59	68	60	46	73	65	62
Year built/modified	66	68	59/63	51/69	66	63	68	50/57	40/70	
Plant capital cost ($ million)	-	7	11	2.1	12	6.2	26	78	128	
Instrument capital cost ($ million)	-	-	-	-	.87	.38	1.25	-	-	
Instrument cost, % of plant cost	-	-	-	-	7	6	5	-	-	6
Instrument maintenance (MH/yr)	100	2100	16	1100	2400	3100	8400	9200	-	
Instrument maintenance (MH/yr/design MGD)	4	35	.3	11	19	14	26	22	-	
Instrument maintenance (MH/yr/$1000 of installed cap. cost)	-	(8)[a]	-	(13)[a]	3	8	7	(3)[a]	-	7
Contract inst. maint. ($1000/yr)	0	0	0	0	0	5	4.3	0	0	
Inst. maint. skill, available[b]	1	4	1	3	4	3	2	3	2	2.5
Inst. maint. skill, required[b]	2	4	3	3	4	3	3	3	3	3.1

[a] denotes estimated cost at 3.3% of plant cost

[b] Refer to Definitions

Table 4-B. BACKGROUND AND ECONOMIC DATA FOR SECONDARY TREATMENT FACILITIES SURVEYED

Facility Code-Secondary	B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8	B-9	B-10	B-11	B-12	B-13
Design flow (mgd)	1	6	6	-	5	-	12	-	21	24	24	35	36
Present average flow (mgd)	.7	2.2	2.5	4	5	6.5	15	20	24	10	28	35	22
Present average flow, % of design	70	37	42	-	100	-	125	-	114	42	117	100	61
BOD removal, %	95	93	96	90	92	75	96	96	90	88	94	-	70
Solids removal, %	92	75	97	-	94	81	96	93	90	88	94	-	70
Year built/modified	47/69	72	61/70	67	65	63/71	62	67	36/72	72	65	72	58
Plant capital cost ($ million)	1	5	8	2.2	.82	2.4	1.7	5.9	175	10.8	9	10.7	5
Instrument capital cost ($ million)	-	.2	-	.12	.02	.16	-	.16	-	-	.37	.075	-
Instrument cost, % of plant cost	-	4	-	5	3	7	-	3	-	-	4	.7	-
Instrument maintenance (MH/yr)	100	2000	300	1700	30	1000	600	1800	800	-	6500	100	700
Instrument maintenance (MH/yr/design mgd)	100	333	50	425	6	154	50	93	38	-	270	27	19
Instrument maintenance (MH/yr/$1000 of installed cap. cost)	(3)[a]	10	(1)[a]	14	1	6	(9)[a]	12	(1)[a]	-	18	13	(6)[a]
Contract inst. maint. ($1000/yr)	1	-	0	0	0	0	0	13	0	0	0	0	2
Inst. maint. skill, available	3	3	4	3	2	3	3	3	3	4	4	4	3
Inst. maint. skill, required	3	4	4	3	2	3	3	3	4	4	4	5	3

[a] denotes estimated cost at 3.3% of plant cost

Table 4-B (Cont). BACKGROUND AND ECONOMIC DATA FOR SECONDARY TREATMENT FACILITIES SURVEYED

Facility Code-Secondary	B-14	B-15	B-16	B-17	B-18	B-19	B-20	B-21	B-22	B-23	B-24	B-25	Av.
Design flow (mgd)	36	37.5	44	44	-	123	-	180	200	218	250	900	
Present average flow (mgd)	30	31	23	40	105	130	150	260	-	-	175	900	
Present average flow, % of design	8	83	52	91	-	106	-	144	-	-	70	100	
BOD removal, %	90	88	89	76	90	90	73	80	97	74	64	90	86
Solids removal, %	90	97	57	73	87	90	66	80	97	83	73	90	84
Year built/modified	59/64/71	71	64	29/52	64	31	43	36	25/32	38/66	65	30	
Plant capital cost ($ million)	16	9	3.3	7	29	9.5	43	62	200	32	-	-	
Instrument capital cost ($ million)	-	.35	-	-	.52	-	.6	-	-	-	-	-	
Instrument cost, % of plant cost	-	4	-	-	2	-	1	-	-	-	-	-	
Instrument maintenance (MH/yr)	(400)	1500	150	600	4000	1000	2500	700	2100	14100	800	14000	
Instrument maintenance (MH/yr/design mgd)	11	40	3.4	14	38	8	17	3.7	12	65	3.1	16	
Instrument maintenance (MH/yr/$1000 of installed cap. cost)	(6)[a]	4	(1)[a]	(2)[a]	8	(3)[a]	4	(.3)[a]	(.3)[a]	(11)[a]	-	-	5.8
Contract inst. maint. ($1000/yr)	.1	0	1	0	-	-	1	0	0	1.2	0	0	
Inst. maint. skill, available	4	4	3	3	4	2	3	1	4	4	4	2	3.2
Inst. maint. skill, required	4	4	3	4	4	3	3	2	4	4	4	2	3.4

[a] denotes estimated cost at [illegible] of plant cost

Table 4-C. BACKGROUND AND ECONOMIC DATA FOR VARIOUS OTHER TREATMENT FACILITIES SURVEYED

Facility Code	Tertiary			Industrial			Storm Water			
	C-1	C-2	C-3	D-1	D-2	Av.	E-1	E-2	E-3	Av.
Design flow (mgd)	2	7.5	8	.36	-		-	-	-	
Present average flow (mgd)	-	3.9	6	.36	2		-	-	-	
Present average flow, % of design	-	52	75	100	-		-	-	-	
BOD removal, %	98	99+	98	-	95		-	-	-	
Solids removal, %	98	99+	98	-	97		-	-	-	
Year built/modified	71	65/68	63/72	54	-		71	72	70	
Plant capital cost ($ million)	3	5.5	4.9	1	-		5	17	2.1	
Instrument capital cost ($ million)	-	.35	-	.08	-		.125	.035	.075	
Instrument cost, % of plant	-	6	-	8	-		2.5	.2	3.6	
Instrument maintenance (MH/yr)	-	2000	-	65	320		100	300	-	
Instrument maintenance (MH/yr/design mgd)	-	267	-	161	160		-	-	-	
Instrument maintenance (MH/yr/$1000 of installed cap. cost)	-	6	-	.8	-		.8	9	-	
Contract inst. maint. ($1000/yr)	-	20	0	0	-		-	-	-	
Inst. maint. skill, available	3	3	3	3	4	3.3	1	1	2	1.3
Inst. maint. skill, required	3	4	4	3	4	3.3	3	3	3	3

Table 4-C (Cont). BACKGROUND AND ECONOMIC DATA FOR VARIOUS OTHER TREATMENT FACILITIES SURVEYED

	Data Centers (active and passive)					Pilot Plants		
Facility Code	F-1	F-2	F-3	F-4	F-5	G-1	G-2	G-3
Design flow (mgd)	-	-	-	-	-	-	-	-
Present average flow (mgd)	-	-	-	-	-	-	-	-
Present average flow, % of design	-	-	-	-	-	-	-	-
BOD removal, %	-	-	-	-	-	-	-	-
Solids removal, %	-	-	-	-	-	-	-	-
Year built/modified	71	70	70	69	70	68	70	70
Plant capital cost ($ million)	3.1	2.1	-	1.8	-	.12	-	1.5
Instrument capital cost ($ million)	-	-	-	-	.3	.006	-	-
Instrument cost, % of plant	-	-	-	-	-	-	-	-
Instrument maintenance (MH/yr)	8500	4000	300	6300	-	-	4000	300
Instrument maintenance (MH/yr/design mgd)	-	-	-	-	-	-	-	-
Instrument maintenance (MH/yr/$1000 of installed cap. cost)	-	-	-	-	-	-	-	-
Contract inst. maint. ($1000/yr)	2	-	2	3	-	-	-	-
Inst. maint. skill, available	5	3	4	3	3	2	4	2
Inst. maint. skill, required	5	3	4	4	3	3	5	3

(AWT) removes 94% of the BOD. The mean BOD removals for the currently surveyed facilities were 37 percent by primary treatment, 86 percent by secondary treatment, and 98 percent by AWT. The ratio of present average flow to design flow measures the degree of loading. If the ratio is significantly higher than 100%, design capacity has been exceeded and overloading is severe. Although secondary plant number B-21 was somewhat overloaded, the majority of the surveyed facilities operated within their design limits. Thus, these facilities have BOD and suspended solids removals which are in harmony with literature values.

INSTRUMENT COST DATA

Although the percentage of installed plant cost allocated to instrumentation has several shortcomings* as an effective yardstick of the degree of a plant's instrumentation, the scarcity and non-specific nature of available economic data necessitate the use of this measure.

Calculations showing percentage of total plant cost have been successfully used for many years in the chemical processing industry for preliminary instrumentation-cost estimates. Out of the 50 facilities surveyed, only eighteen had instrumentation-cost data. This was expected, since instrument expenses are usually imbedded in the overall construction contract. In some recent projects, however, the instrumentation has been awarded as a separate contract. With only 35 percent of the facilities having sufficient cost data, straightforward conclusions from a statistical summary must be tempered by the limited sample size and good judgment.

Mean values for installed instrument costs indicate that primary plants spend 6%, stormwater-treatment facilities 2.5%, secondary plants 3.3%, and AWT plants 6% of their construction costs on instruments. However, only three primary facilities and one AWT plant had instrument-cost data; on the other hand, instrument-cost data are available for ten secondary plants. Accordingly, the survey results show that 3.3% of secondary plant costs are allocated to instrumentation; no statistical conclusions can be made about the instrumentation costs for primary, stormwater and industrial plants, or for data centers. Based on annual product-shipment data published by the U.S. Department of Commerce,[7] Smith[4] reasoned that about 1.5% of the municipal wastewater-treatment plant's cost is allocated for meters and control-equipment purchases before installation. As a rule of practice, 0.5% of plant cost is dedicated to instrument installation; thus, the nationwide product shipment data indicate that about 2% of the plant's cost is allocated to instrumentation. Because secondary plants typically spend more on instruments than primary, the estimated 3% of plant costs spent on instrumenting secondary plants seems reasonable. Previous data[7] show that industrial wastewater-treatment facilities spend slightly more on instruments than do municipalities.

*The estimate, based on percent of plant cost, includes several sub-costs (such as the site and its development, buildings, and aesthetic improvements) that are not related to instruments. Also, linear scale-up of the measure is not strictly valid. For example, a plant twice as large usually does not require the same percent of installed plant cost for instrumentation as does the smaller plant.

Notwithstanding the scarcity of economic data, all the information indicates that secondary treatment plants purchase considerably fewer instruments than do continuous chemical-processing plants, a related application. Surprisingly, stormwater plants (operational only during storm events) spend even less on new instrumentation then do secondary plants. This appears contradictory to the goal of automatic, unattended operation usually associated with auxiliary wet-weather facilities. One would think that unmanned operation would necessarily require a large amount of automation. An inspection of the stormwater-plant surveys (Appendix C) discloses that most of these facilities do not operate properly when unattended. In short, these plants rerely start up, treat, and shut down without human intervention and control.

Typically, the chemical industry allocates anywhere from 6 to 10% of a plant's cost for instruments[8]. Water supply facilities, moreover, allocate about 5 to 7% of plant cost on instruments. A partial explanation for this observation is that water supply and chemical plants must keep effluent (product) quality within certain narrow limits, whereas most municipal plants are not penalized for poor quality effluent. If effluent guidelines were strictly enforced, motivation to employ instrumentation would increase by virtue of the "compliance stimulus." Alternatively, clear demonstrations of significant cost-benefits would naturally encourage instrument usage.

MAINTENANCE-COST DATA

In some instances, insufficient O & M funds precluded good maintenance practices. The amount of funds and manpower dedicated to instrument maintenance reflects not only the attitude of management, but also the entire community's attitude toward effective operation of their treatment facility. Table 4 (A, B and C) illustrates the annual manhours expended on instrument maintenance, including outside contract maintenance. In order to normalize the maintenance manpower, the ratio of manhours to thousands of dollars of installed instrument costs are reported in Table 4 (A, B and C). High ratios show that adequate (or perhaps excessive) manhours are allocated for maintenance; low ratios indicate poor maintenance practices. On the average, primary plants spent 7 manhours per year for every thousand dollars worth of instrumentation; similarly, secondary and stormwater facilities allocated 5.8 and 4.9 manhours per year per thousand dollars of instrument cost, respectively. This maintenance manpower is comparable to industry's maintenance schedule for non-fouling instrument applications. An alternate basis for ascertaining the adequacy of maintenance resources is the percent of instrument cost spent on maintenance for a period of one year. If maintainance labor costs ten dollars an hour, then the manhours per thousand dollars of installed instrumentation are equivalent to the percent of instrument cost spent on maintainance:

annual manhours X \$10 = % instrument cost for maintainance.

Thus, in the aggregate, wastewater-treatment facilities earmark about 6% of their installed instrument cost for annual maintenance. Chemical processing and other related industries spend about the same amount for instrument maintenance. In short, a favorable comparison of the resources allocated to instrument maintenance among wastewater-treatment works, chemical plants, and water-supply plants shows that most municipal wastewater plants satisfy their maintenance requirements as far as manpower is concerned. Those readers interested in comments from individual plant managers may refer to the completed General Questionnaires in Appendix C.

MAINTENANCE SKILLS

The level of skill applied also significantly affects the instruments's operational success or failure. Comparisons of levels of skill applied versus those required provide a measure of competency of the instrument-maintenance group. The surveying engineers found that primary plants employed a 2.5 level of skill*, while a 3.1 level of skill was required; this corresponds to an 80% compliance. In other words the majority of primary plants need Level 3 instrument technicians, while only a small number need Level 2 or Level 4 technicians. Since most of these primary facilities employ Level 2 and 3 instrument technicians, they tend to use under-qualified maintenance personnel. Secondary treatment plants satisfy about 94% of the required skill; therefore, their maintenance staffs are adequately qualified. Industrial facilities, control centers and data centers similarly utilize amply trained instrument-maintenance staffs. Stormwater facilities, however, supplied less than half the required level of skill; their poor performance can partially be attributed to a lack of sufficiently trained instrument-maintenance personnel.

PROCESS KNOWLEDGE

Successful process instrumentation and automation must consider process behavior and the availability of essential instrumentation components. Although most processes employed in wastewater treatment are well understood in the static sense, dynamic characteristics are not thoroughly known. Useful mathematical models that describe unsteady-state behavior simply do not exist for most wastewater-treatment processes. This shortcoming makes selections of appropriate control strategies and manipulated variables somewhat difficult, but a combination of good engineering judgment and experience should produce workable control strategies.

SUMMARY

The lack of appropriate measuring devices, as well as improper maintenance of available devices, have greatly impeded the optimum instrumentation of wastewater-treatment facilities.

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*See Appendix A for level of skill definitions. Although the meaning of a 2.5 skill level is not precisely defined there (i.e., Appendix A defines only integer levels, not fractional levels), it denotes the average value of the plant's skill levels.

After identifying measuring devices as a problem area, the survey team expended considerable effort investigating existing measuring equipment. A comprehensive discussion addresses measurement principles, practices and performance. On the other hand, transmitters, indicators, controllers and final control elements utilize well-established technology, and numerous mechanical, electrical, or pneumatic devices are commercially available; consequently, very little attention was devoted to them. In short, the user survey concentrated on the most serious problems -- measurement of wastewater variables, and control-loop performance.

SECTION V

MEASURING DEVICES

INTRODUCTION

Analytical sensors, transducers, and measuring systems pose special problems in wastewater applications because these devices often are in contact with a potentially fouling or damaging fluid. During the plant survey, many types of measuring devices were observed, and users' experiences were recorded. The reliability (that is, the dependability of obtaining an accurate answer from the sensor over a given period of time) and the amount of maintenance required were also determined. Most of the instruments that measure physical variables, such as level, flow, pressure, speed and position, performed well in wastewater-treatment plants; whereas, some of the analytical sensors were judged as unsatisfactory by the interviewed users. The forthcoming discussion examines measurement principles, potential applications, operating characteristics, maintenance requirements and users' experiences for each measuring device observed during this survey.

LEVEL-MEASURING DEVICES

Because wastewater treatment involves liquid flow and storage, level measurement is an important parameter. Level-measuring instruments for wastewater facilities should be (in order of importance) accurate, reliable, easily serviced, and inexpensive.

Applications

Level-measuring devices are almost always used for wet-well control. The level instrument sends information to an automatic controller or plant operator, and pumps, gates or other final control elements are adjusted accordingly. In auxiliary excess-stormwater facilities, liquid level was frequently used to automatically start up and shut down these plants.

Principles

Liquid level is determined by measuring the relative height of the air-liquid interface or by measuring the hydrostatic pressure at some fixed point below the minimum operating level. Bouyant floats can gauge air-water interface locations of clean liquids, but fouling and high maintenance makes floats a generally poor choice for the hostile environment of a wastewater-treatment plant. Slack diaphragm pressure-sensing elements also perform satisfactorily and have become widely adopted for special applications such as determining sludge levels in digesters. However, bubble tubes, which measure the back pressure of an air stream being slowly forced into a liquid at a predetermined level, are the most common (and usually the most successful) liquid-level detectors.

Other level-monitoring devices, such as ultrasonic, thermal, conductance, or capacitance probes, cannot compete with the bubble-tube or differential-pressure sensor in cost or reliability, although two successful ultrasonic liquid-level probes were encountered.

Diaphragm-box pressure-sensing level detectors are often used in small standby wastewater-treatment stations, such as those for storm water; diaphragm boxes require no compressed air or power and are quite reliable, but they need occasional servicing to replace any air that may have escaped.

Field Experiences

Numerous types of satisfactory liquid-level detectors, using established designs, are commercially available in the $200 to $1500 cost range. The interested reader may refer to Appendix D for a representive list of supplies and product-performance specifications. During the user survey, all the types of liquid-level sensors encountered, except conductivity, demonstrated a ninety-percent-plus field acceptance. The small number of dissatisfied users cited corrosion and fouling as the culprits. Most users reported bubble-tube level detectors as the preferred primary elements; other devices are usually more expensive and require careful application.

The liquid-level performance data, shown in Table 5, contain no mean-time-between-failures, and only scant maintenance data, since level-measuring devices in most plants require only modest amounts of maintenance and are often virtually ignored. It is apparent that, when properly installed, liquid-level detectors should cause no difficulties in wastewater-treatment facilities.

Table 5. LIQUID-LEVEL MEASURING INSTRUMENTS

	Type					
Survey Results	Bubble Tube	Diff. Press.	Float	Diaphragm Box	Ultra-sonic	Conduc-tivity
Number of Not Acceptable	1	1	1	0	0	2
Number of Fair	0	0	3	0	0	0
Number of Successful	39	9	2	0	2	1
% Acceptance	98	90	93	-	100	33
Median Labor (MH/yr)	8	5	60	-	-	
Median Frequency (no/yr)	2	0.6	24	-	-	

FLOW METERS

Applications

Flowrate is probably the most important measurement required in wastewater treatment since it is the basis for hydraulic and mass loadings and for material balances. For example, the product of flowrate and organic strength (i.e., BOD concentration) determines the plant's organic loading; also, throughput rates indicate how near the plant is operating relative to its hydraulic capacity, paces chemical-addition systems (i.e., the chlorinator at most plants), and is the basis for controlling many treatment processes. Moreover, flowrate measurements are used to monitor sewer throughput, to activate sewer flow diverters (or regulators), to calculate hydraulic and material balances for storm events, and to control (i.e., automatic start-up or shut-down) stormwater-treatment facilities. In most wastewater-treatment plants, influent, sludge recycle, sludge wasting, air flow, chemical flows, and utility flowrates are continuously metered. To be useful, flow meters must measure reliably, require only occasional and simple maintenance, must resist damage by momentum exchange with high-energy fluids, must not impede flow (i.e., must be non-intrusive), and should be competitively priced. Some wastewater applications, such as stormwater monitoring, require flow-measuring instruments with 50:1 rangeability.

Principles

The large-scale flow-measuring devices commonly used for liquids are weirs, flumes, venturis, nozzles and magnetic flow meters. Weirs and flumes, which operate in accordance with Bernoulli's Theorem since they develop a differential head that is related to flowrate, are employed in open channels and for other non-pressurized service. Venturis and flow nozzles, which also operate according to Bernoulli's Theorem, measure flows in pressurized pipes.

Magnetic flow meters, based on Faraday's law (EMF generation is proportional to the velocity of a flowing conductor), are suitable for pressurized full-pipe fluid-transport monitoring. These well-known methods are discussed in the literature[10].

Other methods, such as mechanical propellers and other positive-displacement mechanisms, pitot tubes, rotameters, and thermal or ultrasonic flow meters, are either too expensive, too sensitive to process conditions, or too intrusive to be suitable for many wastewater applications. One ultrasonic flowmeter, however, was observed working fairly well during the user survey. A few propeller-type flow meters, common in smaller water plants, were successfully working in several of the surveyed treatment plants. Orifices and positive-displacement meters, in addition to nozzles and venturis, are commonly used for gas- and air-flow monitoring.

Field Experiences

Wastewater-treatment plant operators reported serious sensing-line plugging problems with their flumes, weirs, and venturis. Magnetic flow-meter users frequently cited the accumulation of a non-conductive film as a principal source of failures. Ultrasonic and thermal electrode cleaners are being evaluated by many plants to eliminate such fouling difficulties.

The principal advantage of flumes, venturis, and the like is that they are simple, well proven, and so well understood that for almost any plant, they can be installed with good assurance that they will perform with reasonable accuracy (approx. 1 to 5% of full scale) [see reference 11]. Their principal disadvantage lies in measuring the generated differential pressure. Techniques for connecting the primary element (or sensing lines) to the differential-pressure instrument are well established, but a certain amount of frequent and concientious maintenance is required to assure continuing operation. Magnetic flow meters have gained wide acceptance because of their low maintenance requirements, and they have proven to be about as reliable as the venturi or flume when properly installed. They also do not obstruct the flowing streams, and have no small passages or liquid connecting lines to plug or foul. Magnetic flow meters, however, are fairly expensive.

Flow-meter experiences, displayed in Table 6, indicate that propeller-type meters may not be well suited for wastewater service. Venturi meters had the highest degree of acceptance among the surveyed plants, but also required the largest amount of maintenance manpower (necessary to keep the differential-pressure sensing lines clear). Both flumes and magnetic flow meters had a moderately high degree of acceptance. Flumes, which require only a small amount of maintenance manpower, are only applicable to open-channel flow.

Table 6. SEWAGE AND SLUDGE FLOWRATE METERS

Survey Results	Venturis	Flumes	Magnetic	Propeller
Number of Not Acceptable	1	1	6	2
Number of Fair	1	12	1	1
Number of Successful	34	14	28	5
% Acceptable	94	82	80	63
Median Maintenance Labor (MH/yr)	20	2	12	10
Median Maintenance Frequency (MH/yr)	4	1.4	12	7

The survey results clearly demonstrate that venturis, flumes, and magnetic flow meters can successfully monitor sewage flowrates within acceptable limits of reliability, accuracy and maintenance requirements. However, pulsating flow can not be monitored by these devices. During the plant survey, BIF venturi meters and Brooks, Fisher & Porter, and Foxboro magnetic meters were all found to provide acceptable service. A representative list of flow-measuring instrument suppliers is contained in Appendix B.

Obviously flow-meter cost will vary as a function of size, accuracy and range. As an approximate guide, flumes, weirs, flow tubes and nozzles are the least expensive devices, often costing within the $500 to $5,000 range. Venturis and magnetic flow meters (often used for sludge streams) are more expensive.

Storm and combined sewage flow monitoring poses special difficulties due to large operating ranges, debris, flooding, etc.; suitable flow-measuring devices that have demonstrated their usefulness in wastewater-treatment facilities are not readily adaptable to use in stormwater flow monitoring.

Presently, sonic flow-monitoring demonstration projects[22] and open-channel magnetic-flowmeter development programs[23] are underway to find satisfactory devices for storm-related flowrate monitoring. Moreover, Hydrospace Challenger Inc. has reported on an assessment of devices for storm flow measurement[24].

DISSOLVED OXYGEN MONITORING

Applications

Most secondary wastewater-treatment processes involve aerobic biological destruction of soluble organics. Intensive secondary processes, such as activated sludge, contact stabilization and extended aeration, require aerating the wastewater-microorganism mixture. If the dissolved oxygen concentration (DO) drops below a critical level (usually 0.5 mg/l), oxygen becomes rate limiting. On the other hand, too high a dissolved oxygen concentration represents needless power consumption and can cause sludge bulking[12].

Principles

In spite of the many techniques available for DO measurement, only the electrochemical DO sensors are compatible with in situ monitoring service. Three types of DO sensors are commercially available, and they operate on the following principles:

- A galvanic sensor in which molecular oxygen diffuses through a membrane and reacts with the lead/silver electrode system to produce a current proportional to the DO concentration.

- A similar polarographic cell that requires oxygen to diffuse through a membrane; after which, the oxygen is reduced by a small polarizing voltage applied across two noble metal electrodes. This cell produces a current proportional to the DO concentration.

- A thallium cell in which oxygen reacts with thallium metal thus producing thallous ions in portion to the DO concentration. The potential developed is a function of thallous ions at the surface of the metallic electrode; hence, this type of electrode needs no membrane.

All of the electrochemical DO sensors are affected by temperature, sample-stream velocity, and other environmental factors such as ionic strength.

Field Experiences

23 out of 50 visited facilities practiced continuous DO monitoring. Only six plants used automatic DO-control systems; the other facilities used their DO measurements to indicate trends. Seventy-nine percent of the users considered their DO-monitoring probes acceptable; whereas, the other 21% of the facilities judged their DO-measuring probes unsatisfactory or only fair. Most of the dissatisfied users reported that probe fouling, drift and "noisy" data are the principle problems with DO probes. Discussions with successful users suggest that daily-to-weekly probe inspections are advisable, depending upon the service requirements. Moreover, in-place weekly calibrations, such as zero and span adjustments and cross-checks with portable (laboratory) DO meters, ensure continued accuracy. Membrane fouling was cited as the chief maintenance problem, and mean-time-between-failures ranged from 1 to 9 months. When the membranes are changed, the instrument should be thoroughly recalibrated by a Level 3 technician. Galvanic, polarographic and thallium DO probes worked equally well in the surveyed wastewater-treatment plants.

All in situ DO-monitoring systems (except perhaps the thallium cell) require a considerable amount of maintenance because the probes for these systems are in direct contact with wastewater, usually under conditions conducive to sensor fouling. Partial membrane plugging, poisoning of sensor or membrane surface by toxic chemicals, and bacteriological growth lead to errors and noisy data. Choosing measuring devices equipped with jet cleaners, ultrasonic agitators, or stirring-type agitators should minimize fouling problems. Ionics, Weston and Stack, and Beckman DO probes were found to work well in several of the facilities visited. Although DO analyzers require frequent inspection and maintenance, accurate and reliable galvanic, polarographic, and thallium DO-measuring systems that are suitable for continuous duty in wastewater-treatment plants are available from the above, and other manufacturers within the $1,000 to $2,000 price range (see Appendix D for a partial list).

TOC, TOD, AND COD MONITORS

Applications

Monitoring influent loads (the product of flowrate and organic strength) and subsequent treatment efficiencies requires on-line organics-measuring instruments. Historically, BOD_5 data were used to estimate the wastewater's organic content, but this test takes five days to complete. The amassed information consequently would have little impact on daily operation. Clearly, the need exists for real-time data that permit operational control.

Instruments such as total organic carbon (TOC) analyzers, total oxygen demand (TOD) monitors, and automated chemical oxygen demand (COD) devices have been developed for rapidly measuring the organic content of wastewater. Potential streams for on-line organic monitoring operations, and potential control functions addressable by any of these rapid organic analyzers in a typical activated sludge plant, include:

- Influent or head works(such as grit chamber) to assess incoming load
- Sludge thickener return to ascertain load on primary settlers
- Primary sedimentation effluent to measure clarifier efficiency and to provide feed-forward control of subsequent biological processes.
- Aeration tank liquor to furnish feed-back control (e.g., measurement of TOC in order to maintain proper food-to-microorganism ratios through cascaded control of RAS)
- Secondary clarifier effluent to indicate removal efficiency
- Chlorination chamber effluent to assess organic load to receiving waters.

Principles

Breifly, TOC and TOD analyzers oxidize wastewater samples at high temperatures, usually 950°C. In TOC systems, the concentration of carbon dioxide produced by oxidation of the sample's organic matter is measured in an infrared analyzer, or that same carbon dioxide is quantitatively reduced to methane and subsequently analyzed with a hydrogen-flame ionization detector. TOD instruments, on the other hand, measure the oxygen deficit of the instrument's carefully-controlled, carrier-gas, oxygen concentration after sample combustion. Automated COD devices oxidize organics in the liquid phase, usually by a modification of the classical, acidic dichromate, oxidation method; the instrument's colorimeter then measures the resulting color change which is proportional to the initial COD concentration. To date, TOC instruments employing infrared detectors appear to be the most-promising on-line organic monitors.

During the user survey, one facility (an industrial wastewater plant) utilized several on-line, automatic, TOC analyzers. This plant's management believed, however, that their TOC instruments required an excessive amount of maintenance since the mean-time-between-failures ranged from 3 to 30 days and since a Level 5 instrument technician was necessary for proper calibration and maintenance. For these reasons, the plant managers characterized their TOC analyzers as unacceptable.

Currently, five manufacturers supply continuous on-line organic analyzers. Appendix B contains their names and the important specifications. Most of these instruments cost between $7,000 to $12,000. Although commercially available, rapid, organic monitors use known analytical techniques, their adaptability to continuous service in wastewater monitoring has not been established. The fact that only one treatment plant (industrial) practiced on-line organic monitoring attests to current low-level utilization of these instruments. Attempts to adapt the then-current models to this application illustrate that improvements and refinements are needed. The propensity of most organic analyzers to fail by plugging and corrosion shows that special consideration should be given to sample conditioning (see samplers on page 41) and construction materials. Design engineers and plant managers will expect to see clear-cut demonstrations of workable on-line organic analyzers prior to their widespread usage.

Field Experiences: (NONE)

WET-CHEMICAL ANALYZERS

Applications

With the increased emphasis placed on nutrient removal, a need developed for continuously monitoring and controlling the efficiency of nutrient-removal processes, such as ammonia stripping, phosphorus precipitation and breakpoint chlorination. Nutrient addition for the effective biological treatment of industrial wastewaters may also make on-line nutrient analyses advisable.

Consider an activated sludge plant that is practicing phosphate removal by chemical addition to the primary clarifier; the phosphate concentration of raw sewage, in conjunction with the flowrate (mass loading), can be used to pace chemical additions. Subsequent monitoring of the primary clarified effluent for its phosphate concentration permits the assessing of phosphate-removal efficiency, as well as the trimming of feed-forward control with feedback information. Other potential areas for phosphate monitoring include final effluent and digester supernatant.

Principles

To date, automated wet-chemistry procedures are the only reliable methods for on-line phosphate and ammonia analyses. These devices utilize a colorimetric reaction under temperature-controlled conditions.

Two surveyed facilities attempted on-line phosphate monitoring, and one pilot plant measured ammonia using wet-chemistry analyzers. All three analyzers performed unsatisfactorily because of extremely poor reliability, sample-line plugging and pump failure. Most users commented that adequate sample pretreatment may alleviate plugging problems.

Field Experiences

Several manufacturers provide continuous on-line wet-chemical analyzers in the $3,500 to $5,000 price range (see Appendix B for a partial list). The more-promising wet-chemical analyzers have fail-safe alarms and status indicators. In spite of the use of standard chemical procedures, mechanical difficulties and reliability problems make most commercially available wet-chemical analyzers unsuitable for continuous unattended operation in many wastewater-treatment projects (especially where suspended solids are present in the sample). Additional development work is needed to improve sample pretreatment and increase analyzer reliability before unattended wet-chemical sensors can provide reliable continuous information on nutrient concentrations.

SLUDGE DENSITY

Applications

Since the bulk of pollutants are settled as solids in wastewater-treatment plants, continuous automatic density meters are almost indispensible for the measurement and control of solids concentration in modern treatment facilities. Sludge densities range from 1% to 15% solids (10 to 150 g/l), but the density of pumpable sludge rarely exceeds 10% solids (100 g/l). Most treatment plants measure the sludge density of the primary clarifier underflow in order to regulate sludge pumping. If the primary clarifier removes sludge with too low a density, an undue load is placed on downstream thickeners, digesters or incinerators. Underflow solids-concentration data, in tandem with flowrate information, also permits calculation of sludge loads sent to digesters and dewatering facilities.

Principles

Slurry densities can be determined directly by weighing a known volume. Fully automatic process instruments, based on this principle, are used in several industries for slurry density measurements, but not in waste treatment. Nuclear and ultrasonic instruments that measure radiation or sound-level attenuation, respectively, can be calibrated to report density directly. Nuclear devices are the most popular sludge-density instruments used in the wastewater field. Nuclear sources for sludge density meters are licensed and controlled by Federal and State authorities; none of these sources has been involved in any radiation accidents to the best of the authors' knowledge.

Field Experiences

Nuclear density meters require frequent recalibration to ensure accuracy since the nature of sewage solids is continually changing and since sewage solids tend to adhere tenaciously to the inner walls of most types of piping and thus produce calibration errors. Correct installation is also essential for reliable operation. Many instruments, however, were installed without simple provisions for isolation (i.e., to permit easy standardization and flushing) and sampling.

The major problems with nuclear density meters is the unreasonably long time usually required to repair the meter because it must be returned to the manufacturer. As one plant superintendent put it, "We have two density meters, one to work with while the other's at the factory."

The survey found that nuclear density meters were unsatisfactory in 7 instances, fair in 4, and successful in 8, for an acceptance rating of only 42%. Mean-time-between-failures is estimated as typically 1 to 3 years; typical (median) maintenance required in order to keep such instruments working is 51 man-hours per year, with a servicing frequency of 48 times per year. Only a portion of radiation instrument servicing is within a Level 4 instrument technician's capabilities.

Because of their newness, no ultrasonic sludge-density instruments were observed during the user survey.

As might be expected, sensor fouling was mentioned as the main disadvantage of available sludge-density instruments. Since the sensing surfaces are directly in contact with the sludge, fouling occurs rapidly. Although glass or ceramic liners and high-velocity scouring tend to minimize solids accumulation, a significant amount of required maintenance should be anticipated. Several commercial suppliers offer sludge-density measuring instruments which cost from $2,500 to $4,000 (see Appendix B for a partial list). During this survey, devices manufactured by Ohmart and Nuclear Chicago performed satisfactorily in several wastewater-treatment plants. Inasmuch as commercially-available sludge-density measuring devices use well-established technology, they should provide fairly reasonable service with proper installation and maintenance.

SAMPLING SYSTEMS

Applications

Because of liquid and solid phases present in sewage, taking a representative sample is a difficult task. Analytical data on unrepresentative samples are totally useless, and frequently less desirable than no data at all. Correct sampling is so essential to wastewater instrumentation that it was investigated as a separate item. A real-time on-line sampling system takes a representative sample, preconditions it, and transports it to a final destination; then, this sample must be suitably conditioned for subsequent analyses without causing any unacceptable changes in the parameters of interest. Most sampling systems can be categorized as either off-line, or real-time on-line.

With off-line systems, the sample must be transported to a preservation module, typically a refrigerated compartment maintained at 4°C. The collected samples can be stored as separate grab samples, or they can be composited on a timed or flow-proportional basis. Occasionally some modified samplers make it possible to bring the sample into the control room and thus greatly reduce sample-collecting labor. Since off-line samplers allow the plant's chemist to make periodic tests on accumulated grab samples or composites, they effectively satisfy the need for cumulative historical influent and effluent data.

Real-time samplers macerate, transport, and suitably condition samples for continuous analyses. Principle advantages of real-time sample systems over in situ monitoring include:

- Immunity from main-stream flow variations
- Ability to pre-condition samples
- Instrument economy through time-shared use of analytical devices
- Centralized location for better servicing and calibrating of analytical instruments
- Opportunity to maintain special temperature and humidity conditions for delicate instruments at a central location.

Principles

Since many articles report on the details of successful sample systems, only a brief discussion - limited to the important components and practices of continuous samplers - is justified here:

- Sampling intake probes should be located in a well-mixed turbulent region--at least fifty pipe diameters downstream of process-stream junction points. The velocity of sample entering the probe should have the same speed and direction as the main flow (isokinetic sampling).
- Special attention should be directed towards suspended solids precipitation, biological growth, corrosion, and sample stability in the delivery system.
- When applied to raw sewage, fluids with high suspended solids concentrations, and mixed liquors, the sample must be macerated prior to transmission; otherwise, the transmission lines will plug. Pumps are available that grind and macerate the sample, as well as provide sufficient head and flow to prevent settling-out of most suspended material.
- Rugged, non-clogging, 1 to 3-horsepower pumps should be utilized with 1-in. to 2-in. sample-conducting pipe. These pumps must deliver enough flow to maintain a velocity of at least two feet per second.

All sample lines must be of uniform and smooth bore, and also be easily cleanable; stagnant regions must be avoided to prevent septicity and solids deposition.

Adherence to these practices should provide a reliable system capable of delivering samples in most municipal plants. Virtually any process stream may be a candidate for continuous real-time sampling; the accumulated sample information documents treatment efficiencies and provides data for process control. When used for control purposes, consideration must be given to the effects of transportation delay; allowance must also be made for automatic analyzer delay, if significant.

Field Experiences

Sampling systems were observed in fifteen treatment facilities during the plant survey. Eleven out of the twelve high-flow continuous samplers performed satisfactorily according to the interviewed personnel; this represents a 92% acceptance. All three non-high-flow samplers were judged unsatisfactory. None of the visited plants practiced real-time data sampling. With regard to failure modes, all of the surveyed plants which possessed continuous samplers cited plugging. It also should be noted that very few plants seriously questioned the representative nature of the delivered sample. Frequent inspections are essential to ensure proper operation; most of such repair and inspection efforts are within the capabilities of Level 1 technicians.

With careful design and faithful maintenance, mechanically reliable, continuous sampling systems are obtainable with current technology and equipment. Representative sample transport, conditioning, and (real-time) analysis have all been relatively unexplored. In fact, the USEPA sponsored a contract to develop a wastewater sample transport and conditioning system; this project was recently completed, and a final report is presently being prepared for public release. That project's mission was to develop and field-evaluate the necessary hardware to transport sewage, primary effluent, aeration basin mixed liquor, secondary effluent, primary sludge and secondary sludge; moreover, these samples had to be conditioned to make them compatible with existing analytical devices for TOC, orthophosphate, hydrolyzable phosphate, ammonia, nitrite, and nitrate. The developed system had to be able to run unattended and require only a reasonable amount of maintenance effort.

Chicago Pump, N-CON, and Sonford off-line samplers use established designs, and these worked well in the visited plants. Many automatic samplers are commercially available in the $2,000 to $6,000 price range, and a recent EPA report[18] reviewed all these presently available sampling systems. Experience to date suggests that more field demonstrations are advisable prior to widespread application to streams with high concentrations of suspended solids. Sampling systems, however, can be readily applied to primary and secondary clarifier effluents.

RESIDUAL CHLORINE

Applications

Public health protection (i.e., preventing the spread of water-borne disease) makes it essential that municipal wastewater-treatment facilities eliminate pathogenic organisms. Maintaining a prescribed residual chlorine level after a minimum contact period provides effective destruction of most harmful microorganisms. Accordingly, most wastewater-treatment facilities must, under current laws, monitor the residual chlorine concentrations of final effluents to assure adequate disinfection.

Fully automatic, residual chlorine analyzers are well proven for ensuring proper chlorination and for providing a continuous record of residual chlorine levels; moreover, when incorporated into a feedback system to optimize adjustment of the chlorine/wastewater ratio, residual chlorine analyzers can often pay for themselves in chlorine savings. When a plant effluent with extremely low chlorine residual is required, a fully automatic residual chlorine analyzer-controller with an auxiliary dechlorinator system may be the only practical means for achieving compliance.

Principles

The operation of commercially available residual chlorine analyzers is based on the ability of chlorine, as a strong oxidizing agent, to depolarize one of the two electrodes in an amperometric cell, thus permitting electric current to flow in proportion to the concentration of oxidizer[16].

All, commonly used, residual chlorine analyzers measure total residual chlorine by adjusting the sample pH, reacting the sample with potassium iodide or similar reagent, and measuring the resulting depolarizing effect. If only the free uncombined chlorine is to be measured (as might be desired to monitor breakpoint chlorination), replacement of the potassium iodide by potassium bromide usually permits only free chlorine to be detected. However, automatic free chlorine measurements are not commonly practiced, and interferences from excessive concentrations of chloramines may be a significant problem.

Successful operation of the analyzer for wastewater depends on the sampling system because the sample must be treated with a pH-adjusting reagent, as well as a KI (or KBr) solution, before measurement. A successful sampling system must function quite reliably, eliminate dirt from the sample stream, and then bring the sample to the titration cell within a reasonable elapsed time. Most residual chlorine analyzer failures are caused by the inability of the analyzer installation's designer to appreciate these problems.

Field Experiences

Out of the 19 residual chlorine analyzers observed during the user survey, 3 were rated only fair, and the other 16 seemed to work well; this represents an acceptance of 85%. Thirteen of the residual chlorine analyzers supplied information to automatic control systems, On the average, residual chlorine analyzers required 140 man-hours per year for maintenance, with 365 checks per year. In the course of this survey, Fischer and Porter and Wallace and Tiernan residual chlorine analyzers worked well and provided their users with reliable service, Several other manufacturers also supply residual chlorine analyzers (see Appendix B). Presently available residual chlorine analyzers employ well-known designs and should be suitable for continuous duty in wastewater-treatment plants.

CHLORINE-GAS DETECTORS

Applications

Chlorine is the most common disinfectant used in American water and wastewater plants, but it is also a hazardous material. Methods and procedures for handling chlorine are well developed; when these are carefully observed, accidents caused by chlorine are infrequent. For better protection from accidental release of chlorine to the atmosphere, automatic analyzers capable of detecting free chlorine in personnel-occupied areas are often specified. The allowable chlorine concentration (threshold limit value, or TLV[13]) is commonly 1 part per million; detector ranges are often 0-5 ppm.

Principles

The common chlorine-gas detector consists of a polarized amperometric cell, identical in principal to the residual chlorine detector cell. Ambient air is introduced into the cell, either by diffusion through a porous cell wall or by pumping a small stream of air through the electrolyte. Traces of chlorine depolarize the cell, producing a current porportional to chlorine concentration. Sampling systems can be readily fitted to the analyzer inlet to filter and condition the sample; such systems can also collect and transport samples to the analyzer from adjacent areas.

Chlorine-gas monitors are built to be self-checking and to alarm on certain internal failures, but routine and competent maintenance is crucial.

Field Experiences

Six of the seven chlorine-gas monitors encountered were working well, for an acceptance rating of 86%. Median maintenance was found to be 50 man-hours per year with checks twice a month. The Fischer & Porter and Wallace and Tiernan chlorine-gas detectors embodied established designs and provided good service.

TURBIDITY MEASUREMENTS

Applications and Principles

Historically, turbidity refers to the tendency of small suspended particles to obscure light transmission through a liquid; it is an optical property of the sample that causes light to be scattered and absorbed rather than merely transmitted in a straight line. Turbidity in water is usually caused by the presence of clay or silt, bacteria, and other finely divided materials. Although turbidity measurements do not rigorously correlate with the weight concentration of suspended matter, in-plant turbidity data indicate suspended solids removal trends. As the suspended solids concentration increases from zero to about 200 mg/l, the turbidity also increases (and conversely). Frequently, wastewater-treatment facilities monitor effluent turbidity to appraise its effects on receiving waters and to denote suspended solids removal efficiency. Turbidity measurements of secondary effluent also serve as early warning devices for sludge bulking or clarifier malfunction, similarly, turbidity measurements of filtrates can be used to signal filter breakthrough. Most of the time, unacceptable turbidity levels alert plant operators to initiate corrective actions, such as adding coagulants to a bulking sludge, adjusting food/microorganism ratio, or backwashing a filter. Turbidity data are occasionally used to regulate coagulant additions.

Continuous turbidity-measurement devices measure the fraction of a light beam that is either transmitted by a turbid sample fluid or scattered from the fluid's surface. Some devices measure turbidity levels by determining the intensity of light scattered at small angles (15-degree surface scatter) or at large angles (90-degree, or "right-angle", scatter). Other devices relate a sample's percent optical transmission to the sample's turbidity. Light-scattering devices are referred to as nephelometers, while those devices utilizing optical transmission measurements are called transmissometers; the former are best suited for measuring low turbidities, while the latter should only be applied to water of relatively high turbidity. A temperature-controlled photodetection system is desirable since the device's output is temperature sensitive.

Field Experiences

Aside from sample-line plugging, optical window fouling represents the most common failure mode. Some manufacturers minimize this problem by including self-cleaning devices that periodically flush the optical surface with a cleansing fluid, but such methods have not proven practical for wastewater service. Light-scattering instruments that involve no contact between the optical surfaces and the sample also performed well. During the plant survey, 11 facilities practiced turbidity monitoring; 8 out of these 11 users were satisfied with their turbidity-meter performance. Principal complaints cited interferences from sample color and optical surface fouling. Depending upon the type of sensor utilized, weekly-to-monthly inspections are necessary to ensure proper operation. After optical component servicing (such as cleaning and changing light sources), the meters were found to work well in several of the wastewater-treatment plants visited during this survey. Reliable turbidity instruments are available from commercial sources within the $1,000 to $3,000 cost range (Appendix B), and with proper maintenance they can successfully monitor secondary effluent turbidities.

RESPIROMETERS

Applications

Respirometers measure the rate of oxygen consumption as the microorganisms metabolize substrates (food); for on-line respirometers, the output is usually reported as a time-related oxygen demand (OD) (e.g., a 15 minute OD). Because a wastewater's aerobic biological activity correlates with its OD, many investigators have attempted to correlate on-line (i.e., short-term) OD measurements with 5-day BOD's. Unlike TOC, TOD, and COD analyzers, respirometers utilize a biological technique to assess soluble organic concentration; they can thus estimate organic loading for a plant's raw sewage, primary clarifier effluent, aeration tank liquor, and secondary clarifier effluent. (The reader should be forewarned that considerable effort is necessary to determine correlation coefficients or graphs predicting process behavior). In addition, respirometers can allow estimation of the viability of return activated sludge by furnishing measurements of the sludge's endogenous respiration rate. Monitoring aerator influent TOC and sludge respiration rate permits a rapid estimation of the optimum food-to-microorganism ratio on a biological basis; this is a more-reliable control measurement for the secondary treatment process than are chemical and/or physical measurements.

Principles

The numerous respirometer designs which have been developed in the last half-century are all batch instruments. Automatic on-line devices take a sample and subject it to intense aeration for a prescribed time, then the resultant oxygen decay is measured over an adjustable time interval. The difference between the initial DO and the terminal DO yields the oxygen demand. Some instruments measure the oxygen consumed by coulometry (electrolytic replacement of the oxygen consumed), differential pressure techniques, or electrochemical DO determinations via DO probes. Respirometers may be operated isothermally or adiabatically. Principal drawbacks of most respirometers are their tendency toward inlet clogging and the high amount of maintenance necessary to ensure proper operation.

Field Experiences

During the user survey, the investigators encountered only one on-line respirometer. The plant manager commented that his staff was disenchanted with this instrument because of its high maintenance requirements and poor reliability. Only two manufacturers supply automatic on-line respirometers (see Appendix B), and these instruments cost between $4,000 and $6,000. Notwithstanding fifty years of respirometer experiences, additional development and demonstration efforts may be necessary prior to general use of automatic respirometers in wastewater-treatment plants.

SLUDGE LEVEL

Applications

Liquid-solid separation is a fundamental unit operation of wastewater-treatment technology. Solids are usually collected by gravity settlers where the solids with a specific gravity of about 1.05 collect as a "sludge blanket" in the lower regions of the settling tank. Once accumulated, this sludge can be segregated from the upper layer by keeping track of the phase boundary or interface. Detecting sludge interface is not easy, since it may be 2 to 12 feet below the surface and since the upper layer is often too dirty to see through.

Principles

For wastewater treatment, several promising sludge-level detectors use optical sensors to determine the sludge interface at fixed levels in a settling tank. Although such instruments measure only at single points and have an on-off output, the devices are quite useful for controlling sludge withdrawal from a clarifier. Rising sludge attenuates the light beam sufficiently to actuate an on-off switch that controls the sludge pumping cycle.

Field Experiences

Three manufacturers (Kay-Ray, Keene and National Sonics) offer sludge-level detectors in the commercial market place, and these units typically cost from $800 to $1,400. Biospherics, Inc., is another manufacturer of these devices; however, as of the time the survey was initiated, Biospherics analyzers were too new to be found in established plants. Only three plants out of the fifty surveyed measured sludge level, and all of them used optical probes. Although all the users were satisfied with their initial results, it has been reported that the life expectancy may be as short as six months because of poor-quality assemblies.

pH

Applications

pH measurements in biological treatment systems are useful for monitoring industrial spills (i.e., toxic loads of acidic wastes entering the treatment Plant); also, pH values for anaerobic digesters should be monitored to permit the maintenance of an optimum acid/base balance. pH measurement and control, moreover, is an integral part of most physical-chemical waste-treatment processes.

Principles

pH measurements in water- and wastewater-treatment plants utilize a glass and reference electrode pair; the glass electrode is specific for hydrogen ion, while the reference electrode provides a stable and reliable means of completing the circuit and of furnishing a reference EMF.

Both electrodes may become inoperative when coated by oil or slime, but the reference electrode has the additional problem of plugging, which disrupts electrical continuity of the porous-media salt bridge. The major problem in wastewater pH measurements is to make the probes easily serviceable so that they can be quickly cleaned and recalibrated.

Field Experiences

In the last few years, the development of preamplifiers that mount either on top of or within the electrode holders, coupled with special electrode housings and mountings (or other systems) to make probe installations easily serviceable, has resulted in reasonable acceptance of on-line pH instrumentation. In the survey, pH-measuring installations were found satisfactory in 11 of 13 cases, for an acceptance of 85%. The median maintenance requirement for domestic sewage applications was 50 man-hours in 96 checks per year. Beckman, Foxboro, Leeds and Northrup, and Universal Interlock Instruments supply well-designed units that performed well in several of the surveyed wastewater-treatment facilities. Numerous commercial sources sell pH probes in the $1,200 to $2,000 price range (see Appendix B). Most, commercially available, pH probes use well-established designs that are suitable for continuous duty in wastewater activities if properly installed and maintained.

ORP

Applications

Oxidation-reduction potential devices measure the ratio of oxidants to reductants in aqueous solutions. The measurement itself is non-specific and does not yield concentration data; however, it is useful in monitoring the progression of such oxidation-reduction reactions as aerobic oxidation and anaerobic sludge digestion. For aerobic oxidation processes, dissolved oxygen measurements are more meaningful and thus eliminate the need for ORP data; whereas, in anaerobic sludge stabilization, ORP monitoring frequently can be useful for process control. ORP is also useful for measuring reduction of hexavalent chromium and oxidation of cyanide in the treatment of plating wastes.

Principles and Field Experiences

ORP measurements are usually made by employing either a platinum or gold indicating electrode in conjunction with a reference electrode. Like many other in situ electrochemical methods used for sewage samples (pH and DO), oil and slime quickly foul the probe and thus cause a large amount of maintenance. When reliable methods have been established to reduce fouling problems, ORP may become more useful in domestic waste-treatment facilities. Only three ORP installations were encountered in the survey; two were unsatisfactory and one was only marginally acceptable. Numerous commercial sources supply ORP analyzers within the cost range of $1,000 to

$2,000 (see Appendix B). Since ORP probes foul so easily, they are not suitable for continuous monitoring in a wastewater environment unless users make a commitment to clean the electrode surface frequently.

FLAMMABLE GAS DETECTORS

Applications

Wastewater-treatment plants are routinely required to continuously monitor the atmosphere in certain areas for the presence of combustible or explosive gases. This type of gas detector typically sounds an alarm when gas concentration exceeds a predetermined fraction of the lower explosive limit (LEL). Common hazardous areas are near the digesters, where methane may be leaking to the atmosphere, and possibly at the plant headworks where sewer gases or incoming gasoline can cause hazards.

Principles

Commonly used gas detectors are nonspecific. They pass a constant flow of warm sample over a hot filament, the temperature of which is continuously monitored. Combustible material in the sample burns at the filament, thus raising its temperature and triggering an alarm. A monitor consists of a sampling system, detector, and measuring and alarm circuitry. The sampling systems and detectors are the parts requiring the most maintenance, but the entire system must be checked frequently on a fixed schedule if the instrument is to remain reliable.

Gas monitors in industry have often been neglected until an accident occurs. The sample system plugs or the detector becomes insensitive; in either case, the instrument cannot detect a hazardous situation. Gas monitors are usually provided with self-checking circuitry for filament and alarm systems, but routine system checks (preferably using hazardous gas samples) are also necessary.

Field Experiences

Flammable gas monitors were found at 10 sites; 6 performed satisfactorily and 4 did not, for an acceptance of 60%. Typical maintenance for only one monitor is estimated at 12 man-hours per year with 12 checks; 8 additional man-hours are required for each additional sample point in the same vicinity. During the plant survey, flammable gas detectors manufactured by Davis and by Mine Safety Appliance worked best. Most flammable detectors cost $2,000 to $4,000 per unit.

RAINFALL

Rainfall measurements are important in anticipating loads to stormwater facilities and sewer-regulation networks because they permit stormwater-treatment facilities to take immediate steps to anticipate the arrival of the stormwater. Either the tilting bucket or the accumulative rain gauge can be successfully tied into telemetering systems for data transmission to a control location.

Rain gauges have proven quite practical, especially when the output signal is well designed and when the system is properly protected from surges. Rain gauges were found to be working successfully at 5 sites. Maintenance for the typical instrument may be estimated at 50 man-hours, (i.e., 24 checks) per year. Adequate rain gauges are commercially available in the $500 to $2,000 range.

TEMPERATURE

Most sewage-treatment facilities generally obtain process-temperature measurement only for digesters and incinerators. The well-developed gas-filled systems, resistance thermometers, or thermocouples are quite suitable. In a waste-treatment facility, the objective is to make the instrument sufficiently rugged, accessible, and corrorion-proof.

Commercially-available resistance thermometers are sufficiently sensitive (even when protected by heavy, stainless steel, thermometer wells) to indicate changes as small as 0.1 degree Fahrenheit in plant influent temperature. Such sensitivity can occasionally be useful in detecting changes in wastewater characteristics arising from slugs of industrial waste. Good-quality platinum resistance bulbs (or a proven and certified equivalent) are recommended, especially since few facilities have temperature-calibration capabilities adequate for temperature instruments. Suitable temperature-measuring devices are commercially available from several suppliers; types appropriate for wastewater duty usually cost from $400 to $1,600 for a complete instrument (see Appendix B).

Temperature measurement instruments worked well in 18 locations, and only one plant reported marginal performance, for an acceptance of 95%. Maintenance requirements are estimated at 8 man-hours per instrument with one check per year for a well-designed system; note, however, that these maintenance estimates do <u>not</u> include incinerator applications or high-corrosion environments.

WEIGHT

Common applications for scales in a waste-treatment plant include inventory control of chlorine, lime, and other chemicals. A newer use is the continuous weighing of dewatered sludge on belt scales to monitor sludge-filter and centrifuge performance and to indicate incinerator charge rates.

The mechanical, lever-type, floor scale is being challenged by hydraulic systems which are cheaper to install, relatively corrosion resistant, and waterproof. Belt scales are more apt to be hydraulic or electric (i.e., strain-gauge type) than mechanical; all weight-measuring instruments, however, require regular and competent maintenance. A radiation-type belt scale was installed at one plant, but operational experience was unavailable. Belt scales are usually furnished as a part of moving-belt conveyor systems. Weighing systems (belt scales) were successful at 5 locations, for a 100% acceptance; maintenance data and more detailed performance figures were not available.

CONDUCTIVITY

Wastewater conductivity denotes the presence of ionized substances. In some domestic waste-treatment facilities, high conductivity values indicate sea-water intrusion, either through open tide gates or flooded inlet/outlet structures. Sometimes increases in conductivity can be correlated to industrial waste spills or salt runoff from highways.

On-line conductivity monitoring requires inert probes (as resistant as possible to corrosion and fouling), alternating current to prevent polarization, and sensitive (but stable) electronics. At seven plants the survey team found all conductivity installations working well for monitoring either influent or effluent streams; i.e., acceptance was 100 percent. The personnel responsible for obtaining these continuous conductivity measurements were apparently willing to give this equipment the proper care because average maintenance was 60 man-hours in 200 checks, annually. Most commercially-available conductivity instruments are priced in the $1,000 to $1,500 range, use good designs, and are suitable (when properly maintained) for continuous duty in wastewater activities (see Appendix B).

SPEED

Rotational speed measurements in wastewater treatment are usually confined to centrifugal pumps, variable-speed centrifugal blowers, small positive-displacement pumps used for chemical addition, and clarifier sludge flights. The older common method for speed measurement utilized a dc tachometer-generator that feed a special meter in a calibrated loop. This method is simple and practical, but is subject to wear and requires considerable maintenance. A newer method utilizes a magnetic pick-up and an electronic converter to produce a digital pulse or pneumatic analog signal. Although slightly more expensive to buy and install, it is cheaper and easier to apply because it has no moving parts and, therefore, requires little maintenance.

Speed-measuring instruments are usually designed and furnished as subsystems with pumps or pump drives. Meaningful maintenance and failure-rate data are unavailable, but speed-measuring systems were noted at 8 locations, and all of them worked well.

POSITION

Remote position indicators are essential for those wastewater-treatment plants that automatically direct and control flow. Large valves, sluice gates and the like are already routinely controlled from a remote location, even when such control is manual; in most cases, a position signal must be sent back to let the instrument or operator know that the control system is indeed functioning acceptably. Industrial-type limit switches are simple and adequate devices for detecting extreme positions (full open or full closed). More-sophisticated devices, however, are needed to detect the position of modulating gates and valves. There is little difficulty when an electric positioner drives the gate if the position sensor (usually a slidewire) is installed as part of the actuator drive, but the later addition of position sensors to hydraulic and pneumatic operator installations is difficult; such sensors should be furnished with the operators at the time these latter are installed.

Position-monitoring measurement was found at 11 sites: one was unsatisfactory, one was fair, and nine were successful. All successful applications, however, were electric. The difficulty in practical position sensors lies not in the sensor itself, but in the lack of suitable devices for connecting the sensor to an appropriate transmitter or readout device. Tapes and pulley systems are usually unsuccessful. Commercially available position indicators usually sell for \$300 to \$1,600.

SECTION VI

TYPICAL CONTROL STRATEGIES

INTRODUCTION

A large number of processes are utilized in industrial and municipal wastewater purification, and an even larger number of potentially viable automatic control strategies exist. This report, however, discusses only the automatic control processes observed during the plant survey. All manual control methods have been excluded because they add little in appraising the state-of-the-art of instruments and automatic devices. For the reader's convenience, the subject matter is divided into two sections:

Level and flow control.

Treatment-process control.

With this format, the similarities regarding control philosophies, implementation, and performance become more apparent. Control systems can be classified, in order of increasing complexity, as shown in the following paragraphs.

Fixed Program Control

Fixed program controllers follow a pre-set command to activate devices regardless of surrounding conditions; they are open loop controllers.

Remote Manual Control

This is not automatic control, but it involves signal generation by a sensor, signal transmission, then actuation of a final control element by the operator. Such a system cannot, of itself, modify its action; it is also open loop control.

Two-Position Control

This is the simplest variety of closed loop control because it contains all of the essential components. Two-position control, by definition, means that the final element is either fully open or closed. Two-position control includes on-off and differential gap as special cases; on-off control, however, is the most common. In general, as soon as the measured variable exceeds the control point, the final control element travels to its extreme position.

Modulating Control

Any type of control system that intentionally maintains a final control element in some intermediate position is modulating control. Although most modulating systems are analog feedback types, modulating control also includes open loop and feed-forward which are implemented either by analog or digital methods. Modulating control may also be combined with programmed responses.

Multiloop Control

This unites several open and closed loops (synthesized either by digital or analog techniques) into a control strategy appropriate for the process requirements; loops can be linked in ratio, feed-forward feedback, cascade and adaptive combinations. Present-day wastewater facilities were found to use all five degrees of control.

Control System Hardware

Although signal transmission and final control devices are not emphasized in this discussion, they play an important part in wastewater-control-system performance. Final control elements in wastewater plants are almost always pumps or large valves. Large valves and sluice gates are usually operated as two-position, full-open or full-closed devices; occasionally, however, they are used to modulate flows. Small variable-speed positive-displacement pumps and dry-feeders are also quite common, but the variety of valves frequently employed in other process industries is rarely used as final control elements in wastewater-treatment plants. Pneumatic sensors and sensing transmitters have become fairly common, utilizing the standard 3-15 psi signal and sometimes a vacuum signal (20 to 70 inches of water). Comparable success has been obtained with electronic transmission systems, usually standardized at 4 to 20 milliamperes dc.

Switches, proportional controllers, and proportional-plus-reset (PI) controllers, developed for the process industries, are used with considerable success in wastewater treatment; however, derivative (or "anticipatory") controllers are very rarely encountered in a waste-treatment plant. The latest trends in instrument miniaturization and modularity have been incorporated into controller and recorder designs for most new plants; for example, the latest improvements in controller design (e.g., standardized transmission signals and good process-control interfacing devices) were evident in most of the newer plants.

In summary, transmitting devices, controllers, and final control elements for waste-treatment processes employ well-established technology. Most of the observed commercial devices performed satisfactorily in the surveyed wastewater-treatment facilities.

LEVEL AND FLOW CONTROL

Liquid Level Control

Principles and Applications

In any process involving the flow and storage of liquids, such as those in wastewater treatment, level control becomes essential for plant operation. Since the actual level itself is not important (so long as it is between acceptable limits in most wastewater-treatment facilities), highly accurate level control can often be sacrificed for stability and simplicity. With the typical wet-well arrangement, automatic level control keeps the plant's throughput approximately equal to the influent rate by adjusting pump speeds or throttling the pump discharge. On-off controllers with adjustable differential gaps, or proportional-only controllers, are the most frequently used control devices for wastewater-treatment level-control applications since they are stable, simple, and relatively cheap. Single-mode (i.e., proportional only) level-modulating controllers are usually preferable because supplementary derivative action is unnecessary and can even be a disadvantage due to noisy level signals. A slow integral (reset) action can help drive the working level toward the mid-range of the wet-well, thus providing maximum capability for coping with sudden changes; however, reset is rarely used for wet-well level control.

There are two philosophies regarding wet-well size: a generously sized wet-well results in simpler pump drives and may even allow flow equalization; whereas, more-sophisticated level control permits using a smaller and less expensive wet-well. Although sewers and other in-line storage structures smooth out some of the flowrate variations, flow ratios of 10 to 1 at the headworks are not unusual.[14] For smaller plants, good engineering practices require minimizing pump starts because starting a motor heats it much more than running it and accordingly shortens the pump motor's service life; frequent pump start-ups are also very wasteful of electricity. Because of all these considerations, a storage time-constant of 30 minutes at "average" pumping rate is recommended for most on-off liquid-level control systems. (Storage time-constant for a wet-well is defined as the time required to pump out the well's working volume with the particular pumping strategy used).

A common criterion for designing wet-wells and pumping stations is to minimize wet-well costs. By using variable-capacity pumping systems, pumping rates can be maintained equal to influent rates, and wet-well volumes can be kept small. A storage time-constant of 10 minutes at maximum pumping rate is recommended as a practical rule of thumb to ensure that the wet-well neither overflows nor runs dry. Except for rather small systems, multiple phased-operation pumps are used; the control system for such an installation can become complex and requires separate study.

Flow, or hydraulic-loading, equalization requires a combination of large capacity wet-wells and variable-speed pumping systems to minimize undesirable flow surges. Proportional control with unity gain would provide maximum pump speed at maximum level and, conversely, minimum pump speed at minimum level. Other gains might be more suitable, but the choice would depend on the wet-well time-constant and the anticipated influent flow variability. To be effective for flow equalization purposes, the wet-well would require a time-constant of several hours, but this would require an expensive structure and cause difficult problems in preventing settling and septicity. Non-linear control, to provide slow changes in output rate when the level is reasonable and yet change the rate sharply as the level approaches an extreme, would also be useful.[15] (Analog controllers of this type are commercially available.)

Field Experiences

All level-control systems encountered in the survey used on-off pumps, multi-step or variable-speed pumps with proportional control. Of the 33 cases reported, 3 were unsatisfactory and 3 were marginally acceptable, for an acceptance of 82%. Level control is not a major problem with commercially available equipment because precise level control is usually not required; oscillatory or conditionally stable control is adequate in most cases. For these reasons, presently available liquid-level control systems are suitable for almost all wastewater-treatment activities.

Flow Control

Principles and Applications

Liquid flow is a fast-responding process which has a small capacitance. Usually the sensor, transmitter, and controller account for the largest lags; process lag is often negligible. Accordingly, controllers that feature low proportional gain with fast reset action are most frequently used for liquid flow because this control mode avoids false actions based on noise, yet its fast reset feature causes it to act promptly to correct any persistent error.

Field Experiences

Most automatic flow-control loops, which this survey encountered in wastewater-treatment plants, regulated rates of return sludge and compressed air flow. For this purpose, these installations used proportional-plus-reset closed-loop analog controllers. Although liquid flow optimization of large streams is rare in wastewater-treatment facilities, one plant practiced influent flowrate equalization. They regulated the influent flowrate by means of variable-speed pumps, rather than control valves, to minimize energy losses and pumping costs. All 20 of the observed, automatic, flowrate-control systems performed satisfactorily for 100% acceptance.

Presently available commercial flow-control systems are adequate for regulating flowrate in wastewater-treatment facilities.

TREATMENT PROCESS CONTROL

Chlorination Control

Principles and Applications

Disinfection, one of the most important unit processes practiced in most water and wastewater-treatment plants, kills most microorganisms present in sewage by contacting the wastewater with an effective biocide. Chlorine is used in the majority of these facilities. For safety, convenience, and economy, pure chlorine is received as a pressurized liquid which is then applied, in the form of a relatively concentrated aqueous "carrier" stream, in ratio to the main process flow as shown in Figure 8.

Almost all chlorinators have been designed to reduce the incoming chlorine-gas pressure to below atmospheric. The flow of water through the ejector draws the chlorine out of the chlorinator; thus, in case of a broken or leaky line, chlorine is not released to the atmosphere. The high-pressure chlorine system is quite conservatively designed, and it is treated with care so that chlorine leaks rarely occur.

Successful disinfection with chlorine depends on good mixing, adequate chlorine concentrations and sufficient contact time; a contact chamber ensures complete reaction before the effluent is discharged from the facility. This contact chamber usually holds the wastewater for at least 30 minutes at maximum flowrate[16].

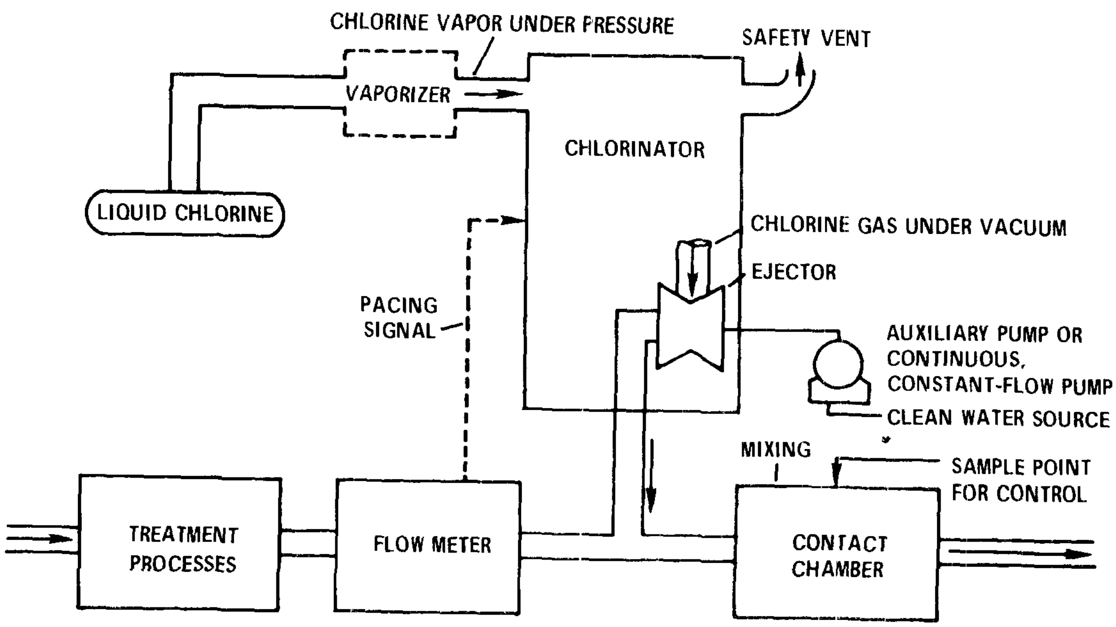


Figure 8. Flow-proportional chlorination control

The following methods of automatic chlorination control are practiced in wastewater treatment:

Open-loop flow-proportional control

Compound control: flow-proportional control of Cl_2 addition, with residual chlorine feedback to the chlorinator to trim dosage

Post-contact (i.e., downstream) residual chlorine control, plus compound control (cascade configuration); this control strategy is also called double compound control.

Open-loop flow-proportional control is simple and fast; unfortunately, it is also not flexible enough, especially for widely varying chlorine demands. Nevertheless, flow-proportional control is adequate for many plants. Better control, however, is obtained by trimming the chlorinator's set point with residual chlorine feedback; this automatically re-adjusts the ratio of chlorine flow to main process flow, as shown in Figure 9.[17] If the wastewater has a high chlorine demand, the residual chlorine concentration drops and the feedback controller increases the ratio of chlorine added to the wastewater; for lower chlorine-demand wastewater, the residual chlorine feedback controller automatically lowers the ratio of chlorine added. This compound control loop provides somewhat slower, but more accurate, control; the survey team observed many successful compound chlorine control loops.

A common chlorinator design that is inexpensive and requires no auxiliary air supply utilizes the vacuum developed by the ejector to control chlorine gas flow in ratio to the main process flow. A flow transmitter, similar to a conventional pneumatic transmitter, leaks air into the vacuum signal line to maintain a vacuum-control signal proportional to the flow differential in the main line. This vacuum, applied to a special regulator, maintains chlorine pressure-drop proportional to main-flow pressure-drop. The residual signal, on the other hand, drives a servo that re-adjusts a linear valve (usually a Vee-notch valve) in the chlorine vapor line. Mass flow of chlorine is, therefore, proportional to the product of hydraulic flow through the plant and residual chlorine concentration.

Good residual chlorine control, however, poses some difficult problems because most standards and codes require that a prescribed residual chlorine be maintained after at least 30 minutes contact time. On the other hand, residual chlorine feedback control systems which have potential 30-minute lags are prone to instabilities. For the feedback control system to perform adequately, the overall response time of the loop should be within a three- to 10-minute range; this means that residual chlorine must be determined a short time after mixing. The difficulty now is to relate the control residual to the residual at the end of the proper contact period. This is best handled by a second residual chlorine analyzer that records the residual after sufficient contact. To assure an adequate residual, it may

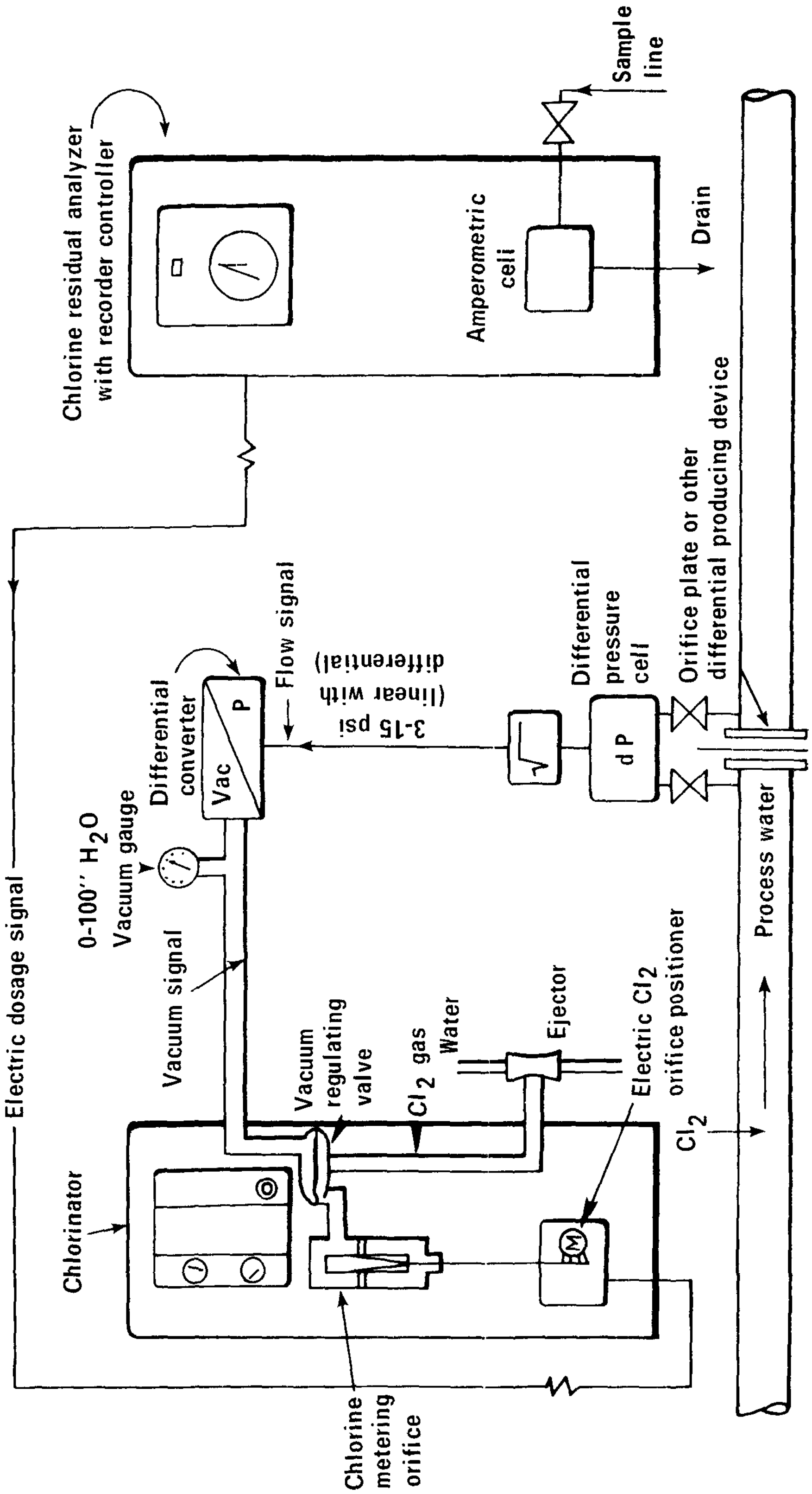


Figure 9. Compound, residual chlorine, control system

be necessary to use a second, or post-contact, residual chlorine analyzer to readjust the chlorine application rate at the head of the contact chamber as shown in Figure 10; note that the second analyzer's output signal controls the set point of the first analyzer (cascade control).

Field Experiences

Since the chlorination process is dominated by large reaction-time lags, the aqueous chlorine concentrate must be well mixed into the main flow, the main process flow signal must be properly represented at the point of chlorination, and the measurement lag should not vary appreciably with rate of plant throughput; if these conditions are met, residual chlorine feedback control will be optimum. Residual chlorine control was found to be successful at 10 sites, unsatisfactory at 1 and fair at 2, for an acceptance rate of 77%.

Presently available, automatic, residual-chlorine control devices are well proven for assuring proper chlorination of wastewaters, especially after secondary treatment. Occasionally, chlorination control of raw sewage, stormwater and combined sewage may fail because of the residual analyzer plugging with debris. Residual chlorine control systems are usually cost-effective since they pay for themselves in chlorine savings and assure compliance with discharge standards.

Dechlorination Control

Although most wastewater facilities effectively disinfect their effluents, in some cases the effluent must also be essentially free of active chlorine to protect shellfish beds, bathing beaches, etc. To accomplish this, active chlorine is usually reacted with aqueous sulfur dioxide (i.e., H_2SO_3), whereby sulfite is oxidized to sulfate and hypochlorite is reduced to chloride, as shown by equation 1:

(1) $H_2SO_3 + HOCl \rightarrow H_2SO_4 + HCl$

The sulfur dioxide gas feeder is practically identical in construction and function to the common chlorinator.

A continuous, automatic, residual chlorine analyzer is essential in all but the smallest plants if residual chlorine is to be kept very low (perhaps less than 1 ppm), while simultaneously avoiding excess sulfite. The extent of instrumentation will vary with the seriousness of the problem, but alarms and signal limiters from the analyzer to the feeder are recommended to avoid chemical over-dosages.

A residual chlorine analyzer is usually necessary to control the sulfur dioxide feeder. The arrangement and precautions are the same as given for chlorination, but one signal is reversed so that as residual chlorine increases the sulfur dioxide feed is increased, and vice-verse. Automatic dechlorination was included under residual control in the survey results.

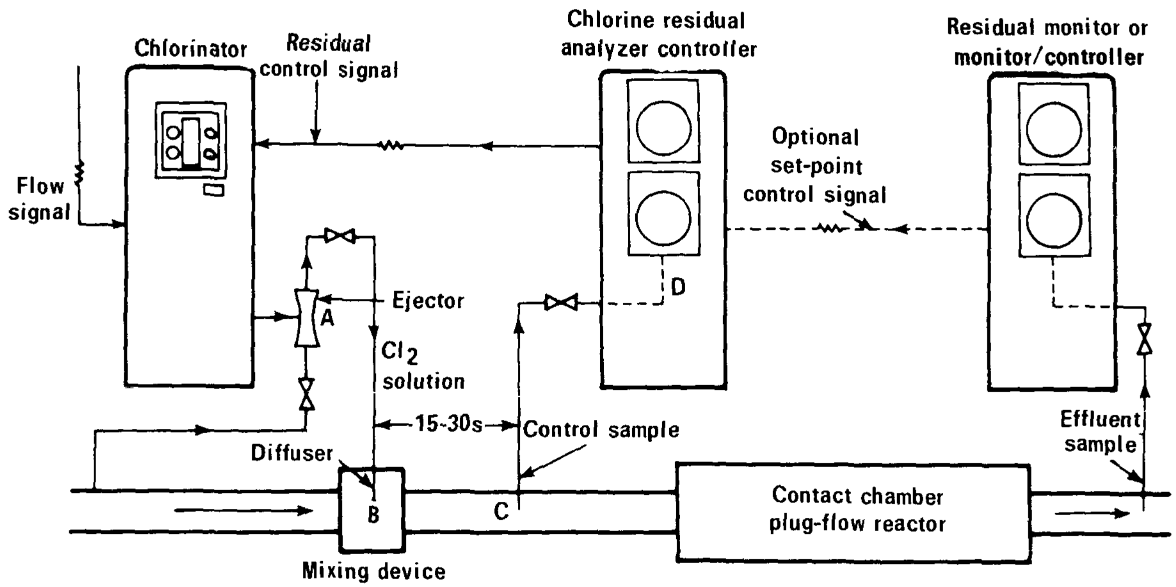


Figure 10. Double compound, residual chlorine, control system

Dissolved Oxygen Control

Principles and Applications

To achieve high BOD removals with any of the activated sludge process modifications, proper dissolved oxygen (DO) levels must be maintained in the aeration basins. Adequate DO should be available to satisfy the metabolic needs of the aerobic microorganisms. If the DO decreases below a critical level, the aerobic bacteria lose their activity, and effluent quality deteriorates. Excessive DO concentration, however, can hinder secondary solids settling. Moreover, the aeration equipment consumes wasteful amounts of energy when the DO level is too high. Oxygen demands fluctuate over a wide range because of changes in flowrate, organic concentration, ease of degradation, and activate biomass concentration. The degree of nitrification also affects oxygen demand.

Most of the surveyed plants practiced manual DO control where the operator attempted to regulate the oxygen transferred in proportion to the oxygen demand. To save manpower and assure adequate oxygenation, most operators provided more oxygen than necessary. With the current energy shortage, automatic DO control has become very important since it can reduce aeration power consumption by as much as forty percent.[21]

Automatic DO control paces oxygenation rate (input energy to the aeration equipment) to oxygen demand. Two DO-control strategies were observed during the user survey of automation practices in wastewater-treatment facilities: flow ratio (or flow proportional) control and DO feedback control.

Flow ratio control regulates the rate of oxygen transferred to the mixed liquor in direct proportion to the influent flowrate. This strategy, which is simple, inexpensive and fast-responding, is predicated on a constant oxygen demand per unit volume of sewage. Flow ratio control of the aeration equipment, however, does not work well in most plants because the oxygen demand per unit volume of sewage changes dramatically throughout the day. For example, stormwater infiltration or industrial dumps cause large variations in plant-influent oxygen demand. Only one plant out of the fifty visited facilities practiced flow proportional DO control, and they discontinued it since a satisfactory DO level could not be maintained in the aeration basins.

DO feedback control systems use actual DO data from the aeration basins to regulate the rate of oxygen transferred. A DO probe senses the DO concentration and sends a signal, by means of a transmitter, to a controller which computes the deviation from the desired value (i.e., an error signal). The controller, acting on the error signal, usually outputs a signal for control action proportional to both the instantaneous error and the integral of past errors (PI control). Other useful control modes include proportional only, two-position, and combination flow ratio-DO feedback trim.

Final control elements such as motor-speed relays or valve positioners, execute the control strategy by producing corrective changes in the manipulated variable which, in turn, alter the oxygen transfer rate. Table 7 contains the manipulated variables and final control elements for commonly available, oxygen transfer equipment; the corresponding feedback control systems are shown in Figure 11.

Table 7. OXYGEN TRANSFER EQUIPMENT

Aeration Device	Manipulated Variable	Final Control Element
Air Diffusers	Air Flowrate	Valve, or variable-speed motor, or blower vane pitch
Submerged Aerator (Turbine/Orifice)	Air Flowrate	Same
Surface Aerator	Immersion Depth, or Motor Speed	Adjustable weir, or motor speed

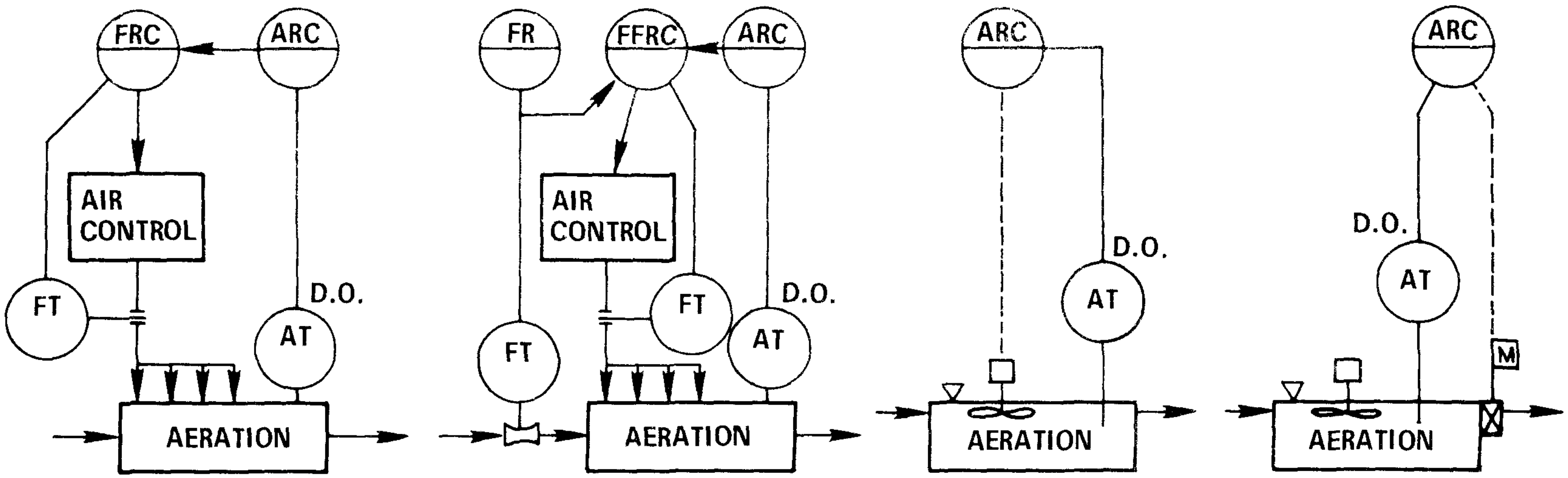
For example, consider the diffused aeration tank equipped with variable-speed blower. When the DO probe reports a low oxygen level the controller generates an error signal that calls for increasing the blower's speed; this then tends to raise the aeration basin's DO concentration.

Since the DO feedback control system acts on DO probe readings, it is important that these DO data represent the "true" DO concentration of the aeration basin. Consequently proper DO-probe location is essential for good control. If the DO probe is located either remotely from, or in an unrepresentative region of, the aeration basin, the control system may exhibit erratic or unstable performance. Since the entire contents of a completely mixed aeration basin are virtually uniform, DO probe placement is not critical for this type of aeration.

For single- or multiple-pass plug-flow aeration basins with large length-to-width ratios, the probe-mounting arrangement should have enough flexibility to permit easy probe-location changes since a significant DO gradient exists along the tank length. For mechanically aerated plug-flow basins, DO probes should be placed in each aerator's zone-of-influence; alternatively, suitable single-probe locations may be found by trial and error.

Field Experiences

Four of the five treatment plants that utilized automatic DO feedback control were satisfied with the performance of such control - an 80% acceptance These four plants could effectively hold their DO concentrations within 10% of the desired operating level (i.e., anywhere within 1.0 to 5.0 mg DO/1 in spite of widely varying oxygen demands. Plant managers commented that aeration power savings ranged from 10 to 40% for automatic DO regulation. Moreover, the BOD removal generally increased about 10% when DO control was applied. One plant practiced a slightly more sophisticated DO control by basing their equipment adjustments on the product of raw sewage flowrate and aeration-tank DO level; but no significant increase in control performance, cost savings, or BOD removal was observed.



DIFFUSED AERATION, CASCADE FEEDBACK DO CONTROL

DIFFUSED AERATION, RATIO FEED-FORWARD DO CONTROL, WITH CASCADE FEEDBACK DO TRIM

MECHANICAL AERATION, FEEDBACK DO CONTROL, USING A TWO-SPEED MOTOR

MECHANICAL AERATION, PROPORTIONAL DO CONTROL, USING AN ADJUSTABLE WEIR

Figure 11. Dissolved oxygen control schemes

Most users cited excessive DO-probe maintenance requirements as a major disadvantage of presently available, automatic, DO-control systems. Transmitters, recorders, indicators, controllers, and final control elements functioned without any problems. Consequently, with proper installation and periodic maintenance, satisfactory automatic DO control is within the capabilities of commercially available equipment. Field observations recorded decreases in power consumption, prevention of septic conditions, and increased BOD removals as benefits of applying DO control to aeration tanks.

Sludge Pump-Down Control

Principles and Applications

The two control objectives for pumping down a clarifier's sludge blanket are (1) preventing the sludge blanket from spilling over the weir along with clarified effluent, and (2) transporting a dense sludge to downstream stabilization processes. Inherently, these two control objectives conflict because control that leads to good thickening also tends to produce a high sludge blanket which causes the effluent to pick up significant amounts of solids. On the other hand, if the sludge blanket is too shallow, the solids will contain excessive water. Ideally, keeping the sludge blanket within an optimum range of heights will satisfy both requirements, but the non-ideal nature of wastewater liquid-solid separations makes this approach difficult. Instead of basing sludge-blanket level control on any set of fixed rules, good judgment based on actual experience should guide the control-strategy selection. It seems reasonable that more emphasis should be placed on sludge-density control methods for primary clarifiers; whereas, secondary clarifiers should use appropriate types of sludge-blanket level control.

As might be expected, two possible control strategies (shown as a composite in Figure 12) are practiced in wastewater-treatment facilities: With the first strategy, a timer initiates sludge pump-down, during which time the sludge density is continuously monitored; pumping is terminated when (1) the density of sludge leaving the clarifier falls below some preset value or (2) a predetermined pumping time has elapsed. Sludge pumping control by density measurements is well established, but suffers from excessive sensor maintenance (see Sludge Density Measurement).

With the second strategy, a photoelectric (or ultrasonic) level detector monitors the liquid-solid interface height (sludge blanket level). When the sludge blanket rises above a preset limit (i.e., above the photoelectirc or ultrasonic sensor), sludge pump-down starts; pumping then continues until terminated, usually by a fixed-interval timer. Other shut-off methods, such as low blanket level or low density, are possible but they were not observed during this survey. Only one plant reported using sludge-level probes in conjunction with automatic sludge-pumping control.

Field Experiences

Sludge-pumping control worked well in 72% of the 22 facilities which practiced it. Poor sensor reliability (both sludge level and density) were mentioned as the principal drawbacks of automatic sludge-pumping control. In spite of this sensor problem, commercially-available sludge-pumping control systems are somewhat beneficial, but they need considerable improvement to substantially improve sludge pump-down operations. Also a combined (or combination) control strategy based on sludge blanket level and sludge density should be further investigated.

Scum Removal Control

A highly instrumented, scum-pumping system was encountered at one plant (see Figure 13). Unfortunately the system was ineffective because of poor hydraulic design of the skimming operation. A more careful study of the process would have prevented this misapplication of otherwise-good instrumentation.

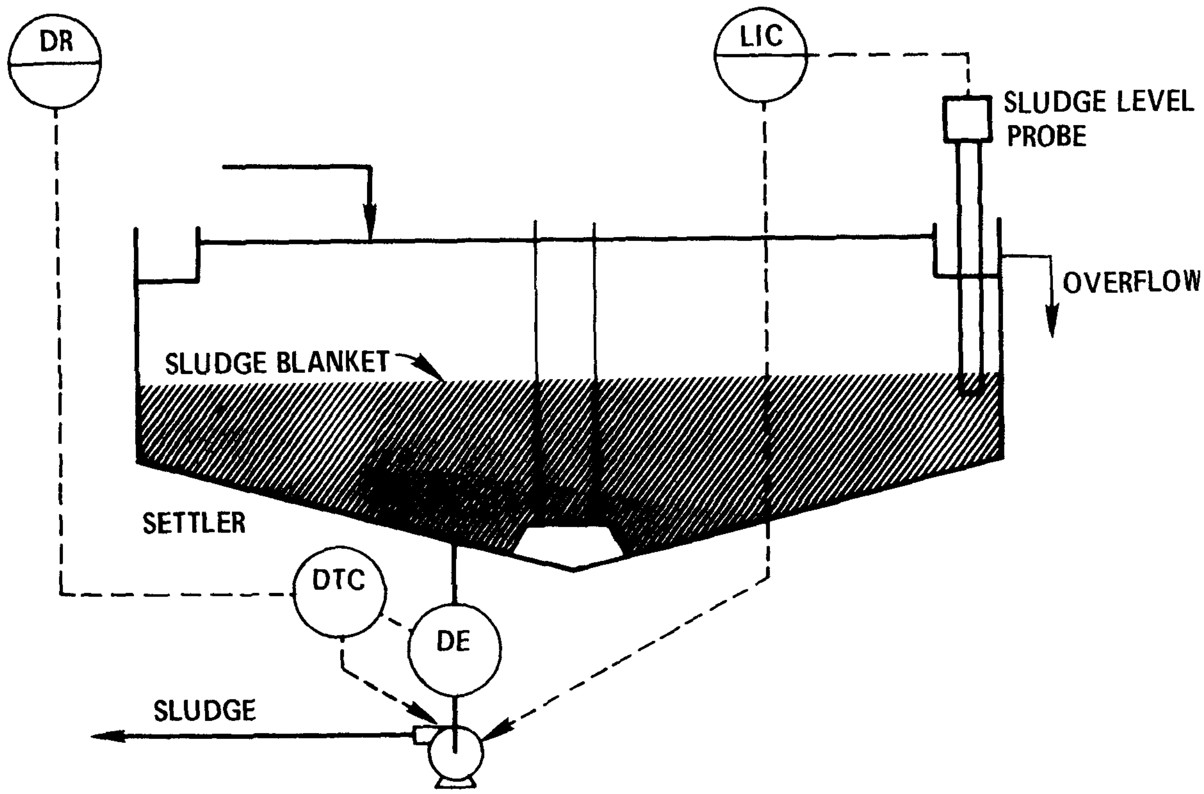


Figure 12. Sludge pumping control strategies

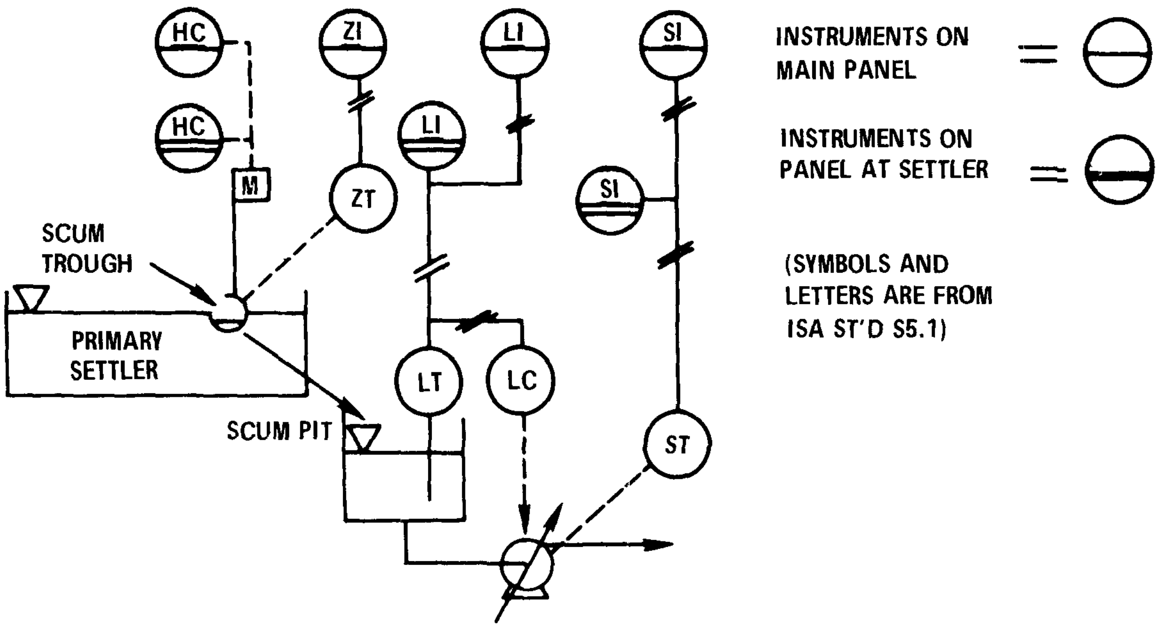


Figure 13. Instrumented scum-pumping system

In operation, the scum trough is rotated by the operator at either the settler or main panel. Panel-mounted instruments also indicate degree of tilt, level in scum pit, and speed of an automatically controlled, variable-speed pump. The only part of this system that is truly automatic involves control of scum level in the scum pit via a signal from LT and LC which, in turn, adjusts the speed of the scum pump (e.g., via a linear variable differential transformer, in combination with either a thyristor power supply or a magnetic drive for the pump motor).

Chemical Addition Control

Principles and Applications

Chemical addition, in ratio to wastewater flowrate, is a well-established automatic control procedure for adding coagulant aids, precipitating agents, and nutrients. Typically, either a variable-speed pump or dry feeder, driven at a rate proportional to the process stream's flowrate, delivers chemicals by a feed-forward control configuration illustrated in Figure 14-A. Automatic analyzers, good enough for reliable feedback control or feedback trim (Figure 14-B), are not available for most parameters. Since dosage accuracy is not critical and the large process capacitance adds a smoothing effect, the simple, inexpensive flow-ratio controller is adequate for most plants. Occasional manual tests are made to check that the ratio is correct and that the equipment is working properly.

Although final control elements for most chemical feeders are usually adequate, the newer equipment uses closed-loop control around the feeder to assure linearity and dependability. A detailed discussion of feeders and their working properties is given by Babcock (19).

Field Experiences

In the plants visited, variable-speed pumps and dry feeders delivered aqueous ferric chloride, pickle liquor, alum, phosphoric acid, lime, and polymers in ratio to the main process stream. Eighty-seven percent of the fifteen installations that practiced chemical addition by means of flow-ratio control were satisfied with their control system's performance. The survey results show that presently available, flow-ratio equipment for automatic chemical addition is suitable for continuous duty in wastewater-treatment plants.

Digester Temperature Control

Since anaerobic sludge digesters have high thermal capacitances, simple on-off temperature control is adequate to prevent temperature upsets. Digester temperature controllers, which are similar to a home heating system, measure the temperature of the digester contents and turn a hot water circulation system on or off, depending upon the desired temperature. Most commercially available temperature controllers can readily satisfy digester service requirements.

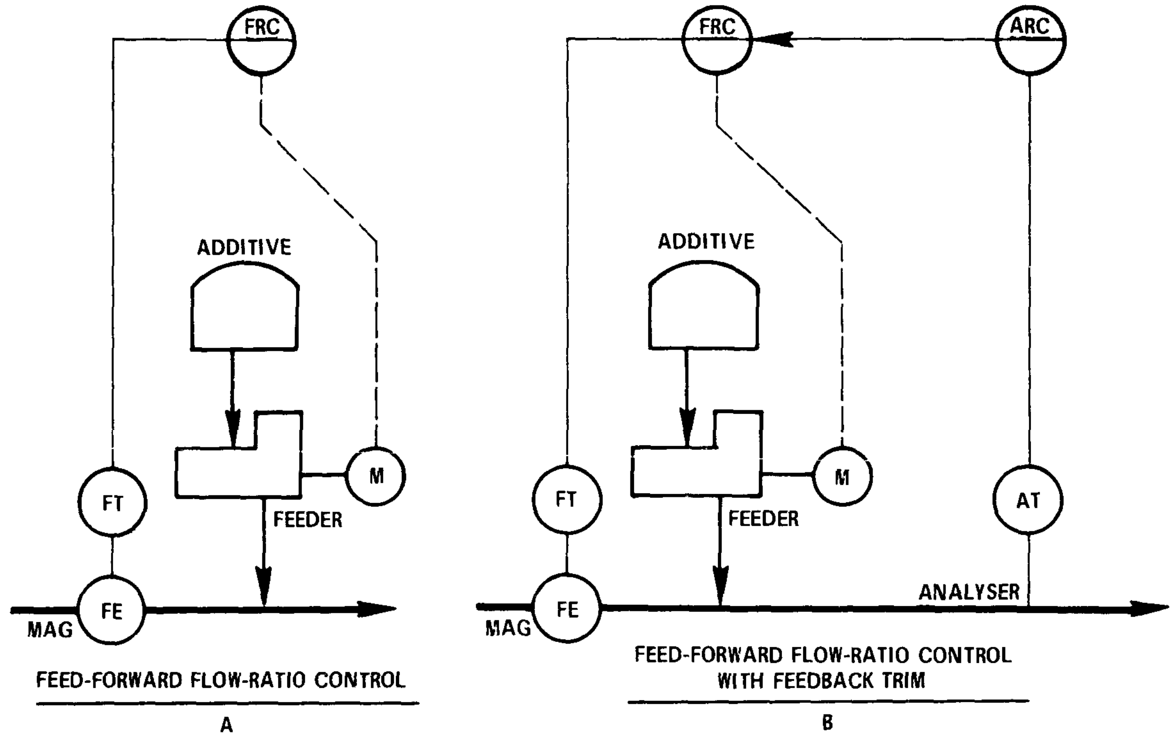


Figure 14. Chemical addition control strategies

pH Control

When the pH fluctuates over a range of 4 or more units, pH control becomes difficult because the pH measurement is logarithmic and each unit corresponds to an order-of-magnitude change in hydrogen ion activity (concentration). Since buffering capacities change as a function of pH itself, the loop gains change non-linearly with the pH. Consequently, controller tuning is very difficult.

Merely measuring a wastewater's pH is often difficult (see pH Measurement discussion), and simple automatic control is often not feasible. One surveyed plant, which used lime as the pH adjusting agent, had an unworkable pH control system. A dry feeder/slaker and long trnsport lines within the control loop introduced so much time lag that the control system became unstable. Out of all the plants surveyed, automatic pH control was observed at only three plants, but was acceptable at 2 of them for a 67% acceptance. As in many industrial processes, presently available pH control systems can provide satisfactory control for many wastewater-treatment applications; however, it may be necessary to install one of the newer, relatively sophisticated systems (e.g., adaptive non-linear control) for those situations requiring very tight limits for rapidly varying pH values.

SECTION VII

CENTRALIZED CONTROL

INTRODUCTION

The main purpose of central control is to provide an efficient communication link among the process, process controllers, plant operators and supervisors. For safe and efficient treatment of wastewater, the instrumentation network must transmit all essential technical data to a convenient location. Accordingly, indicators, recorders, alarms, automatic controls, manual controls (for remote actuators) and background process information are brought to a central location to inform and facilitate manipulation by a relatively small number of human operators. This is practical in most plants because of simple and reliable intra-plant transmission systems, compact instruments, and a well-developed technique in applying automatic controls to processes. This central point, usually built as a control room, uses vertical display panels and consoles. One or more operators oversee the function of the collective processes from this control room, while maintenance men and assistant operators service the equipment. Data display, recording, remote process adjustment and alarm display are the basic functions of a well operated, centralized, control system.

DISPLAY

Most of the available operating information, regarding process status at a wastewater-treatment plant, is displayed on panels for two purposes:

- To illustrate present and past information about the plant

- To permit the operator to control the plant efficiently based on this information

Historically, the graphic panel was once claimed to be the best arrangement for mounting instruments because the display devices are organized into a logical sequence that closely follows process layout. Many graphic panels also include provisions for making adjustments to important automatic controllers. However, the large increase in the number of centralized display devices used in present-day wastewater-treatment plants makes the graphic panel too complex, too expensive to build or modify, and too large to be scanned from a single point.

For semi-graphic panels, the instruments (usually miniaturized versions of the old "large case" instruments that were roughly 1-1/2 feet wide and 2 feet high) are mounted in groups in a rectangular array that is related in some way to the process. A representative semi-graphic panel is shown in Figure 15. (Previously used, non-graphic panels simply mounted the

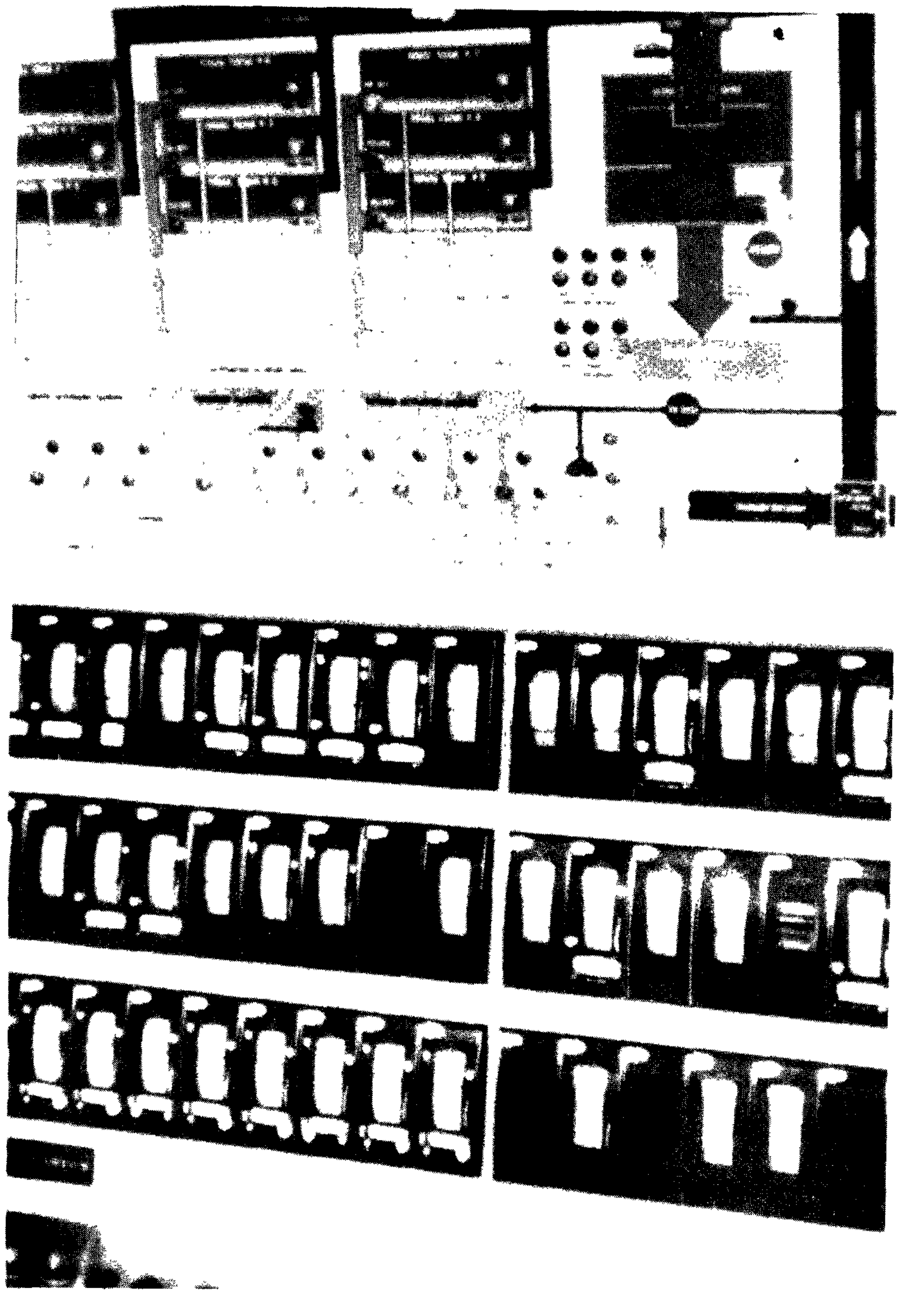


Figure 15. Example of Semi-Graphic Instrument Panels

instruments with no graphic reference, so that the operator had to identify each instrument by nameplate, position, or a distinctive record. Mistakes were easily made and comprehension of the process was difficult, especially for complex plants.) Semi-graphic methods frequently use standardized symbols for process equipment with corresponding symbols marking the display devices; color-keyed block diagrams and display instruments also aid in identification. The most recent development in centralized control substitutes a time shared computer for most of the individual display devices; this extends automation as a replacement for human attention to an ever-increasing degree. This latter trend is proceeding slowly, however, because such installations are expensive and are usually most suitable (economically) for large facilities.

OBSERVING AND RECORDING PLANT OPERATIONS

Whether or not computer control is incorporated, safety and the need for reliable operation of the facility under all conditions dictates the use of basic sensing and control methods to ensure continuing operation. (Flow, wet-well level, and disinfection are usually the most important variables). Consolidated analog recorders are the most reliable (and usually the most effective) means of informing the operator of plant status and trends. The practice, still existing in old plants, of using banks of large one- or two-pen recorders for a recorder density of about 0.2 recorder per square foot of panel space, has been revised to the use of miniaturized instruments for an effectiveness of about 0.8 recorder per square foot. Future designs are unlikely to improve on this figure, but the multiplicity of miniature strip charts with one or two variables is being replaced by larger charts with multi-variable capability and by direct, computerized, data reduction. Analog records will continue to be important for many plant operations, and the use of a relatively few, large, multi-variable charts is superior to the present practice of small strip charts because of labor and material savings, improved data retrieval, and the ability to determine the relative timing of events. (The application of multi-variable recorders, however, requires a judicious selection of variables, and usually requires some degree of signal conditioning and manipulation.)

Computerized data-reduction and data-logging operations will inevitably be incorporated into an increasing number of the larger wastewater-treatment facilities, particularly the new installations now being designed or constructed. In view of the fact that perhaps 20% of the logged data will be from automatically controlled systems, 20% more from automatic measuring devices, and 60% from measurements obtained manually, it is evident that automated data reductions must be compatible with many kinds of signal inputs.

REMOTE PROCESS ADJUSTMENT

The success of centralized control in wastewater-treatment facilities depends on both automatic control and on the laboratory. Wastewater-treatment systems are, at present, only partially capable of automation; this is due almost solely to difficulties in making reliable, automatic, remote measurements of certain, critically important, wastewater parameters without simultaneously incurring prohibitually expensive maintenance problems. In practice many types of routine samples are collected from various areas of the facility, brought back to the laboratory and, in due course, analyzed. The operators review the laboratory data and make appropriate adjustments to process parameters and equipment from the central control room. Because of rapid advances in laboratory procedures over the last decade, most analyses have been automated to such a large extent that, in many cases, the analyst need only introduce the sample and evaluate the instrumental results. This laboratory automation is often confused with on-line automation: in the first case, the analyst has been provided with new devices, but analyses cannot be made without his intervention, and control actions must be made manually. In the latter case, human aid is required only to install, and then periodically calibrate and maintain, the automatic measuring and control system.

The time-consuming conventional procedure consisting of sample collection, sample analysis, data recording, and process adjustment based on the resultant data has been considerably shortened in some plants visited during the survey. In these plants, sampling systems have been arranged so that a representative sample of influent, effluent, activated sludge, or the like, is piped directly into the laboratory. This is an expensive practice and one which introduces some safety problems, but it is a major improvement in overall control of the treatment process. (See Sampling.)

ALARM SYSTEMS

No human being can reasonably be expected to dedicate his entire attention to graphic displays or indicating instruments for eight consecutive hours; a typical waste-treatment plant operator must direct much of his attention to other chores as well. For these reasons, alarm/annunciator systems are needed to alert the operator to dangerous situations by means of flashing lights and audible signals. Process alarms are well-developed forms of persistent surveillance systems common to the process industries; they are a natural result of automated production because they permit a large amount of remote equipment to be safely supervised by only a few men. Most alarm systems use simple on-off light systems. Some new plants with 100 or more alarms use specialized sequenced signals, for which the order (or sequence) of alarming yields very specific information. A typical alarm system uses bells or horns, plus flashing lights, in a well-structured annunciator configuration to draw the operator's attention to any preselected abnormal condition for which he is directed to take action. The audible alarm continues until the operator pushes an "acknowledge" button. The specific condition then remains prominently displayed until corrected. Each alarm variable has its own light and legend.

Commonly observed alarm functions in wastewater-treatment facilities include:

- Escaping chlorine gas
- Explosive atmosphere
- Pump or pump-drive failure (e.g., low oil pressure or high bearing temperature

- Malfunctioning flow regulator or tide gate
- Jammed comminutor
- Overloaded clarifier drive-motor
- Jammed or broken sludge-scraper flights
- Loss of aeration air (either air flow or air pressure)
- Loss of chlorination (e.g., chlorinator malfunction, loss of ejector pressure, interruption of flow signal to chlorinator)
- Abnormal influent pH
- Loss of instrument air
- Abnormal wet-well level

Each of the above conditions is detected, and corrective action is taken; the list is different for each plant.

Alarm systems consist of specially designed annunciators that are simple, highly reliable, and easily tested and repaired. Several varieties of procedural arrangement are available and have been codified[20]. Alarm-system wiring is usually well-defined, well-segregated, and fail-safe. The alarm-condition detectors are on-off devices (switches or latching relays), carefully selected early in the design of the facility to warn of hazards to personnel, to facility, or to the treatment function, in that order. Two of the major sensing devices for protection in wastewater plants are chlorine gas detectors and explosive gas detectors. Each instrument is equipped with a switch that actuates an alarm when a preset level is reached. Alarm systems are reliable and useful only when properly integrated into a general plant-protection policy. For example, an alarm system connected to a hazardous gas detector that is not properly tested and maintained is worse than no detector at all since its protection may be wrongly assumed when the detector itself has become inoperative. On the other hand, putting an alarm contact on a measuring device that frequently goes off-scale (even when no hazardous condition exists) quickly exasperates the operator, and he is apt to disarm or ignore the entire system, to his own and the plant's peril. This latter situation has caused many, avoidable, industrial explosions in recent years.

Computer systems can add new levels of sophistication to facility warning systems, but conventional systems should not be replaced until the more-modern systems have proven their reliability.

SURVEY RESULTS

All but the smallest (e.g., less than 1 mgd) wastewater-treatment plants had central control rooms. The older facilities reflected the concepts of their times; whereas, the newer plants utilized the latest in central control layout, design and displays. Since industrialized central-control technology and equipment is directly applicable to wastewater-treatment facilities, wastewater activities can benefit from presently available, central control devices. Because of the lack of some measuring devices, central control may be less useful than it is in other industries. Central control is, however, one of the areas of instrumentation and automation that can be definitely justified on the basis of operating and labor cost savings.

SECTION VIII

COMPUTER CONTROL

COMPUTER APPLICATIONS

Computers are automatic devices capable of performing calculations and logic operations at very high speeds. A list of tasks addressable to modern computers seems almost endless, but as applied in wastewater-treatment plants, computers are used primarily for three operations:

- Data logging
- Direct digital control (DDC)
- Digital supervisory set point control (DSSC)

To realize the economic potential of computerization, project and plant managers must properly match computer specifications to the application's needs. In order to clarify the role of selection of computer systems in wastewater-treatment projects, a brief discussion of computer function and appropriate hardware follows.

AVAILABLE COMPUTERS

With the explosive growth and revolution in the computer hardware industry, descriptive material is practically outdated before it is printed. Computers, however, will probably continue to be classified as either micro, mini, or large scale (occasionally termed "maxi"). These three classifications are strictly arbitrary, however, and are frequently very misleading to someone who does not closely follow the rapid advances in this field. Core size, flexibility and cost are the principal bases for classification. As currently defined, microcomputers (increasingly referred to as "microprocessors" by the control engineering profession) characteristically possess 1 to 2K (K = 1,000 words) core sizes, and they cost approximately $1,200 to $2,000, exclusive of software expenses. Auxiliary equipment, other than analog-to-digital (A/D) converters, are not ordinarily used with microcomputers. For limited applications, both the low cost and remarkably small size of the microcomputer are encouraging the widespread adoption of "distributed control", wherein several dedicated microcomputers are distributed over a wide area (where they are used for "local" control of several unit operations), but yet they are <u>all</u> supervised by a larger, centrally located computer.

Minicomputers are customarily used as dedicated machines that are programmed in assembly language, but more sophisticated languages such as Fortran are also available. Although reprogramming can be difficult, a knowledgeable programmer can make on-line changes. Minicomputers usually are equipped with teletype and A/D converters; more-elaborate systems use off-line storage devices, cathode ray tube (CRT) displays, paper tape, and other input/output devices. Core sizes can range from 16K to 32K, although 16K seems adequate for most installations. Typical micro-computers systems cost $22,000 to $60,000 without software.

Large-scale systems provide maximum flexibility since all program changes are implemented by means of a user-oriented language such as Fortran. Smaller computers often employ less-user-oriented languages, although this situation is rapidly changing. Additionally, large systems are furnished with core storage in excess of 100K. Representative configurations utilize teletypes, input/output devices, CRT displays, and external memory such as disks or drums. Large-scale systems sell for upwards of $100,000.

DATA LOGGERS

Data loggers record, in an organized format and at regular intervals, the important process variables and key equipment states. Except for special cases, most data loggers employ inexpensive micro-type computers in conjunction with A/D converters, teletype recording devices, and paper tape punches. The accumulated data can be subsequently processed into a usable operating report and/or lists of anticipated maintenance tasks. Data logging systems sell for $5,000 to $50,000, depending upon the auxiliary equipment. Simple data loggers may be advisable for plants in excess of 5 mgd when a large amount of process and operating equipment data are available. Access to an off-line large-scale computer for data reduction makes data logging even more attractive.

DIRECT DIGITAL CONTROL (DDC)

Digital controllers, frequently referred to as direct digital controllers, receive information about the process from on-line instruments at regular intervals. From this data, a programmed control strategy (algorithm) determines a control action which is sent directly to the final control element for execution. Direct digital control usually involves a mini-computer since large-scale systems usually cost too much and since micro-computers lack sufficient flexibility. Digital control, unlike data logging, places the computer in an active role in the facility operation; consequently, back-up provisions must be available for plant operation during computer downtime periods. Since back-up provisions may include manual, analog, or a second digital computer, total computerization costs are difficult to estimate, but computer main frames with auxiliary devices sold for about $100,000 in 1973. If the basic programs have already been developed, software costs about 20 to 25% of the hardware costs; otherwise, software cost often exceeds hardware cost since new program development (like all development projects requiring large expenditures for highly qualified personnel) usually is expensive. Computer control is most easily justified for large (i.e., greater than 50-mgd) plants where process improvements and cost reductions of 3 to 5% offset computerization expenses.

DIGITAL SUPERVISORY SET POINT CONTROL (DSSC)

Digital supervisory control computers monitor all available process variables, key equipment status, and all other relevant data such as rainfall, ambient temperature and receiving water quality. The basic objectives of supervisory computer control involves analyzing all available data, and determining the best operating strategy for achieving the facility's goals. Supervisory control thus involves the total plant. This broader scope of treatment-plant control frequently includes cost-saving sub-system optimization strategies. Sometimes, a portion of the computer's control strategy is automatically implemented by instructions to analog loops or by direct digital control (or by both). Other methods of supervisory computer control generate instructions for the operator so that he can evaluate the wisdom of the recommended strategy prior to any action. Computerized supervisory controllers can also track running time of all major equipment, and publish periodic maintenance schedules. Off-line computations, inventory control, manpower requirements and statistical trend analyses can also be successfully addressed by supervisory computers. These devices, moreover, can be programmed to generate monthly reports. Because of the inherent flexibility and multiplicity of functions, automatic supervisory control requires a large-scale computer system which costs about $250,000 (1973) for hardware. Systems analysis, process investigation, software generation and training expenses add another 30 to 50% of hardware costs.

Because of the high cost, supervisory computers can best be justified for very large plants or sewer districts (i.e., greater than 100 mgd) where process improvements, labor savings, and reduced operating costs (all directly assignable to the supervisory computer) offset the computer costs. On the other hand, if a large number of stations must be modulated, such as in stormwater-overflow regulation, or if it is difficult for the operating personnel to assimilate all the pertinent data and make operating calculations, then it is also possible to justify a supervisory computer.

SURVEY FINDINGS

The survey team encountered ten computers in the fifty wastewater-treatment plants. Four facilities used small computers for automatic data acquisition. Over ninety percent of the users of automatic data loggers considered their data-gathering devices acceptable.

Only two digital process-control computers were identified and both of them performed satisfactorily. Unfortunately, no process-improvement or cost-saving data were available.

Four large-scale computer systems were observed in the surveyed plants; two of them were used as off-line computation devices, and the other two as automatic supervisory controllers for stormwater-overflow regulation. All of the large-scale computer systems performed satisfactorily.

Although computer control of wastewater-treatment facilities has received considerable attention in the literature [21], most dry-weather treatment plants that had a computer used it as a simple data logger. No dry-weather treatment facility, with a computer controlling a large part of the treatment processes, was in operation during 1973. For storm- and combined-sewage overflow control, process and supervisory control computers clearly demonstrated their benefits by significantly reducing manpower and the percentage of overflow events. Computers are successful for stormwater control because sewer hydraulics and dynamics, although quite complex, are well known and readily described by mathematical models. Additionally, suitable physical-type sensors (e.g., liquid level detectors, position indicators, and flow meters) are presently available to guide computer-control efforts.

For example, a typical overflow-regulator station, as shown in Figure 16, transmits combined-sewage level signals from the trunks and interceptor, as well as from the outfall that is receiving water-level signals, to a central computer. In the computer, level and rainfall data are put into programmed hydraulic and hydrologic models, and a set point command is issued by the computer to raise or lower the regulator and tide gates in such a manner as to use the maximum storage capacities of the trunks and interceptors without causing flooding conditions. The regulator- and tide-gate set point commands are telemetered to the regulator station from where position-feedback controllers raise or lower the regulator gates and tide gates. One supervisory stormwater-control system visited during the survey reduced overflow events by 52%.

Lack of adequate process models and suitable analytical sensors has greatly impeded field demonstrations of the desirability of dry-weather computer process control. Digital process and supervisory control computers have proven their reliability and suitability elsewhere, but without appropriate analytical devices, computers cannot improve wastewater-treatment efficiency and reliability. Several computerized dry-weather treatment plants are currently being started up, but meaningful performance data were still not available as of the date this survey was cleared for publication.

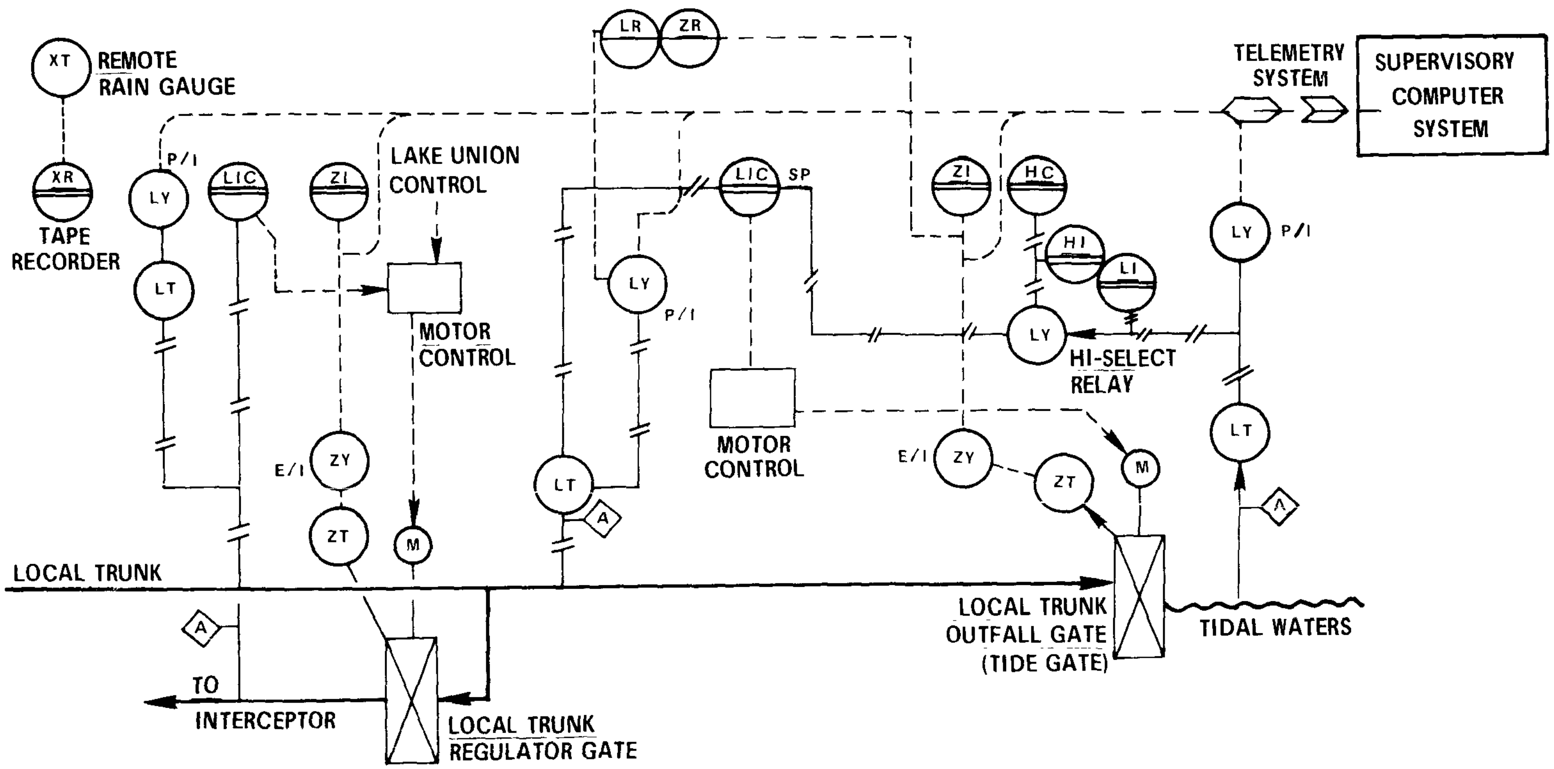


Figure 16. Typical outfall-interceptor control system

SECTION IX

MANPOWER REQUIREMENTS FOR INSTRUMENT MAINTENANCE & CALIBRATION

To be successful, the instruments and automatic control devices employed in any process must be suitably maintained and calibrated. Too often, plant operators and administrators are not adequately informed of the man-hours and levels of skill necessary to maintain their instruments properly. Characteristically, operating personnel soon become disenchanted with instrument performance, and subsequently the instruments are discarded or abandoned. Although instruments can be abandoned for several reasons, fairly high rates for some devices (such as sludge density meters) seem to be due directly to the severity of maintenance problems. Because of the fouling nature of wastewaters (grease coatings, biological growths, and slime), the measuring devices which directly contact wastewater or sludge require a large amount of maintenance. A recent study [9] of industrial maintenance showed that sensors, analyzers, monitors and other on-line measuring devices require an order of magnitude more maintenance than transmitters, indicators, recorders, and final control elements, even for "non-fouling" service encironments. For these reasons, this section will discuss the maintenance skills, maintenance frequencies, mean-time-between-failure, and life expectancies associated with sensors and measuring devices observed during the plant survey.

SKILL LEVELS

Satisfactory instrument performance depends on the availability of adequately trained instrument technicians. Clearly, the level of skill necessary to inspect and clean a bubbler tube is different from the training needed to service a chlorine gas detector. Because no distinguishing classifications for instrument-maintenance skills exist, the survey engineers who are familiar with wastewater treatment and instrumentation proposed the following arbitrary listing of levels:

- Level 1 - A plant operator without any training in instrumentation
- Level 2 - A skilled mechanic, or electrician, whose ability is limited to electro-mechanical repairs
- Level 3 - An apprentice instrument technician who is capable of executing routine maintenance for conventional analog instruments

- Level 4 - The equivalent of an industrial instrument technician who is proficient in instrument calibration, tuning, and repairs

- Level 5 - In most cases a high school graduate, with highly specialized advanced training, who is qualified to maintain complex instruments, automatic devices, and digital computers (or to program digital computers).

The required level of skill for each plant was based on installed instrument complexity, not on process or plant complexity. For example, a primary treatment plant may use a high degree of continuous analyses and computer control. Accordingly, this facility would require highly trained instrument specialists for proper maintenance. On the other hand, a secondary plant may only use simple instruments which can be readily maintained by a low-level instrument technician. In any plant, the instrument maintenance group will contain a mixture of skill levels; but for this survey's purposes, the highest level of skill necessary to supervise the group's activities is listed. The survey team evaluated the maintenance requirements in detail for each type of measuring device encountered; Table 8 summarizes this evaluation.

Table 8.

SKILL-LEVEL DISTRIBUTION

Skill Level:	1	2	3	4	5
Percent of Plants that require this level:	0	10	46	41	3
Percent of Plants that actually have this level available:	8	15	44	33	0

From the distribution of skill levels shown above, none of the surveyed facilities could perform adequate instrument maintenance with only a level-1 instrument group, but 8% of the plants have maintenance personnel who are unfamiliar with the basic principles of conventional process-measuring instruments and analog controllers. Available maintenance skills agreed more closely with the facilities' true needs for skill levels 2, 3 and 4.

Only 3% of the plants required a level-5 instrument group. Most of those facilities had supervisory computer control and used outside contract maintenance for their specialized maintenance needs.

Eighty-seven percent of the plants needed experienced level-3 and level-4 instrument technicians, and about 77% of the facilities indeed employed level-3 and level-4 technicians. Accordingly, a large percentage of wastewater-treatment facilities have adequately trained instrument-maintenance staffs.

Instruments fail because of external and inherent causes. Causes of external failures include environmental factors (such as corrosion and signal interference), hostile process conditions (probe fouling), and interactions with other utilities (line-noise effects and dirty instrument air). Initial failures, wear-out failures, and random failures account for the so-called inherent causes. Proper instrument design and appropriate instrument maintenance minimize failures due to external factors, while preinstallation testing and scheduled replacement can prevent most initial and wear-out failures; however, random failures occur unpredictably. For this reason, resident or short-notice contract-maintenance manpower should be available. The instrument-maintenance staff, in addition to correcting failures, must calibrate the instruments to keep their performance within specified limits. In short, the instrument-maintenance group's mission encompasses repair tasks (breakdown "maintenance"), preventive maintenance, and calibration chores.

Most wastewater-treatment facilities keep inadequate instrument-maintenance records. Rather than anticipating maintenance requirements by accumulating statistics and costs for instrument repairs and calibration services, they have relied on intuitive judgments. Consequently, only a few facilities could supply statistically supportable, maintenance-requirement data. Using the information gathered during the interviews, and instrument conditions observed in the plant inspections, the survey team prepared Table 1 (Page 7) which describes the median maintenance requirements for the important measuring devices. Reliability information (mean-time-between-failures), life-expectancy data, and cost estimates are also listed. A comparable survey of industrial instruments gives typical maintenance requirements for non-fouling services; these are also listed in Table 1 for comparison purposes. In general, the wastewater and industrial maintenance requirements agree, except where fouling is a major problem. Industry appears more sensitive to the dangers from explosive gases since it spends four times as much for servicing explosive gas detectors as the wastewater-treatment industry spends.

To enjoy the benefits of instrumentation, plant management must be prepared to supply enough skilled manpower for proper maintenance and calibration. During the instrument planning stages, maintenance requirements must be appraised since instrument failure frequency, as measured by mean-time-between-failures (MTBF), ranges from one month to ten years depending upon the device and service. If an instrument is essential for plant operation and it has a low MTBF, serious consideration should be given to using back-up instruments. Failures of the less critical instruments may temporarily impair treatment efficiency or increase operational manpower burdens; nevertheless, the plant would continue to operate and back-up instruments would not be required.

SECTION X

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APPENDIX A

DEFINITIONS AND INSTRUMENTATION SYMBOLS

DEFINITIONS

Accuracy

The conformity of an indicated value to an accepted standard or true value [A-1]. High accuracy is a desirable characteristic of a measuring system, but repeatability is even more important when automatic control is considered. "Accuracy is a static characteristic relating to the manner in which a measurement is made and to the quality of the equipment. Reproducibility is the degree of closeness with which the same value of a variable may be measured over a period of time. The periodic checking and maintenance of a control system are generally for the purpose of obtaining reproducibility rather than for determining the static error (i.e., accuracy) of indication" [A-2].

Analytical Sensor

A measuring device, or primary element, whose operation derives from chemical, physical, or other analytical principles.

Cascade Control (Figure A-1)

A control action in which the output of the controller adjusts the set point for another controller [A-1]. For example, the flowrate through a pump can be measured and controlled to satisfy the demand of a level controller; see Figure A-1 where the set point of FRC-1 is adjusted by the output of LIC-1. Other examples of 2-loop cascade control are chlorination rate varied in ratio to final effluent flowrate with the ratio adjusted (or "trimmed") by residual chlorine measurement, and air flow varied in ratio to effluent throughput rate, and the ratio adjusted (or "trimmed") by a dissolved oxygen controller.

Central, or Centralized, Control

The centralized grouping of multiple readouts (display and recordings) and control means to facilitate management of processes. Centralized control, usually located in a specially designed control room, improves the effectiveness and efficiency of human operators and thus simplifies control; its success depends on well-performing sensors, transmitters, the centralized readout and control units, and remote actuators.

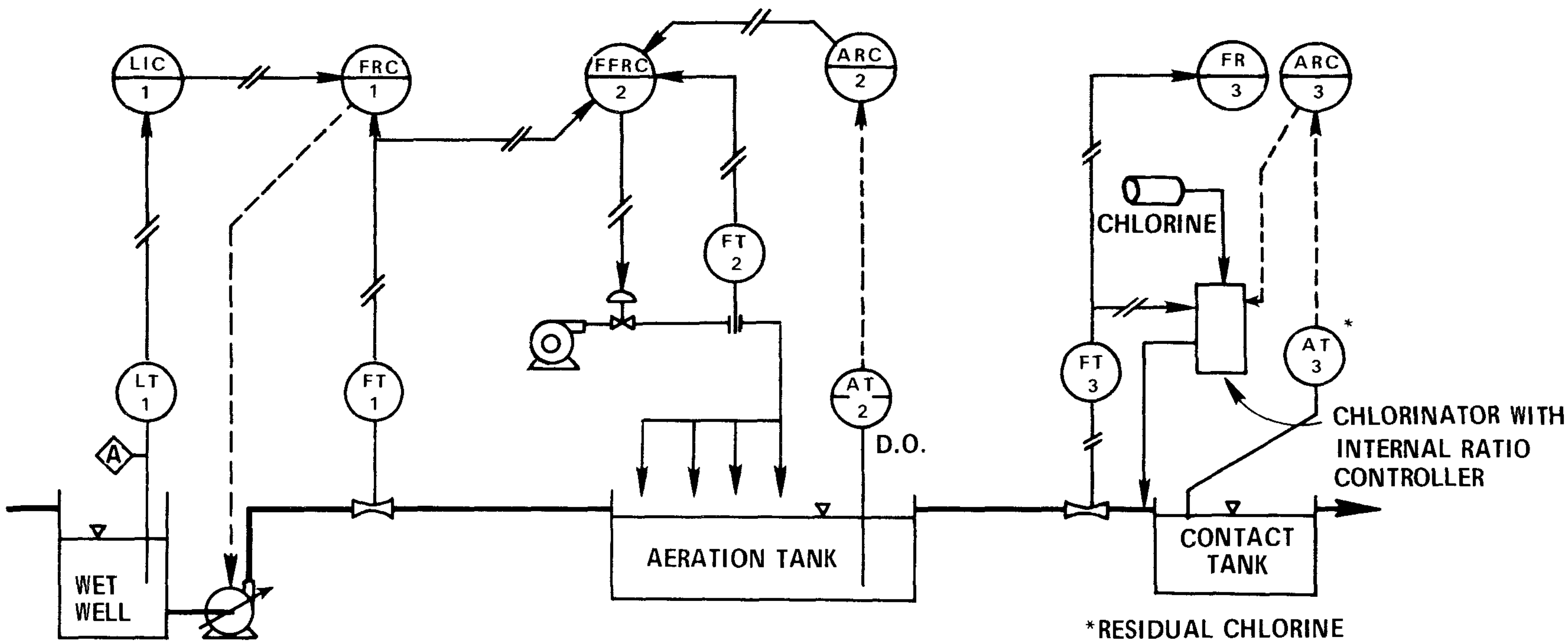

Figure A-1. Examples of cascade loops (schematic)

Closed-Loop

A signal path that includes a forward segment, a feedback segment and a summing point, thus forming a closed circuit [A-3]. In the usual configuration, the forward segment extends from the controller to the final control element and thus to the process; the feedback segment extends from the process, by way of the primary element (sensor), back to the controller, whereupon the summing junction (in the controller) compares the feedback signal with the setpoint to determine if automatic readjustment of the final control element is needed and, if so, how much.

Computer

Practical process computers, which are electronic digital or analog devices, automatically perform calculations and logic operations. A digital computer is usually designed in a manner similar to a calculator with memory, internal control (via the central processing unit or CPU), arithmetic, logic, and input/output (I/O) facilities. Digital computers, the most popular type of electronic data processing machine, are classified as large-scale computers, minicomputers, or microcomputers according to memory size, speed, flexibility and cost. A further classification can be made based upon whether a computer is a general-purpose machine or a dedicated machine.

Controller

A device which has an output that can be varied to maintain a controlled variable in a specified manner. An automatic controller varies its output automatically in response to a direct or indirect input of a measured process variable. A manual controller is a manual-loading station, and its output is not necessarily dependent on a measured process variable because this output can be varied only by manual adjustment [A-4]. In practice, controllers usually have pneumatic or electric outputs for directing final control elements.

Data Center

The term "Data Center", as used in this report, refers to stormwater collection and handling systems - not to the automatic data-acquisition and data-handling activities of wastewater-treatment plants. These latter activities have already been clearly defined and thoroughly described in Section VIII, "Computer Control", of the main text.

Stormwater data centers are usually begun as passive, off-line, data-collection systems for logging precipitation rates, sewer levels, sewer flows, gate position, etc., as a function of time. Active on-line centers can then be set up to control the disposition of stormwater for an extended area. Other data centers also exist to collect outlying sewage flowrates for billing purposes and the like.

Down-Time

The time duration that a machine or device is inactive during normal operating hours, usually because it is incapable of adequately performing its prescribed function. Down-time can be scheduled for normal maintenance, however, as well as an unscheduled occurence due to failure. Freedom from down-time often characterizes a device's reliability.

Down-Time Frequency

See mean time between failures, MTBF.

Electronic

A term relating to the behavior of electrons, as in solid-state or vacuum-tube devices; this term now covers electric systems as well. Electronic intra-plant signals between instruments are usually standardized as 1 to 5 volts dc, or as 4 to 20 (or 10 to 50) milliamperes dc, in each case representing 0 to 100% of measurement.

Feedback

A control strategy in which a measured process variable is compared to its desired value (the setpoint) to produce an error signal that is utilized by a controller in an effort to reduce the magnitude of the error. Because feedback systems act on errors incurred, some tolerance for minor errors (or noise) must be "built into" the feedback system to prevent undesirable overcontrol which would otherwise be occuring almost constantly as a result of normal, but minor, disturbances or pertubations in the system.

Feed-Forward

A control strategy in which advance information concerning conditions that can disturb the process is converted into corrective control action that is then applied to minimize deviations of the process before these deviations become significant. Since feed-forward control schemes mathematically mimic the process to anticipate the effects of disturbances, it is theoretically possible to have almost perfect control; an accurate process model, however, is rarely available. Instead feed-forward control can be effectively combined with feed-back control to generate satisfactory corrective control actions.

Final Control Element

The device that directly changes the value of the manipulated variable of a control loop [A-4]. The final control element in wastewater treatment is commonly a pump or control valve.

Graphic Panel

A panelboard on which the instruments are arranged to conform with a graphic or pictorial representation of the process. Graphic panels are practical when good, miniature, panel instruments are available. A semi-graphic panel uses a process pictorial in close conjunction with instruments mounted in a regular array [A-5].

Instrument

A device used directly or indirectly to measure or control a variable, or both. The term includes control valves, relief valves, and electrical devices such as annunciators and pushbuttons. The term does not apply to parts (e.g., a receiver bellows or a resistor) that are internal components of an instrument [A-4].

Level of Skill

The survey engineers, who are familiar with wastewater treatment and instrumentation, proposed the following level of skills:

- Level 1 - a plant operator without any training in instrumentation, whose ability is limited to inspection and cleaning tasks.
- Level 2 - a skilled mechanic, or electrician, who is limited to electromechanical repairs.
- Level 3 - an apprentice instrument technician, capable of executing routine maintenance for conventional analog instruments.
- Level 4 - the equivalent of an industrial instrument technician; an individual who is proficient in instrument calibration, tuning, and repairs.
- Level 5 - in most cases a full technician, with highly specialized advanced training, who is qualified to maintain complex instruments or automatic devices such as digital computers.

MTBF (Mean Time Between Failures)

The statistically-derived time that can be expected between failures of a device when used in the service for which the MTBF was derived. It is the reciprocal of the unscheduled down-time frequency.

Noise

The unwanted component of a signal or variable which obscures the informational content [A-1]. It is highly desirable to have a large signal-to-noise ratio. Sometimes a suitable filter can reject noise and recover information that would otherwise be unreliable.

Open Loop

A signal path without feedback [A-3]. An example of open-loop control is simple chlorination, where the chlorinator is paced by a flow signal. Since the loop is open, the ratio of chlorine flowrate to the main process flowrate must be periodically readjusted manually to maintain the desired residual. A residual chlorine analyzer could be used to close the loop (See, for example, Figure A-1).

Fixed program control and remote manual control are also examples of open-loop control.

Primary Element

Sensing element, or sensor. The instrument-system element that quantitatively converts measured variable energy into a form suitable for measurement [A-1].

(Also see Transmitter)

Pneumatic

Reference to the use of compressed air for providing power for control (or control-loop) devices, and for signal transmission. Commercial, pneumatic, instrument signals are based on a 3- to 15-psi range, corresponding to 0 to 100% of measurement.

Process

Any operation or sequence of operations involving a change of energy, composition, dimension, or other property that may be defined with respect to a datum [A-4].

Process Variable

Any variable property of a process [A-4].

Ratio Control

A control action that maintains a predetermined ratio between variables [A-1]. Simple ratio control is usually found in open loops. In flow-ratio control, (often called chemical pacing in water treatment), the "slave" flow delivered by chemical-feeder pumps is maintained in ratio to a "master" process-throughput flow. Chlorination control via flow-ratio control is another example of open-loop control. The addition of a continuous residual chlorine analyzer, however, provides a feedback signal to make the system closed-loop. The combination of flow-ratio control with residual chlorine measurements may be regarded as a feed-forward feedback loop because it anticipates (i.e., it feeds forward) changes in flowrate and also employs chlorine-residual feedback information for high accuracy.

Reliability

A measure of the ability of a system or device to function properly in its assigned role for a predetermined period of time. See Down-time and MTBF.

Repeatability

The degree of agreement among repeated measurements under the same conditions. In continuous operation and control, good repeatability is comparable to a "low-noise" signal and also indicates low drift. For process-control purposes, repeatability is usually more important than accuracy.

Response Time

The time interval from the occurrence of a step change in sample concentration at the instrument's sample inlet to attainment of a preselected fraction, or percentage, of the ultimate recorded output; in this report, response time is usually assumed to be 90% of the ultimate recorded output.

Sensor

(See Primary Element).

Storm-Flow (Wet-Weather) Treatment Facility

A structure dedicated to the treatment of stormwater and combined sewage during storm events prior to discharge to receiving waters. These facilities are only operational during storm events, and they frequently utilize liquid-solid separation techniques and disinfection. Some authors refer to these facilities as satellite, or auxiliary, excess-flow plants.

Transmitter

A device that senses a process variable through the medium of a primary element, and that has an output whose steady-state value varies only as a predetermined function of the process variable. The primary element may or may not be integral with the transmitter.

INSTRUMENTATION SYMBOLS

The application of instruments and control devices to production facilities has become a highly organized engineering discipline in several industries. A body of symbols, abbreviations, and specifications is standardized by ISA Standards Committee No. SP 5.1 of the Instrument Society of America [A-4], and these are generally practiced. The engineering function of such symbols, etc., has also become generally standardized. ISA symbols, as used in the Survey, are shown in Figure A-2, while Instrument Abbreviations are shown in Table A-1.

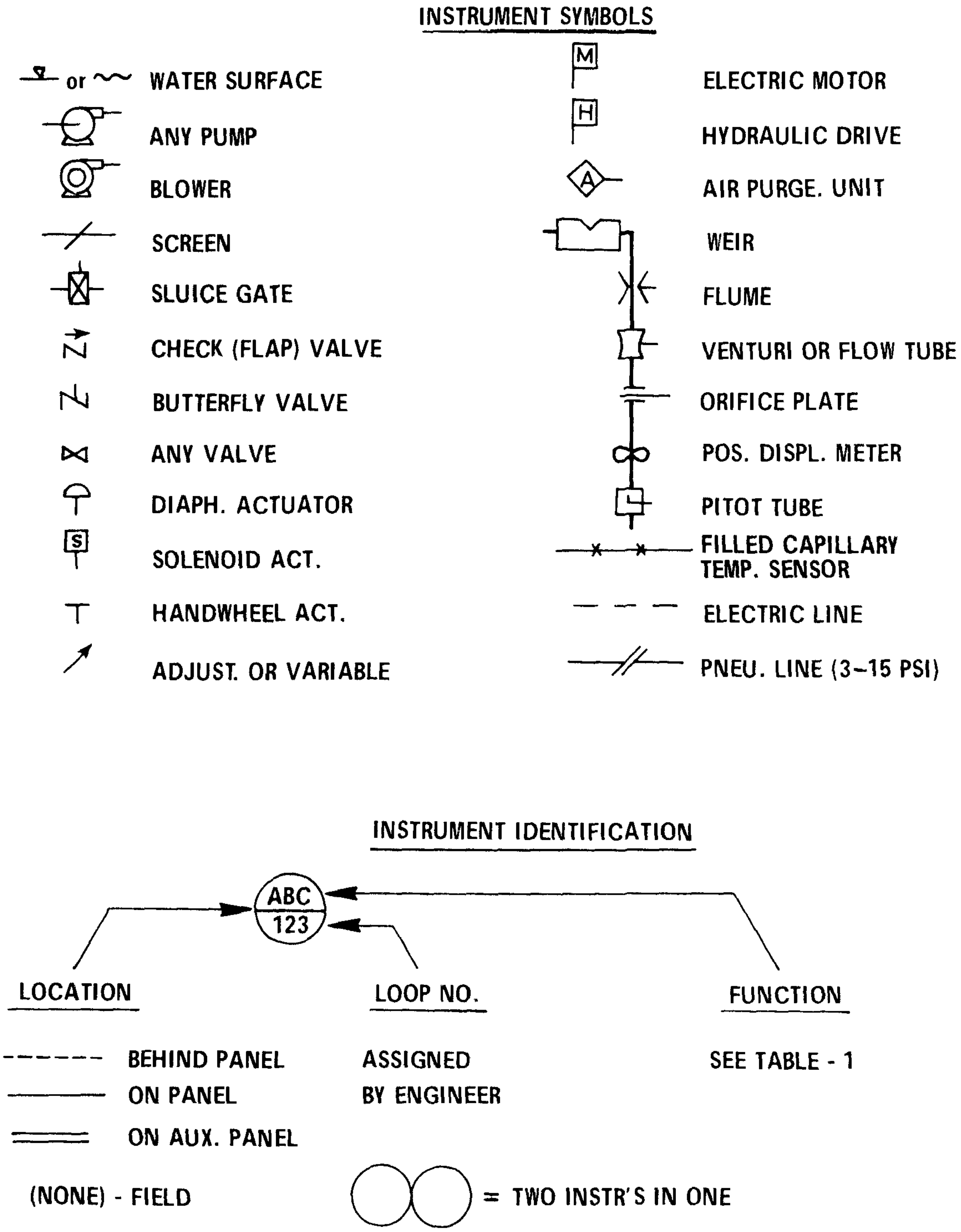

Figure A - 2 ISA symbols

Table A-1. INSTRUMENT ABBREVIATIONS

EXAMPLE IDENTIFICATION LETTERS FOR INSTRUMENT "BALLOONS" - -
A typical tag for a Flow Indicating Controller FIC-3A, can be deciphered as follows:

F	I	C	3	A
first letter	second letter	last letter	loop number	suffix

	Measured or Initial, Variable	Modifier	Instrument Function
A	Analysis (1)	-	Alarm
B	Burner (flame)	-	Special (3)
C	Conductivity (Electrical)	-	Control (controller)
D	Density or SP. GR.	Differential	-
E	Voltage (EMF)	-	Primary element
F	Flowrate	Ratio or fraction (2)	-
H	Hand (Manually Initiated)	-	High
I	Current (Electrical)	-	Indicate
J	Power	Scan	-
K	Time or Time Schedule	-	Control Station
L	Level	-	Low or Light (Pilot)
M	Moisture or Humidity	-	Middle or Intermediate
N	Special (3)	Special (3)	Special (3)
P	Pressure (Vac.)	-	Point (test connection)
Q	Quantity or Event	Totalize or Integrate	-
R	Radioactivity	-	Record or Print (4)
S	Speed or Frequency	Safety	Switch
T	Temperature	-	Transmit
U	Multivariable	-	Multifunction
V	Viscosity	-	Valve, Damper or Louver
W	Weight or Force	-	Well
X	Special (3)	Special (3)	Special (3)
Y	Special (3)	-	Relay or Compute
Z	Position	-	Drive, Actuate, or Unclassified Final Control Element

(1) Type of analysis to be defined outside baloon as: pH, ORP, D.O. (dissolved oxygen), R.C. (residual chlorine), TURB (turbidity), etc.

(2) As a modifying letter to designate (fraction) ratio; i.e. FFIC - Flow Ratio Indicating Controller.

(3) As defined in Instrument List of each job.

(4) Or printer.

BIBLIOGRAPHY

FOR

APPENDIX A

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APPENDIX B

MEASURING DEVICE MANUFACTURERS

AMMONIA ANALYZER

Manufacturer	Model	Type	Range	Response Time	Accuracy
Delta Scientific	8019	Wet Chemistry	0-10 ppm	5 minutes	±2% FS
Enviro-Control	557C, 105-7D	Ion Selective	0-100 ppm	6 min. 90% response	±5% FS
Orion	Series 1000	Ion Selective	As low as .02 ppm	Less than 1 min.	(Range-dependent)
Technicon	Monitor IV	Wet Chemistry	(Highly variable)	8-12 minutes	(Range-dependent)

CHROMIUM ANALYZER

Manufacturer	Model	Type	Range	Accuracy	Response Time
Delta Scientific	8026 (hexavalent or total)	wet-chemistry	0-500 ppm, and up	±2% FS	As low as 45 seconds
Enviro-Control	2073 (hexavalent) 2074 (total)	wet-chemistry		±5% FS	
Hach	CRS Series (hexavalent)	wet-chemistry	0-6 ppm		15 min. to equilibrium
Raytheon	2507 (hexavalent)	wet-chemistry	0.5 - 10 ppm	±5% FS	12 min.
Technicon	Monitor IV (hexavalent)	wet-chemistry	0-5 ppm		
Uni-Loc	1205 (hexavalent)	wet-chemistry	0-5 ppm		

COLOR ANALYZER

Manufacturer	Model	Test Method	Range	Accuracy	Stability
Delta Scientific	Series 8027	Color is measured by a Delta dual-beam spectro-photometer	The low range used is 0-300 ppm in terms of APHA/ platinum/cobalt color units.	Inherent accuracy of the instrument is ± 2% FS, and sensitivity is better than 0.7%	
Hach	CR2	APHA platinum/cobalt color units	0-200 and 0-500 APHA platinum cobalt color units		
Phototronic	400	6, 15-W, flat ribbon, incandes-cent point source	0-100% transmittance.	± 1%	± 2.0%, after initial warmup
Raytheon	2800	Dual beam spectro-photometer	1.0, 0.5, 0.1, or 0.05 absorbance (full scale)	± 2% FS	± 2% for four-week period for 60° to 110°F operating range

CONDUCTIVITY ANALYZER

Manufacturer	Model	Range	Accuracy	Response Time	Stability	Drift
Aquatronics	325	Standard ranges between 0-5 micromhos, and 0-250,000 micromhos. Other ranges available on request.				
Beckman	RA2-A	5-2,000 micromhos	±2%			
Delta Scientific	8014		±1% FS at 20°C (68°F); ±2% over temperature-corrected range of 5°C to 35°C			
Enviro-Control	1015	100; 500; 1,000; 5,000; 10,000; 50,000 micromhos (full scale)	±1% FS at any given temperature		±1% FS/24 hours at any given temperature	
Honeywell	552021 552022	Multiple	±0.5%, including sensor	2.5 sec to 99% of FS step change		±0.25% FS
Hydrolab	6D	0-100, 0-1,000 0-10,000 micromho/cm 0-1,000, 0-10,000, 0-100,000, micromho/cm	±2.5% of reading for internal calibration, or ±1.5% of reading for standard calibration solution	2 sec to step change in conductivity, 10 sec to step change in temperature		
Leeds & Northrup	7070-06 7070-07					

CONDUCTIVITY ANALYZER (Cont)

Manufactuere	Model	Range	Accuracy	Response Time	Stability	Drift
Ohmart	1-1000-2CD	11 ranges: 0-60,000 micromhos	±1% FS	63% of reading in 24 sec max 99% of reading in 2 min max	Over 4 week period: ±1% FS, including sensor ±.5% FS, signal conditioner only	
Raytheon	1403	0-100 to 0-100,000 micromhos	±1% FS to 10,000 micromhos; ±3% FS to 100,000 micromhos			0.5% FS
Schore Automations	CM/2	0-10 micromhos, with a cell constate of 1.0	Meter indication is within 1%, with supply voltage variations up to ±10%			
Uni-Loc	700 Series		±1% FS		±1%/mo	

COPPER ANALYZER

Manufacturer	Model	Type	Range	Accuracy	Response Time
Delta Scientific	8028	Wet-chemistry	0 to 2.5 ppm	±2% FS	1 min
Enviro-Control	1044	Ion-selective	0-1,000 ppm, standard range	±5% FS	
Enviro-Control	2071	Wet-chemistry		±5% FS	
Fischer & Porter	17H1000	Amperometric		±3%	
Hach	CR2 Series	Wet-chemistry	0-2 mg/1		20 min
Orion	Series 1000	Ion-selective	As low as .05 ppm		
Raytheon	2521	Wet-chemistry	From 5 to 10 ppm	±5% FS	12 min
Technicon	Monitor IV	Wet-chemistry	0-10 ppm		

CYANIDE ANALYZER

Manufacturer	Model	Type	Range	Accuracy	Repeatability	Stability	Sensitivity
Enviro-Control	1045	Ion-selective	0-2 mg/1 0-20 mg/1 0-200 mg/1	±5% FS		2% FS/24 hrs.	
Kent Cambridge	8007	Ion-selective	±5%	±2%			
Orion	1206	Ion-selective	As low as .06 ppm				
Raytheon	2903	Ion-selective	0-10 mg/1		±15%	±5% over 24 hrs.	
Technicon	CSM-6	Wet-Chemistry	0-3 ppm				±1% FS

DISSOLVED OXYGEN METER

Manufacturer	Model	Range	Accuracy	Response Time	Linearity	Stability	Drift
American Limnetics Instruments	DO Analyzer	1-10 ppm, 0.1-1 ppm, 0.1-10 ppm	2% max slope error	10 sec for one-sigma change in response to DO step input			
Aquatronics	510	0-2 ppm	±2% FS				
Beckman	735	0-20 ppm	±1% FS	90% of FS in 20 seconds	±.75% of reading	±1%	
Delta Scientific	8010	0-2 ppm 0-10 ppm 0-20 ppm					
Enviro-Control	1012	5, 10, & 20 ppm		20 seconds	±1% of reading at any given temperature	±1% of reading at any given temp. per 24 hours	
Great Lakes	60	0-10 ppm					
Honeywell	552012 552011	DO: 0-12 ppm 0-15 ppm 0-10 ppm 0-24 ppm Span: ±20% Zero: ±20% of span	±.25% FS	3.5 sec for 99% FS step change			.25% FS per 30 days
Hydrolab	6D	0-10 ppm 0-20 ppm	2% of reading				
Interocean	500 SCTD/ O_2 pH T	0-20 ppm	±.1 ppm				

DISSOLVED OXYGEN METER (Cont)

Manufacturer	Model	Range	Accuracy	Response Time	Linearity	Stability	Drift
Ionics	1131		Dissolved Oxygen: ±0.3 or ±3.0% of reading, whichever is larger (at constant temp.)	15-sec maximum to achieve 95% of step change at constant temp.			DO: <0.1 ppm over 30-day period Temp: <0.03°C over 30-day period
Kent Cambridge Inst. Co.	9410 9420	0-30%, 0-100%, 0-200% of saturation	±5% within a temp of ±10°C of standardizing value				Less than 2% drift per day and typically 5% in one wk.
Ohmart	1-1000-2DC	0-12 mg/l 0-24 mg/l	±1% FS for high range	63% of reading in 24 sec.max; 99% of reading in 2 min. max.	±1% FS	±1% FS over a 4-week period, inc. sensor. ±.5% FS, signal conditioner only	
Raytheon	2406	0-5, 0-10, 0-20 mg/l	±4% FS	Less than 1 min.			<0.5% FS four weeks
Uni-loc	802	0-20 ppm	±.1 ppm				
Weston & Stack	3000	0-15 ppm & 0-1.5 ppm, dual readout	±1% FS				.05 ppm/ day

FLOW METERS

Manufacturer	Model	Type	Range	Accuracy	Repeatability
Badger Meter		Ultrasonic		±1% FS	
BIF	Series 230	Butterfly valve with venturi flow-tube	Up to 90:1	±2%	
BIF	Series 137	Flow nozzle	Standard sizes are 1" thru 24"	±1%	
BIF	Series 141	Parshall flume	From 10 gpm to 210,000 gpm		
BIF	Series 180	Universal venturi	Sizes of 2" to 96"	±.75%	
Brooks	Series 7100-7200	Electromagnetic	Sizes from 0.1" to 48"	±0.5% FS	
Brooks	Series 33	Propeller/current	Cold water 1-17,610 gpm Hot water 3.5-3,520 gpm	±2%	
Controlotron	Series 270	Ultrasonic	1" up to 60"	1% nominal	Up to 0.05" for horizontal pipe
Drexelbrook Eng.	Cote-Shield Series	Open channel			
Fischer & Porter	10A Series	Rotameter	0.1 cc/min up to 4400 gpm	±2%	
Fischer & Porter	10D Series	Electromagnetic	Meter sizes of 1/10" up to 96"	±0.5% to ±2% FS	
Fischer & Porter	10F Series	Variable head		0.5% on calibrated tubes	

FLOW METERS (Cont)

Manufacturer	Model	Type	Range	Accuracy	Repeatability
Fischer & Porter	71K Series	Impact (Target)	From 4 to 3200 gpm		
Fischer & Porter	10C Series	Turbine	0.4-16,000 gpm	0.1-.25%	0.1%
Foxboro	B50 Series	Flow tubes, orifice plates, flow nozzles, venturi tubes		±1.0% ±0.5% ±0.75% ±0.75%	
Foxboro	2800 Series	Electromagnetic	1/10"-48" (flows of .07-115,000 gpm)	±1% FS	±.25% FS
Foxboro	81 & 82 Series	Turbine	3/4"-8"	±.2%	±.1%
Leupold & Stevens	61	Open channel	Up to several hundred mgd		
Moore Products	14	Fluidic	Up to 950 gpm		±0.2%
Ramapo	Mark V	Impact (Target)	.1 gal/min, and up	0.5%	
Scarpa-Sonic	CFSM-5-RPS		0.005'-40'/sec		±1%
Wallace & Tiernan	1800 Series	Electromagnetic	Minimum 1500 gpm (14" thru 72")	±0.5%	±1.0%
Wallace & Tiernan	2800 Series	Electromagnetic		±1.0% FS	±0.25% FS

LIQUID-LEVEL DETECTORS

Manufacturer	Model	Type	Range	Accuracy	Repeatability
Arkon	G-3	Pressure sensor	Up to 500'		
Automation Products	CL-10RH Ser.	Pressure Indicator	-	-	-
Autocon	8200	Solid State	.1-23'	.5%	.5%
	1100	Pressure Sensor			
	1600	Bubbler			
	3400	Float (non-indicating)			
	3500	Float (indicating)			
Bindictator	GT-1	Pressure Sensor	3" & up	±1"	
	600 Series	Capacitance probe	0-200'		
	200 Series	Conductive probe	depends on material	±1%	
	700 Series	Capacitance (shield section on probe)	0-200'		
Climet	051-1	Float	0-1', 10', 20', 40', 75', 100'	.1%	

LIQUID-LEVEL DETECTORS (Cont)

Manufacturer	Model	Type	Range	Accuracy	Repeatability
Controlotron	Series 260	Capacitance	3" to 200'		
Controlotron	Series 270	Ultrasonic	1" up to 60"	1% nominal	Up to 0.05" for horizontal pipe
Controlotron	Series 290	Ultrasonic	2' to 300'	.5%	
Drexelbrook	508 Series	Radiofrequency-Oscillator Probe			
Fischer & Porter	10B Series	d/p cell Trans-mitters		±.5% of span	.1% of span
Fischer & Porter	13C 2260	Float	0-37'	±1/8"	
Foxboro	pneumatic (13 FA & 15 FA; electronic E17DM & E17DL)	d/p cell trans-mitters		±.5% of span	
Foxboro	B9284, B9593, E512, E510	Force-balance transmitters		±.5% of span	.1% of span
Honeywell	29 Series	Electronic & pneumatic		±.5% of full scale	.25% over 24 hrs.

LIQUID-LEVEL DETECTORS (Cont)

Manufacturer	Model	Type	Range	Accuracy	Repeatability
Magnetrol	TF Series	Float			
Manning	P-70015, P-70060, P-70120	Conductive probe	0-120"		
Moore	25C415, 27C415, 25C415C	Float or bubbler			
National Sonics	300 & 400	Ultrasonic			better than 0.002"
Robertshaw	305	Capacitance probe			

NITRATE ANALYZER

Manufacturer	Model	Method of Analysis	Range	Accuracy
Delta Scientific	Series 8038	Spectrophotometry	0-0.2 ppm	±2%
Enviro-Control	1049		0-10 mg/1 0-100 mg/1 0-1000 mg/1	±5% FS
Kent/EIL	8006	Ion-selective		
Orion	Series 1000		As low as 0.6 ppm	±5%
Technicon	Monitor IV	Spectrophotometry	0-0.2 mg/1, minimum	

OIL ANALYZER

Manufacturer	Model	Range	Accuracy	Linearity	Reproducibility
Bull & Roberts	240	Heavy oil: 0-50 ppm Light oil: 0-100 ppm	5% FS for standard applications		2%
Teledyne	661R 661C 660R 660C	Not given in literature received	±1%	±1% or better	Better than ±1%

ON-LINE RESPIROMETERS

Manufacturer	Model	Range	Accuracy	Repeatability	Response Time	Sample period	Sample Flowrate
Badger Meter	OD 200	No limit	-	Within 2%	Varies as to loading of sample	1/4, 1/2, & 4 hrs.	3 gpm
Robertshaw	970	0-100 ppm O_2/Hr; 0-200 ppm O_2/Hr	±5%	±2%	2 minutes	Continuous	1800 ml/min

ORP ANALYZER

Manufacturer	Model	Range	Accuracy	Repeat-ability	Response Time	Stability	Drift
American Limnetics	R20	1400 mV	3 mV			0.5 mV/24 hr period	
Aquatronics	725	-1400 to +1400 mV					
Acquatronics	710	-500 to +500 mV	±2% FS				
Beckman	940 941	Selectable span of 200, 500, or 1000 mV				±2 mV	
Delta Scientific	8012	-700 to +700 mV					
Delta Scientific	7012	-700 to +700 mV					
Foxboro	ORP	(Consult factory)	±1%	0.1% span	2.5 sec to 99% FS step change		±3 mV
Honeywell	552030	-600 to +600 mV; 0-1200 mV	±2 mV for ORP				
Hydrolab	6D	3 decades of activity (0 to +1000 mV) (0 to -1000 mV)	±5% mV for ORP				
Kernco	KR-8	0-±700 mV	±5 mV				
Leeds & Northrup	7070-03	0-±1000 mV Redox Monitor	±1% at recorder terminals; ±2% at meter		1 second	0.06 mV/wk	
Ohmart	1-1000-20R	-600 to +600 mV; 0-1200 mV	±1% FS		63% of reading in 24 sec max.; 99% of reading in 2 min max.	Over 4-wk period: ±1% FS, incl. sen-scr' ±.5% FS, sig. cond. only	
Raytheon	1408	-500 mV to +500 mV; 0-1000 mV	±1% FS				Not to exceed 0.5% of FS
Uni-Loc	1022	-100 to +100 mV; -250 to +250 mV; -500 to +500 mV; -750 to +750 mV; -2000 to +2000 mV	±1.2 mV			6.0 mV	
Wallace and Tiernan	81-035	0-1000 mV	5% of FS	0.1 mV	Instantaneous		

OZONE ANALYZER

Manufacturer	Model	Range	Accuracy	Response Time	Sensitivity
Delta Scientific	8040	0 to 2.4 ppm	Inherent accuracy of the instrument is ±2% FS	The major influences on response time are reagent consumption rate and sample flow rate	0.7%
Fischer & Porter	17L1000	0-1 ppm, standard			As low as 0.01 ppm
Mast/Keystone	724-2M	0-100 ppm, based on volume (not weight)		75% of true value	±1 ppm up to conc. of 50 ppm; ±2 ppm above conc. of 50 ppm
Meloy	OA 310 OA 325 OA 350	0 to 0.01 ppm 0 to 0.1 ppm 0 to 0.5 ppm 0 to 1.0 ppm 0 to 5.0 ppm 0 to 10.0 ppm	±2%	Less than 5 sec	0.001 ppm

pH ANALYZER

Manufacturer	Model	Range	Accuracy	Response Time	Stability	Drift
American Limnetics	20	0-14 pH, or any increment therein	0.1 pH		0.03 pH units/24-hr period	
Acquatronics	110	1-13 pH	±2% FS	Operates continuously for 30 days		
Beckman	940 & 941	Selectable span of any 2, 5, or 10 pH. Lower units, 0-2.			±0.02 pH units/24-hr period	
Chemtrix Digital	60	0-14 pH	0.01 pH			
Delta Scientific	8012	0-14; 3-11 pH	To 0.1 pH			
Enviro-Control	1001	0-10, 2-12, 4-14 pH units; ±0.01 pH			0.005 pH units/24 hrs	
Foxboro		0-14 pH	0.25% at base temperature; 0.5% FS			
Great Lakes		0-14 pH		0.1 or 1.0 seconds		
Honeywell	552026, 552027, 552126	0-14, 2-12 pH, 1-5 Vdc 0-5 and 0-10 Vdc outputs	±0.02 pH	2.5 seconds to 99% FS step change		±0.05 pH
Hydrolab	6D	2-12 pH	±0.05 pH	10 sec for step change in pH, 20 sec for step change in temperature		
Interocean	500	1-14 pH	±0.1 pH			

pH ANALYZER (Cont)

Manufacturer	Model	Range	Accuracy	Response Time	Stability	Drift
Kent Cambridge	2836	Any 2, 5, or 10 pH units in the range of 0-14 pH	Better than 5% FS		Drift at constant temperature less than 0.02 pH/wk. Change with temperature less than 0.03 pH/10°C.	
Kernco	SR-15	2-12 pH 4.5-9.5pH	0.1 pH for 2-12 pH range; 0.05 pH for 4.5-9.5 pH range			
Leeds & Northrup	7075	0-14 pH		1 second	0.001 pH units/wk	
Ohmart	1-1000-2pH	0-12 pH	±1% FS		±1% FS over 4-week period	
Raytheon		0-10 pH 2-12 pH	1% FS			0.5% FS over a 4-week period
Robertshaw		0-14 pH	±0.02 pH			
Uni-Loc	1002		±0.02 pH		0.1 pH units per year including electrodes, except on streams which coat or etch glass	
Wallace & Tiernan	81-035	0-14 pH	0.5% FS			

PHOSPHATE ANALYZER

Manufacturer	Model	Range	Accuracy	Response Time
Delta Scientific	8042 (ortho) 8043 (total)	0–2 ppm	±2%	5 min
Hach	CR2 Series (ortho)	0–2, 0–10, 0–30 ppm		20 min to equilibrium
Ionics	1836	0–20 ppm		12 min
Raytheon	2512 (ortho)	0–12 ppm, 0–20 ppm	±5%	12 min
Technicon	Monitor IV (ortho or total)	0–50 ppm total 0–10 ortho		
Uni-Loc	1203 (total)	0–6 ppm, 0–30 ppm		

RESIDUAL CHLORINE ANALYZER

Manufacturer	Model	Range	Response Time	Type of Measurement	Sensitivity	Reagents
Delta Scientific	Series 8025	Most generally used range is 0-1 ppm	For standard conditions a chlorine change can be detected in 1 minute		Sensitivity is better than 0.7%	
Fischer & Porter	17S2210 17S2000	0-0.5, 0-1, 0-2, 0-3, 0-5, 0-10, 0-20 ppm		Amperometric	As low as .01 ppm	Sodium acetate and acetic acid used as buffer solution. Approximate usage 1.8 liters per 3-day operation
Hach	2111	0-3 ppm or 0-10 ppm	1 min to detect a change in chlorine, 20 min to reach equilibrium			
Honeywell	19S-872	0-1, 0-2, 0-3, 0-5, 0-10, 0-20 ppm	Time lag between analyzer inlet and measurement: 4 sec. Measurement is continuous and instantaneous		0.01 ppm	
Wallace & Tiernan	Residual chlorine analyzer		Registers a residual change within 10 sec after sample enters instrument	Amperometric	0.1 mg/l ; if sample is diluted, up to 0.03 mg/l	Buffer & acid solutions, 1 gallon every 3-4 weeks

SLUDGE DENSITY METER

Manufacturer	Model	Type	Range	Accuracy	Repeatability	Response Time
Biospherics	52H	Photo-electric Cell	0-10% solids	(Varies with solids concen.)		
Kay-Ray	3500A	Nuclear	0-10% standard	.2% solids		30 seconds
National Sonics	494T	Ultrasonic	1 to 5.5% solids		within .5%	10 seconds
Nuclear Chicago	Submersible density probe	Nuclear	Up to 3 SGU*	better than 2.5% of FS		
Ohmart	EDS ECS	Nuclear	0-10% solids standard	±1% of FS	±1% of FS	30 sec
Robertshaw	172	Nuclear	0.2 to 2 SGU*	±2% of FS		2 to 200 sec

*SGU (Specific Gravity Units)

SLUDGE LEVEL DETECTOR

Manufacturer	Model	Type	Range	Accuracy	Repeatability	Response Time
Kay-Ray		Nuclear	0-10%	0.1% for a span of 0-6% solids		
Keene	8100	Optical	200-5,000 ppm	±1/2"	±1/2"	50 seconds (adjustable)
National Sonics	494T	Ultrasonic	1-5.5% solids		within .5%	10 seconds

SUSPENDED SOLIDS METER

Manufacturer	Model	Ranges	Accuracy	Repeatability	Response Time	Accuracy
Anacon	17					
Audin Corporation	S-5	0 to 1%	2% of FS		As low as 1 sec FS	
Biospherics	51L-52L	0 up to 10,000 ppm (51L-52L) 0 up to 1,000 (53-54)		±1%	1 minute	
Enviro-Control	1003	25,250 & 1000 mg/l equivalent Formazin. Front-panel range-switch. Other ranges available on request	2% of FS			
Gam Rad, Inc.	150	1. 10-5000 ppm silica scale, 2. 5000-50,000 ppm silica scale 3. 50,000-150,000 ppm silica scale		±1% of indicated value		±2% of indicated value for range 1 ±5% of indicated value for range 2 ±10% of indicated value for range 3
Keene Corporation	8200	500-5,000 ppm	±5% of indicated value	±3% of indicated value	10 seconds	Up to 10 ppm
Monitek	LT-210/ 130	.1 ppm-1000 ppm	±1% FS		.001 sec	.001 ppm

TEMPERATURE ANALYZER

Manufacturer	Model	Type	Range	Accuracy
American Limnetics	Not stated	Linear thermistor	0-50°C	±.10°C
Ametek	Series 8000	Liquid-vapor	20°F to 450°F, standard.	
Acquatronics	425	Thermocouple or platinum resistance thermometer	Customer specification	±.1%
Astro Systems		Thermocouple	-200°F to +3000°F	.1% of FS
Ecologic	400-11	Passivated semiconductor		±1°F, Standard
Enviro-Control	1009	Platinum resistence sensor	0-50°C	±1% of FS
Fisher & Porter Foxboro Honeywell	Manufacture a full line of temperature instruments of the mechanical and electrical types generally covering ranges from -268°C to 1540°C			A function of span setting and sensing element generally of the order of ±0.5% of span (i.e., FS)

TEMPERATURE ANALYZER (Cont)

Manufacturer	Model	Type	Range	Accuracy
Hydrolab	6D	Thermistor	$5^{o}C$ to $45^{o}C$	$\pm.25^{o}C$
Ionics	1131	Thermistor	0^{o}-$50^{o}C$	$\pm.5^{o}C$
Ohmart	1-1000-2 TP	Thermistor	0^{o}-$120^{o}F$	$\pm1\%$ of FS
Raytheon	2401	Thermistor	0^{o}-$50^{o}C$	$\pm.3^{o}C$
Rosemount Nashville, Inc.	Series 3000 A, lab analyzers only	Platinum resistance sensor	0^{o}-$250^{o}F$	$\pm1\%$ of FS
Weston & Stack	3500	Thermistor	0^{o}-$50^{o}C$	$\pm1\%$ of FS

TOC, TOD and COD Instruments

Manufacturer	Model	Range	Repeatability	Accuracy	Duration of Analysis
Astro Ecology	1000 TOC	0-5000 ppm			
Calibrated Instruments	Hydromat TOC	0-500 mg/l		Approximately 2%	20 min.
Calibrated Instruments	Hydromat COD	0-1,000 mg/l		Approximately 2%	20 min.
Delta Scientific	8055 TOC	0 to 10, 0 to 500, and 0 to 5000 mg/l	±2% of FS	±2% of FS	5 min.
Enviro-Control	3024 TOD	0 to 4,000 mg/l	±2%		
Ionics	1236 TOD	0-25 ppm, 0 to 10,000 ppm	±2% on high range ±8% on low range		
Ionics	335 TOC	0-250 ppm, 0-1000 ppm			20 min.
Ionics	335 COD	0-250 ppm, 0-1000 ppm	+3% of range		20 min.

TURBIDITY METER

Manufacturer	Model	Range	Accuracy	Response Time	Sensitivity
Anacon	17				
Aquatronics	625				
Biospherics	CLAM 53 & 54	0 to 1,000 JTU			
Enviro-Control	1004	Up to 500 JTU			
Fischer & Porter	17UC1000	0 to 500 JTU			
Gam Rad	260 & 270	0 to as high as 150,000 ppm			From 2% to 10%, depending on range desired
Hach		Up to 0-1,000 FTU		30 seconds	1% of FS
Hadron		0 to 10,000 JTU			
Honeywell	552201	Multiple ranges		3.5 sec. to reach 99% of ultimate reading	
Interocean	500 CSTD/ 02pHT	0-200 JTU			
Jacoby Tarbox	3	0 to 1000 ppm			
Monitek	Series 500 Model 350	0-500 Series 500 (Standard) 0-1000 Model 300 (Standard)			±.05 JTU
Ohmart	1-1000 JTU 2 TB	0 to 2,400 JTU		2 min to reach 99% of ultimate reading	
Photronic	200				
Raytheon	2404	0-100 FTU 0-1,000 FTU	±2.5% of FS or 0-100 FTU. ±2.0% of FS, or 0-1,000 FTU.		

APPENDIX C

PLANT SURVEY DATA AND INSTRUMENTATION SCHEMATIC DIAGRAMS

Form approved
OMB No 158-S72006

GENERAL SURVEY QUESTIONNAIRE

STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address A-1

Responsible Supervisor

Flow Rate Design (Average and Maximum) 23-25 mgd (85 mgd by-passed)

Storm Water Collection and Treatment None (Sanitary sewage plus infiltration)

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Primary

Performance Data (Individual Units and Overall)

Year Built 1966 Modifications (Year and Description) Extensive process improvements by operating dept.

Original Cost $5M Modification Cost

Instrumentation Minimal, much abandoned after plant start-up

Equipment Mag. Flow, sludge density

Panels Local

Installation and Start up Costs Original Cost Total Cost

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total

Computer None

Type Manufacturer I/O Devices

Process Control

Data Logging

Parameter/Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control None Inst. air from plant air compressor

Supervisory Control No

Alarm and Safety Systems Local

Automatic Emergency Program (e g , Power Failure) Standby Diesels

Maintenance and Calibration

Special Equipment By city, off-site Down Time None

Special Operator Training None Frequency (no mo)

Total In-Plant Man Hours/Year

Total Cost of Outside Service

Estimate of Over-all Benefits of Instrumentation and Automation
Typical wet-well level control and burner controls are indispensible.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Frequency (no/mo)	Total Downtime	Downtime Frequency (no/mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Sludge Density	Ohmart			None	MTBF* 3 Weeks	None	No	Slow and Expensive	1 (Est.)			Hostile atmosphere	Good			Poor resistance to corrosive atmosphere and expensive, slow maintenance caused inst. to be abandoned. Operators had gained process experience; inst. less necessary to operation.
Raw Sewage Flow	1 - Foxboro 1 - Fischer & Porter Magnetic			None	--	None	No	None	--	None	--	None	Est 2%			
	Installation at Pumping Station															
Residual Chlorine	Wallace & Tiernan A780021 PP2438	A792021 NN25789		Only after Failure	--	None	--	--	--			Sample pump and no maintenance			Remote Recorder	Analyzer, part of a demonstration hypochlorination system at Drain Water Pumping Station, abandoned for lack of maint. funds Sample pump often failed.

* Corrosion, fouling, etc

** Limiters, alarms, ratio relays

*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							Comments
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min.)	Manpower (mh/yr)	Utility (kW hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min, max (mg/l)	Maintenance & Calibration by In-Plant Personnel ($ or mh/yr)	Maintenance Frequency (no. mo.)	Special Training	Service by Contract ($ or mh yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no. mo.)	
LS - 2	Wet Well Level	1	Proportional (Stepwise)	Bubbler & Step switches	Pneumatic, Electric	Wound rotor var. speed pump	0.4													Bubbler pipe co-rosion (external) from ozone; high maint. of microswitches in G.E. control console.

* Control mode relay, proportional, proportional plus reset, etc

** Types of controllers analog (pne., hyd or elec media), computer (supervisory, direct digital or set analog)

*** Final control element: pne values, variable speed pump, etc

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address A-2

Responsible Supervisor

Flow Rate Design (Average and Maximum) 60 mgd design, 30 avg., 120 mgd peak

Storm Water Collection and Treatment Only by way of regulators and interceptors

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Primary, with sterilization and sludge digestion.

Performance Data (Individual Units and Overall) BOD 54% removal Note: Local lime plant also drains to plant, improves efficiency.
SS 76% removal

Year Built 1968 Modifications (Year and Description) 1973 - Secondary

Original Cost $7m Modification Cost $25m.

Instrumentation Honeywell, W & T, F & P

Equipment Flow and chlorination, sludge solids, etc.

Panels Large semi-graphic display, central control console

Installation and Start up Costs Equip. - $200K Original Cost Total Cost

Instrumentation Modification Minor

Description	Year	Equipment	Panels	I & S	Total

Computer No
Type Manufacturer I/O Devices

Process Control

Data Logging

Parameter Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control Yes

Supervisory Control Yes

Alarm and Safety Systems Yes

Automatic Emergency Program (e.g., Power Failure) Standby generator handles entire plant.

Maintenance and Calibration Inst. Shop.

Special Equipment Pneu. loop checker, manometers, standard mv source, VOM, mag. meter checker Down Time None

Special Operator Training Frequency (no./mo.)
Inst. man is tech. school graduate w/experience.

Total In Plant Man Hours Year 2100

Total Cost of Outside Service None (Warrantee service where required).

Estimate of Over all Benefits of Instrumentation and Automation
Reduced cost in the areas of chlorine addition, sludge pumping and manpower.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no/mo)	Total Downtime	Downtime Frequency (no/mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Gas Flow	Hagen Ring-Balance			40	6	None	No	No	--	None	--	Wet Gas	Good	Integrator	Yes	Well maintained, good service. (Six meters, 2 years). Sensing lines drained often, manually.
Raw Sewage Flow	F & P (42" magnetic)			20	1	None	No	No	--	None	--	Electrode Fouling	+5%	Integrator	Yes	Mech. balance servo is obsolete. Electrodes show high impedence, scaling, are inaccessible.
Chlorine Residual	Wallace & Tiernan	A792011 LL382		300	30	None	No	No	--	Little or None	1	Rea. Pumps; Sample dirt	+5%	Sample System	Yes	Records and controls. Checked by titration every other hour. Drifts due to probe fouling. Reagent handling and corrosion are problems. (W & T Titrator A790012)
ORP	Wallace & Tiernan	A774012-KK24636		100	30	None	No	No	--	Little or None	Unknown	Maintenance Sample dirt	+20% but responsive	Sample System	Yes	Demonstration unit proved that ORP could be used to indicate over and under chlorine dosage, approximately, but inst. maint. (esp. cell filling) excessive and awkward.
Chlorine Gas	Wallace & Tiernan (Solvay optical type)	A689012-KK26768		40	30	None	No	No	--	Little or None	--	Moisture, Weak Blower	Quite Sensitive	No	No	Instrument susceptible to sample moisture; air mover too weak to permit desiccants in line. Good but takes daily attention.
Chlorine Flow	Wallace & Tiernan	A766082-KK28003		6	0.5	None	No	No	--	None	--	None	+2%		Remote	LVDT type transmitter in conventional chlorinator to local retransmitter.
Sludge Density	Nuclear Chicago, and Qualicon	506, and Mod. 5302		150	15	1 week	No	No	--	2 days/yr	0.1	Electronics	+2% Before Drift	Convert. & Transmit.	Remote	Continual drift, non-conventional electronics, long repair times. Otherwise, good. Uses source decay timer.

* Corrosion, fouling, etc

** Limiters, alarms, ratio relays.

*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

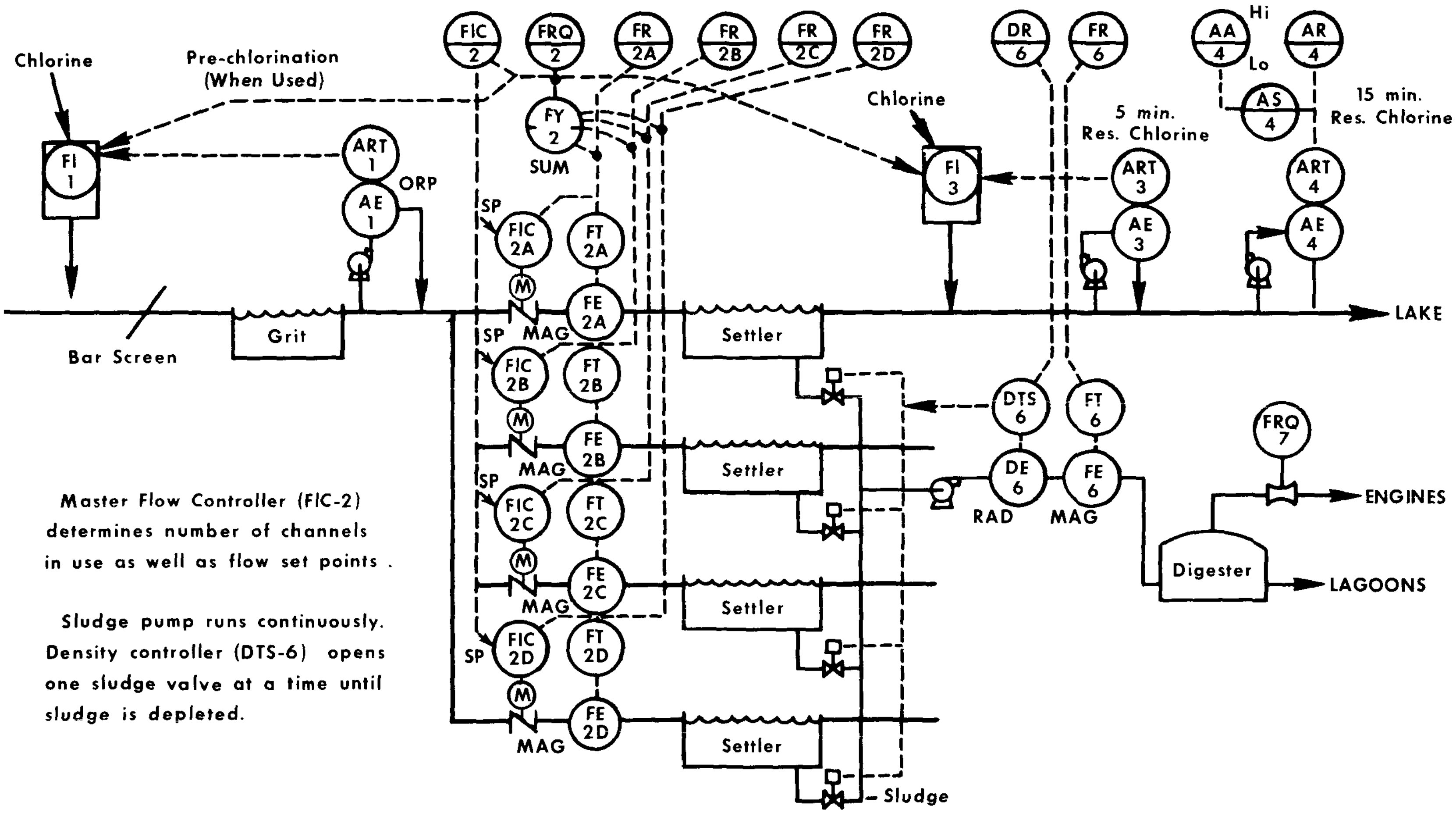
Control Techniques								Benefits					Operating Experience							Comments
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Percent of Variance min max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no/mo)	
AE-3, 4	Chlorine Residual	2	On-Off, 15 min. period	Relay	Electric	V-notch Valve	15 min.	None	None	300,000 lb. Chlorine, Total	No	Maintains 0.4 – [illegible]	450 mh	30	No	No	No	None	--	[illegible] because of standby units and continuing maintenance

* Control mode relay, proportional, proportional plus reset etc

** Types of controllers analog (pne, hyd or elec media), computer (supervisory direct digital or set analog)

*** Final control element pne values, variable speed pump, etc

FIGURE A-2



Master Flow Controller (FIC-2) determines number of channels in use as well as flow set points .

Sludge pump runs continuously. Density controller (DTS-6) opens one sludge valve at a time until sludge is depleted.

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address A-3

Responsible Supervisor

Flow Rate Design (Average and Maximum) 50 mgd (Ave.) 170 mgd (Max.)

Storm Water Collection and Treatment Combined Sewer System

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Primary, with Chemical Precipitation (Seasonal - Lime and Ferric sulfate)

Performance Data (Individual Units and Overall)
55% S.S. 25% BOD Removal (using Polymers)

Year Built 1959

Modifications (Year and Description) 1963 Abandoned lime and ferric sulfate and substituted polymer shortly after plant started.

Original Cost $11.3m (Bond Issue)

Modification Cost

Instrumentation

Equipment Penn, Foxboro, Bristol, Bailey

Panels Foxboro

Installation and Start up Costs Original Cost Total Cost

Instrumentation Modification (Some Abandoned)

Description	Year	Equipment	Panels	I & S	Total
Analyzer	Installed 1959	GasAnalyzer (MSA) and Bristol Recorder			
Foxboro Mag Meter					
Foxboro Pneumatic Flow Transmitter - (Abandoned later)					

Computer None

Type Manufacturer I/O Devices

Process Control

Data Logging

Parameter Frequency	Parameter Frequency	Parameter Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control Yes

Supervisory Control No

Alarm and Safety Systems Orig. plant had digester shut down on dangerous gas level (MSA). Multiple alarms from Remote Installation (Audio Tone Tel)

Automatic Emergency Program (e g , Power Failure) Lighting Generators start on power failure

Maintenance and Calibration

Special Equipment

Down Time 6 weeks since 1960 (single occurrence due to gas analyzers)

Special Operator Training One man (Bristol, 2 wks)

Frequency (no /mo)

Total In-Plant Man Hours/Year 16, over 10 years

Total Cost of Outside Service Service - $175; parts - $180 ($35.50/yr). (Purge systems for influent flowmeters).

Estimate of Over all Benefits of Instrumentation and Automation

Reduction of manpower requirements on pumping station operation. Other instrumentation largely made superfluous by gross flow increase and process changes.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In Plant Maintenance (mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no./mo.)	Total Downtime	Downtime Frequency (no./mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Lower Explosive Limit (XT-7A,B,C.)	Mine Safety Appliance Co.	Type EX-SMT Serial No. 189798-99		High	4 ea.	Bristol School (1 wk)	No	No	-	Frequent. See below	-	See Comments	-	-		Unit responds to hydrocarbons in sewage and thereby gives a false signal of Lower Explosive Level. Some interference from local radio transmitters. Sample filter plugs in 7 to 10 days from particulates in atmosphere - Unit Abandoned.
Lower Explosive Limit (XT-8)	Davis Instruments	1-3640-1C Special		High	4	Bristol School (1 wk)	No	No	-	Frequent. See below	-	See Comments	-	-		Some experience - also abandoned.
Sludge flow FT-7,8	Foxboro (magnetic)			High	Often	None	No	No	-	Frequent. See below		Installation and Maintenance	Unknown		Yes	System abandoned shortly after start-up due to plugging and other high maintenance problems. Sludge velocity was insufficient to keep meter scoured.
Influent Flow (FT-1,2)	Penn (Electric dP Trans.) (mercury)			16	0.2	None	No	Not over $40/yr in 10 years	.01	None	-	Purges were installed	Unknown	Summer-integrator	Yes	System has run many years with little or no maintenance or calibration. Accuracy unknown.

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW hr yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min max (mg/l)	Maintenance & Calibration by In-Plant Personnel ($ or mh yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no/mo)	Comments
XT-7A, 7B, 7C XT-8	Explosion meters	4	On-off	Relay	Electric	Alarm	0.1						Too high	Too often	No	No	No	-	-	Abandoned because of maintenance problems and because erratic action tripped alarms and actuated automatic shut-down circuits. See inst. tabulation.
LT-10	Wet Well level	1	Proportional (when in use)	Analog (Bailey-meter)	Pneu. piston and switches	Wound rotor V.S. motor	1					Reduce upsets	100 mh/yr (unaccept-able)	4 (unaccept-able)	No	No	No	-	-	Maintenance and parts (for wear of) cams and switches unacceptable to plant personnel. Control now manual only.
FT-1B FT-2B	Chemical Feeders	2	Proportional	Built-in	Electro-mech.	Chem. Feeder	0.5			Est. 20%		Potential improvement	Undetermined	Undetermined	No	No	No	-	-	Chemical feeding abandoned before instru. service history was established. (Three transmitters operating off each venturi)

* Control mode relay, proportional, proportional plus reset etc
** Types of controllers analog (pne hyd or elec media), computer (supervisory direct digital or set analog)
*** Final control element pne values, variable speed pump, etc

FIGURE A-3. (WET WEATHER TREATMENT PLANT)

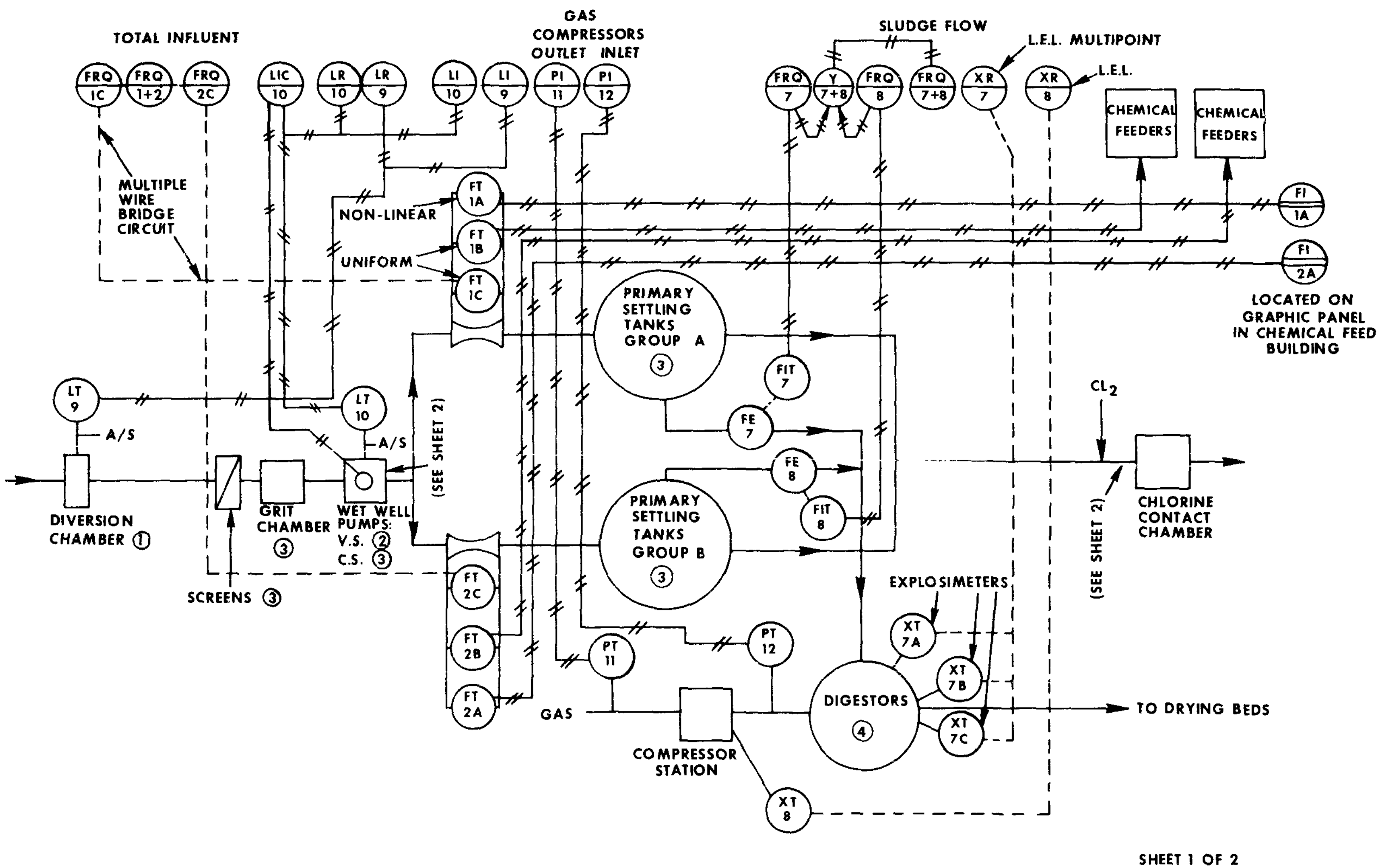
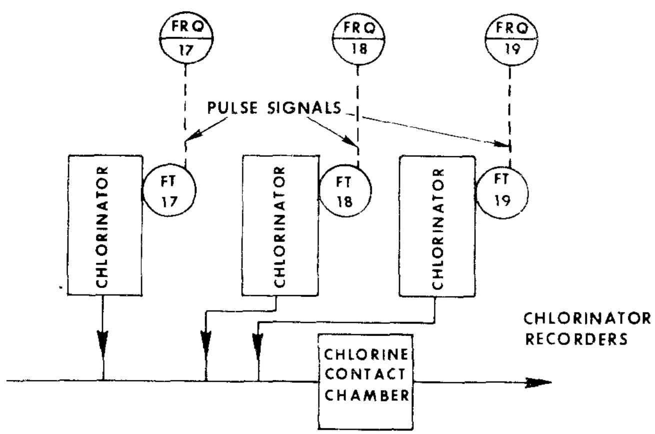
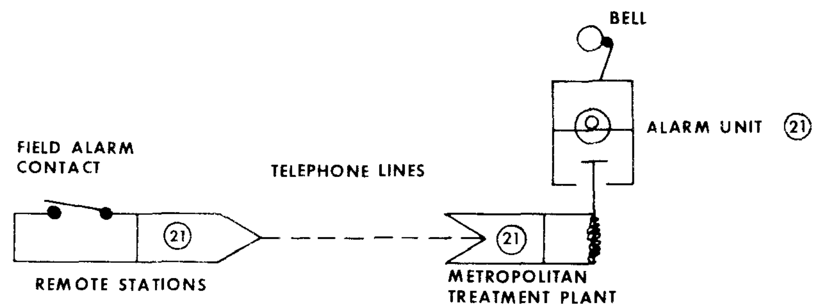


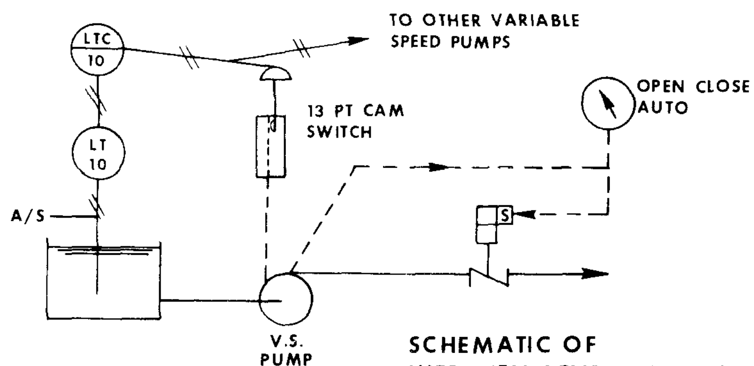
FIGURE A-3. (WET WEATHER TREATMENT PLANT)

FRQ s LOCATED ON GRAPHIC PANEL IN CHEMICAL FEED BLDG.





TYPICAL TELEMETERED ALARM



SCHEMATIC OF
WET WELL LEVEL CONTROL

SHEET 2 OF 2

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address A-4

Responsible Supervisor

Flow Rate Design (Average and Maximum) 300 mgd - maximum hydraulic capacity
88 mgd - present average
100 mgd - design average

Storm Water Collection and Treatment.
The system contains about 80% combined sewers

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)

Primary treatment plant with sludge digestion

Performance Data (Individual Units and Overall)
31% - overall BOD removal
59% - overall suspended solids removal

Year Built 1951 and 1969

Modifications (Year and Description) 1961 - Chlorination Facilities installed
1973 - Secondary Treatment Facilities under construction

Original Cost $957,000

Modification Cost 1961 - $91,000
1973 - $16,190,000

Instrumentation

Equipment Mostly electrical, some pneumatic

Panels. No central control panel except for total flow and clock in administration building.
Local control panels in screen house, sludge transfer building, sludge digestion building, chlorination building.

Installation and Start up Costs Original 1951 costs not available - Part of lump sum cost

Original Cost

Total Cost

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
Sludge Density Meters for thickened sludge	1970	Installed slide gates and drilled holes to facilitate cleaning of thickened sludge from meters			
Sludge Density Meters for preheated sludge	1970	Abandoned their use and operate without them on preheated sludge			
Sludge Mass Recorder for preheated sludge	1970	Abandoned its use and operate without it			
Sewage and Sludge Metering	1969	$29,000			

Computer

Type None

Manufacturer

I/O Devices

Process Control

Data Logging

Parameter Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost

Software Cost

Installation Cost

Central Control

Supervisory Control None

Alarm and Safety Systems Yes

Automatic Emergency Program (e g Power Failure) Portable equipment to generate power can be brought in; flow continues by gravity through treatment plant in case of power failure.

Maintenance and Calibration

Special Equipment Electrical equipment; electricians maintain instruments

Down Time No plant downtime due to instrument downtime.

Special Operator Training Some training for preventive maintenance in plant.

Frequency (no mo)

Total In-Plant Man Hours Year 20 man-hours/year except for sludge density meters which require about 1100 man-hours/year.

Total Cost of Outside Service None

Estimate of Over all Benefits of Instrumentation and Automation

If sludge density meters worked properly, plant personnel would be pleased with instrumentation and automation of primary treatment plant. Instrumentation and automation are essential to the plant's operation.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In Plant Maintenance (mh/yr)	Maintenance Frequency (no./yr)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no./mo.)	Total Downtime	Downtime Frequency (no./mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Thickened Sludge Density	DeZurik	Ident. No.: 400244-H5 Wo. #244466 Type: 5 Frame: 258 Hp: 1/2 volts: 220/440. RPM: 1725 Code: K.	$7,000 (1968) for entire system, thickened and preheated sludge density & flow metering. $13,000 for recording & control equip.	1095 mh/yr	90	None	None	None	None	No downtime on operation. Switch to other unit during cleaning	Switch to other unit 0.90 times per month - no downtime.	Grease & stringy material hang up and give distorted readings unless cleaned frequently.	O.K. when cleaned.	Alarms, controller for sludge pumps.	30-day strip-chart	Due to frequent maintenance requirements, the meter is unsatisfactory for controlling sludge pumps and for recording and indicating sludge consistency. The installation was modified to facilitate frequent cleaning by installing slide gate on each side of the density meter to shut off flow and by drilling an opening on one side so that the disk could be cleaned by removing cleanout plate rather than removing the entire instrument. Fiberglass coated sensor.
Preheated Sludge Density	DeZurik	Same equip. as for thickened sludge density		1095 mh: Abandoned	90, Abandoned	None	None	None	None	None; Its use abandoned	None Its use abandoned	Same problems as with thickened sludge	O.K. when cleaned	Alarms, integrator-totalizer to determine mass.	30-day strip chart	Preheated sludge density meters were not intended for control of preheated sludge pumps but are merely to record density and mass of preheated sludge to digestors. The contractor and the manufacturer could never get this equipment to work properly to record mass from flow and density. The absence of mass and density of sludge to digestors is not critical to operation.
Preheated Sludge Flow	Brooks Instrument Co. 4" Magnetic Sludge Flow-Meter with Teflon Liner & Stainless Steel Electrodes	7104-811H		Abandoned; High Maint.	Abandoned; High Freq. of Maint.	None	None	None	None	None; Its use abandoned	None Its use abandoned	Could not get auxiliary mass recorder to work.	Couldn't get it to work accurately	Alarms, integrates flow to totalizer.	30-day strip chart	The use of meter was abandoned because they could never get it to work properly because of fouling of electrodes. Frequent cleaning required. Gave up also because of transmission problems, and combining with density meter to obtain mass was a problem.
Sludge Flow	4 Parshall Flumes. Hershey-Sparling Float and Cable	261P Serial 15753	$9,000 (1968) For entire system	None	None	None	None	None	0.03	3 weeks once in 3 years	0.3	Totalizer didn't work once in 3 years was repaired under warranty.	O.K.	Summer-Totalizers	30-day strip chart	The equipment is satisfactory.

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

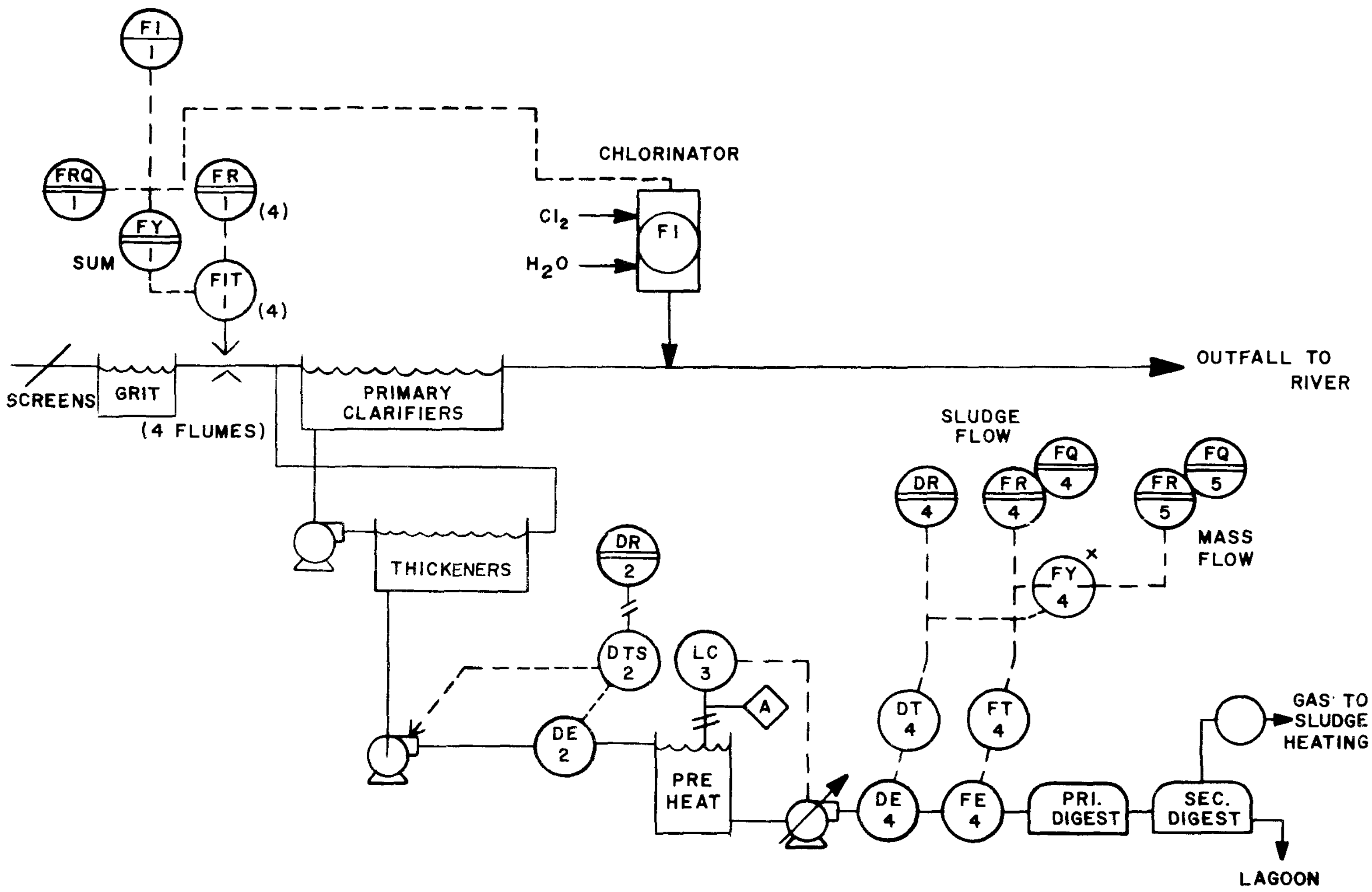
Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW-hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min max (mg/l)	Maintenance & Calibration by In-Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no/mo)	Comments
DE-2	Thickened Sludge Pumping	2	On-off	Set-time interval to turn on pumps. Set point on value of sludge density to turn off pumps.	Electric	Thickened sludge pump	10		Minor	Minor	None	Good control to avoid pumping thin sludge	1095 mh/yr.	90 times/month	None	None	None	None; switch to second unit	None. switch to second unit	Due to excessively frequent cleaning requirements for sensor disk, this method of operation for controlling sludge pumping from thickeners (and recording and indicating sludge consistency) is unsatisfactory. Savings in manpower for operation of pumps are nullified by manpower for maintenance.
LC-3	Preheated Sludge Pumping	2	Proportional	Level control of pumps. Bubbler system for levels; Brooks Instrument Div. of Emerson Electric Co. Sho-Rate	Pneumatic	Variable speed pump	0.16		None	None	None	None	None	None	None	None	None	None	None	This system is working satisfactorily.

* Control mode relay, proportional, proportional plus reset, etc

** Types of controllers. analog (pne., hyd. or elec media), computer (supervisory, direct digital or set analog)

*** Final control element pne values, variable speed pump, etc

FIGURE A-4



FI 1
FRQ 1
FR 1
(4)
FY 1
SUM
FIT 1
(4)
CHLORINATOR
Cl2
H2O
FI
SCREENS
GRIT
(4 FLUMES)
PRIMARY CLARIFIERS
OUTFALL TO RIVER
THICKENERS
DR 2
DTS 2
DE 2
LC 3
A
PRE HEAT
SLUDGE FLOW
DR 4
FR 4
FQ 4
FR 5
FQ 5
MASS FLOW
FY 4
x
DT 4
FT 4
DE 4
FE 4
PRI. DIGEST
SEC. DIGEST
GAS TO SLUDGE HEATING
LAGOON

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address A-5

Responsible Supervisor

Flow Rate Design (Average and Maximum)
Design Average ~ 125 mgd   Max. Hydraulic Capacity ~ 350 mgd.
Present Average ~ 95 mgd

Storm Water Collection and Treatment
70% Combined   30% separate with high infiltration

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)

Primary treatment plant with sludge digestion.

Performance Data (Individual Units and Overall)
35 - 40% BOD removal
65 - 70% Suspended solids removal

Year Built 1966

Modifications (Year and Description)
Centrifuges added - 1971
Vacuum filters added - 1973
Flash mixers and post chlorination added - 1973

Original Cost $11.9 million

Modification Cost $2.2 million for above modifications.

Instrumentation

Equipment Pneumatic, electronic, mechanical

Panels. One central control panel; local control panels at clarifiers, digestors, effluent pumps, centrifuges, process water pumps and chlorination.

Installation and Start up Costs **Original Cost** **Total Cost**

Foxboro Company	$330,000
Minneapolis Honeywell	$259,000
Taylor Instruments	$284,000

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
Effluent Pump Control	1969	Changed pneumatic Honeywell System to electronic Foxboro (Part of general policy to convert pumping stations to electronic in conjunction with CATAD System electronics even though pneumatic systems were satisfactory).			$1,000 +

Computer Type Sigma II Computer located in Metro office building as part of CATAD System*

Manufacturer Xerox Data Systems

I O Devices Telemetry with Philco-Ford system between computer in Metro office building and printer (with keyboard input and display) at West Point Plant.

Process Control No direct process control. (Manual control with readout on printer of alarms, operating data, and quality data from treatment plants, pumping stations and regulator stations).

Data Logging Data logging of alarms, operating data and quality data of various locations.

Parameter Frequency	Parameter Frequency	Parameter Frequency	Parameter Frequency
Alarm Functions: once every hour	Operating Data: Date, time, where, what levels, flows, Set points, etc. Frequency varies.	Quality Data: Date, time, where, what temperature, D.O , etc. Frequency varies.	*Computer-Augmented Treatment and Disposal System.

Storage Part of CATAD System.

Software Description Part of CATAD System

Computer Cost Part of CATAD **Software Cost** Part of CATAD **Installation Cost** Part of CATAD*
West Point Terminal - $25,090 (1972) Cathode Tube Display Unit - $13,715 (1972)

Central Control

Supervisory Control No

Alarm and Safety Systems Yes

Automatic Emergency Program (e g , Power Failure) Automatic start for 3 emergency generators.

Maintenance and Calibration

Special Equipment
Digital Multimeter - Weston Model 1240, Density shims
Wallace & Tiernan Test Kit for Pneumatic Calibration WAA 650100;
Foxboro, & Fischer and Porter Calibration boxes for magnetic meters; Wheatstone bridges; manometers; oscilloscope.

Down Time No major instrument downtime causing plant downtime.

Special Operator Training
No special training. 5 instrument specialists and 3 electrical specialists maintain this plant and other plants and pump stations.

Frequency (no mo) None

Total In-Plant Man Hours Year
1600 for instrument maintenance and repairs.
800 for instrument preventive maintenance and calibration.

Total Cost of Outside Service None

Estimate of Over all Benefits of Instrumentation and Automation
Without use of instrumentation, the required number of plant personnel would increase and plant efficiency would go down to a level where the plant would become inoperable.

INSTRUMENT SURVEY FORM

Instrument: Parameter	Instrument: Manufacturer	Instrument: Model Number	Instrument: Equipment Cost	Operating Experience: In-Plant Maintenance (mh/yr)	Operating Experience: Maintenance Frequency (no./mo.)	Operating Experience: Special Training	Operating Experience: Service by Contract ($ or mh/yr)	Operating Experience: On Demand Service ($ or mh/yr)	Operating Experience: Frequency (no./mo.)	Operating Experience: Total Downtime	Operating Experience: Downtime Frequency (no./mo.)	Operating Experience: Problems*	Operating Experience: Accuracy	Peripheral Equipment: Auxiliary Devices**	Peripheral Equipment: Recording Devices***	Comments
Raw Sewage Flow	Hersey-Sparling Propeller Meter	Type 906 120" meter 40-400 mgd		15	1	None	None	None	None	None	None	Requires lubrication once per month.	Good	Converter, Integrator, alarms, automatic samplers	Central Control Panel	The meter is working well.
Raw Sludge Flow	Fischer & Porter Magnetic Meter	10D1418A 3" meter 200 gpm		400 mh before abandonment	Abandoned	None	None	None	None	Used to be down for cleaning	Used to be 2 times per month for cleaning	Grease build up on electrodes required frequent cleaning.	Very poor due to grease build up	Converters, alarms	Primary clarifier control panel	The meters are not satisfactory and were abandoned. The operators tried for 3 years to get them to operate satisfactorily. Tried cleaning electrodes frequently. Installed burn-out kits on electrodes but burned out the probes. Replaced Teflon lining with porcelain. Made their own electrodes. Flow measurement not critical to operation. Measure sludge by cover level.
Raw Sludge Density	Ohmart	RTSP		50 per meter x 6 meters= 300 total	4	None	None	None	None	Cleaning 50 hrs. per yr per meter	Cleaning 4 per month	Frequent cleaning & frequent calibration	Drift in accuracy as solids build up	Converters, alarms, relays	Primary clarifier control panels	Although the meters work, build-up of strings and solids and frequent calibration are a problem. Used to shut off sludge pumps turned on by preset timers.
Digester Sludge Gas	Penn Venturi Meter	PVFS 12" meter 2000 LFM		None	None	None	None	None	None	None	None	Too large initially	Good	Alarms, counters, integrators	Digestor Control Panel	The meter is working well. Initially, the meter was too large. A steel venturi was inserted to increase readings.
Level	Minneapolis Honeywell Bubble Tube Systems	Transmitter 52303-24-80		Per system 4	.17	None	None	None	None	None	None	None	Good		Local control panels & Central Pump Panel	The bubble systems are working well. Initially, the bubble tubes were not deep enough. They have extended the tubes and made them larger.
Combustible Gas Detector	General Monitors Inc.	175		Per Unit: 2. There are 16 units or 32 mh/yr	0.5	None	None	None	None	None	None	Requires calibration every 2 mos. & changing filter guards.	Good	Transmitters, alarms, indicator	None	Working satisfactorily.
Sewage Sampling	Chicago Pump Sampling Equipment and Probe Suppliers	Thru-test		400	10	None	None	None	None	Frequent	Frequent	Plugging of sampling lines	Good if probes are clean	Flow-control valve and flow indicator controller transmitter	Temperature pH, & other recorders	Plugging of 2-inch sampling lines to sampling pumps occurred frequently, converted from automatic to manual sampling. A sample reservoir was built for D.O. and all electrodes. The probes still have to be cleaned frequently.

* Corrosion, fouling, etc

** Limiters, alarms, ratio relays

*** Local and central

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Frequency (no /mo)	Total Downtime	Downtime Frequency (no /mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Dissolved Oxygen	Snyder	Probe RM25-7228 Temp. Compensator Snyder RM25-242TC		10 per probe	Wipe probe, 4. Replace probe .17	None	None	None	None	2 hrs, per year per probe	.17	Replace probes every 6 mos. Wipe once a week	Good - if maintained		Main Control Panel	Requires some maintenance and calibration.
Conductivity	Beckman for fresh water; Snyder for salt water	Probe Salt RM25-1K 10 Probe fresh VK J-1 Temp. Compensator Snyder RM25-244 TC		10 per probe	Wipe probe, 4	None	None	None	None	None	None	None	Good		Main Control Panel	Works satisfactorily.
pH	Beckman Glass Electrode	Probe 19500 Reference Electrode 19730 Temp. Compensator Snyder RM25-245 PC		10 per probe	Wipe Probe, 4	None	None	None	None	None	None	Wipes probes once a week	Good - if maintained		Main Control Panel	Requires some maintenance.

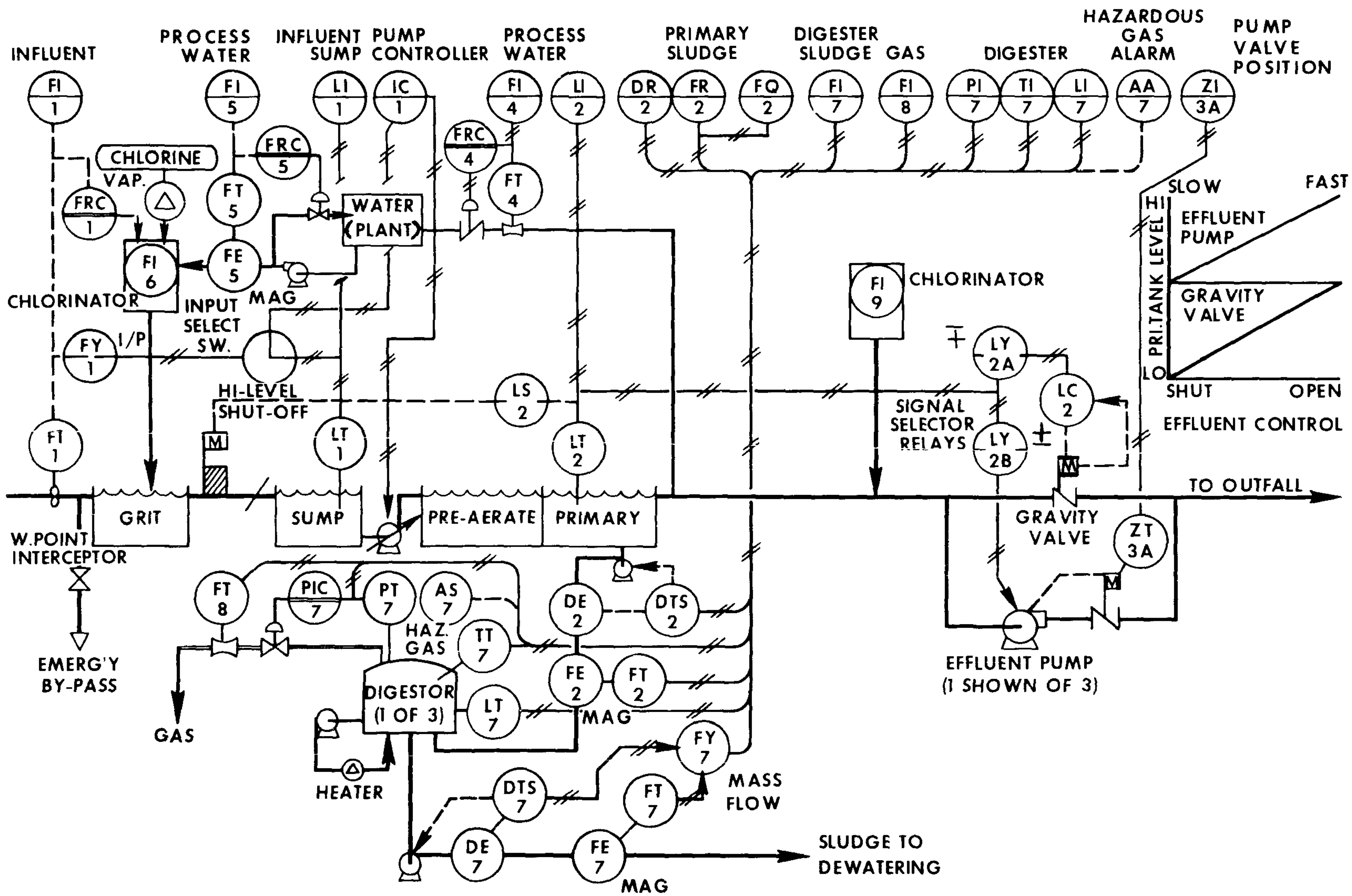
* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits: Annual Cost Savings			Benefits: Process Improvement		Operating Experience							
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW-hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min-max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no/mo)	Comments
LT-1	Influent Sewage Pumping	1	Proportional plus reset	Pneumatic	Pneumatic	Speed control of pump engines through governors	1/2 +	8760	None	None	None	Yes	50 +	1 +	None	None	None	None	None	Extensive pneumatic control system provides alternate control means, and limits extremes of flow or level. System works well.
LT-2	Effluent Sewage Pumping	1	Proportional	Pneumatic	Pneumatic	Speed control of pump engines through governors	1/2 ±	8760	None	None	None	Yes	30 ±	1 +	None	None	None	None	None	Extensive pneumatic control system provides for closing of gravity-flow valve, opening pump valves, starting of engines and controlling speed of pumps during periods of high tide when pumping is required. System works well.
DE-2	Raw Sludge Pumping	6	On-off, with low-density shut off and timed starts	Electric	Electric	Sludge density. On-off operation of sludge pumps	1 min. ±	4040	Yes-less heating - less pumping	None	None	Yes	350 ±	4 +	None	None	None	50 hours per year	4 times per month	Frequent cleaning and calibration of sludge density meters is a problem.
FT-1	Chlorination	6	Proportional (feed-forward)	Fisher & Porter Chlorination	Electric	Residual Chlorine by lab. tests; Manual adjustments of chlorinators	1 min. ±	8760	None	Yes	None	Yes - Chlorine variance reduced	200 ±	1 ±	None	None	None	None	None	System works well.

* Control mode: relay, proportional, proportional plus reset, etc.
** Types of controllers: analog (pne., hyd. or elec. media), computer (supervisory, direct digital or set analog)
*** Final control element: pne. values, variable speed pump, etc.

FIGURE A-5, (SIMPLIFIED INST. DWG)



GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address A-6

Responsible Supervisor

Flow Rate Design (Average and Maximum) Design about 230 mgd average.
100 mgd being handled with peaks about 170 mgd,

Storm Water Collection and Treatment No

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Primary

Performance Data (Individual Units and Overall) 30% BOD Removal
60% SS Removal

Year Built. 1963 Modifications (Year and Description) 1 New Primary Digestor

Original Cost $6.2 million Modification Cost $1.5 million (estimated)

Instrumentation

Equipment Control, recording and indication.

Panels Control

Installation and Start up Costs $25,000 est. Original Cost Est. $300,000 Total Cost $325,000 to $400,000 est.

Instrumentation Modification None

Description	Year	Equipment	Panels	I & S	Total

Computer
Type None Manufacturer I O Devices

Process Control

Data Logging

Parameter Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control

Supervisory Control No

Alarm and Safety Systems Yes - Pumps, flow, density, etc.

Automatic Emergency Program (e g., Power Failure) Flow by gravity at plant.

Maintenance and Calibration

Special Equipment Typical testing equipment Down Time Unknown

Special Operator Training General Frequency (no /mo) Unknown

Total In Plant Man Hours Year 2600

Total Cost of Outside Service $5,000 est.

Estimate of Over all Benefits of Instrumentation and Automation

Reduces manpower.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no /mo)	Total Downtime	Downtime Frequency (no /mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Raw Sludge Venturi	Penn	Type PVFU	--	4	0.3	General	No	No	--	4 hr/yr	0.3	Plugging Taps	3%	No	Yes	No Problems
Venturi On Outfall	BIF (84")	--	--	4	0.3	General	No	No	--	4 hr/yr	0.3	Plugging Taps	3%	No	Yes	" "
Digested Sludge Density	Ohmart	CP-8-WC	$4,000+	52	4	General	No	Available	--	--	--	--	1%	No	Yes	" "
Secondary Digester Gas	Penn Loss-loss tube	Type PMT-1	$400	2	0.16	General	No	No	0.16	2 hy/yr	0.16		3%	No	Yes	" "
Digester Gas Flow	Badger & Penn ASME Low-loss flow tube	Penn PMT-1 Badger PMT-1	--	2	0.16	General	No	No	0.16	2 hr/yr	0.16	--	3%	No	Yes	" "
Raw Sludge Density	Ohmart	CP-8-WC SDG	$4,000+	52	4	General	No	Available	--	--	--	Greasing Up	1%	No	Yes	" "
Aeration Air Pressure	Honeywell		$200	4	0.16	General	$300	--	0.16	4 hr/yr	0.16	No	2%	No	No	" "

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central.

LOOP AND PROCESS CONTROL SURVEY FORM

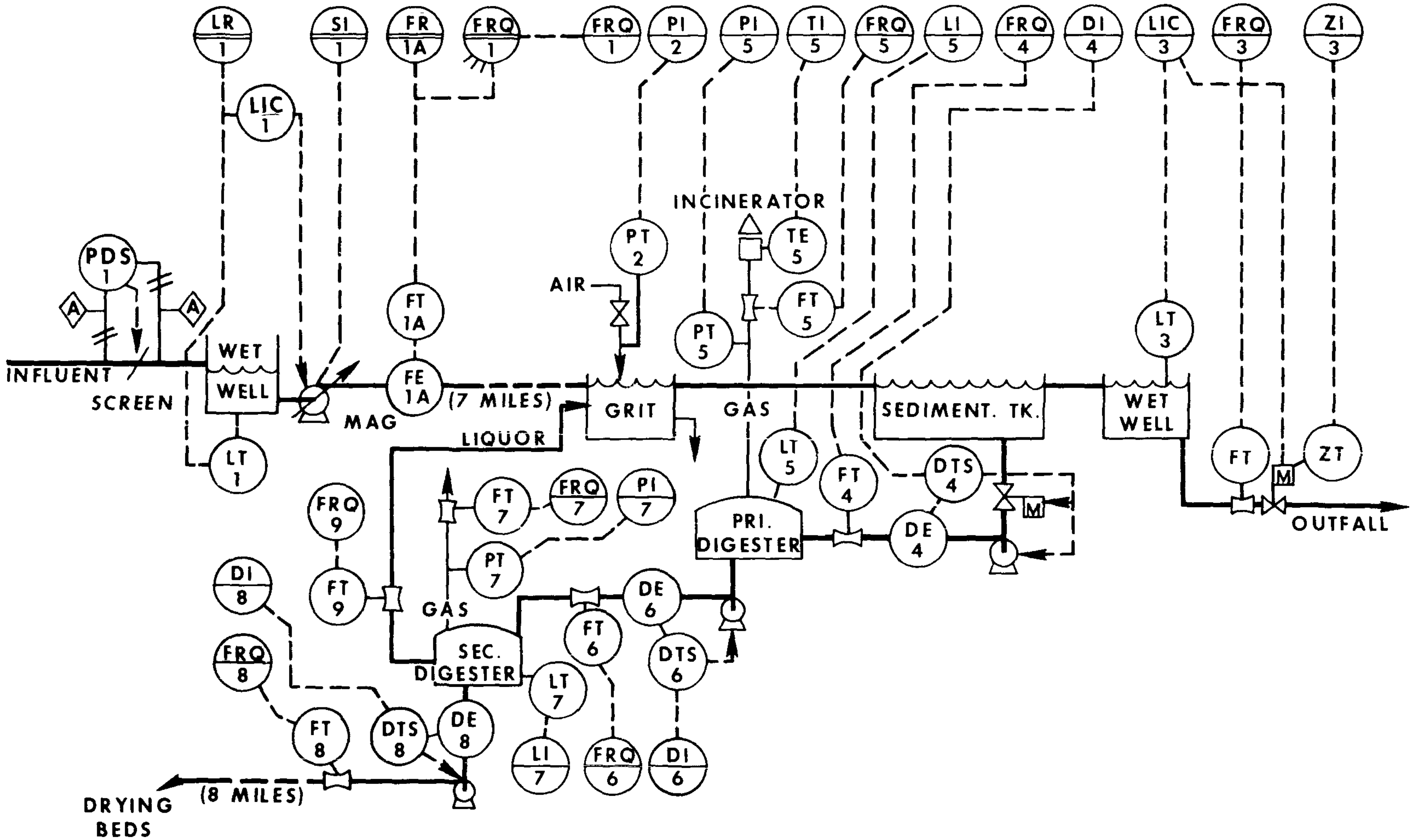
Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW-hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no. mo)	Comments
LT-3	Outfall Well Level	1	Prop. and Reset and Deriv.	Analog Elec.	Elec.	Butterfly Valve	0.5	8,750	--	--	--	--	12 mh	1	General	No	None	12	1	No Problems
DE-4	Sed. tank Sludge flows	1	Prop + Relay	Elec. Analog	Elec.	Valve	0.1	8,750	--	--	--	--	12 mh	1	General	No	None	See Comment	--	Control system O.K. - Pumps give trouble.
LT-1	Headwork No. 2 Main pumps	1 3 units	Prop + Reset	Elec. Analog	Elec.	Multiple Output Adapter & Main Pumps	0.5	8,750	--	--	--	--	240 mh	20	General	No	None	None	--	Instruments are obsolete with 0 to .5 Volt AC Signal.

* Control mode relay, proportional, proportional plus reset, etc

** Types of controllers analog (pne , hyd or elec media), computer (supervisory, direct digital or set analog)

*** Final control element pne values, variable speed pump, etc

FIGURE A-6.


LR 1
SI 1
FR 1A
FRQ 1
FRQ 1
PI 2
PI 5
TI 5
FRQ 5
LI 5
FRQ 4
DI 4
LIC 3
FRQ 3
ZI 3
LIC 1
PDS 1
A
A
INFLUENT
SCREEN
WET WELL
LT 1
MAG
FT 1A
FE 1A
(7 MILES)
LIQUOR
AIR
PT 2
GRIT
INCINERATOR
TE 5
FT 5
PT 5
GAS
LT 5
FT 4
SEDIMENT. TK.
DTS 4
DE 4
M
PRI. DIGESTER
LT 3
WET WELL
FT
M
ZT
OUTFALL
FRQ 9
FT 9
DI 8
FRQ 8
FT 8
DTS 8
DE 8
FT 7
FRQ 7
PI 7
PT 7
GAS
SEC. DIGESTER
FT 6
DE 6
DTS 6
LT 7
LI 7
FRQ 6
DI 6
DRYING BEDS
(8 MILES)

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address A-7

Responsible Supervisor

Flow Rate Design (Average and Maximum) Avg. = 343 mgd; running @ 330 mgd
Max. = 978 mgd

Storm Water Collection and Treatment Treats Combined Wastewater

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems) Primary treatment - screening and grit removal at three remote headworks. Influent via deep rock tunnels, shaft level controlled by pumping based on telemetered signals. Influent is pumped into settling tanks and chlorinated. Sludge is anaerobically digested and discharged into ocean outfall.

Performance Data (Individual Units and Overall) BOD 29%, Sus. Sol. 46% (Removals)

Year Built 1968 Modifications (Year and Description) Systematic (see below) 1970

Original Cost $26,000,000 Modification Cost $10,000

Instrumentation Telemeter, Electronic, Pneumatic

Equipment Foxboro & ITT ($1,000,000); F&P ($250,000)

Plant functions because of extensive duplication, planned maintenance. (Pneumatic instrument troubles slight because of quality instrument air).

Panels 25' central semi-graphic control panel, many local panels.

Installation and Start up Costs Original Cost Total Cost $1,250,000

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
Vacuum Amplifier to Solid State amplifiers for mag meters	1970				$10,000

Computer
Type No Manufacturer I O Devices

Process Control

Data Logging

Parameter Frequency	Parameter Frequency	Parameter Frequency	Parameter Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control Shaft levels at headworks maintained by pumping via telemeter system control

Supervisory Control No

Alarm and Safety Systems Level, temp., engine failure, Cl_2 failure, pump, etc.

Automatic Emergency Program (e g , Power Failure) Generates own power from digester gas, purchased fuel.

Maintenance and Calibration

Special Equipment Various gauges & electronic equipment Down Time

Special Operator Training Foxboro & ITT at manufacturers' facilities. Frequency (no mo) ITT 1/mo.
F&P 1/mo.

Total In Plant Man Hours Year 8000 mh/yr

Total Cost of Outside Service ITT - $2500/yr; F&P - $1800/yr

Inst't air is dried, and system cleanliness is carefully ~~maintained.~~

Estimate of Over-all Benefits of Instrumentation and Automation

Influent pumping control essential for meeting hydraulic demands and preventing surges.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no/mo)	Total Downtime	Downtime Frequency (no/mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
																Notes 1) F&P has service contract for all their equipment for 1800$/yr for 8 hrs/mo.
Sluice-Valve Position	Furnished by Rodney-Hunt			32 (est.)	1.5 (est.)	No	None	None	-	Now 100%	-	Fragile, Corroded	Est. 2%	None	No	Design of tape, pulley, rotary resistor too light; unit not water-tight; system failed and was not repaired after 6 mo. service.
Sludge Flow	F&P (Magnetic meter)	-	-	20 (est.)	.15 (est.)	No	See Note	None	See Note	-	-	-	Good	-	No	
Chlorine Gas Detection	Davis Electrolytic type (no longer available)	11-7010-W1-SP	-	50 (est.)	2	No	None	None	-	-	-	Cannot get replacement parts	Good	Alarm	No	1) Manufacturer no longer in business. 2) Opens Cl_2 tank storage door and starts ventilation system when Cl_2 is detected.
Flow & Level	ITT Telemeter System	-	-	100/system	1	At manufacturer	2,500$/yr	None	1/mo. (8 hrs)	See Comment	-	None	Good	-	Yes	1) Radio microwave backed up by telephone system. Reliability of each system is approx. 95%. 2) Microwave and telephone system down about 1 week/each in 1 year.
Flow	Foxboro (Venturi)	-	-	10	.5	At manufacturer	None	None	-	-	-	D/P cell fouled	Good	-	Yes	1) D/P Cells fouled because of scale formed when purged with salt-water. No longer purged in this manner.
Level	Foxboro (Bubble Tube)	M44	-	10	.5	At manufacturer	None	None	-	-	-	-	Good	-	Yes	

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

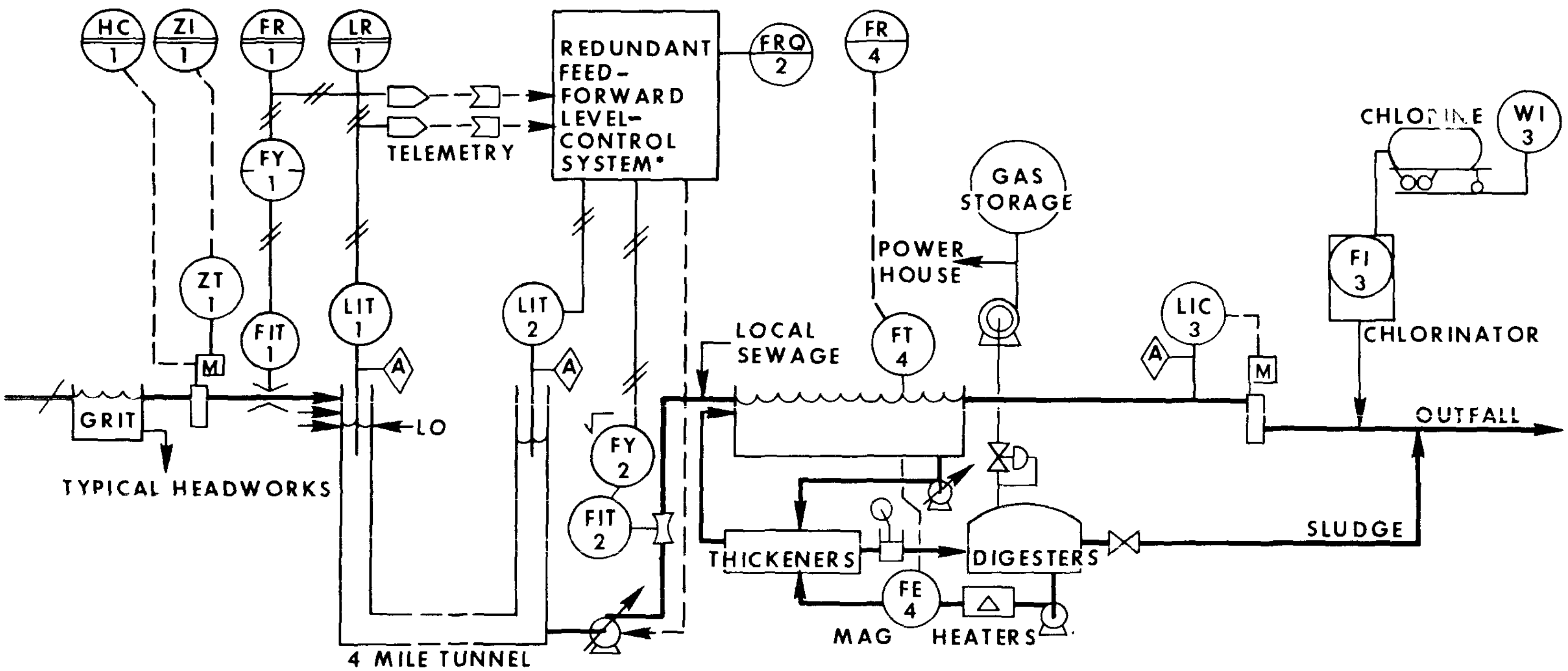
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kWh/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter variation minimizing	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no/mo)	Comments
Control Techniques								Benefits: Annual Cost Savings			Benefits: Process Improvement		Operating Experience							
FIT-1	Influent	1	Prop'l Reset	Analog Computing Relay	Pneumatic	See Comment	Response time for complete system is about 3.5 minutes	Manpower savings by using system is tremendous	--	None	None	Total system provides smooth pumping	Total maintenance and calibration is about 1000 mh/yr	Maintenance frequency for system is about 2/mo	mfr (4 weeks, total)	Telemeter portion of system is about 2500$/yr	No	No process downtime, but 300 mh/year downtime while standby systems are used for primary control.	--	Flow recorder controller transmits signal which governs Chelsea Creek pump speeds.
FIT-1	Influent	1	Prop'l Reset	Analog Computing Relay	Pneumatic	See Comment			--	None	None				mfr		No		--	Flow recorder controller transmits signal which governs Ward-Columbus pump speeds.
FIT-2	Influent	1	Feed Forward	Analog Computing Relay	Pneumatic	See Comment			--	None	None				mfr		No		--	All systems with prefix "2" transmit signals to the Chelsea Creek feed-forward analog computer systems.
FIT-2	Influent	1	Feed Forward	Analog Computing Relay	Pneumatic	See Comment			--	None	None				mfr		No		--	All systems with prefix "1" transmit signals to the Ward-Columbus feed-forward analog computer systems.

* Control mode relay, proportional, proportional plus reset etc

** Types of controllers analog (pne , hyd or elec media) computer (supervisory, direct digital or set analog)

*** Final control element pne values, variable speed pump etc

FIGURE A-7. (SIMPLIFIED FLOW SHEET)



* ELABORATE PNEUMATIC CONTROL SYSTEM WAS REQUIRED TO PREVENT FLOW OSCILLATIONS. PUMP RATE IS SET SO THAT CONTROLLED $Q=\sum Q_{in}+B_1(H_1(1-e^{-t/T_1})-H0)+B_3H_3\ e^{-t/T3}$ OR, APPROX., CONTROLLED $F=\sum F_{in}+B_1\int(L_1-L0)+B_3\ \frac{dL_2}{dt}$

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address A-8

Responsible Supervisor

Flow Rate Design (Average and Maximum) 420 mgd Average 720 mgd Maximum

Storm Water Collection and Treatment No

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems) Primary treatment; 100-MGD fixed rate to activated sludge treatment

Performance Data (Individual Units and Overall) SS Removal 72.6% annually
BOD Removal 54.4% annually

Year Built 1950

Modifications (Year and Description) 1957 - 1960 - Added Headworks, primary settling, effluent pumping plant, 7-Mile Sludge and 5-Mile Effluent ocean outfalls.

Original Cost $45,000,000

Modification Cost $33,000,000 1972-73 - Conversion of secondary digestion tanks and re-build digested sludge screening facility.

Instrumentation Level, flow, residual chlorine, digester gas flow, raw and digested, sludge flow, telemeter from out-lying plants.

Equipment Analog control loops, process monitoring instruments, pneumatic - Honeywell, Taylor and Foxboro

Panels Nine control, recording, alarm, and indication panels for: Headworks, Primary Settling, Secondary Treatment, Digestion (3), Eff. Pumping Plant, Power and Blower, and Shift Superintendent.

Installation and Start up Costs Original Cost Total Cost

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total

Analog control, process indicators, recorders, alarms
$10,000/year for 22 years = $220,000

Computer None Now

Type Manufacturer I/O Devices Remote Multiplexers (future)

[illegible] Planned completion July 1974

Data Logging

Parameter/Frequency	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost $1,100,000 including computers and software

Central Control None Now

Supervisory Control

Alarm and Safety Systems Explosive gas alarm for gas compressor building, level alarms for digesters, sent to power and blower building - man on duty 24 hours. Flow alarms sent to effluent pumping plant.

Automatic Emergency Program (e.g., Power Failure) Manual transfer from plant-generated electrically to outside power utility.

Maintenance and Calibration Wheatstone bridge, osc. scope, tube tester, manometer, test gauges, dead weight tester.

Special Equipment Lab. potentiometer, V.O.M. and V.T.V.M.

Down Time None due to instrument failure

Special Operator Training Short courses at Honeywell and Foxboro

Frequency (no/mo) Inst. air refrigerator to remove moisture, dry type compressor with teflon rings - air also filtered through 5 micron filters.

Total In-Plant Man Hours Year 9240 (4 man-yrs)

Total Cost of Outside Service Virtually none - all done in-house

Estimate of Over-all Benefits of Instrumentation and Automation

Improved process control, monitoring, and reliability with minimum operator attendance are the main benefits gained from instrumentation.

Present plant has about 240 personnel.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no/mo)	Total Downtime	Downtime Frequency (no/mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Residual Chlorine	Wallace & Tiernan	V-800	$5,000													Just installed - therefore Operational Characteristics unknown. Operating satisfactorily. (not continually)
Gas Flow from Digesters	Roots Connorsville (Propeller Meter)	Type LP	--	80	0.16	General	No	None	Repaired 3 year	--	--	None	3%	Counter	None	Getting old - will be replaced by turbine types.
Hazardous Gas	Sieger	1501	500	--		General	No	None	--	--	--	None	5%	Alarm	--	
Digester Sludge-Gas Flow	Daniel Industries (Orifice)	520	100	20	1	General	No	None				None	3%			Some are made at Plant - No problem.
Sludge Venturi	Made by Plant Forces		--	10	0.16	General	No	None	--	--	--	--	5%	Water purge	Yes	Problem with grease build-up; being replaced by F & P mag. meters.
Level (Wet Well)	Moore Products Pneumatic Repeater	19K	$75	0	0	-	No	None	--	--	--	None	2%		--	No problem.

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no /mo)	Total Downtime	Downtime Frequency (no /mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Main Inflow to Plant (Venturies)	BIF (108")	--	--	10/yr	0.008	--	No	None	--	2 days in 20 years	--	--	5%	Water Purge	Yes	No problem.
Digester Temp.	Honeywell	--	--	5/yr per unit	0.16	--	--	--	--	5 hr/yr per unit	--	--	2%	Local Indicator	None	No problems - downtime during maintenance only.

* Corrosion, fouling, etc.
** Lamaters, alarms, ratio relays.
*** Local and central.

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Downtime (hrs yr)	Downtime Frequency (no mo)	Comments
FT-6, FT-7	Raw Sludge Flow	3	Prop. & Reset & Relay	Analog	Pneumatic	Valve	15 sec.	--	--	--	--	--	100 hrs.	1	General Instrum. Training	No	None	5	2	Works well - Assures proper digester tank flow distribution.
FIT-1	Main Plant Flow	1	Prop. & Reset	Analog	Pneumatic	Valve	30 sec	33,000	--	--	--	--	50 hrs.	1	General	No	None	10	1	Works well - Permits plant flow distribution to 3 primary settling tank batteries - Eliminates need for 3 (est) workmen - No major problems.
LT-1	Primary Settling Tank Levels Only West Battery	4	Prop. & Reset	Analog	Pneumatic	Valve	15 sec.	33,000	--	--	--	--	50 hrs.	2	General	No	None	2		No problems at all.
FT-3	Secondary Treatment Flow Control	2	Prop.	Analog	Pneumatic and elec.	Sluice Gate	15 sec.	33,000	--	--	--	--	60 hrs.	0.16	General	No	None	2	2	Electric signal lines and contacts - trouble due to moisture.
	Digester Gas	1 loop	On-Off	Pressure Switch	Pneumatic and elec.	Compressor	2 sec.	See Comment	See Comment	--	--	--	20 hrs.	0.16	General	No	None	20	2	Surplus gas sold to power plant, and also need for scum break up and internal heating and power.
LT-5	Effluent Pumps to 5-mile outfall	1	Prop. & Reset	Analog	Pneumatic and elec.	Pumps	30 sec.	--	--	--	--	--	Est. 75 hrs.	1	General	No	None	48	3	3 separate level controls for safety.
	Digester Steam	3	Prop. & Reset	Analog	Pneumatic	Steam Valve	15 sec.	--	--	--	--	--	30 hrs.	1	General	No	None	4	2	Excellent performance - Provides proper steam distribution for digester heating control.

* Control mode relay, proportional, proportional plus reset, etc

** Types of controllers analog (pne hyd or elec media), computer (supervisory, direct digital or set analog)

*** Final control element pne values, variable speed pump, etc

LOOP AND PROCESS CONTROL SURVEY FORM

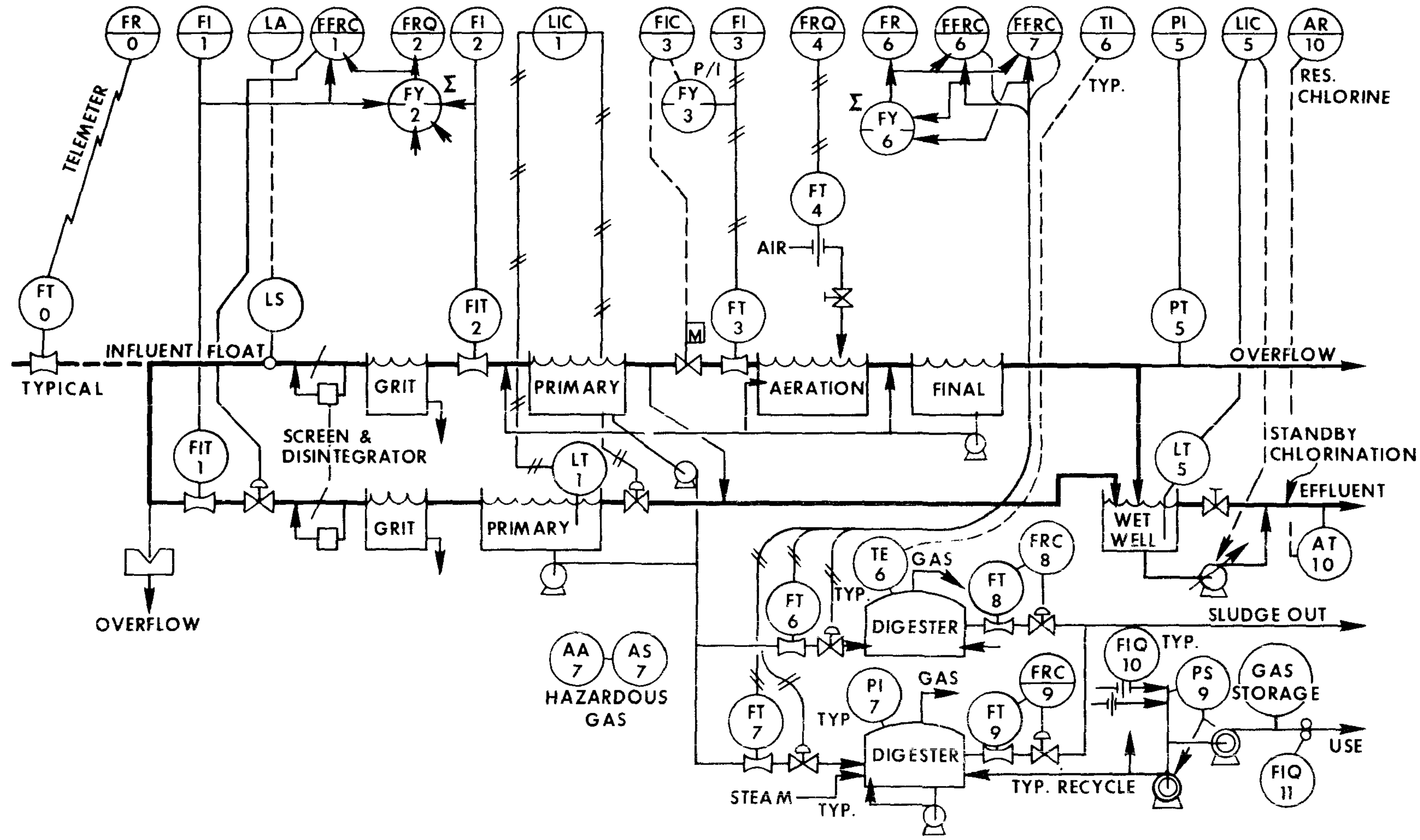
Control Techniques								Benefits: Annual Cost Savings			Benefits: Process Improvement		Operating Experience							Comments
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kWh/yr)	Chemical (lbs/yr)	Incr. in Removal (%)	Parameter Variance (min max) (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Serv ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no/mo)	
FT-8 FT-9	Digested Sludge Flow	3	Prop. & Reset	Analog	Pneumatic	Valve	15 sec.	-	-	-	-	-	50 mh	2	-	No	None	10	.2	No problems.
	Secondary Effluent to Sludge Outfall	1	Prop.	Analog	Pneumatic	Valve	15 sec.		-	-	-	-	50 mh	2	-	No	None	10	.2	No problems.
	Chlorine	1	Prop.	Analog	Pneumatic & Elec.	Valve	8 min.	-	-	-	-	-	Unknown	Unknown	-	No	None	-	-	New system just installed.
	Sludge Screen Reject Well Level	1	Prop.	Analog	Pneumatic	Pump	15 sec.	-	-	-	-	-	50 mh	2	-	No	None	None	-	Works o.k.
FT-4	Aeration Tank Air	2	-	-	Manual to Pneumatic	Valve	-	-	-	-	-	-	50 mh	2	-	No	None	-	-	No problems.

* Control mode relay, proportional, proportional plus reset, etc

** Types of controllers analog (pne, hyd or elec media), computer (supervisory, direct digital or set analog)

*** Final control element pne values, variable speed pump, etc

FIGURE A-8. (SIMPLIFIED FLOW SHEET)



GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address: A-9

Responsible Supervisor:

Flow Rate Design (Average and Maximum): 750 mgd Avg. 1200 mgd Max.

Storm Water Collection and Treatment: Plant flows include intercepted storm water.

Type of Plant: Description of Treatment Process (Attach schematic diagram for process monitoring and control systems.)
Primary sedimentation with polymer and pickle liquor addition followed by chlorination.
Sludge disposal by vacuum filtration and multiple hearth incineration.

Performance Data (Individual Units and Overall): 45 - 50% BOD reduction
60 - 70% Suspended solids

Year Built: 1940

Modifications (Year and Description): Major expansion program begun in 1968 to give greater capacity, 2nd Treatment

Original Cost: $22.6M

Modification Cost: Expansion program construction costs, to date = $105M

Instrumentation

Equipment: Fischer and Porter Velatrol controls (local, electronic, analog; Local manual and local switchover to computer control)

Panels: At various sites throughout plant for local analog or manual control.

Installation and Start up Costs: Original Cost Total Cost

Instrumentation Modification: Centralized, computer assisted, monitoring and control system with local analog back-up added as part of expansion program.

Description	Year	Equipment	Panels	I & S	Total
Computer System	1972-73	See below	--		$530,000
Analog	1972-73	F & P (also Linde)	Yes	$0.5 - 1M	$2.5-3M

Computer: Future

Type: SC 1774 (two) On-line and Back-up

Manufacturer: Control Data Corp.

I/O Devices:
3 Videojet Printers
2 Hazeltine 2000 CRT Terminals
4 G.E. Terminets
2 Conrac Color CRT & Oper. Cons.
1 CDC Card Reader
2 HP XY Plotters
12 Trend Records

Process Control: Pickle liquor and polymer feed, aeration tank flow & level control; final clarifier flow splitting, chlorinated water flow splitting, process water pumping.

Data Logging: All other plant parameters
Lab Analyses
Process monitoring
Out-of-service equipment

Parameter Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency

Storage: 3 2.4-million-word disk drives

Software Description: Process Monitoring & Control; Fortran; Autran; Data Reduction & Analysis

Computer Cost: $400,000 Software Cost: $129,000 Installation Cost: $129,000

Central Control (Future)

Supervisory Control: Graphic Panel and Computer-Assisted Operation Through CRT Oper. Console

Alarm and Safety Systems: Through Computer; Local On-site Alarms

Automatic Emergency Programming Power Failure: Back-up Power Systems, Dual Control Computers
Dual D.C. Power Supplies

Maintenance and Calibration

Special Equipment: Electrical shop

Down Time: None

Special Operator Training: No

Frequency (no. mo.): None

Total in Plant Man Hours/Year: None as such. Mechanical equipment primary. No remote control.

Total Cost of Outside Service: N/A

Estimate of Overall Benefits of Instrumentation and Automation

Wastewater treatment process will be monitored from central location thus helping to reduce manpower and increase plant efficiency.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In Plant Maintenance (mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no./mo.)	Total Downtime	Downtime Frequency (no./mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Flow (Valve)	Kates	-- (Stainless)		Est. 30	Est. 3	No	No	No	--	Little or None	--	Dirty or wet air	--	No	No	Kates regulator with pneumatic actuator used as control valve on polymer sol'n with very good results.
Sludge Level	Fischer Governor	115 (Diaphragm Repeater)	--	10	.1	No	No	No	--	None	--	Dirty or wet air	5%	Constant-Flow Relay	No	Works well in sensing sludge level in vacuum filter basin.
Sludge Flow	F & P Magnetic			See below	See below	No	No	No	--	100%	--	Electrode Fouling	--		Yes	Meters used only occasionally, since meter fails 4 to 6 hrs. after cleaning electrodes.
Level	Selsyn	--	--	Est. 60	2	No	No	No	--	None	--	Synchroni-zation	2%	Purges	Yes	Float, chain and selsyn system ancient but good, except that selsyns have to be checked often for synchronization.
Flow	Venturis			Est. 24	Est. 1	No	No	No	--	None	--	Plugged lines	Est. 5%	Purges	Remote	Works well on main plant influent. Old Simplex meters abandoned.
Control Valve		Saunders Type		Est. 16	Est. 16	No	No	No	--	Little or None	--	Corrosion; Diaphragm Wear	--	I/P trans-ducer	No	Works very well on pickle liquor. Replaces Kates regulator that kept plugging up.
Flow of Pickle Liquor	Fischer & Porter Magnetic			Est. 30	Est. 3	No	No	No	--	Little or None	--	External Corrosion	Est. 2%	No	Yes	Works very well; pickle liquor is $FeCl_2$.

* Corrosion, fouling, etc

** Limiters, alarms, ratio relays

*** Local and central

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Frequency (no/mo)	Total Downtime	Downtime Frequency (no/mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Weight	Merrick	Weight-ometer	--	300	30	No	No	No	--	None	--	Drift, dirt, belt.	1%	Integrator	--	Works well because rezeroed daily. Main problem is build-up and wear of belt.
Temp.	Leeds & Northrup	Micromax	--	Low	Infrequent	Some On-site	No	No	--	Little or None	--	Obsolete	1%	--	Yes	Obsolete multipoint self-balancing recorder, but works well. Uses C/A thermocouples.
Smoke (In Stack)	TV	--	--	See below	See below	No	Occasional	--	--	See below	--	Not needed	--	--	No	Partially successful, ignored by operator.
Smoke (In Stack)	ECZ Fireye	27VHG 1000B	--	See below	See below	No	No	No	--	See below	--	Dirty windows	Fair, when clean	Alarm	No	Abandoned because windows kept fouling.
CO (Flue Gas)	Hays	CDPRI 790795		50	4	Some On-site	No	No	--	10	.2	Plugged lines	5%	No	Yes	Very reliable although sampling lines frequently plug.
Flow (Valve)	Red Devil (Pinch Valve)			Est. 24	.25	No	No	No	--	Est. 8	.25	Wear	--	No	No	Successfully controls flow of sludge into vacuum filter basin.

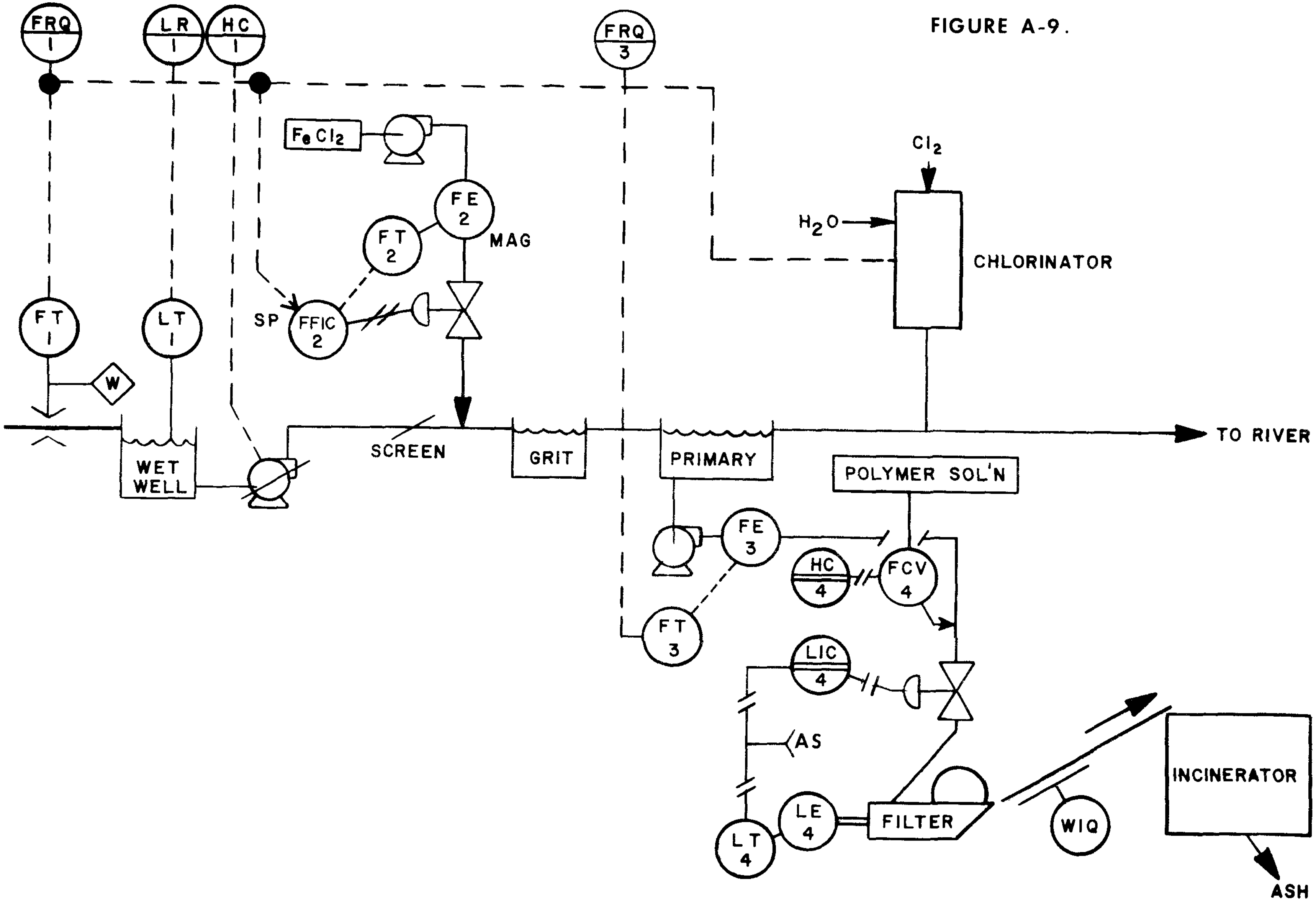
* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits: Annual Cost Savings			Benefits: Process Improvement		Operating Experience							Comments
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min, max (mg/l)	Maintenance & Calibration by In-Plant Personnel ($ or mh/yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no mo)	
LE-4	Filter Level	12	Proport. and Reset	Pneumatic	Pneumatic	Pinch Valve	0.02	12,000	Some	Some	Some	Good Level Control	30 mh	1	No	No	No	Est. 1[illegible]	Est. 2	Successfully maintains sludge level for high filtration rate.
LT-1	Wet Well Level	2	--	Manual	Electric	Var. Speed Pumps	.5	6,000	--	--	--	--	120 mh	2	No	No	No	None	--	Works adequately.
FE-2	Pickle Liquor Addition	1	Proport. and Reset	Electronic	Pneumatic	Saunders Valve	0.01	2,000	--	60,000	Yes		Est. 60 mh	1	No	No	No	Est 20	Est 16	Good system. Major problems are corrosive environment, dirty fluid.

* Control mode relay, proportional, proportional plus reset, etc
** Types of controllers analog (pne , hyd or elec media), computer (supervisory direct digital or set analog)
*** Final control element: pne values, variable speed pump, etc

FIGURE A-9.


FRQ 1
LR 1
HC 1
FRQ 3
Fe Cl2
FE 2
MAG
FT 2
SP
FFIC 2
FT 1
W
LT 1
Cl2
H2O
CHLORINATOR
WET WELL
SCREEN
GRIT
PRIMARY
TO RIVER
POLYMER SOL'N
FE 3
HC 4
FCV 4
FT 3
LIC 4
AS
LE 4
LT 4
FILTER
WIQ
INCINERATOR
ASH

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-1

Responsible Supervisor

Flow Rate Design (Average and Maximum) 1 mgd, max.; dry weather 0.7, infiltration (12-12-72) 1 mgd

Storm Water Collection and Treatment No

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Activated sludge w/aerobic digestion.

Performance Data (Individual Units and Overall)
BOD Reduc. 95% Solids Reduc. 92%

Year Built 1947 (Trickle Filter) Modifications (Year and Description) 1969, Converted to act. sludge.

Original Cost Modification Cost Approx. $1M

Instrumentation BIF w/electric pulse-duration telemetering.

Equipment Flow meters, wet well level, chlorinators, D.O. probes.

Panels 1 Central indicating-totalizing panel

Installation and Start up Costs Original Cost Total Cost

Instrumentation Modification No

Description	Year	Equipment	Panels	I & S	Total

Computer
Type No Manufacturer I/O Devices

Process Control

Data Logging

Parameter/Frequency	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control Indication only. No control loops or automatic process control.

Supervisory Control No

Alarm and Safety Systems 1 alarm (water seal pumps)

Automatic Emergency Program (e g , Power Failure) None

Maintenance and Calibration

Special Equipment None Down Time None

Special Operator Training None Frequency (no /mo)

Total In-Plant Man Hours/Year All call-in (i.e., all M&C is conducted by outside personnel)

Total Cost of Outside Service 20 hrs/mo @ $4/hr, or approx. $1,000/yr.

Estimate of Over-all Benefits of Instrumentation and Automation

Good operation with little manpower.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no/mo)	Total Downtime	Downtime Frequency (no/mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Dissolved Oxygen	Union Carbide	1101		100	15	None	100 mh		4	None	--	Fouled Probe. drift	+1 part/15 (+7 1/2%)		None	3 probes, multi-pt. indicator, 0-15 ppm/0-50C. Checked against Winkler method.
Sampler	Chicago Pump "Tru-test"	NB		(Pump only)	--	None	--	None		0.5% Est.		Pump				Good service, pump strainer clogs occasionally.
	NOTE: The following process history was obtained from the August, Ga. Plant (Mr. Marshall Mott, 404-322-5471)															
Dissolved Oxygen	Union Carbide			Not over 10 mh	Less than 1	None	No	No	--	None	--	Probe dissolved 0.25 inch 6 weeks	+1 part/15 (est.) 0.5-6. ppm	Indicator	No	Side-by-side comparison in aerated sludge tank showed that Thalium type "worked"; membrane type (Y.S.) or membrane with wiper (W & S) did not, in constant service; 6 weeks trial.

* Corrosion, fouling, etc

** Limiters, alarms, ratio relays

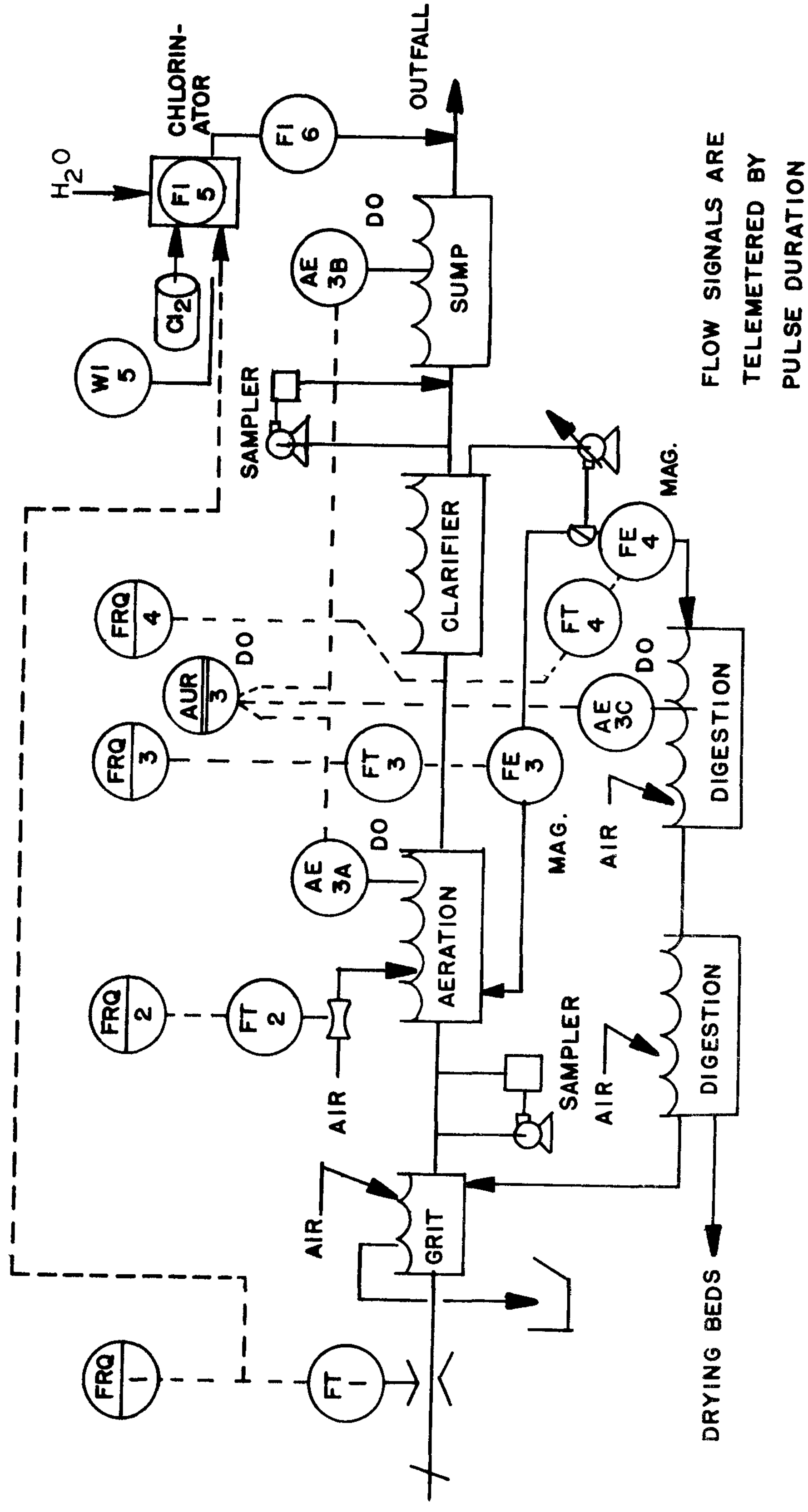
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							Comments
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min.)	Manpower (mh/yr)	Utility (kW-hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min, max (mg/l)	Maintenance & Calibration by In-Plant Personnel ($ or mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no. mo.)	
FE-3	Return Sludge	1	Fixed Ratio	Manual	--	Splitter Box	--						None	--	No	No	No	None	--	Manual flow ratio control device is easily set but would require constant readjustment to actually follow process changes.

* Control mode: relay, proportional, proportional plus reset, etc.
** Types of controllers: analog (pne., hyd. or elec. media), computer (supervisory, direct digital or set analog)
*** Final control element: pne. values, variable speed pump, etc.

FIGURE B-1.


FRQ 1
FT 1
FRQ 2
FT 2
AIR
FRQ 3
FT 3
FRQ 4
AUR 3
DO
AE 3A
DO
AE 3B
DO
WI 5
Cl_2
H_2O
FI 5
CHLORIN-
ATOR
FI 6
OUTFALL
AIR
GRIT
AERATION
CLARIFIER
SUMP
SAMPLER
SAMPLER
FE 3
MAG.
FT 4
FE 4
MAG.
AE 3C
DO
AIR
AIR
DIGESTION
DIGESTION
DRYING BEDS
FLOW SIGNALS ARE
TELEMETERED BY
PULSE DURATION

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-2

Responsible Supervisor

Flow Rate Design (Average and Maximum) 6 mgd max.; running 2.2 (12-72)

Storm Water Collection and Treatment Combined sewage

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Secondary, contact stabilization or extended aeration.

Performance Data (Individual Units and Overall)

BOD removal 90-95% Settleable solids removal 75%

Year Built 1972 Modifications (Year and Description)

Original Cost $5M Modification Cost

Instrumentation F & P electronic

Equipment

Panels Central Control with local panels

Installation and Start-up Costs Original Cost $138K Total Cost $205K (including chlorinators)

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total

Computer None, although plant is designed to be computer compatible.

Type Manufacturer I O Devices

Process Control

Data Logging

Parameter/Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control Analog and remote manual

Supervisory Control Aeration rate and sludge return rate

Alarm and Safety Systems Conventional

Automatic Emergency Program (e.g., Power Failure) No standby generator, but two feeders (12KV)

Maintenance and Calibration

Special Equipment None

Down Time None to date

Special Operator Training None (Instrument trainee left position vacant)

Frequency (no/mo) --

Total In-Plant Man Hours/Year

Total Cost of Outside Service

Estimate of Over all Benefits of Instrumentation and Automation

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		Comments
Parameter	Manufacturer	Model Number	Equipment Cost	In Plant Maintenance (mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Frequency (no. mo.)	Total Downtime	Downtime Frequency (no./mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	
Liquid Flow	Fischer & Porter	(Dall Tube)		slight	--	None	None	None		None		None	± 4% (est.)	Liquid purge relays	Yes	Good service, instruments well accepted in 6 months plant has been running.
Chlorine Gas	Fischer & Porter	51A1102DB		30	2	None	None	None		None		--	Apparently good	Alarm	No	Kept in operation, not checked.
Sludge Density	Ohmart	RTR-N		Out of service	--	None	None	None to date		Frequent		Calibration kept shifting	Poor		Yes	Instrument not successful. Output drifted; unit then failed completely. Awaiting service man.
D.O.	Union Carbide	1101		200	90	None	None	None		Occasional, depending on maint.		Fouling, air bubbles, probe corrosion	±0.2 above 0.5 mg/l	Selector sw Temp. indic	No	Probes in aerator require cleaning every 6 hours. Range 0-5 ppm. Yellow Springs portable D.O. probe used as standard.
Sampler (in-plant)	Chicago Pump "Tru-Test"	BR (revised)		12	1	None	None	None		None		None	--	Sample pump	No	Sampler works well. These are newer, corrosion-resistant models.
Sampler (influent)	Chicago Pump	BR (revised)		1400	120	None	None	None		Occasional, depending on maint.		Pump fouling	--	Sample pump	No	Sampler works well; pump strainer keeps plugging, every 6 hours or so, on plant influent.
pH/ORP	Union Carbide	(illegible)		Abandoned								Humidity; pump & probe fouling	--	Sample pump	No	Monitoring system installed in building with 100% RH. System abandoned because in primary sewage service, pump strainer and probes could not be kept clean more than 1 or 2 hours. Inst. package designed for clean water service.

* Corrosion, fouling, etc.
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

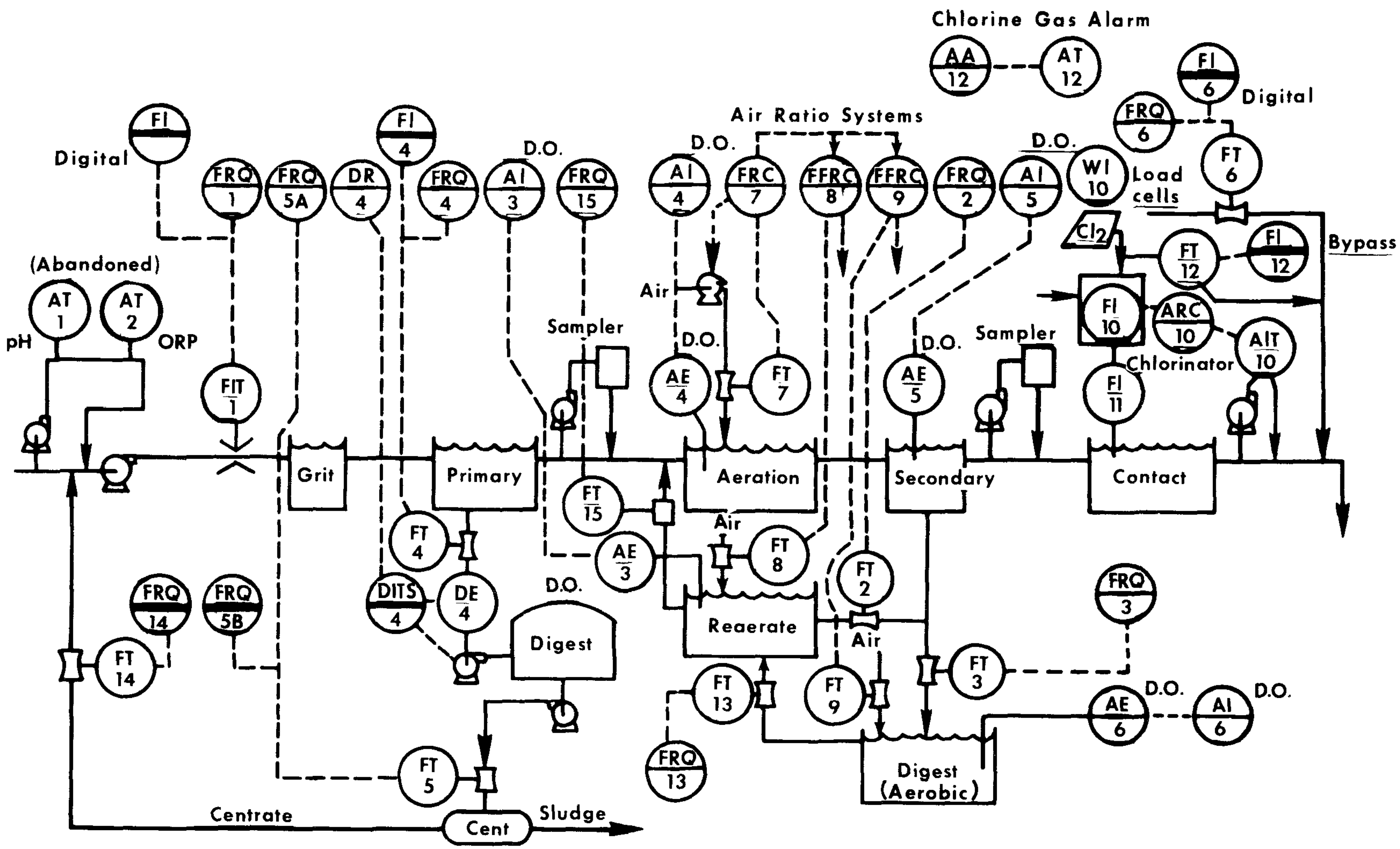
Control Techniques								Benefits					Operating Experience							Comments
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW hr/yr)	Chemical (lbs yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In-Plant Personnel ($ or mh/yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no mo)	
DE-4	Sludge Density	1	On-off	Relay	Electric	Pump	.5	No	No	Yes	Perhaps	Improves digester performance	96 mh (est.)	2 (est.)	No	No	$400 (est.)	600 (est.)	2	System valuable and repeatable, but when it fails factory service is usually required.
FT-7, FT-8	Air Flow	5	P & R	Electronic Analog	Electric	Butterfly Valve	2	No	No	No	Perhaps	Maintains uniform aeration	40 mh each (est.)	0.4 (est.)	No	No	No	None	--	Ratio system works well to maintain air flows proportional. Any one flow can be used as master.
AIT-10	Chlorine Residual	1	Proportional	Mech. Analog	Water	Chlorinator	.5	No	No	Yes	No	Maintains uniform dosage	32 mh (est.)	0.3 (est.)	No	No	No	None	--	Good performance in 6 months. Unit checked with visual color standard every other month, F & P 1752000.

* Control mode relay, proportional, proportional plus reset, etc

** Types of controllers analog (pne , hyd or elec media), computer (supervisory, direct digital or set analog)

*** Final control element pne values, variable speed pump, etc

FIGURE B-2.



Chlorine Gas Alarm
AA 12
AT 12
Air Ratio Systems
Digital
FI
FRQ 1
FRQ 5A
DR 4
FI 4
FRQ 4
D.O.
AI 3
FRQ 15
AI 4
FRC 7
FFRC 8
FFRC 9
FRQ 2
AI 5
WI 10
Load cells
FRQ 6
FI 6
FT 6
Cl2
FT 12
FI 12
Bypass
(Abandoned)
AT 1
AT 2
pH
ORP
FIT 1
Sampler
Air
AE 4
FT 7
AE 5
FI 10
ARC 10
AIT 10
Chlorinator
FI 11
Grit
Primary
Aeration
Secondary
Contact
FT 15
AE 3
FT 8
FT 4
DE 4
DITS 4
FT 2
Reaerate
Digest
FRQ 14
FRQ 5B
FT 14
FRQ 3
FT 3
FT 13
FT 9
AE 6
AI 6
FRQ 13
FT 5
Digest (Aerobic)
Centrate
Cent
Sludge

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-3

Responsible Supervisor

Flow Rate Design (Average and Maximum) 6 mgd max. design, running 2-3 mgd

Storm Water Collection and Treatment Mostly sanitary

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)

Activated sludge (step aeration - 1.6 hr. aeration)

Performance Data (Individual Units and Overall)

BOD removal 94-98% Susp. solids removal - 97%

Year Built 1961 Modifications (Year and Description) 1970 Primary rebuilt as secondary

Original Cost $2.5M Modification Cost $5.5M

Instrumentation F & P Electronic

Equipment Density, samplers, flow, level, res. chlorine

Panels Central and local

Installation and Start up Costs Original Cost Total Cost $140,000 (est.) before installation

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total

Computer

Type Manufacturer I/O Devices

Process Control

Data Logging

Parameter/Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control Pumping (effluent and sludges) and chlorination rate. Local aeration control.

Supervisory Control

Alarm and Safety Systems Extensive

Automatic Emergency Program (e g , Power Failure) None

Maintenance and Calibration

Special Equipment Off-site Down Time None

Special Operator Training None Frequency (no /mo)

Total In-Plant Man Hours/Year 300 mh/yr.

Total Cost of Outside Service

Estimate of Over-all Benefits of Instrumentation and Automation

High performance, good labor savings.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no mo)	Total Downtime	Downtime Frequency (no mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Sludge Density	Ohmart			30	1.5	No	No	No	--	Inst. down 4 mo. for factory repair		Grease Build-up	±2% of 10% range	Alarm	Strip chart recorder	Unit valuable, hot water flush necessary to achieve zero solids reading with water. Long factory repair time.
Auto Sampler	Chicago Pump	BR (Old style)		120	30	No	No	No	--	2 weeks per year	1	Electrical Contact Corrosion	--	Sample Pump	No	New design much better in resisting corrosion.
Chlorine Vapors	Fischer & Porter			50 (est.)	2	No	No	No	--	2 days/yr (est.)	.2 (est.)	None	±5% (est.)	Alarm	No	Reliable instrument because maintained regularly.

* Corrosion, fouling, etc.
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

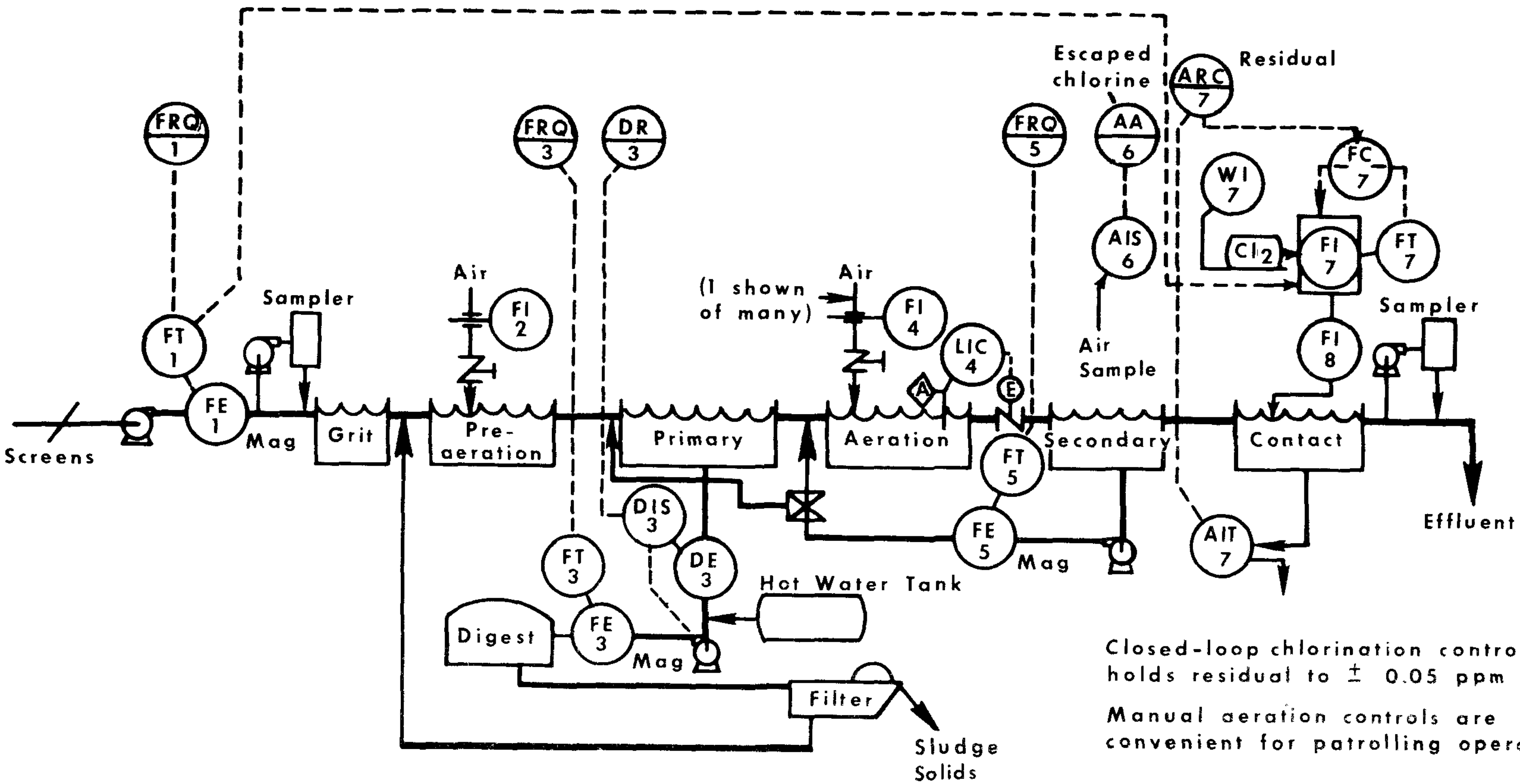
Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no /mo)	Comments
AIT-7	Residual Chlorine	1	P & R	Analog Electronic	Water	Chlorinator	0.03					+5% of 0-2 ppm	100 mh	90	No	None	None	Manual Control 100 hrs.	0.33	Inner chlorine flow loop in chlorinator detected by dP trans. transmitting actual chlorine flow. Good control.
LIC-4	Level	1	P & R	Analog Electric	Electric	Butterfly Valve	.05						16 mh (est.)	0.2 (est.)	No	None	None	None	--	Unit level control (bubbler, indicating controller, motorized valve) maintains precise basin level, releases all levels continuously.
FI-4	Air Flow	12	Manual	--	--	Butterfly Valve	--						4 mh (est.)	0.1 (est.)	No	None	None	None	--	Convenient location of orifice, flow indicator and adjacent valve makes manual control possible and accurate.

* Control mode relay, proportional, proportional plus reset, etc

** Types of controllers analog (pne , hyd or elec media) computer (supervisory, direct digital or set analog)

*** Final control element: pne. values, variable speed pump, etc

FIGURE B-3.



Closed-loop chlorination control holds residual to ± 0.05 ppm

Manual aeration controls are convenient for patrolling operator.

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-4

Responsible Supervisor

Flow Rate Design (Average and Maximum) Ave. 4 mgd; 6 mgd peak

Storm Water Collection and Treatment None

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)

Conventional Activated Sludge Treatment followed by Oxidation Ponds and Percolation Beds.
(set-up for tertiary treatment not being used due to lack of Federal funding).

Performance Data (Individual Units and Overall)

Average BOD Influent - 250 mg/l, BOD Effluent - 25 mg/l } conventional plant only or 90% BOD removal.

Year Built 1967 Modifications (Year and Description) None

Original Cost $2,224,944 (Activated Sludge Process only) Modification Cost None

Instrumentation

Equipment Flow meter, turbidity meter, sludge density, alarms and general recorders.

Panels 4: testing, secondary, primary and blowers.

Installation and Start up Costs est. $20,000 Original Cost est. $100,000 Total Cost $120,000 est.

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
Micrometer totalizers converted from mechanical	1972		--	--	--

Computer
Type None Manufacturer I O Devices

Process Control

Data Logging

Parameter Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control

Supervisory Control All pumps and valves.

Alarm and Safety Systems Industrial-type alarm system.

Automatic Emergency Program (e g , Power Failure) Generator for main pumps only.

Maintenance and Calibration

Special Equipment Fox. Calibrator, Scope, Temp. probes Megger multimeter Down Time

Special Operator Training Foxboro, Taylor, Bristol, Honeywell Frequency (no mo)

Total In Plant Man Hours Year 1 man, 1700 hrs/yr., available for instrument maintenance.

Total Cost of Outside Service

Estimate of Over all Benefits of Instrumentation and Automation

Permits operation of plant with 3 men; would require 6 to 8 men without use of instrumentation.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In Plant Maintenance (mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Frequency (no./mo.)	Total Downtime	Downtime Frequency (no./mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Sludge Pump Control	Autocon	--	$35,000	52	4	General	No	Available	--	None	None	Component burnout	--	None	None	No major problems.
Flow Meter	McCrometer (Propeller 4")	--	$800	Continuous	Continuous	General	No	Available	--	6/hrs per day	Every day	See Comment	Questionable	None	1 strip chart and Totalizer, F&P	Poor design in bearings, shafts, totalizers and housings, causing fouling, burned out bearings, broken cables and totalizer falling apart; i.e., absolutely worthless.
Activated Return Sludge Flow, 2 - 8 inch	McCrometer (Propeller 2-8")	--	$1,200	Continuous	Continuous	General	No	Available	--	About 6/hrs per day	Every day	See Comment	Questionable	None	2 strip charts, F&P	
Sludge Flow: Mag. Meter, 8-inch	F & P	TOD-1408A	$14,000	12	1	Fischer & Porter	No	Available	--	None	None	None	1%	None	2 strip chart Recorders, F&P	No problems.
Main Flow: Mag. Meter, 16-inch	Fischer & Porter	TOD-1416A	$23,000	12	1	Fischer & Porter	No	Available	--	None	None	Some ground water seepage into cal. box	1%	None	Circular chart Recording Totalizer, F&P	Seepage of ground and other water causing problems in electronics chamber.
Air-Flow: Orifice Plates	Made On-Site		$150.00	None	None	--	--	--	--	None	None	None	1/10 of 1%	None	Flow recorder (strip chart) controller	None
Sludge Density	Ohmart	CP-6-W(C)	$4,000	52	4	General	No	Available	--	None	None	None	1/4 of 1%	None	1 strip chart; 1 circular (Fischer & Porter)	None

* Corrosion, fouling, etc.
** Limiters, alarms, ratio relays
*** Local and central.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no /mo)	Total Downtime	Downtime Frequency (no /mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Turbidity	HACH Chemical Corp.	CR-T 262	$3375	12	1	General	No	Available	--	See Comment	See Comment	See Comment	1%	None	Strip Chart F & P	No problem with meters. Pipes to meters clog.

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays.
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no/mo)	Comments
FT-3	Aeration Tank Air	3	Analog-Prop. & Reset	Analog	Electric	Blowers	.01	8750 mh	--	--	--	--	15 mh	1	General	No	Available	None	None	No downtime - only maintenance.
LT-6	Return Activated Sludge Pump control	2	Prop. & Reset	Analog	Electric	Pump	.5	8750 mh	--	--	--	--	12 mh	1	General	No	Available	12	1/mo	No problems - maintenance only.
LT-2	Main Plant Pumps	2	Prop. & Reset	Analog	Electric	Pump	.5	8750 mh	--	--	--	--	12 mh	1	General	4 mh	4 mh	2	1/yr	No problems - maintenance only.
AT-4	Turbidity of final Sedimentation	1	Proportional	Analog	Electric	Valve	.01	120 mh	--	--	--	--	6mh	1	General	No	Available	See Comment	See Note	Never worked due to clogging of pipes to meter (black iron) caused by being too close to flights in tank; however, meter works o.k.

* Control mode relay, proportional, proportional plus reset, etc

** Types of controllers analog (pne, hyd or elec media), computer (supervisory, direct digital or set analog)

*** Final control element pne values, variable speed pump, etc

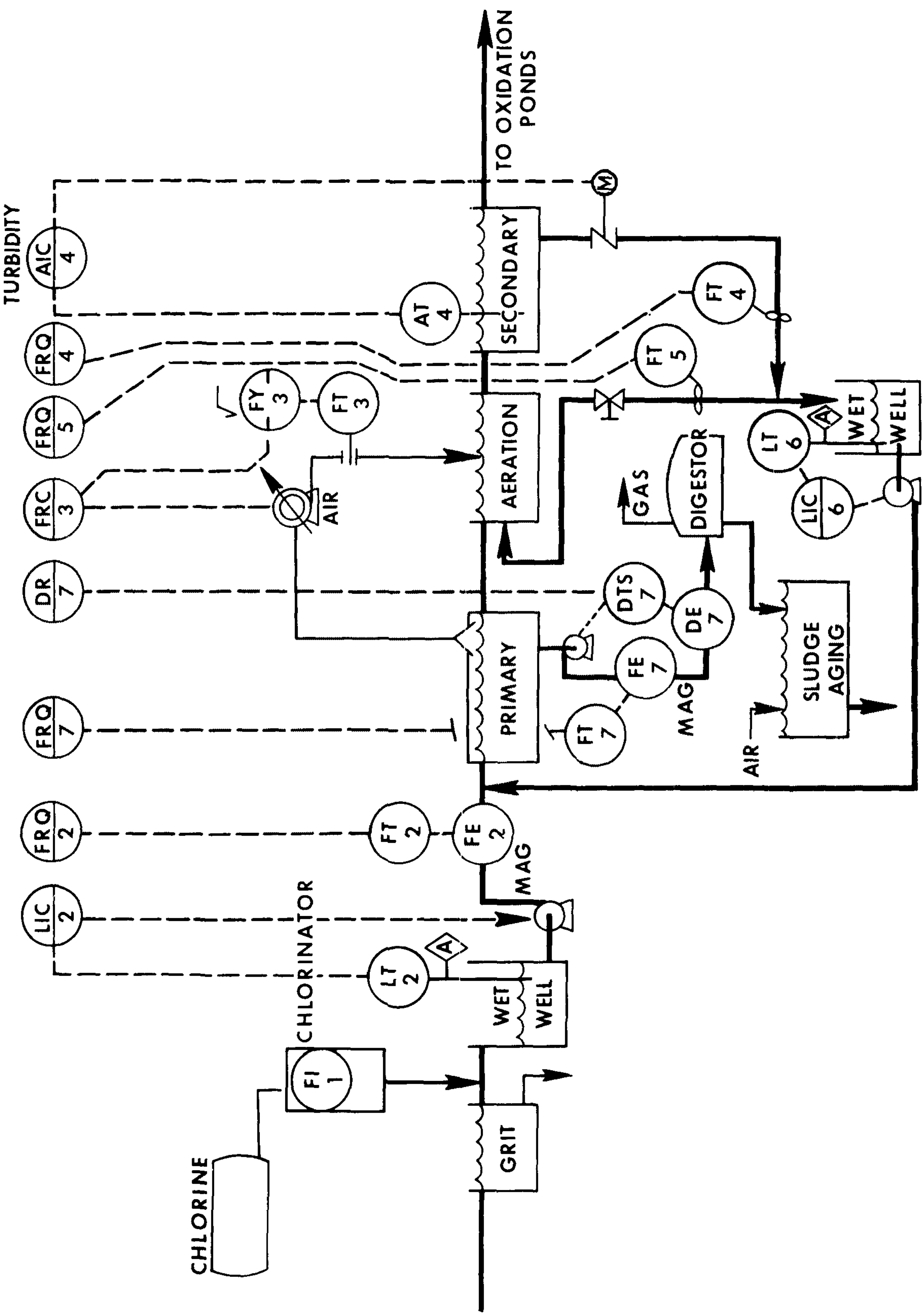
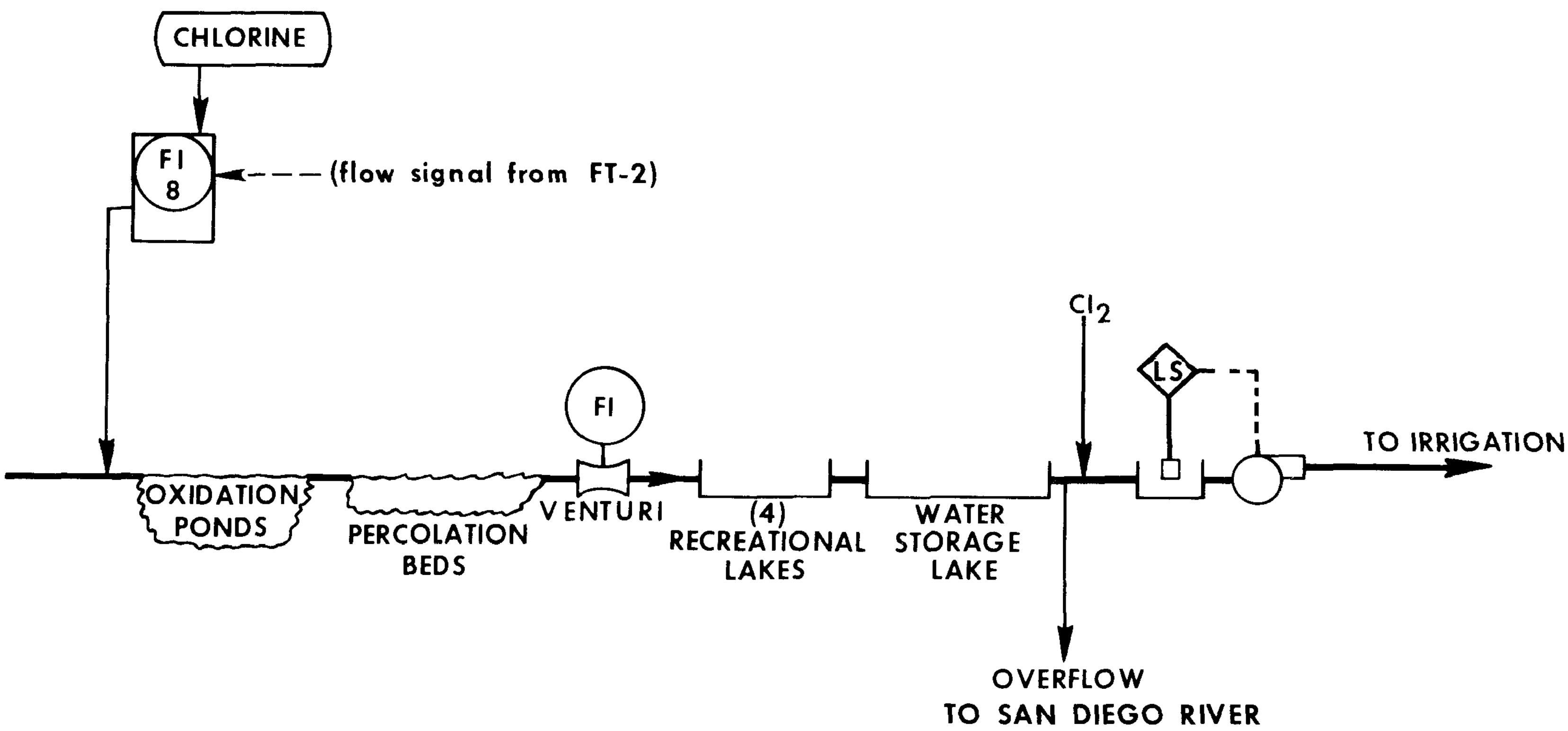

TO OXIDATION PONDS
TURBIDITY
AIC 4
FRQ 4
FRQ 5
FRC 3
DR 7
FRQ 7
FRQ 2
LIC 2
CHLORINATOR
CHLORINE
FI 1
GRIT
WET WELL
LT 2
A
MAG
FE 2
FT 2
PRIMARY
FT 7
FE 7
MAG
DE 7
DTS 7
AIR
FY 3
FT 3
AERATION
AT 4
SECONDARY
M
FT 4
FT 5
GAS
DIGESTOR
SLUDGE AGING
AIR
LT 6
LIC 6

FIGURE B-4(a).

FIGURE B-4(b).


CHLORINE
FI
8
(flow signal from FT-2)
OXIDATION PONDS
PERCOLATION BEDS
FI
VENTURI
(4) RECREATIONAL LAKES
WATER STORAGE LAKE
Cl2
LS
TO IRRIGATION
OVERFLOW TO SAN DIEGO RIVER

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-5

Responsible Supervisor

Flow Rate Design (Average and Maximum)
5.0 mgd - Present Average; 5.0 mgd - Design Average; 25 mgd - max. hyd. capacity

Storm Water Collection and Treatment
The system is separated.

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Secondary treatment plant with activated sludge process and sludge digestion.

Performance Data (Individual Units and Overall)
Overall BOD removal - 92%
Overall SS removal - 94%

Year Built 1965 **Modifications (Year and Description)** None

Original Cost $822,000 **Modification Cost** None

Instrumentation

Equipment Mostly electrical

Panels One main central control panel, some local panels.

Installation and Start up Costs **Original Cost** **Total Cost**

Controls for hydropneumatic tank & auxil	$3,900	(1965)
Chlorination equipment	6,200	(1965)
Flow metering equipment	8,750	(1965)
Gas control equipment & piping	3,200	(1965)

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
None					

Computer
Type None **Manufacturer** **I/O Devices**

Process Control

Data Logging

Parameter Frequency	Parameter Frequency	Parameter Frequency	Parameter Frequency

Storage

Software Description

Computer Cost **Software Cost** **Installation Cost**

Central Control

Supervisory Control None

Alarm and Safety Systems Yes

Automatic Emergency Program (e g , Power Failure) Gravity flow through treatment plant continues during power failures. Portable generator actuated during power failures.

Maintenance and Calibration

Special Equipment Electrical equipment maintained by electricians.

Down Time No plant down-time due to instrument down-time.

Special Operator Training None

Frequency (no mo) No down-time due to instrumentation

Total In Plant Man Hours Year 30±

Total Cost of Outside Service Minor

Estimate of Over-all Benefits of Instrumentation and Automation
More instrumentation at the plant would be desirable, such as measurement of primary and waste sludge flow and density. Automatic measurement of suspended solids would be helpful.

Most of the instrumentation is for record keeping and to assist in on-off operation of pumps, ejectors, compressor, etc.; would be difficult to operate without it.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In Plant Maintenance (mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no./mo.)	Total Downtime	Downtime Frequency (no./mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Sewage Flow (Influent)	Two Parshall Flumes; Hersey-Sparling Mech. Float Transmitter	Serial 12012 Type 261	Entire system Flow metering Equipment $8,750 (1965)	1	0.08	None	None	None	None	None	None	Problems with receivers; repaired gears; freq. cleaning of wheel to avoid skipping necessary on floats.	OK	Indicator, integrator-totalizer, transmitter	Yes	The system is satisfactory with minor maintenance.
Primary Sludge Flow	Counter for ejector operation. Oil immersed switch.	None		None	None	None	None	None	None	None	None	None	Not accurate	Integrator & Counter	Yes	Ejector operation counter is used to determine raw sludge flow.
Plant Effluent	27-inch Propeller Meter; Hersey-Sparling	D15-1E	Entire system Flow metering Equipment $8,750 (1965)	6	1	None	None	None	None	None	None	Transmitter problem once; occasional cleaning required	Inaccurate at low flows	Alarms, local control panel, central record & totalizer		The system is satisfactory with minor maintenance.
Return Activated Sludge	12-inch Propeller Meter; Hersey-Sparling	D15-1E	Entire system Flow metering Equipment $8,750 (1965)	6	1	None	None	None	None	None	None	Periodic cleaning required	OK	Local recorder; central record and totalizer		The system is satisfactory with minor maintenance.
Digester Gas Flow	American Gas Meter	80-B	Entire system gas control. Equip. & Ship-ing, $3,200 (1965)	Abandoned completely after 2 yrs operation	Freq. maint. & cleaning before abandonment	None	None	None	None	Abandoned completely after 2 yrs operation	Abandoned	Corrosion caused instrument to become inoperative	Abandoned; Accuracy lost due to corrosion	Indicator-totalizer attached to instrument	None	Abandoned; lasted about 2 years. The meter does not measure gas production but merely how much gas is utilized; also, they don't consider this measurement critical.
Dissolved Oxygen	Home-made by J. Burns, Asst. Supt., Portland	Membrane type		60	1	None	None	None	None	None	None	Probe fouling and drift	+ 1 ppm., 0 5-10 ppm. range	Special Holder	No	Indication used as generally reliable operating guide, checked twice vs. Winkler. Installed in lower end of aeration tank.
ORP	Beckman (Laboratory Type)		(Temporary)	80 (est.)	9	None	None	None	None	Frequent (See below)	1 (est.)	Probe fouling and breakage	Good when maintained	No	No	Test installation on secondary sludge. Results indicate permanent installation promising based on 6-week trial.

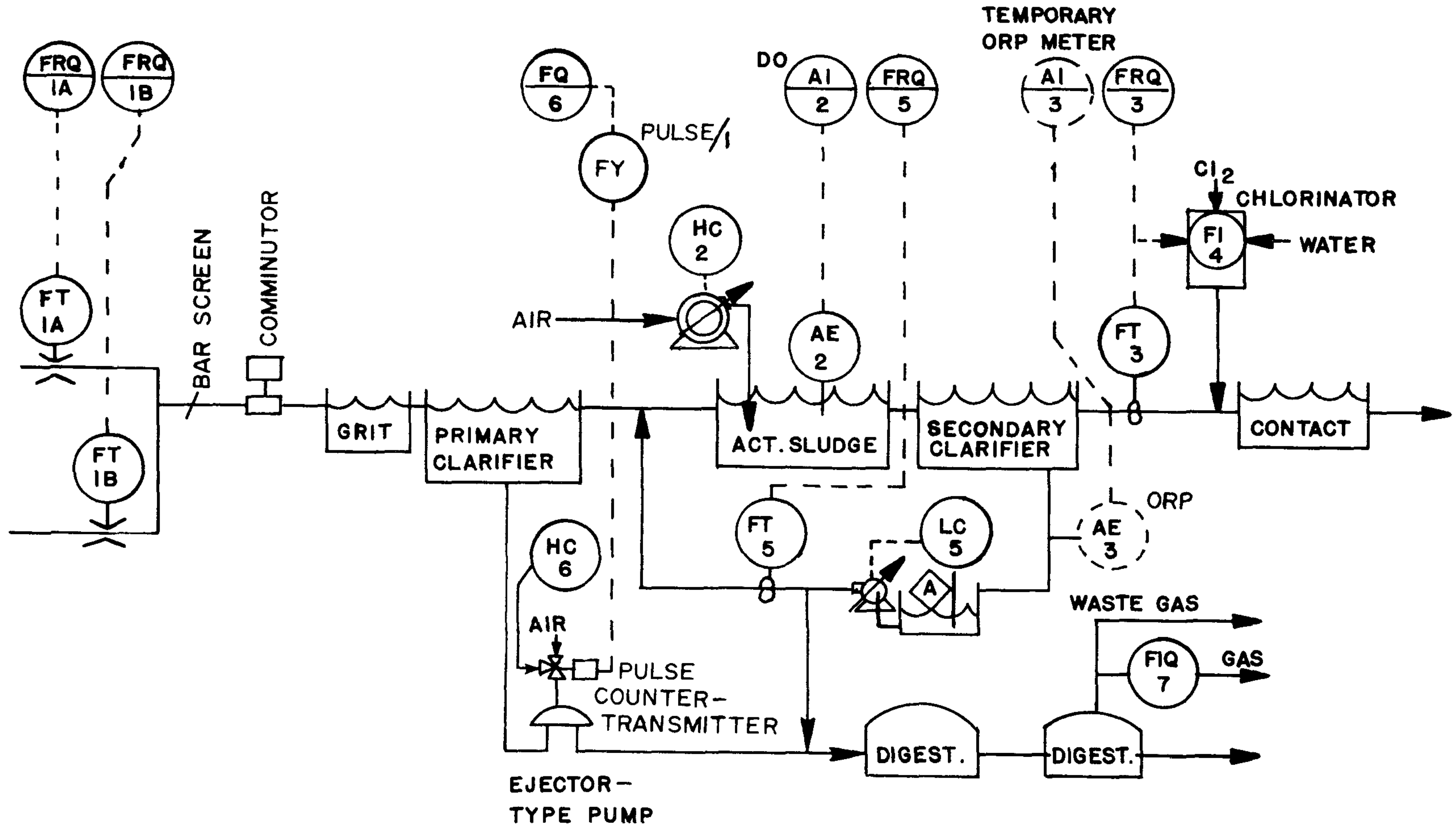
* Corrosion, fouling, etc.
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW-hr yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Downtime (hr/yr)	Downtime Frequency (no mo)	Comments
HC-2	Compressed air to aeration tanks	2	On-off	Manual on-off operation and speed control of 1 compressor	Electric	Manual control of compressors	Manual	None	Some	None	Some	Yes	None	None	None	None	None	None	None	Manual readings of DO in aeration tanks are used to adjust the compressors. The procedure works well, but is cumbersome—requiring several adjustments per day. (See previous sheet)
FT-3	Chlorination	2	Porportional to flow	V-notch Wallace & Tiernan chlorinator	Electric	Manually adjusted chlorinator	0.2	Yes	None	Yes	None	Yes	8 mh	0.16	None	None	None	None	None	The system works well.
LC-5	Return activated sludge pumping	1	Proportional and on-off	Flow-matcher speed control of 1 pump	Electric	Manual influent valve	0.5	Yes	None	None	Some	Yes	16 mh	0.3	None	None	None	None	None	Manual flow observations and manual adjustment of valve. A chart indicates valve position to give desired return rate. The valve has to be adjusted 3 to 4 times per shift and is time consuming.
HC-6	Primary sludge pumping	3	On-off	Manual on-off operation of pneumatic ejectors	Electric	Manual operation of ejectors from manual tests	Manual	None	Some	None	None	Yes	None	None	None	None	None	None	None	Manual observations of sludge consistency are used to turn on pneumatic ejector. This procedure works well, but requires several observations per shift and is time consuming.

* Control mode relay, proportional, proportional plus reset, etc
** Types of controllers analog (pne , hyd. or elec media), computer (supervisory, direct digital or set analog)
*** Final control element pne values, variable speed pump, etc

FIGURE B-5.


FRQ IA
FRQ IB
FT IA
FT IB
BAR SCREEN
COMMINUTOR
GRIT
PRIMARY CLARIFIER
FQ 6
FY
PULSE
HC 2
AIR
DO
AI 2
FRQ 5
AE 2
ACT. SLUDGE
SECONDARY CLARIFIER
TEMPORARY ORP METER
AI 3
FRQ 3
FT 3
Cl_2
CHLORINATOR
FI 4
WATER
CONTACT
ORP
AE 3
FT 5
LC 5
A
HC 6
AIR
PULSE COUNTER-TRANSMITTER
EJECTOR-TYPE PUMP
DIGEST.
DIGEST.
WASTE GAS
FIQ 7
GAS

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-6

Responsible Supervisor

Flow Rate Design (Average and Maximum) 6.5 mgd average; 13.25 mgd Peak

Storm Water Collection and Treatment Combined storm-sanitary system with 5 regulator stations to divert excess flow to a river without treatment.

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems.) Partially flow-equalized, 2-stage high-rate Trickling Filter with PO_4 removal; Zimpro sludge treatment; vacuum filters for sludge dewatering.

Performance Data (Individual Units and Overall)
About 75 percent BOD_5 reduction; effluent ≈20 mg/l BOD_5.

Year Built 1963

Modifications (Year and Description) 1971 - added PO_4 removal, retention basin, and Zimpro sludge oxidation reactor.

Original Cost

Modification Cost

Instrumentation

Equipment

Panels Central Control

Installation and Start-up Costs 24K

Original Cost

Total Cost

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
Mag flow meter, remote station Telemetry, PO_4 Analyzer					

Computer

Type None

Manufacturer

I O Devices

Process Control

Data Logging

Parameter Frequency	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost

Software Cost

Installation Cost

Central Control

Supervisory Control Pump stations, regulator over-flow stations, and essential in-plant wastewater and sludge pumps.

Alarm and Safety Systems

Automatic Emergency Program (e g , Power Failure) 2 separate power feeds, & stand-by generators.

Maintenance and Calibration

Special Equipment None

Down Time

Special Operator Training None

Frequency (no /mo)

Total In-Plant Man Hours/Year 1,000 man-hours/year

Total Cost of Outside Service Replacement parts

Estimate of Over-all Benefits of Instrumentation and Automation

The plant superintendent believes the remote control devices and the automatic control loops reduce the manpower required to run this plant by about 50 percent. Previous experiences with analytical instruments, such as orthophosphate, demonstrated that the maintenance requirements exceeded this plant's capabilities; they consider on-line analytical sensors too unreliable for municipal treatment plants.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In Plant Maintenance (mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Frequency (no/mo)	Total Downtime	Downtime Frequency (no/mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Flow	F & P	--	--	12 mh/yr	Annual	None	--	--	--	--	--	None	Good	Flow proportional control	Local and central	Flow measurements used in flow-proportional chemical-addition loop.
Level	F & P	--	--	12 mh/yr	Monthly	None	--	--	--	--	Rare	None	Good	Level control	Local and central	
PO_4	HACH	--	--	Constantly required	Continual	One week of factory training	--	--	--	Abandoned	Abandoned	Very poor reliability	Poor	Controlled $FeCl_3$ addition	Local and central	On-line measurements of ortho-phosphate proved very unreliable in municipal wastewater-treatment-plant environment. Subsequently, Midland abandoned the on-line o-PO_4 instrument.

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays.
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							Comments
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW-hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no./mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no./mo)	
	Retention basin	1	Porportional	Analog	Pneumatic	Valve	5 min.	--	--	--	20%	--	50-100	--	--	--	--	--	--	Partial flow equalization was achieved by using the retention basin to handle flows in excess of 6.5 MGD.
	Chemical addition	3	Flow Proportional	Analog	Pneumatic	Metering pumps	1 min.	--	--	30%	--	--	50	2/mo	--	--	--	Small	Rare	$FeCl_3$, Alum, and polymer additions controlled by flow. Originally a PO_4 sensor in conjunction with flow directed the chemical additions; however, PO_4 analyzer was so unreliable that this plant abandoned the PO_4 analyzer.
	Wet Well	1	Proportional	Analog	Electric	Variable-speed pump	2 min.	--	--	--	--	--	25	--	--	--	--	Small	Rare	Satisfactory control system.
	Trickling Filter Recirculation	4	Proportional	Analog	Electric	Pump	5 min.	--	--	--	--	--	--	--	--	--	--	--	--	Trickling filter recirculation control essential for proper hydraulic loading of these units.
	Vacuum Filters	2	Proportional and on-off	Analog	Pneumatic	Pumps and drum speed	--	--	--	--	--	--	1,000 mh/yr	High	--	--	--	--	Frequently	Because of frequent downtime and difficulty of repair, automatic control of the vacuum filters was abandoned. Part of the problem was due to unavoidably frequent start-up and shut-down of sludge-dewatering operations.

* Control mode relay, proportional, proportional plus reset, etc

** Types of controllers analog (pne hyd or elec media) computer (supervisory, direct digital or set analog)

*** Final control element pne values, variable speed pump, etc

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no./mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no./mo)	Comments
	Pumping station	2	Propor-tional	Analog	Electric	Pumps	2 min.	--	--	--	--	--	--	--	--	--	--	--	--	Pump station levels and pump status telemetered to control plant.
	Regulator stations	5	Open-loop remote manual	Analog	Electric	Gates	5 min.	--	--	--	--	--	--	--	--	--	--	--	--	Positioning of overflow regulator was remotely controlled from central plant. Position indicators telemetered regulator status to central plant.

* Control mode relay, proportional, proportional plus reset, etc
** Types of controllers analog (pne , hyd or elec media), computer (supervisory, direct digital or set analog)
*** Final control element pne values, variable speed pump, etc

GENERAL SURVEY QUESTIONNAIRE

Form approved
OMB No 158-S72005

STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-7

Responsible Supervisor

Flow Rate Design (Average and Maximum)
Average Design - 12 mgd Peak Design - 20 mgd (Excess
Average Actual - 15 mgd Peak Actual - 20 mgd bypassed)

Storm Water Collection and Treatment
None (separate system)

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Secondary Treatment Plant with Actived Sludge Step Aeration. Effluent is groundwater-basin recharge. The plant receives flow at a constant rate.

Performance Data (Individual Units and Overall)
Suspended Solids - overall - 95.8% removal
BOD - overall - 96.1% removal

Year Built 1962

Original Cost $1.7 million

Modifications (Year and Description) 1963 - influent pumps changed to variable-speed magnetic drives
1965 - primary sludge valves changed from butterfly to gate in order to avoid plugging.

Modification Cost --

Instrumentation

Equipment Mostly electric, some pneumatic.

Panels Central control panel without subpanels

Installation and Start-up Costs -- Original Cost -- Total Cost --

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
Influent Pump Controls	1964	Bubble-tube level controls for speed control of pumps.			
Chlorine Tank Switchover	1967	Automatic changeover system installed to switch from one chlorine storage tank to another when chlorine runs out.			

Computer

Type None at plant Manufacturer I/O Devices

Process Control: None

Data Logging: Plant operating data is phoned in to San Jose Creek daily. Monthly summary is prepared and sent from main office to local plant. Time sharing console at San Jose plant is used for data transmission. Future teletype is planned for surveyed plant.

Parameter/Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control

Supervisory Control Waste sludge percentage, influent pump flow, primary sludge valve-opening schedule, and chlorination rate are set from central control panel.

Alarm and Safety Systems Yes

Automatic Emergency Program (e g , Power Failure) Two tie lines, portable generator.

Maintenance and Calibration

Special Equipment Oscilloscope, test gauges, water manometer precision and milliamp detector

Down Time No plant downtime due to instrumentation; however, some instrument downtime

Special Operator Training 2 hrs. per week for 4 men in the entire Los Angeles County Sanitation District

Frequency (no mo) 2

Total In-Plant Man Hours/Year 600 (400 routine maintenance and 200 trouble shooting)

Total Cost of Outside Service None

Estimate of Over-all Benefits of Instrumentation and Automation

Improved plant efficiency.
Savings is required manpower (a total of 3 men run the entire plant; in case of emergency an operator can be called in).

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In Plant Maintenance (mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no/mo)	Total Downtime	Downtime Frequency (no/mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Flows	Hersey-Sparling Propeller Meter	221	--	30	4	None	None	None	None	24 hrs. per year	0.08	Problems with switches	5%+	Switches, totalizer, controllers	Central Control Panel	The meters are satisfactory. There are some minor problems with auxiliaries requiring some maintenance, particularly with switches.
Influent Level	Autocon Air-Bubbler System	--	--	20	4	None	None	None	None	24 hrs. per year; switch to another unit	0.16	The unit is obsolete	7%+	Transducers, controller	None	Moisture and dirty air affect operation of springs which require cleaning and lubrication. The Autocon unit is obsolete for these reasons.
Waste Sludge Flow	Micro-meter Propeller Meter	MC 0900	--	4	.3	None	None	None	None	12 hrs. per year	0.8	None	5%+	Totalizer, controller	Central Control Panel	Very good, requires very little maintenance. Switched from Hersey-Sparling propeller meter to reduce plugging problems and because parts are cheaper and easier to get.
Return Sludge Turbidity	Hach Falling Stream Turbidimeter	1031	--	Abandoned	Abandoned	None	None	None	None	Abandoned	Abandoned	Many problems. Could not get the system to work.	Unknown	Alarms, sampling lines, air-lift, transducers	None	Turbidimeter received sample through 1-inch line pumped by air lift. Plugging, pulsation, and foaming problems, as in the San Jose plant. System abandoned
Effluent Turbidity	Hach Turbidimeter See Note	CR	--	15	4	None	None	None	None	1 hr. per year for cleaning	.25	Requires some cleaning. Obsolete	10%+	Transducer	Central Control Panel	This unit is older and not as good as the surface scatter turbidity at San Jose plant which requires less maintenance and is more accurate
Chlorine Residual	Wallace & Tiernan	A-720	--	100	30	None	None	None	None	Some for cleaning	None	High maintenance	25%+	Alarms, indicators, switches, transducers	Central Control Panel	Unit requires high maintenance to clean probes and make buffer solution. Since chlorine residual is not used to control chlorinators at Whittier Narrows plant, the maintenance is infrequent. There is a gradual drift in accuracy due to build-up of material on probes with less frequent cleaning.
Air Flow	Manufacturer unknown Insert Dall-Venturi Meter	Unknown	--	8	0.16	None	None	None	None	24 hrs. per year due to totalizer problems	0.17	Totalizer causes some problems	3%	Alarms, transducers	Central Control Panel	The instrument system is satisfactory provided auxiliaries are maintained twice per year.

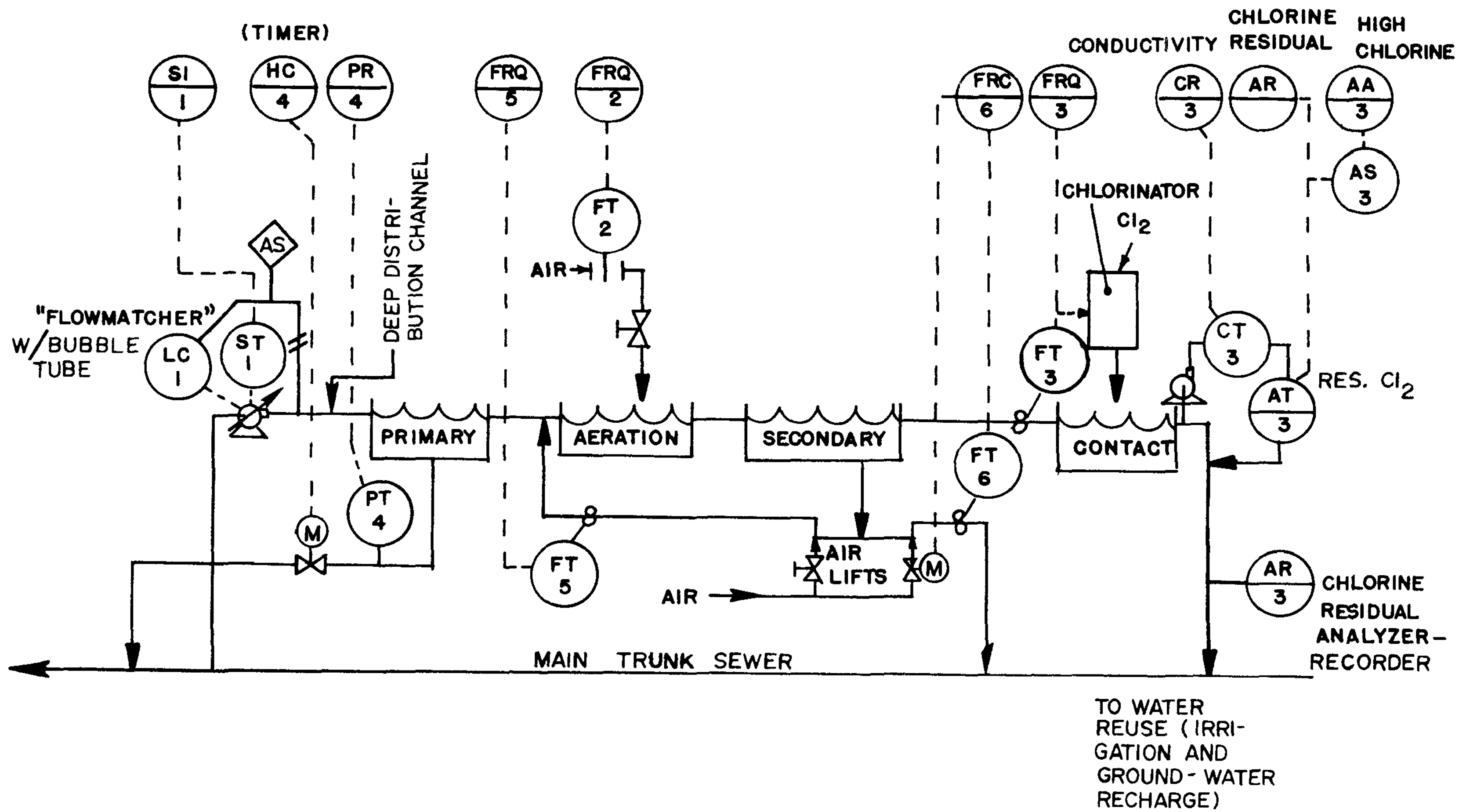
* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							Comments
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min.)	Manpower (mh/yr)	Utility (kW-hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no. mo.)	
AT-3	Chlorination	1	Proportional to flow	Electric	Electric	Chlorinator	1	2,190	None	Minor	Minor	Reduces Effluent Cl_2 Residual Variations	150 mh	30	In-House	None	None	None	None	The system works well. The plant has constant flow. Residual chlorine analyzer is not in the control loop.
	Influent Sewage Flow	1	Proportional plus reset	Electric	Electric (Magnetic Drives)	Variable-Speed Pumps	.08	4,380	Minor	None	Minor	Reduces Influent Level Variations	50 mh	4	In-House	None	None	12	0.08	The Autocon unit is obsolete and requires high maintenance.
	Waste Sludge Flow	1	Proportional plus reset	Pneumatic	Pneumatic	Control Valve	25	2,190	None	None	None	Reduces Flow Variations	5 mh	0.3	None	None	None	12	0.08	The system works well.
FT-5	Return Sludge Flow	10		Manual	Manual	Air Lift Control Valve	1	None	None	None	None	None	10 mh	4	None	None	None	12	0.08	Operation takes a lot of time. Observation of sludge blanket is made 8 times per day, requiring 15 minutes each time for operation of control valves. Turbidity meter was never in the control loop.
FT-2	Aeration Air Flow	1		Manual	Manual	Butterfly Valve	1	None	None	None	None	None	5 mh	.08	None	None	None	24	.17	The system works well manually. Constant setting can be used, since plant flow is constant.
	Primary Sludge Flow	4	On-off with programmed timer	Programmed Open loop	Electric	Gate Valve	5	4,380+	None	None	Minor	Reduces drawing too thin sludge	10 mh	0.3	None	None	None	None	None	Works well - could be better.

* Control mode relay, proportional, proportional plus reset etc
** Types of controllers analog (pne, hyd or elec media), computer (supervisory, direct digital or set analog)
*** Final control element pne values, variable speed pump, etc

FIGURE B-7.


(TIMER)
SI 1
HC 4
PR 4
FRQ 5
FRQ 2
FRC 6
FRQ 3
CONDUCTIVITY
CR 3
CHLORINE RESIDUAL
AR
HIGH CHLORINE
AA 3
AS 3
AS
"FLOWMATCHER" W/BUBBLE TUBE
LC 1
ST 1
DEEP DISTRI-BUTION CHANNEL
FT 2
AIR
CHLORINATOR
Cl_2
FT 3
CT 3
RES. Cl_2
AT 3
PRIMARY
AERATION
SECONDARY
CONTACT
FT 6
M
PT 4
FT 5
AIR LIFTS
M
AIR
AR 3
CHLORINE RESIDUAL ANALYZER-RECORDER
MAIN TRUNK SEWER
TO WATER REUSE (IRRI-GATION AND GROUND-WATER RECHARGE)

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-8

Responsible Supervisor

Flow Rate Design (Average and Maximum) 20 mgd Avg.; 32 mgd Peak

Storm Water Collection and Treatment Some stormwater from Reno, plus infiltration

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems) Plug flow activated sludge with post aeration; anaerobic sludge digestion with sludge drying beds (see attachments).

Performance Data (Individual Units and Overall)

Year Built

Modifications (Year and Description)

Original Cost

Modification Cost

Instrumentation Honeywell pneumatic

Equipment Parshall Flumes; level and flow measurement and control; D.O. monitoring and control; sludge density meas with clarifier pump-down; Residual Cl_2 meas. and control.

Panels 30-ft. graphic panel in central control room.

Installation and Start-up Costs N/A

Original Cost 155K

Total Cost

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
Range change	1972	Return activated sludge controls			

Computer None

Type

Manufacturer

I/O Devices

Process Control

Data Logging

Parameter/Frequency	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost

Software Cost

Installation Cost

Central Control

Supervisory Control Yes; most, important, unit operations and processes are automatically controlled from the central control room.

Alarm and Safety Systems Annunciator panel alarms - (Minn-Honeywell); No Cl_2 detector.

Automatic Emergency Program (e.g., Power Failure) No internal; but plant has two independent power sources.

Maintenance and Calibration Contract with Minn-Honeywell for control systems w/in-plant analytical calibrations.

Special Equipment Lab D.O.

Down Time Very short interruptions

Special Operator Training. In-plant programs

Frequency (no./mo.) Less than once a month

Total In-Plant Man Hours/Year 560 mhrs/yr

Total Cost of Outside Service $13,000

Estimate of Over-all Benefits of Instrumentation and Automation

Instr. and automatic control devices reduce manpower, utility, and chemical expenses in addition to increasing plant effluent quality by approximately 20%. Sludge density instruments and automatic control equipment abandoned because of poor reliability; currently, clarifier pump-down manually regulated. Reliable sludge density instruments would improve operations.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh yr)	On Demand Service ($ or mh yr)	Frequency (no mo)	Total Downtime	Downtime Frequency (no mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
D.O.	Beckman		Approx. $1,200	30mh/yr per probe	Daily Calibration	w/quarterly membrane changes	Honeywell, about 10 hrs/yr per probe	None	--	Less than 24hrs/yr	1/yr	probe too far from transmitter	5% full scale	Automatic Control	Local & Central	Initially, probe was located several hundred feet from signal conditioner, thus causing about 15% signal loss in transmission: corrected in 1972. Probe located in aeration effluent-sample pipe; probe has no mechanical agitator. D.O. calibrated daily by atmospheric air method.
Residual Chlorine	Wallace & Tiernan			50mh/yr	Weekly	None	Honeywell, about 75mh/yr	None	--	Service Only	Monthly Service	None	5%		Local Rec.; Remote Ind.	Reliable instr., but requires reagent replacement, periodic calibration and preventive maintenance.
Flow	Parshall Flume preceded by a Crest Weir			--	--	--	Honeywell, ≈100mh/yr	None	4/yr	During Tests Only	4/yr	Unreliable Readings	10%	Flow-Prop. Controller	Remote Ind. & Rec	Flow measurement difficulties due to insufficient approach-length for Parshall Flumes (after gates) and direction changes. Calibrated with staff gauges.
Liquid Level	Honeywell			None	--	None	Honeywell, ≈25mh/yr	--	--	Service Only	Service Only	None	5%	Pump Control		Bubble-tube liquid-level sensors provide reliable level data, suitable for pump control.
Sludge Density	Chicago Nuclear		Approx. $3,500	None	--	--	Honeywell	--	--	Instr. Abandoned	--		Very Poor	Clarifier Pump-down Control	Remote Recording	Sludge density instr. never worked. Plant personnel maintain poor design, and improper installation, render SD measurements useless. Erratic operation; unacceptable performance; sludge density instruments abandoned.

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW-hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh yr)	On Demand Service ($ or mh yr)	Downtime (hrs/yr)	Downtime Frequency (no mo)	Comments
Control Techniques								Benefits: Annual Cost Savings			Benefits: Process Improvement		Operating Experience							
AIT-201	Aeration D.O.	3	PI Compound Cascade	Pneumatic	Pneumatic	Butterfly Valve	10-15 min.	1100mh/yr	25%	--	Approx. 10%	+0.2mg/1 95% of time	See D.O. Probe	See D O. Probe	None	Honeywell 50hrs/yr	--	Less than 24 hrs/yr	1/yr	Originally, D.O. control system flow-paced with feedback D.O. trimming; but because of high D.O. offset during storms, D.O. control loop modified to operate only on aeration tank D.O. This loop effectively controls the D.O. in the 1 to 1.5mg/1 range. Manual control required for D.O. S.P. of 0.5mg/1. or less.
AIT-212	Chlorine	2	Proportional	Pneumatic	Pneumatic	Vacuum Reg.	1 min	--	--	25%	--	+0.3mg/1	50mh/yr	4/mo	None	Honeywell	--	For Calib. Cl_2 Analyzer	For Calib. Cl_2 Analyzer	Satisfactory Cl_2 control system, capable of fast responses. Controller proportions Cl_2 dosage according to residual chlorine.
FIT-209	Blower Surge	3	PI	Pneumatic	Pneumatic	Butterfly Valve	<1 min (fast)	--	--	--	--	--	--	--	--	Honeywell 20mh/yr	--	--	--	Some difficulty experienced during plant start-up, but afterwards, blower surge control has been trouble-free. Essential for air flow regulation.
FE-104	Clarifier Pump-Down	3 On-off	Timer cycle w/density override	Electric	Electric	Pump	--	--	--	--	--	--	Excess Maint. on Density Inst.	--	--	--	--	--	--	Time-initiated, low sludge density, or end-of-time-cycle termination of sludge pumping. Because of poor performance, sludge density equipment abandoned. Currently, pump-down is timer controlled.
TI-107	Digester Temp.	2	Manual On-off	--	--	--	Very Slow (24 hrs)	--	--	--	--	+2°F	--	--	--	--	--	--	--	Manual on-off temp control provides acceptable digestion temp. regulation. Checked twice per shift.

* Control mode relay, proportional, proportional plus reset, etc

** Types of controllers analog (pne, hyd or elec media), computer (supervisory, direct digital or set analog)

*** Final control element pne values, variable speed pump, etc

FIGURE B-8(a).

SECONDARY PLANT B-8
PRIMARY & SLUDGE DIGESTION
100 LOOP

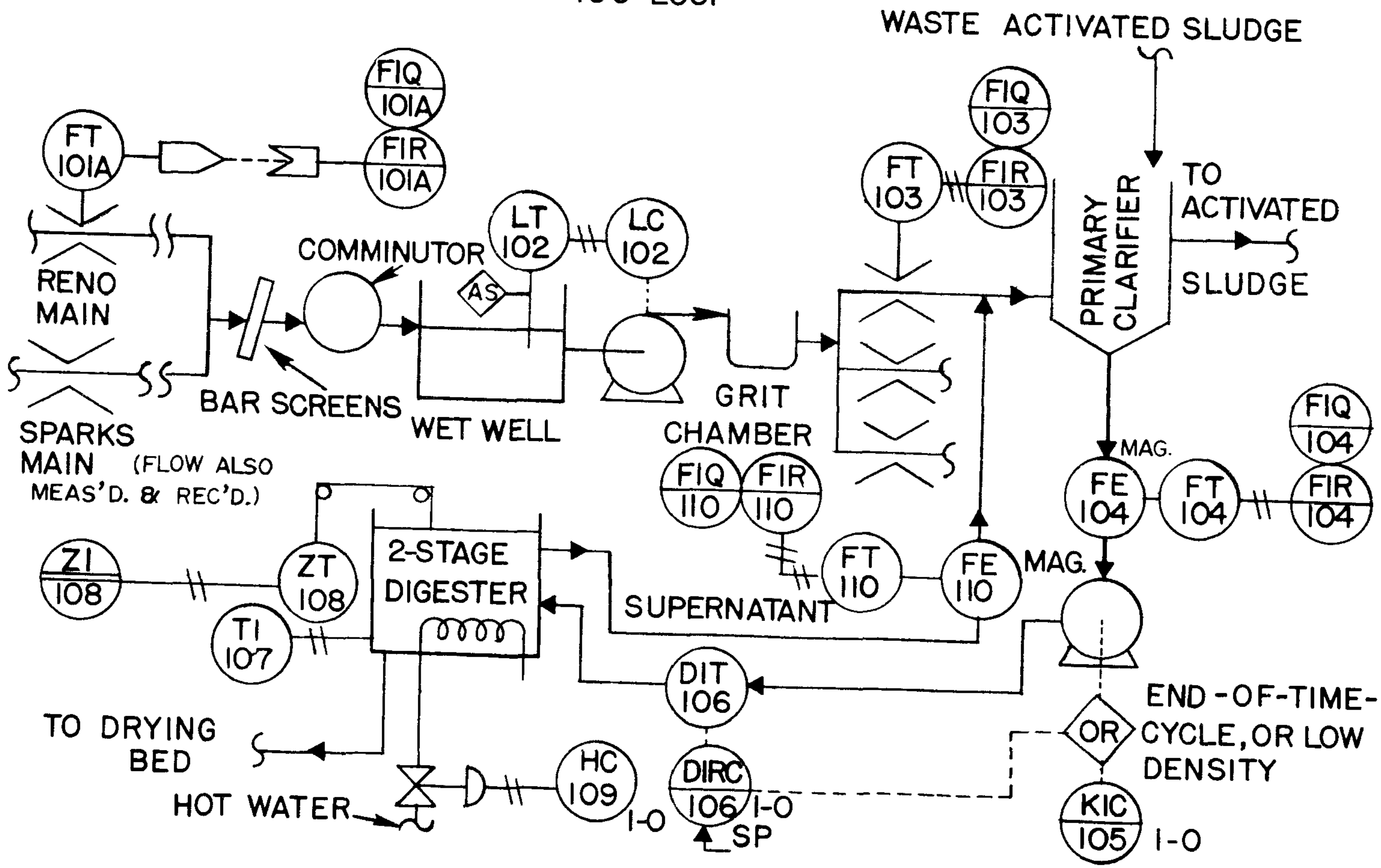
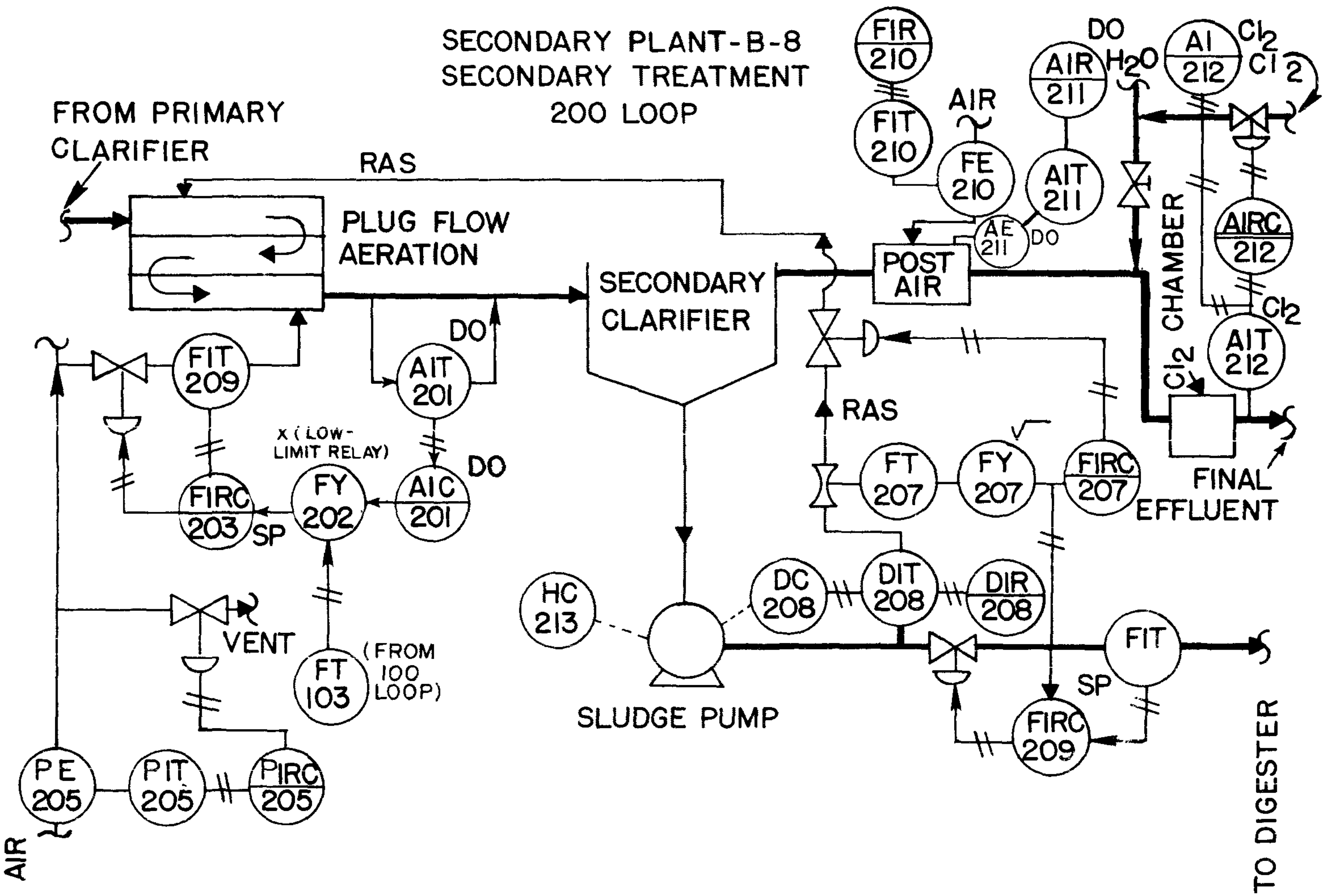


FIGURE B-8(b).



SECONDARY PLANT-B-8
SECONDARY TREATMENT
200 LOOP
FROM PRIMARY CLARIFIER
RAS
PLUG FLOW AERATION
SECONDARY CLARIFIER
POST AIR
CHAMBER
FINAL EFFLUENT
SLUDGE PUMP
TO DIGESTER
AIR
VENT
DO
H_2O
Cl_2
SP
X (LOW-LIMIT RELAY)
(FROM 100 LOOP)
FIR 210
FIT 210
FE 210
AE 211
AIR 211
AIT 211
AI 212
AIRC 212
AIT 212
FIT 209
AIT 201
AIC 201
FY 202
FIRC 203
FT 103
PE 205
PIT 205
PIRC 205
HC 213
DC 208
DIT 208
DIR 208
FT 207
FY 207
FIRC 207
FIT
FIRC 209

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GENERAL SURVEY QUESTIONNAIRE

STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-9

Responsible Supervisor

Flow Rate Design (Average and Maximum) 21 mgd 24 mgd (36 peak)

Storm Water Collection and Treatment No. Sanitary with Industrial (paper mill waste) and heat, including 27,500 ppd solids and infiltration.

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Secondary (activated sludge). Paper mills have primary treatment, discharge cellulosic effluent.
Treatment plant adds ammonia and phosphoric acid to promote activated sludge.

Performance Data (Individual Units and Overall) BOD Removal 90%
SS Removal 90%

Year Built 1936-1972 Modifications (Year and Description). 1972 - Secondary treatment added

Original Cost $10M Modification Cost $7.5M

Instrumentation Fischer & Porter

Equipment Mag. meter, bubblers, D.O., suspended solids, etc.

Panels Local

Installation and Start-up Costs Original Cost Total Cost

Instrumentation Modification None

Description	Year	Equipment	Panels	I & S	Total

Computer Type None Manufacturer I/O Devices

Process Control

Data Logging

Parameter/Frequency	Parameter Frequency	Parameter/Frequency	Parameter Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control No

Supervisory Control Local panels

Alarm and Safety Systems Typical

Automatic Emergency Program (e g , Power Failure) Two tie-lines.

Maintenance and Calibration Mag. meter calibrators, ultrasonic power source, V-O-M

Special Equipment Down Time None

Special Operator Training None Frequency (no /mo)

Total In Plant Man Hours/Year 80 mh

Total Cost of Outside Service Still on warranty

Estimate of Over-all Benefits of Instrumentation and Automation
Reduction in manpower.
Good, consistent treatment efficiencies.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In Plant Maintenance (mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no./mo.)	Total Downtime	Downtime Frequency (no./mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Sludge Level	Home-made / Air Lifts	--	--	Est. 8	0.08	No	No	No	--	None	--	Corrosion and Plugging	Fair	No	None	Small, parallel, air lifts with suctions at different depths help operator determine sludge blanket level.
Turbidity	Biospherics / Probe	52		300	90 (Mostly cleaning)	No	No	No	--	None	--	Fouling; Color; Accuracy	10%	None	Local Portable	Sensitive trend detector, washed off every shift. Drifts are affected by industrial dyes.
D.O.	Beckman / Probe	735		100	15	No	No	No	--	None	--	Probe Fouling; Accuracy	Est. 10%	None	Remote	Poor accuracy. YSI portable used as transfer standard, Winkler calibrations.
Sampling	Chicago Pump			Est. 8	0.17	No	No	No	--	Est. 4 mh/yr	0.08	Minor; General	--	Pump and Strainer	No	Work very well (timed); few problems.
Flow	Fischer & Porter / Magnetic			8 each	0.17	No	No	No	--	4 mh/yr	0.08	Electrode Fouling	2%	Some Sonic Cleaners	Remote	Good service on raw sewage and sludge. Probes suitable for ultrasonic cleaning periodically; effectiveness unknown.

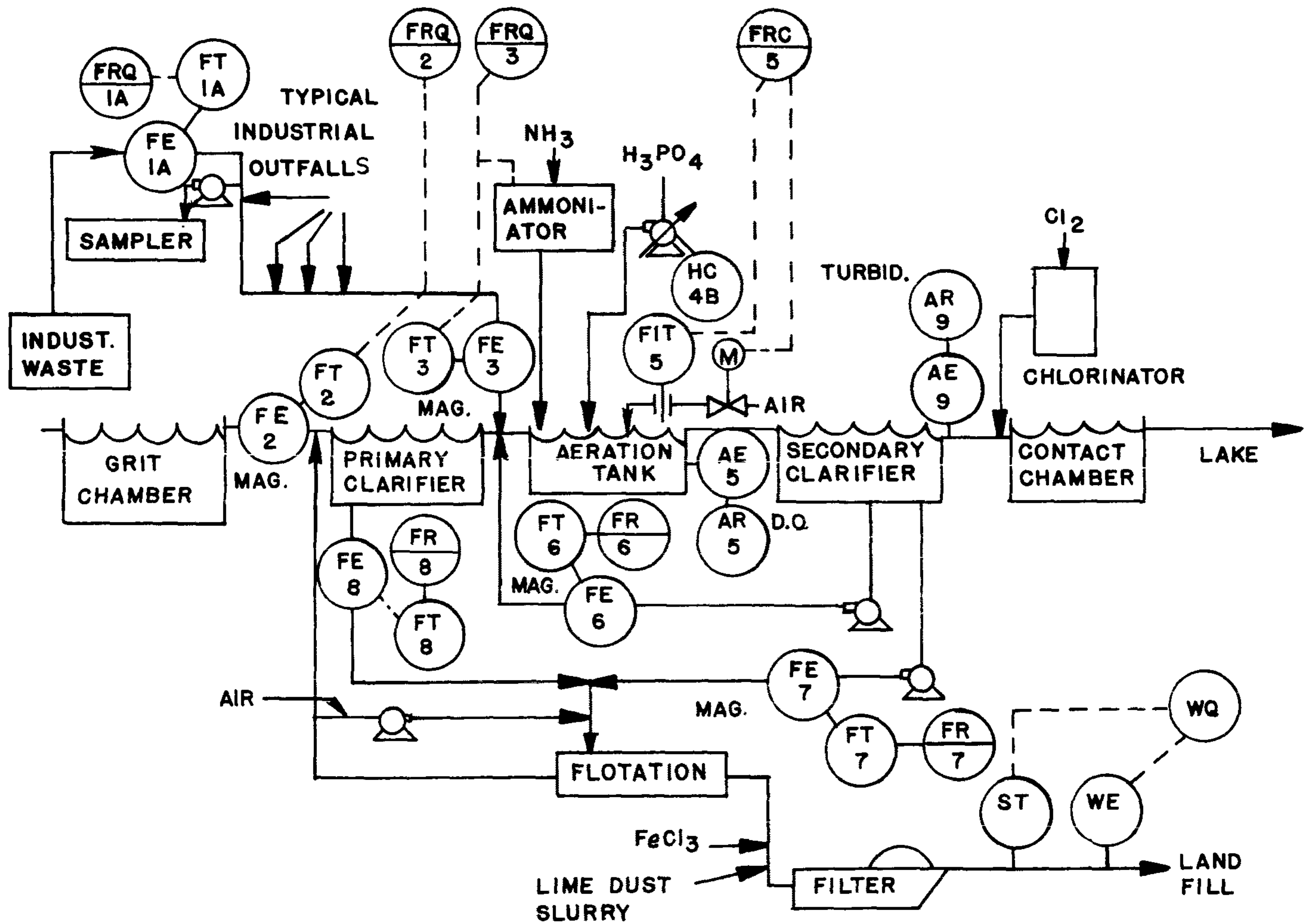
* Corrosion, fouling, etc.
** Limiters, alarms, ratio relays.
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							Comments
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In-Plant Personnel ($ or mh yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no /mo)	
	Sludge Level	6	--	Manual	Air	Air lifts	--	None	No	No	No	No	8	.08	No	No	No	None	--	Air lifts are a crude method for determining blanke level, but are direct and an operating convenience.
HC-4B	Phosphoric Acid Addition	2	--	Manual	Electric	Proportioning pump	0.05	2,000	No	30%	Yes	Yes	Est. 80 mh	Fst. 1	No	No	No	Little or None	--	Pump maintenance is main problem.
FT-3	Ammonia Addition	2	Proportional	Electronic	Electric	Ammoniator	0.1	2,000	No	30%	Yes	Yes	Est. 90 mh	Est. 4	Some On-site	No	No	Little or None	--	Ammoniator is very similar to chlorinator. Few problems.

* Control mode relay, proportional, proportional plus reset, etc
** Types of controllers analog (pne, hyd or elec media) computer (supervisory, direct digital or set analog)
*** Final control element pne values, variable speed pump, etc

FIGURE B-9.


FRQ 1A
FT 1A
FE 1A
TYPICAL
INDUSTRIAL
OUTFALLS
SAMPLER
INDUST. WASTE
FRQ 2
FRQ 3
NH3
AMMONI-ATOR
H3PO4
HC 4B
FRC 5
FIT 5
M
AIR
TURBID.
AR 9
AE 9
Cl2
CHLORINATOR
FT 2
FT 3
FE 3
MAG.
FE 2
GRIT CHAMBER
MAG.
PRIMARY CLARIFIER
AERATION TANK
AE 5
SECONDARY CLARIFIER
CONTACT CHAMBER
LAKE
FT 6
FR 6
AR 5
D.O.
FE 8
FR 8
FT 8
MAG.
FE 6
AIR
FE 7
MAG.
FT 7
FR 7
WQ
FLOTATION
ST
WE
FeCl3
LIME DUST SLURRY
FILTER
LAND FILL

Form approved
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GENERAL SURVEY QUESTIONNAIRE

STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-10

Responsible Supervisor

Flow Rate Design (Average and Maximum) 24 mgd design, 10 mgd av., 12 mgd peak

Storm Water Collection and Treatment No. Residential only.

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Secondary (mechanical aeration, flotation-type sludge thickening, sludge incinerators)

Performance Data (Individual Units and Overall) BOD - 88% Removal
SS - 887 Removal

Year Built 1972 Modifications (Year and Description)

Original Cost $10.8 Million Modification Cost

Instrumentation Varied, mostly F & P

Equipment Flow, D.O. probes, level, etc.

Panels Central for treatment, sludge disposal

Installation and Start up Costs Original Cost Total Cost

Instrumentation Modification No

Description	Year	Equipment	Panels	I & S	Total

Computer
Type None Manufacturer I O Devices

Process Control

Data Logging

Parameter/Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control Yes (treatment and sludge disposal)

Supervisory Control Yes

Alarm and Safety Systems Yes

Automatic Emergency Program (e g , Power Failure) Two tie lines only

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Maintenance and Calibration

Special Equipment Very little Down Time Sone start-up problems

Special Operator Training On-site and future Frequency (no mo)

Total In-Plant Man Hours Year Not established

Total Cost of Outside Service Still on warantee

Estimate of Over all Benefits of Instrumentation and Automation

Labor reduction
Effective treatment
Data production

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Frequency (no. mo.)	Total Downtime	Downtime Frequency (no./mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Analog Signal	Arizona Gear & Mfg. (Tucson, Arizona)	TA-5000-4		None (Replace only)	0.02 (failures)	No	No	No	--	Not Established	0.02	Tight Wiring	±1%	None	-	Replace mechanical 15-second pulse transmitters by small, solid state, non-indicating. Early failure rate on a previous production lot. 120 units in service.
Level	Fischer & Porter; Flush-diaphragm d/p Trans.			Very little	None (in 6 months)	No	No	No	--	--	--	None to date	Est. ±10% (Adequate)	Local Indication	No	
Sampler	Nappe	4630-11-ST		See Below	See Below	No	No	No	--	100%	--	Plug-up	-	No	No	Sampler is designed to handle fairly clean streams, plugs immediately on sewage. Eight installed; all abandoned within first two months.
Dissolved Oxygen	Beckman			300	100 (cleaning)	No	No	No	--	Not Established	Not Established	Probe fouling; Air bubbles		None	Yes	Control mechanical aerator basin level with tilting weirs. Probe installation to be revised for accessibility.
Flow	Fischer & Porter; Magnetic			4	0.25	No	No	No	--	None	--	Probe fouling	Good	Some sonic cleaners	Remote	Ultrasonic power source used manually to clean probes; effectiveness unknown.
Flow	Fischer & Porter; Weir Float & Cable, Time Pulse			4	0.1'	No	No	No	--	None	--	Pulse-motor, receiver clutches	±1½%	Stilling Well	No	Used for chlorinator pacing.
Flow	Fischer & Porter; Parshall, Bubbler, Time Pulse			60	4 (Blow-out bubbler)	No	No	No	--	2 hrs/yr.	0.1	Pulse-motor failure, tube ~~clogging~~	±5%	Air Comp. Housings	Remote	Frequently checked (because flow determines billing). Excellent service.

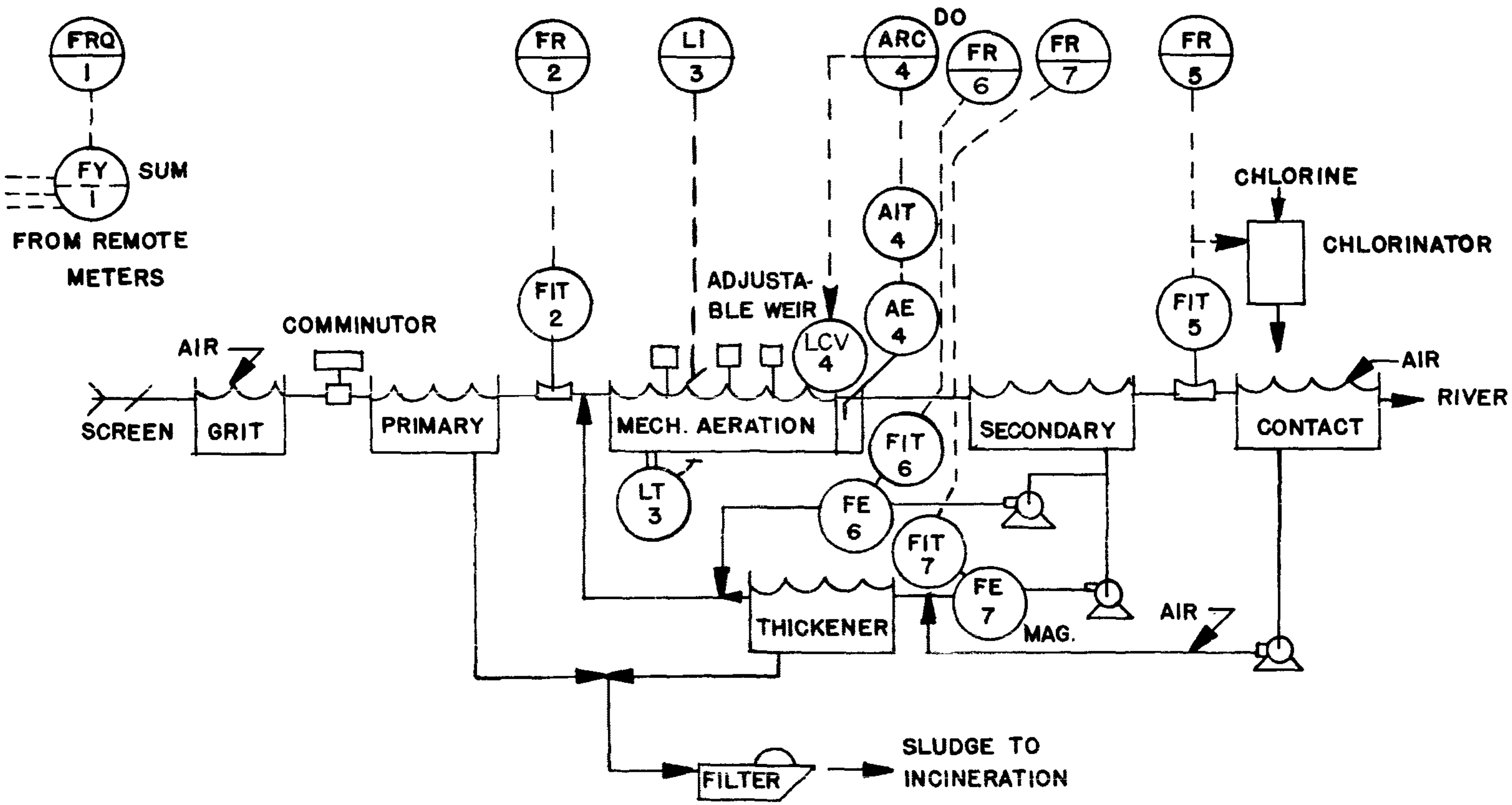
* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh yr)	Utility (kW-hr yr)	Chemical (lbs yr)	Increase Removal (%)	Parameter Variance min max (mg l)	Maintenance & Calibration by In Plant Personnel ($ or mh yr)	Maintenance Frequency (no mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no/mo)	Comments
AE-4	Aeration	4	Proportional, Reset, and Batch	Electronic	Electric Motor	Tilting Weir	120		None	None	Yes	Held at 3-5 ppm	300 mh	100	No	No	Not established	-		On manual control. Probes must be relocated for easy cleaning.
FIT-5	Chlorinator	8	P & R	Electronic	Electric	Chlorinator	0.5	None	None	Yes	--	--	20 mh	0.17	No	No	None to date	-		System still on manual from control panel.

* Control mode relay, proportional, proportional plus reset, etc
** Types of controllers analog (pne , hyd or elec media), computer (supervisory, direct digital or set analog)
*** Final control element pne. values, variable speed pump, etc

FIGURE B-10.


FRQ 1
FY 1
SUM
FROM REMOTE METERS
SCREEN
AIR
GRIT
COMMINUTOR
PRIMARY
FR 2
FIT 2
LI 3
ADJUSTA-BLE WEIR
MECH. AERATION
LT 3
LCV 4
ARC 4
DO
AIT 4
AE 4
FR 6
FR 7
FIT 6
FE 6
FIT 7
FE 7
MAG.
THICKENER
SECONDARY
FR 5
FIT 5
CHLORINE
CHLORINATOR
AIR
CONTACT
RIVER
AIR
FILTER
SLUDGE TO INCINERATION

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GENERAL SURVEY QUESTIONNAIRE

STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-11

Responsible Supervisor

Flow Rate Design (Average and Maximum) Average design - 24 mgd
Maximum design - 26 mgd
Average actual - 28 mgd   Future (1973) Average design - 48 mgd

Storm Water Collection and Treatment Separate system, less than 10% of area is combined; high infiltration.

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Secondary treatment plant with activated sludge process.
Contact stabilization in winter and conventional activated sludge process in summer.
No sludge digestion, sludge is processed at West Point STP.

Performance Data (Individual Units and Overall)

	Winter	Summer		Winter	Summer
Primary BOD Removal	34%	41%	Total BOD Removal	90.5%	97.5%
Primary Suspended Solids Removal	62%	70%	Total Susp. Solids Removal	92%	95%

Year Built 1965   **Modifications (Year and Description)** Additional Aeration Blowers - 1967
Additional Chlorination Ejectors

Original Cost 9.0 Million   **Modification Cost** Aeration - $235,000
Chlorination - 15,000

Instrumentation

Equipment Pneumatic, electronic, some mechanical.

Panels Central graphic panel, pump control panel, primary control panel, secondary control panel, secondary indicating panel, chemical control panel.

Installation and Start up Costs   **Original Cost**   **Total Cost** Foxboro instrumentation - $283,442
Fischer & Porter - 85,000

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
DO Control System	1967	Amplifiers & Probes changed	-	-	$15,000±
Chlorine Control System	1967	Pneumatic to Electronic Control	-	-	5,000±
Influent and Effluent Gate Controls	1967	Pneumatic to Electric Control	-	-	--
Pump Controls	1967	Level signal from Primary Tank instead of pump	-	-	--

Computer Type Sigma II Computer located in Metro office building as part of CATAD System*   **Manufacturer** Xerox Data Systems   **I/O Devices** Telemetry with Philco-Ford System between computer in Metro office building and printer with keyboard input at surveyed plant.

Process Control No direct process control at present. Future Computer under installation. Direct control of process with utilization of D.O. Signals is planned. (Manual control at present with readout on printer of alarms, operating data, and quality data from treatment plants, pumping stations and regulator stations.)

Data Logging
Data logging of alarms, operating data, and quality data at various locations.

Parameter/Frequency	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency
Alarm functions Once every hour Date, Time, Where, What	Operating Data Date, time, where, what: Levels, flows, set points, etc.	Quality Data Date, time, where, what: Temp., D.O., pH, etc.	Various parameters at surveyed STP, 17 Pumping Stations and 2 small treatment plants.
Also Repair status Example: shear pin failure	Frequency varies Example: SO_2 depletion	Frequency varies	

STORAGE: Part of CATAD System

Software Description Part of CATAD

*Computer Augmented Treatment and Disposal System

Computer Cost Part of CATAD   **Software Cost** Part of CATAD   **Installation Cost** Part of CATAD

Central Control

Supervisory Control Yes, process adjustments are made from central graphic panel data.

Alarm and Safety Systems Yes, about 300 alarms are monitored at central graphic panel.

Automatic Emergency Program (e g , Power Failure) Emergency standby generator for lights, telemetry, instrumentation, blowers, sedimentation tanks. Also 80 hours of storage at normal flow are available in influent sewer.

Maintenance and Calibration

Special Equipment Current meters, dead weight tester, voltmeters, manometers, digital voltmeters, oscilloscope, amperometric titrator, load cell tester, atmospheric detector-calibrator.   **Down Time** No downtime due to instrumentation failure.

Special Operator Training Yes. 44-week session given at the plant to train operators. Many types of courses. There is a staff of 4 maintenance men. About 60% of their time is for surveyed STP instrumentation maintenance and calibration.   **Frequency (no mo)** None

Total In-Plant Man Hours/Year 6,500

Total Cost of Outside Service Almost none.

Estimate of Over all Benefits of Instrumentation and Automation

Realize cost reductions in the areas of chlorine addition and power consumption. Additional benefits derived include optimized D.O. control and higher quality effluent. If plant had to operate on manual control, the addition of approximately 35 people would be required.

INSTRUMENT SURVEY FORM

Parameter	Manufacturer	Model Number	Equipment Cost	In Plant Maintenance (mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no/mo)	Total Downtime	Downtime Frequency (no/mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Instrument				Operating Experience										Peripheral Equipment		
D.O.	Beckman	735	$10,000+ for 12 probes & amplifiers in 1967	208 (12 probes)	4	None-except by instrument manufacturer	None	None	None	None	None	Initially, leakage problem; solved.	Repeatability is very good. Results don't agree with Winkler tests.	Converters, Switches	Secondary indicating panel	D.O. probes are cleaned once per week, calibrated once every 2 to 3 weeks, and recharged once per year. If they are not cleaned, false readings result. In the initial installation, vibration caused leakage. Extra "O" ring was put in and solved the problem.
Chlorine Residual	Fischer & Porter Residual Chlorine Analyzer	17B220213	--	416 (3 units)	30	None	None	None	None	None (switch to another unit or manual during cleaning)	None	Frequent maintenance	5 to 10% accuracy drifts. Good if calibrated.	Converters, relays, alarms for chlorination	Pump control panel	Cells cleaned daily; complete cleaning weekly; fresh buffer solution is prepared once per week. Chemical costs are $600 per year. Maintenance is also required on rotary Cuno filter, which plugs, and 3/8-inch sampling line, which plugs.
Sewage Effluent Flow	Rectangular Weir (by Contractor)	None	$500+	None (1 Weir)	None	None	None	None	None	None	None	None	Good (30" range max.-to-min. flow).	Indicators, integrators, controllers	Pump control panel	Working satisfactorily; too small, initial Cipolletti Weir. Weir capable of greater flow without excessive losses was required. Level is measured by Foxboro bubbler tube and D/P cell.
Return Activated Sludge Flow	Cipolletti Weir (by plant personnel)	None	$25X8=200+ (for 8 weirs)	None (8 Weirs)	None	None	None	None	None	None	None	None	Good	Converters, Integrators	Pump control panel	Working satisfactorily. Initial rectangular weirs did not have sufficient variation in head. Rectangular weirs are calibrated every 2 years. Level is measured by Foxboro bubbler tube and D/P cell.
Air Flow	Orifice plate, 24"	Taylor Transmitters DR. cell 212 TD	--	None (4 Meters)	None	None	None	None	None	None	None	Problems due to vibrations. Have been solved.	Some question as to accuracy. However, good repeatability.	Converters, alarms, integrators, air valves.	Secondary indicating panel	Air piping is susceptible to vibrations which can cause instrumentation problems. Once the cause of problems was determined, it was solved. The orifice plates are working satisfactorily
Primary Tank Level	Foxboro Bubble Tube System	D/P cell Transmitters Model No. 15A	--	Minor	None	None	None	None	None	None	None	Transmitters not sensitive enough. Have been corrected	Good	Converters, alarms, integrators	On pump control panel	The level transmitters were changed from Foxboro Model No. M45 with 0- 10 foot range to Foxboro Model No. 15A with 0- 20 inch range in order to provide a more sensitive control of sewage pumps.
Gate Position	Position Indicator made by plant personnel	Foxboro Transmitter 631-2A EC1 (Pressure)	--	Minor	None	None	None	None	None	None	None	Problem of sealing pots. Has been corrected.	Good	Converters	None	The position indicator was made by plant personnel by having a worm gear off main shaft of limitorque operator operate 2 dashpots into which 2 resistors were installed.

* Corrosion, fouling, etc
** Limiters alarms, ratio relays.
*** Local and central

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no./mo.)	Total Downtime	Downtime Frequency (no./mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Primary Sludge Flow	Foxboro Magnetic Flow Meter	2804-KARA-OS 4" Fiber-glass lining	$7,000+ (1 meter)	Has been in use only 2 mos. No operating experience.		None	None	None	None	None	None	No problems to date.	Unknown	Converter, alarms	Primary Control Panel	Operating experience is limited. Purging and heating system for the Electrode seems to be working satisfactorily.
Primary Sludge Density	Chicago-Nuclear	Qualicon 5060 Density gauge Model 5151	(1 meter)	Never used	Never used	None	None	None	None	Use abandoned. Total downtime		Provisions for Calibration	Unknown	Alarms, Converter	Primary Control Panel	There are no provisions to calibrate the instrument, and because of anticipated frequent calibration, the instrument was abandoned. The measurement of primary sludge flow is not considered critical.
Combustible Gas Detector	General Monitors, Inc.	175		104	1	None	None	None	None	None	None	Sensors were modified. No problems	Unknown	Alarms	None	The sensor probe was modified from hydrogen to hydrocarbon. The unit was relocated to a more advantageous position.
Effluent Turbidity	Hach	1889	$600+	104	30	None	None	None	None	None	None	Have to flush every day.	Good	Converter alarms	Pump Control Panel	Very useful device which works very well. Has to be flushed daily and calibrated every month. Was intended to be used for closure control of primary gates automatically when turbidity was too high. However, plant personnel want to make the decision on closing of gate. Therefore, controller is not used.
Effluent pH	Beckman	J	$1100+	104	30	None	None	None	None	None	None	Have to wipe probes and flush every day.	Good	Alarms	Pump Control Panel	The reference electrodes were changed from conventional glass probes to porous plastic probes. The probes still have to be wiped every day and the instrument flushed.
Effluent Conductivity	Leeds and Northrup	4957-1-0	$600+	104	30	None	None	None	None	None	None	Have to wipe probes and flush every day.	Good	Converter, switches, alarms	Pump Control Panel	Conductivity measurements are not very useful on the effluent. The probes have to be wiped every day and the instrument flushed.

* Corrosion, fouling, etc

** Limiters, alarms, ratio relays

*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							Comments
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW-hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh yr)	Downtime (hrs/yr)	Downtime Frequency (no/mo)	
AE-659	Aeration	2	Cascade	Pneumatic	Pneumatic	Butterfly valves	Unknown	8760	10% power cost: $7,000+	None	5% to 10%	Small at D.O. control point. Large at other D.O. points	400+	4	None	None	None	None	None	The system is very good and achieves a high degree of treatment.
AT-831	Pre-Chlorination	1	Cascade	Mechanical	Electric	Fischer & Porter Chlorinator	1 min.+	4380	None	15% Chlorine $1,600+	None	1 - 1.5	600+	30	None	None	None	None	None	The system works well.
LT-512	Sewage Pumping	1	Cascade	Pneumatic	Pneumatic	Speed control of pumps	Unknown	8760	Some	None	None	Not over 30 inches variation	100+	1+	None	None	None	None	None	Converted from sump level to primary tank level for better control of pumps. The system works well.
FIC-615	Sludge Pumping	8	Ratio	Pneumatic	Electric	Variable-speed pumps	Unknown	8760	None	None	Yes	Improved	200+	1+	None	None	None	None	None	The system is working well. Flow varies 20% to 50% depending on season and process. Variable-speed poor with U.S. Vari-Drive; change to Eaton Dynamatic Magnetic Clutches at a cost of $7,000.
AT-813	Post-Chlorination	1	Proportional	Mechanical	Electric	Fischer & Porter Chlorinator	1 min.+	4380	None	5% Chlorine $500+	None	1 - 4	200+	1+	None	None	None	None	None	Chlorine demand highly variable; control of chlorine in proportion to flow would waste chlorine. Too high chlorine must be avoided in receiving waters. The system works well.

* Control mode relay, proportional, proportional plus reset, etc

** Types of controllers analog (pne, hyd or elec media), computer (supervisory, direct digital or set analog)

*** Final control element pne. values, variable speed pump, etc

FIGURE B-11(a).

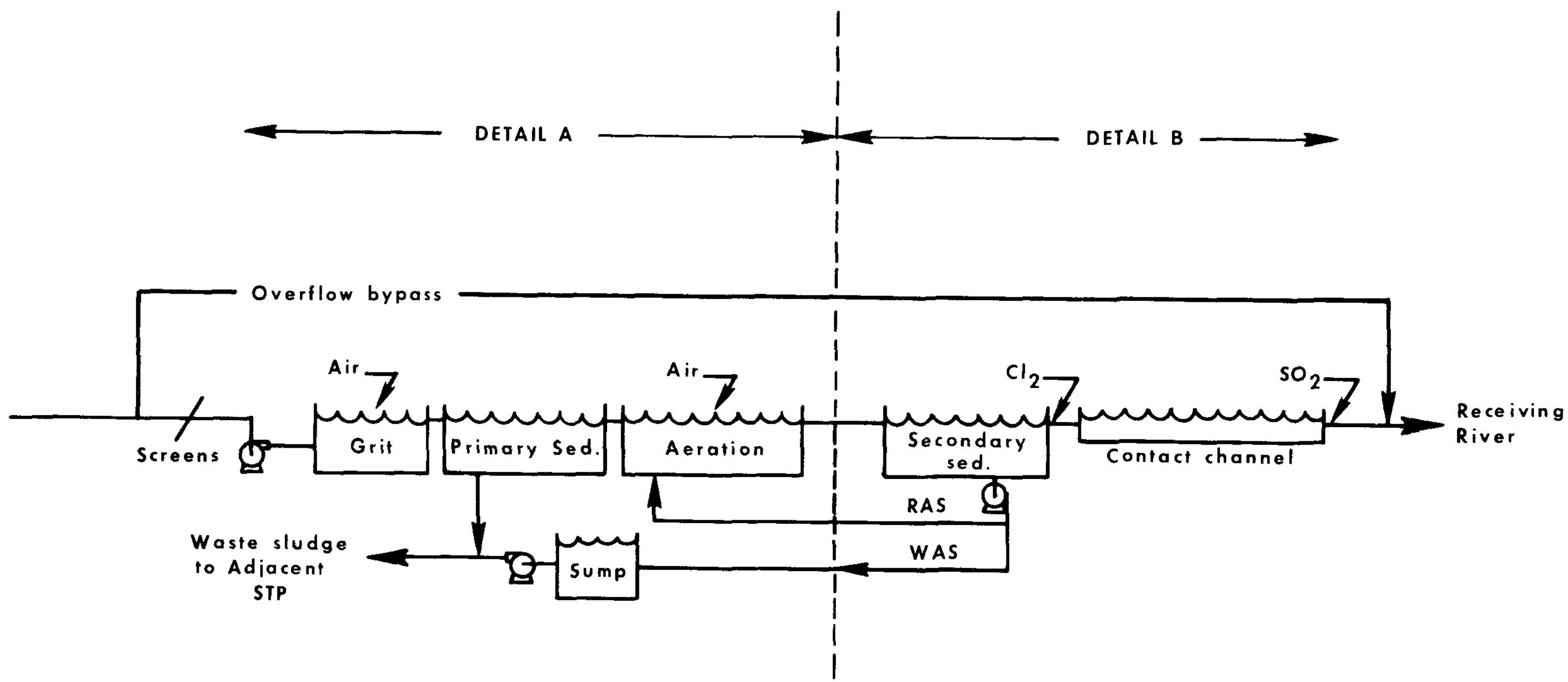

DETAIL A
DETAIL B
Overflow bypass
Air
Air
Cl_2
SO_2
Screens
Grit
Primary Sed.
Aeration
Secondary sed.
Contact channel
Receiving River
RAS
WAS
Sump
Waste sludge to Adjacent STP

FIGURE B-11(b): DETAIL A.

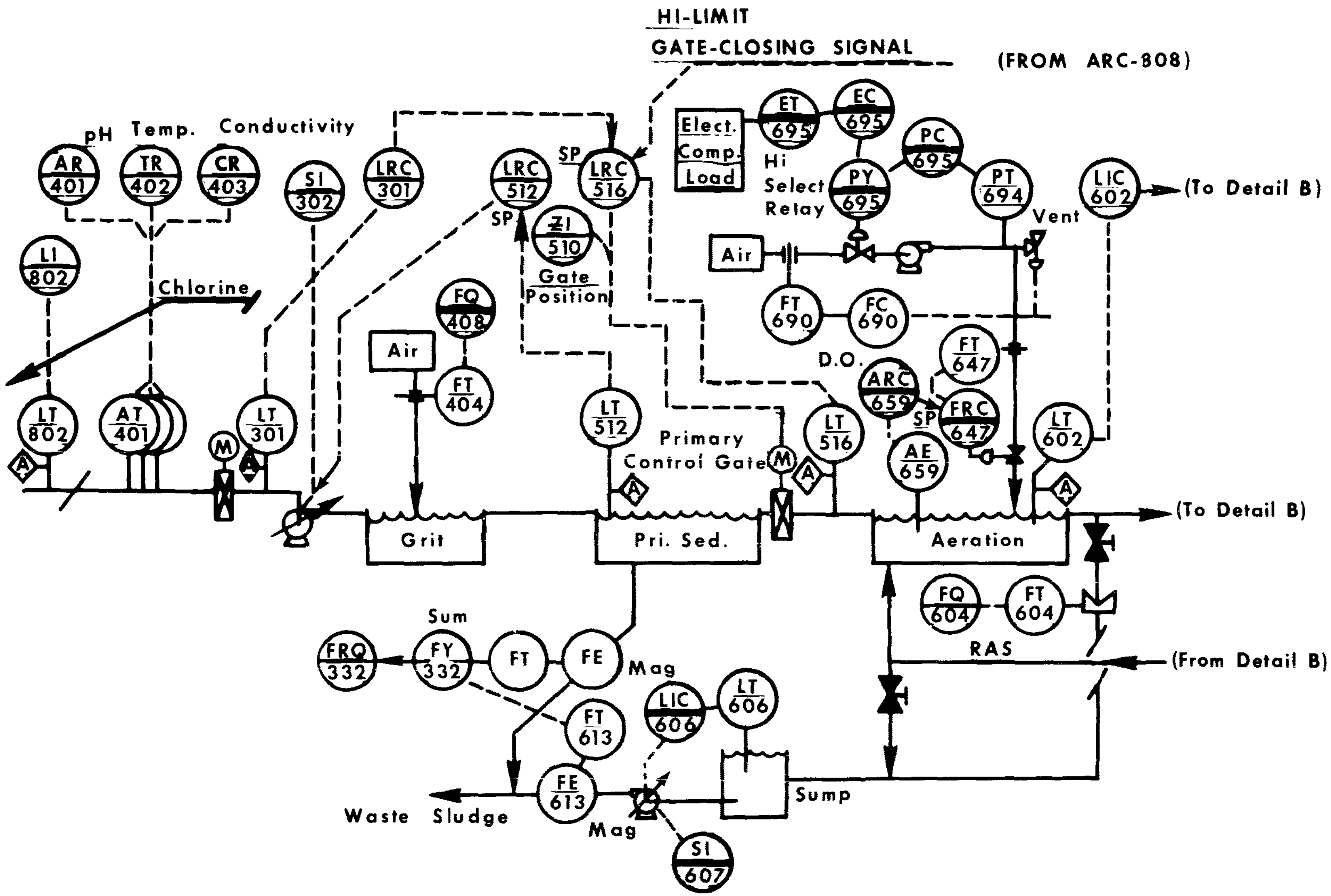
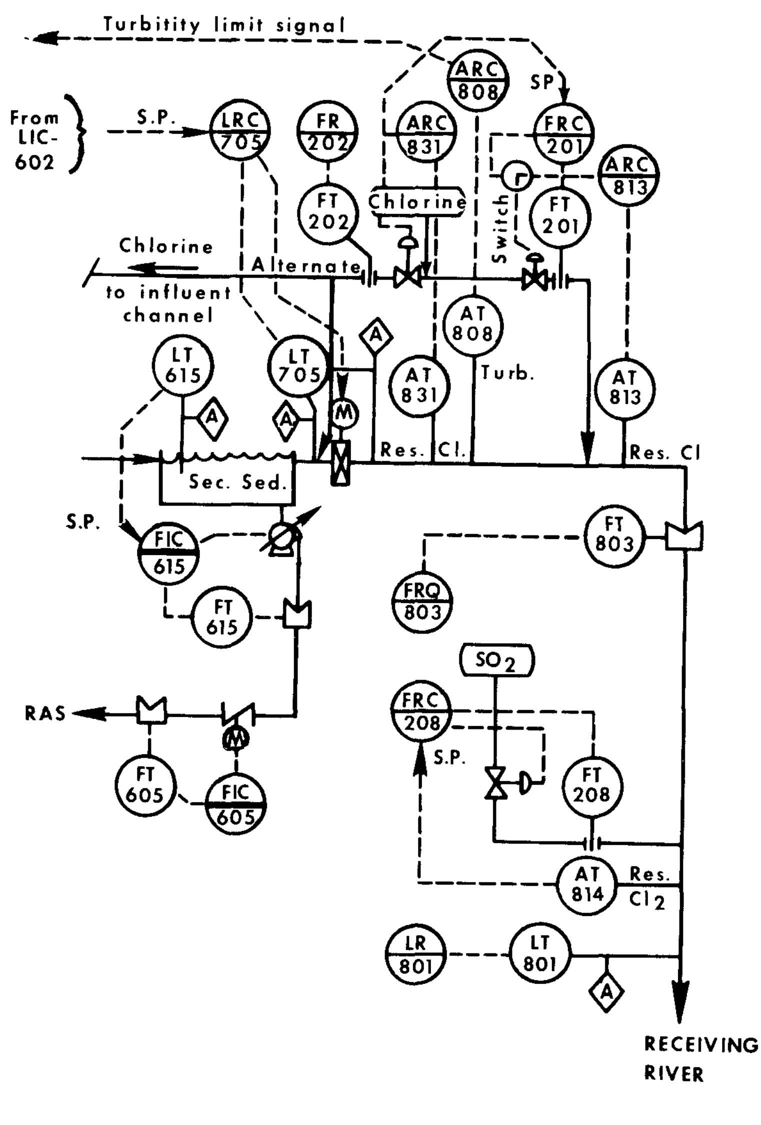


FIGURE B-11(c): DETAIL B.



GENERAL SURVEY QUESTIONNAIRE

Form approved
OMB No 158-S72006

STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-12

Responsible Supervisor

Flow Rate Design (Average and Maximum) 35 mgd Avg. dwf.; 50 mgd Max. dwf.; 70 MGD Max. wwf.

Storm Water Collection and Treatment Separated System, Sanitary Only

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Secondary CMAS, with sludge incineration.

Performance Data (Individual Units and Overall)

Year Built: 1972 Modifications (Year and Description)

Original Cost. $10.7 M Modification Cost

Instrumentation Plant employs electronic instr. with the exception of liquid-level bubblers.

Equipment. Status indicators; remote speed control; recorders; closed loop Cl_2 control; SO_2 control and incinerator controls. Monitoring - Flow, DO, levels and sludge density.

Panels. 30-ft. panel in control room; 20-ft. panel in incinerator room.

Installation and Start up Costs Original Cost Total Cost 75K Instruments Only

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
Computer Control EPA Demonstration Proj.	1972	Computer	None		

Computer EPA-Demonstration Project
Type Mini-process control Manufacturer IBM - 7 I/O Devices Disk, Teletype

Process Control Yes; No DDC, but operator closes the loop; DO, RAS, Sludge Blanket, MLSS, FF-TOC, FB-TOC, Resp. Rate Control

Data Logging Yes; Computer generates daily status report; monthly reports are also computer-prepared.

Parameter/Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency
Scans 6 sec. to Disk-2 min. DO control operates @ 1-min. data rate			

Storage
2.5M (16 BIT Disk)

Software Description Data logging; report writing; process control-AML/7 Language

Computer Cost 107K Software Cost 50K (min) Installation Cost 1 man-mo

Central Control BIF Control Room

Supervisory Control Yes; mostly pump speed control from central; incinerator has separate control room.

Alarm and Safety Systems Major equipment status indicators and alarms; Cl_2 gas detection.

Automatic Emergency Program (e g. Power Failure)
Stand-by generators for pumping sewage during power failures and minimal lighting.

Maintenance and Calibration N.A.

Special Equipment Signal generator; O-Scope; DVM; Time pulse generator; power supply. Down Time

Special Operator Training Instrument Tech. Frequency (no mo)

Total In-Plant Man Hours/Year 0.5 man/yr., w/o computer

Total Cost of Outside Service N.A., w/o computer

Estimate of Over-all Benefits of Instrumentation and Automation

Better supervision of plant start-up.
Economies in power and chlorination.
Computer reduces manpower requirements for data logging and producing periodic reports.

Inv. Comments - Very little process control w/o EPA project most control involves equipment status, alarms and remote speed adjustments.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no/mo)	Total Downtime	Downtime Frequency (no/mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Level Indicator	BIF Bubble Tube	Bubble Tube		5-10mh/yr	1/mo	None	None	None	--	--	--		Good	Alarms	Indication only	Influent wet-well level used to manually control pump speed in such a manner as to keep wet-well level within acceptable range. Also, effluent wet-well level used for manual by-pass control.
Influent Flow	Brooks Mag Meter			--	--	None	None	None	--	--	--		NA	Flow-prop. Cl_2 control	Local ind., remote strip chart recorder	Flow rates are used in flow-proportion chlorination; also, flows are recorded and logged into the IBM-7.
Influent Sampler	Chicago Pump													Refriger-ation		Flow-proportional automatic sampler with refrigerated storage.
DO	Weston & Stack	830	About $1400	Est. 12 hrs/yr per probe	1/mo	--	--	--	--	--	--	None	±0.2mg/1	Computer control	Local ind. & strip chart (one)	IBM-7 computer processes DO information to yield operator instructions for blower speed adjustment. Desired DO level 1.5 to 2.0 mg/1. For good processing and economic reasons, after checkout, DO control will be completely automated.
Air Flow	Dall Tubes														Local ind., remote ind. (strip chart recorder)	Air flow rates to individual aeration. Tanks a. [illegible] operator-adjusted via electrically operated butterfly valves.
S.S.	Keene	No. 8200 SCCS													Local indication	Aeration tank S.S. information will be used to regulate return A.S. flow in an EPA demonstration program.
Sludge Density	Chicago Nuclear											Frequent calibration	Poor		Local indic., remote recording	Sludge density measurements provide operator with information which governs length of thickener pump-down cycle. Pumping stops when sludge density drops below 2 to 3% solids.

* Corrosion, fouling, etc.
** Computers, alarms, ratio relays
*** Local and central

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no /mo)	Total Downtime	Downtime Frequency (no mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Residual Chlorine	Wallace & Tiernan	A-792		50 mh/yr	4/mo	Instr. Tech.	--	--	--	--	--	None	Good	Feedback chlorination	Local and central	No remote commands possible.
Cl_2 gas detector	Wallace & Tiernan	A-689												Audio-visual alarms		Alarm system.
O_2 analyzer	Envirotech															Automatic regulation of incinerator control system.
TOC	Envirotech Dohrmann	Organic Analyzer				Trained Chemist						Noticeable Drift	Fair	None	DVM	Lab Inst.
Rapid Scan Polarograph	Beckman	Electro-scan 30	≈$6.5K			Trained Chemist										Lab Inst. - metal detection for industrial waste.
G.C.	Varian	Series 2800	≈$10K			Trained Chemist										Lab Inst. G.C. used to detect presence of solvents over 25mg/l
pH	BIF		≈$1K													Not operating during survey visit. Insufficient operating data to date.

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques: Code Number (Schematic Diagram)	Control Techniques: Process Being Controlled	Control Techniques: Number of Loops	Control Techniques: Control Mode*	Control Techniques: Type of Controller**	Control Techniques: Actuating Power	Control Techniques: Final Control Element***	Control Techniques: Estimated Response Time (min)	Benefits: Annual Cost Savings: Manpower (mh/yr)	Benefits: Annual Cost Savings: Utility (kW hr/yr)	Benefits: Annual Cost Savings: Chemical (lbs/yr)	Benefits: Process Improvement: Increase Removal (%)	Benefits: Process Improvement: Parameter Variance min/max (mg/l)	Operating Experience: Maintenance & Calibration by In Plant Personnel ($ or mh yr)	Operating Experience: Maintenance Frequency (no/mo)	Operating Experience: Special Training	Operating Experience: Service by Contract ($ or mh/yr)	Operating Experience: On-Demand Service ($ or mh/yr)	Operating Experience: Downtime (hrs/yr)	Operating Experience: Downtime Frequency (no/mo)	Comments
FIR-402	Aeration Tanks	4	PID and FF-Flow	Computer instr. to operator	Electric	Variable-Speed Blowers	Less than 5 min.		$30K based on 10% saving		w/o DO Control eff BOD = 40mg/1, w/DO Control eff BOD = 20mg/1	$\pm$0.2mg/1	12 hrs/yr per probe	1/mo	None	None	None	Same as maint.; 50 hrs/yr	Same as maint.; 4/mo.	DO control - extend blower life. Flexible set pt.; power savings.
ART-601	Chlorination	1	Flow-prop. cascade compound control	F&P res.Cl_2 Analog Electric	Electric	V-notch valve & Vac. Reg.	Less than 1 min.			15-20%		0.2mg/1	100-150mh/yr	4/mo	Instr. Tech	--	--	--	--	
ART-604	De-chlorination with SO_2	1	P to flow & res. Cl_2	Analog Electric	Electric	V-notch valve & Vac. Reg.	Less than 1 min.			15-20%			50mh/yr		Instr. Tech					Zero residual chlorine after dechlorination.

* Control mode relay, proportional, proportional plus reset, etc

** Types of controllers analog (pne, hyd or elec media), computer (supervisory direct digital or set analog)

*** Final control element pne values, variable speed pump, etc

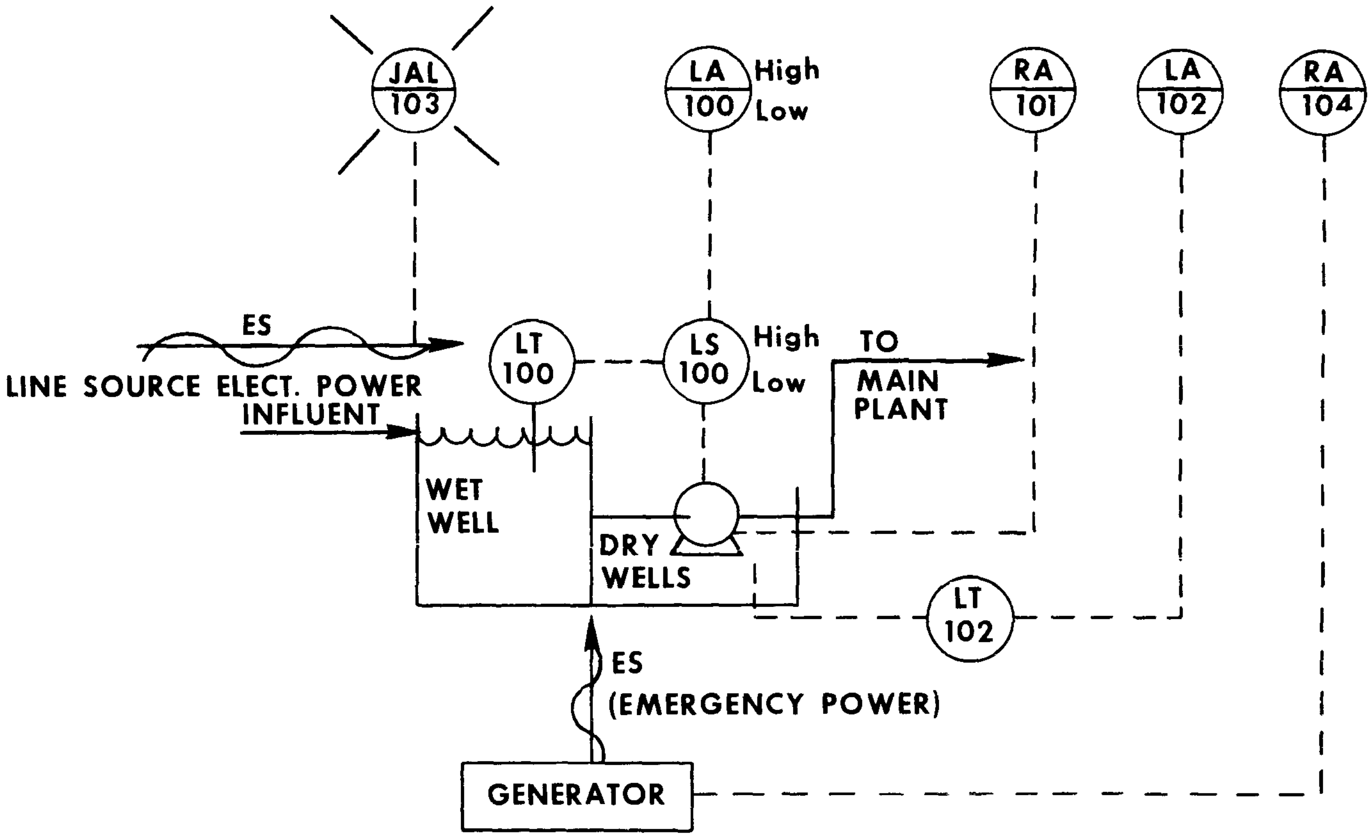


FIGURE B-12(a) REMOTE INFLUENT LIFT STATION
100-LOOP

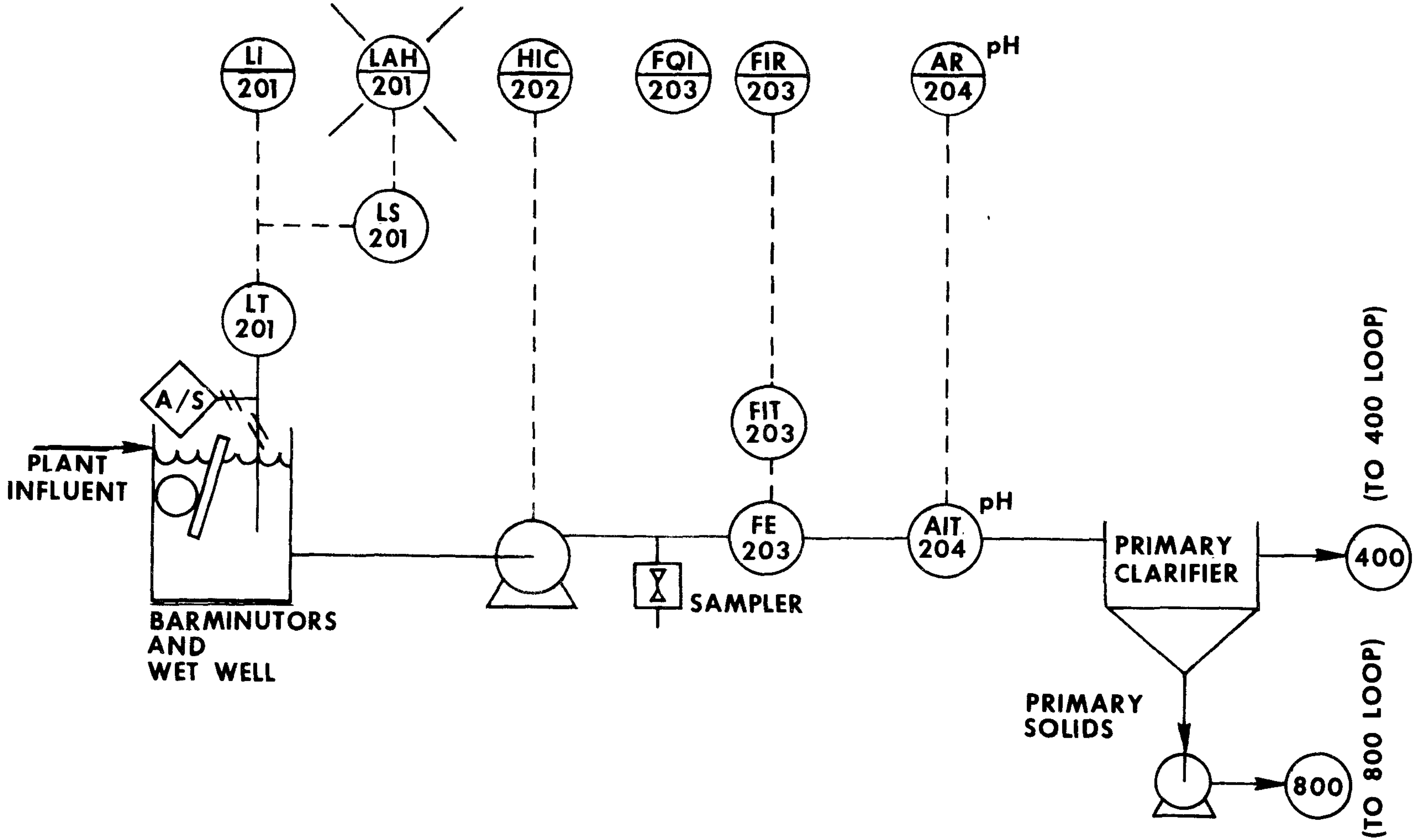


FIGURE B-12(b) PLANT INFLUENT PUMPING
200-LOOP

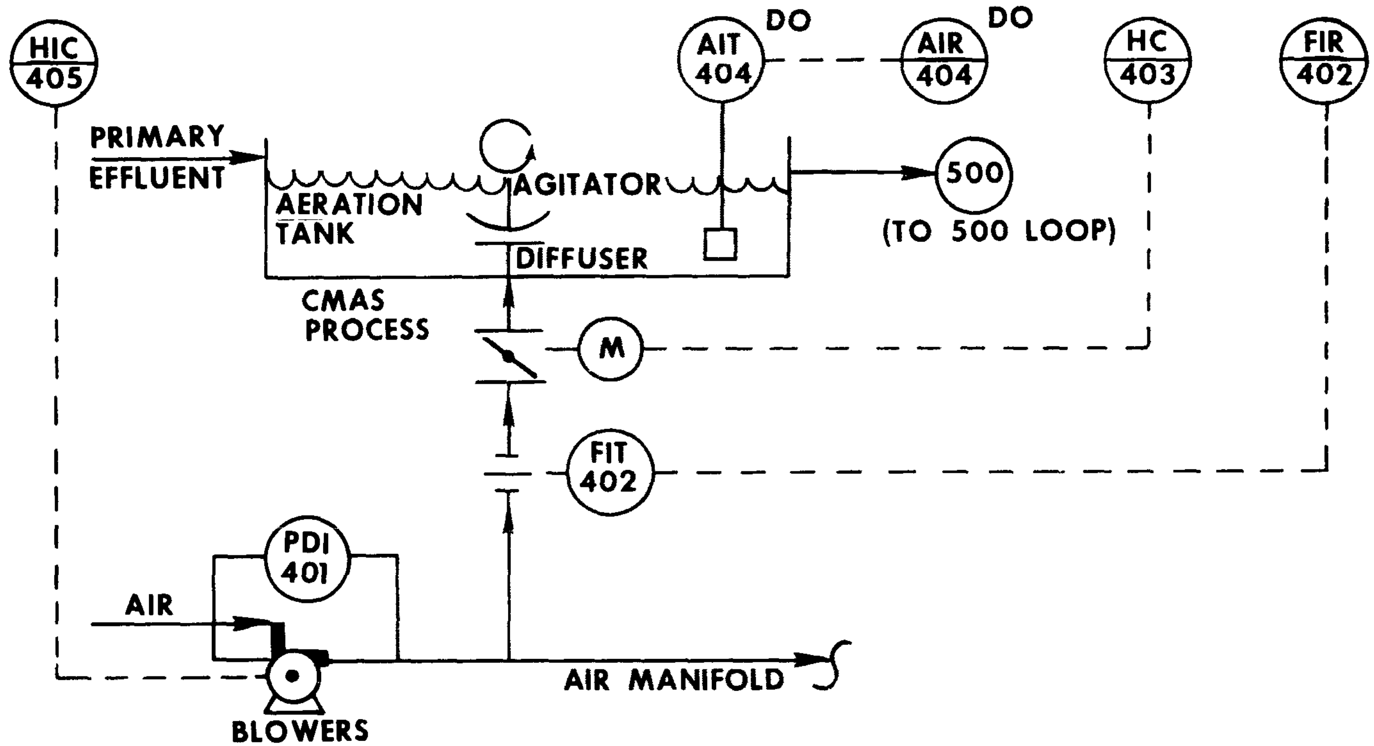


FIGURE B-12(c) AERATION SYSTEM
400-LOOP

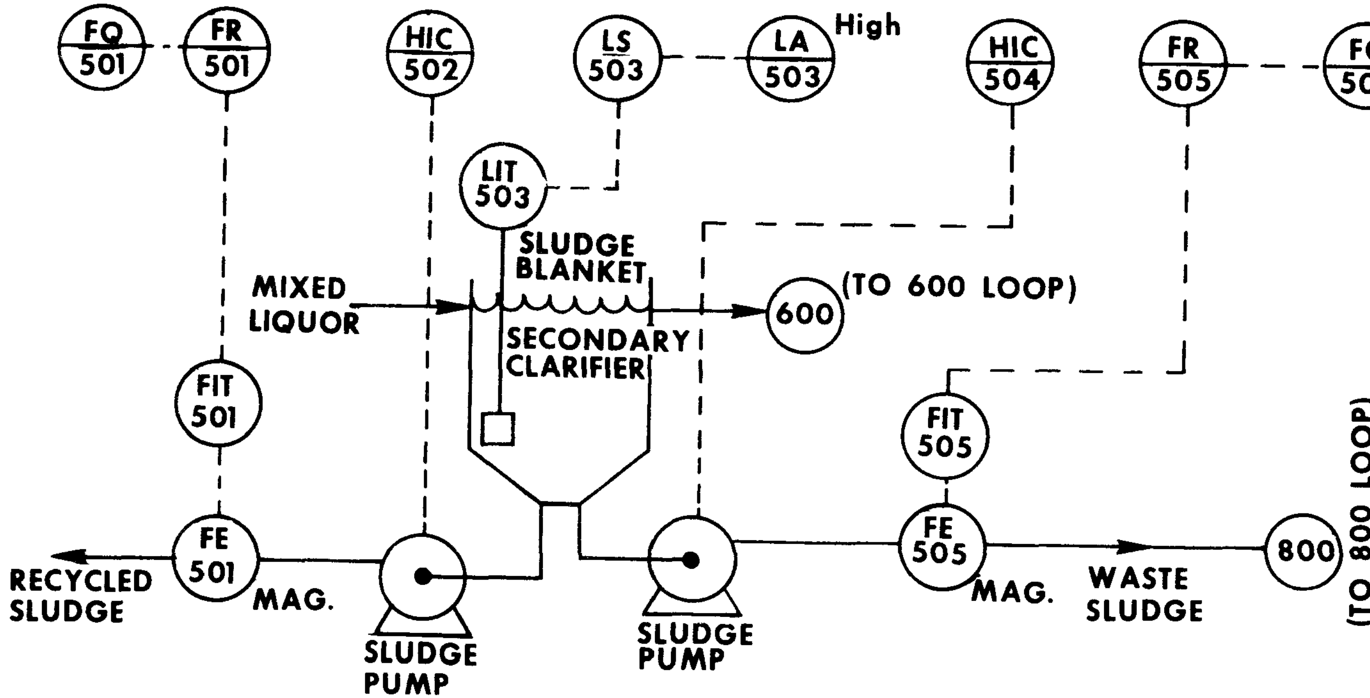


FIGURE B-12(d) SECONDARY CLARIFIER
500-LOOP

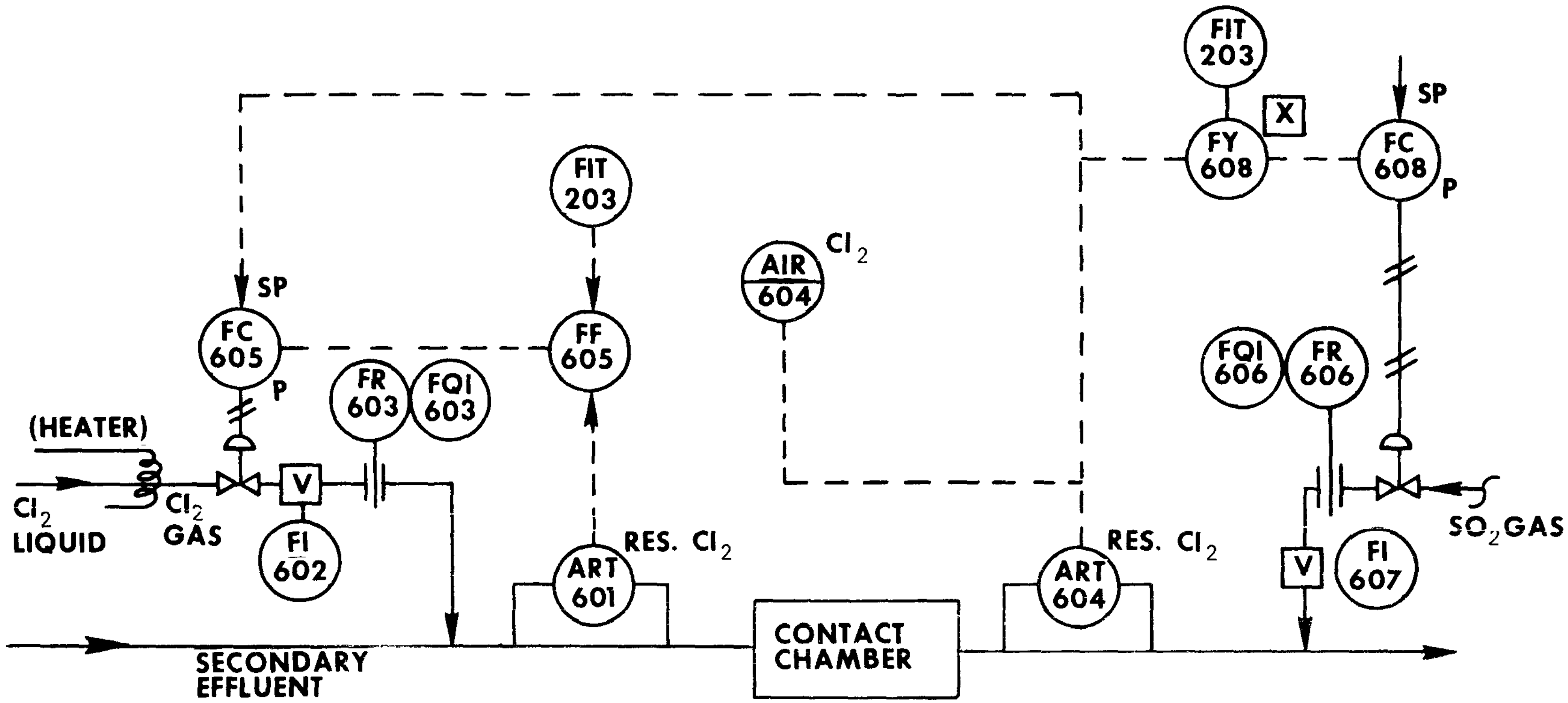


FIGURE B-12(e) EFFLUENT CHLORINATION
600-LOOP

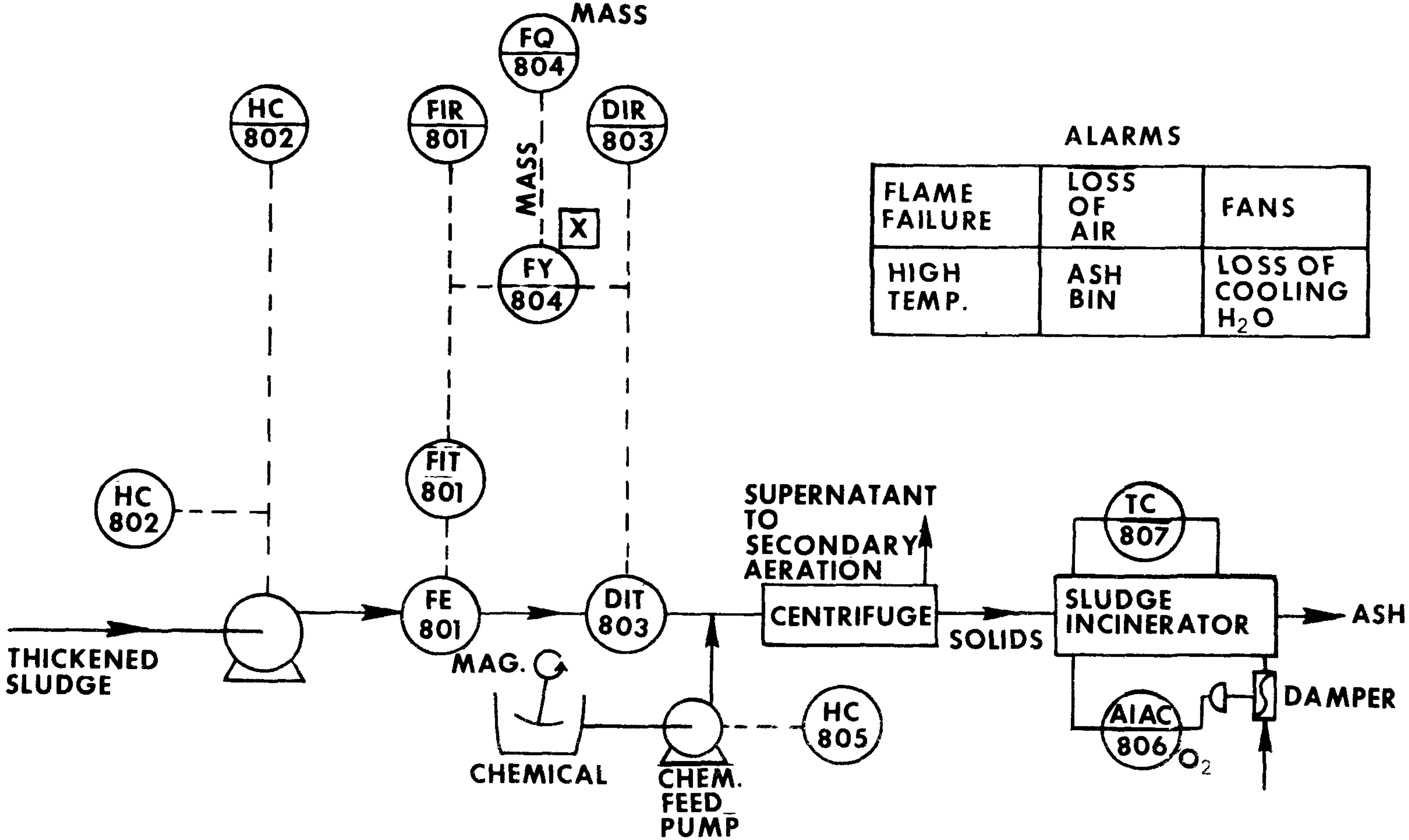


FIGURE B-12(f) SLUDGE THICKENING AND INCINERATION
800-LOOP

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-13

Responsible Supervisor

Flow Rate Design (Average and Maximum) Design max. 36 mgd, running at 22 mgd

Storm Water Collection and Treatment No: sanitary and industrial waste.

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)

Secondary, with trickle filters and activated sludge.

Performance Data (Individual Units and Overall)

70% removal, BOD and settleable solids

Year Built 1958 Modifications (Year and Description) Continuing slight inst. improvements

Original Cost $5M Modification Cost

Instrumentation Foxboro, Pneumatic, etc.

Equipment Flumes, mag. flow and orifices (for gas), flow-control valves, pH and gas analyzers, density meter.

Panels Central graphic (record, alarm, flow control) and auxiliary boards.

Installation and Start up Costs Original Cost ~~xxxxxxx~~ (Inst. Equip.) $250K

Instrumentation Modification (See above)

Description	Year	Equipment	Panels	I & S	Total

Computer None
Type. Manufacturer I O Devices

Process Control

Data Logging

Parameter Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control Flow distribution

Note: Low maintenance needs attributed to clean, dry, oil-free instrument air.

Supervisory Control

Alarm and Safety Systems Conventional, industrial type

Automatic Emergency Program (e g, Power Failure) None, plant is entirely self-contained, generates its own power.

Maintenance and Calibration

Special Equipment. None

Down Time None

Special Operator Training None

Frequency (no mo)

Total In-Plant Man Hours/Year 400 (Est.) + 100 hrs. call-in

Total Cost of Outside Service $2K

Estimate of Over-all Benefits of Instrumentation and Automation

Use of instrumentation is basic to the operation of the plant. Plant operation would not be feasible under manual control. Automatic data generation used for historical purposes.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In Plant Maintenance (mh/yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no /mo)	Total Downtime	Downtime Frequency (no /mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Hazardous Gas	Davis, filament type	11-3680-15		30 mh	1	None	No	No	--	None	--	Replacement parts	Good	Alarms	No	Kept in service and considered dependable.
Gas Analysis	Liston-Becker	21		300	15	None	No	No	--	Abandoned	--	Bad location; "unworkable" sample syst.	Fair		Yes	Info. valuable to keep digesters running well, but bad location (corrosive environ., awkward mounting), instrument deterioration, wet sample and bad sample conditioning system was not worth maint. expense. Inst. abandoned.
Raw sewage pH	Beckman and Foxboro			260	Clean-30 St'dize - 4	None	No	No	--	None	--	Fouled probes	$\pm$2%	Alarms	Yes	Although local sewage has little grease, probes must be cleaned daily. High sample velocity helps. Probes mounted in easily accessible flow-through mounts.
Sludge Flow	Foxboro mag flow meters			8	.1	None	No	No	--	None	--	Grease, etc., in sludge	$\pm$4% (Est.)		Yes	110 volts AC applied to electrodes automatically when pump stops. Good service for over 10 years.

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

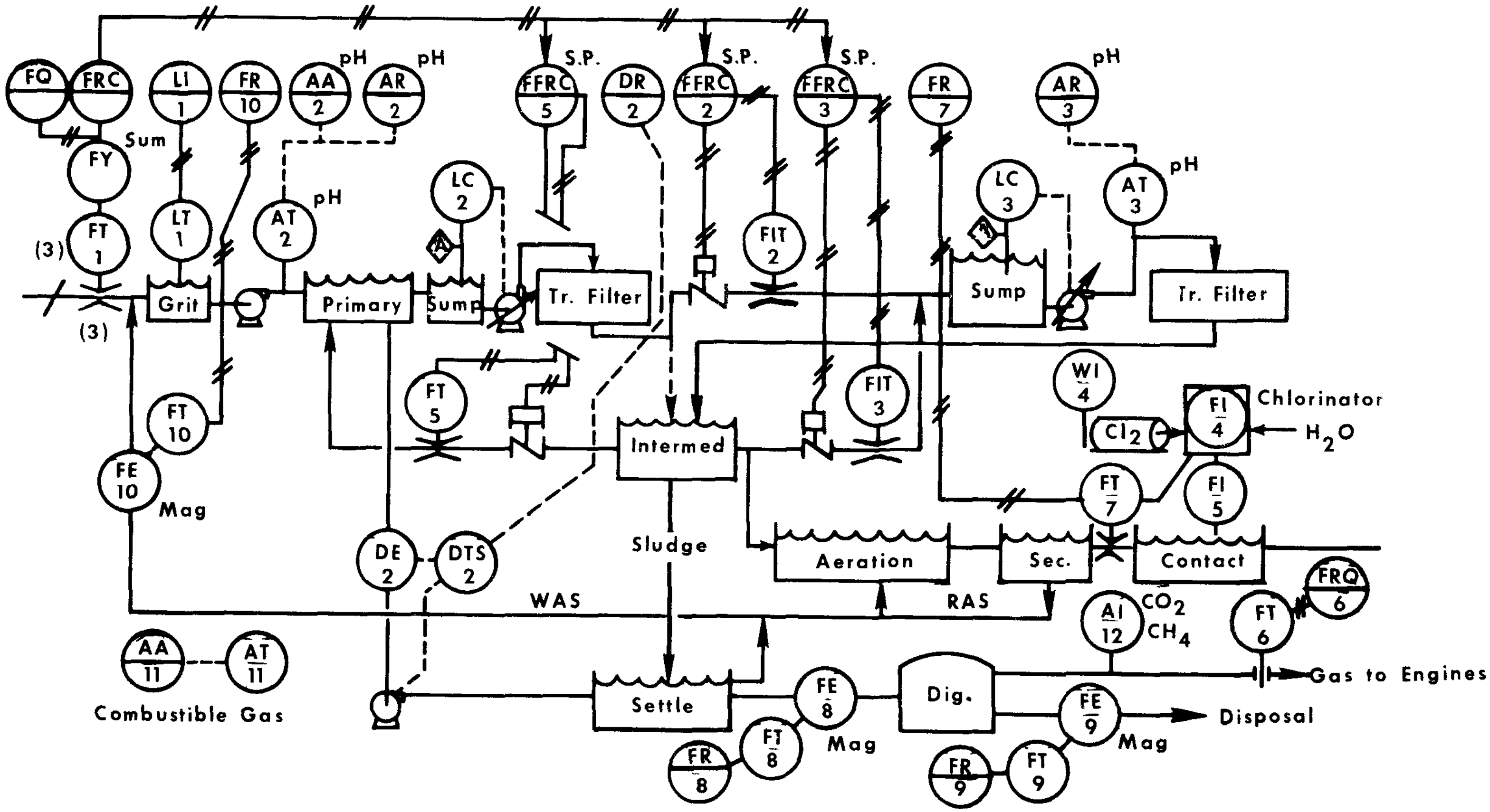
LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits: Annual Cost Savings			Benefits: Process Improvement		Operating Experience							
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW hr yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no./mo.)	Comments
DE-2	Primary Sludge	1	On-off	Nuclear density meter	Electric	Sludge pump	0.15				Yes		24 mh	4 (lab check)	None	No	No			Timer permits build-up of sludge in primary tank before initiation of pumping; timer also delays activation of density meter until meter-pipe is full of dense sludge. Improves digester performance by feeding only a very dense sludge.
FT-1	Process Flow	3	Prop. & Reset	Pneumatic	Air	Butterfly valve	0.05					Evens out flow variations	12 mh (Est.)	0.5	None	No	No			Float-actuated, characterized, pneumatic transmitters and Parshall flumes; remarkably maint.-free due to grease-free waste and clean instrument air.
LC-2	Sump Level	2	Prop.	Variable-speed pumps	Electric	Pump with wound rotor motor	0.4					Evens out flow variations	30 mh (Est.)	2	None	No	No			Successful, reliable system, requiring minor and frequent maintenance.

* Control mode relay, proportional, proportional plus reset, etc
** Types of controllers analog (pne., hyd. or elec media), computer (supervisory, direct digital or set analog).
*** Final control element pne values, variable speed pump, etc.

FIGURE B-13.

Controls in the Archie Elledge plant are principally pneumatic.



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GENERAL SURVEY QUESTIONNAIRE

STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-14

Responsible Supervisor

Flow Rate Design (Average and Maximum) 30 mgd, 36 mgd (Expanding to 50)

Storm Water Collection and Treatment No (Sanitary and infiltration only). ?0 mg influent storage.

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Secondary, activated sludge (diffused air), secondary sludge flotation, sludge filtration, incineration (hearth)

Performance Data (Individual Units and Overall) 90% SS Removal
90% BOD Removal

Year Built 1959 **Modifications (Year and Description)** 1964 (24 mgd - 36); 1971 Storage, pumps, power; 1971 Incinerator

Original Cost $6M **Modification Cost** $2M; $6.4M; $1.5M

Instrumentation Basically Foxboro

Equipment Mag flow, air flow, remote valve operators, filter and incinerator systems.

Panels Local

Installation and Start up Costs **Original Cost** **Total Cost**

Instrumentation Modification None

Description	Year	Equipment	Panels	I & S	Total

Computer Type Not yet **Manufacturer** **I/O Devices**

Process Control

Data Logging

Parameter Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost **Software Cost** **Installation Cost**

Central Control By areas

Supervisory Control Yes

Alarm and Safety Systems Conventional industrial

Automatic Emergency Program (e.g., Power Failure) Two tie lines

Maintenance and Calibration By two licensed electricians.

Special Equipment Minor **Down Time** None

Special Operator Training None, except that both plant inst. maintenance men are licensed electricians. **Frequency (no./mo.)**

Total In-Plant Man Hours/Year 400 mh

Total Cost of Outside Service $100

Estimate of Over-all Benefits of Instrumentation and Automation

Major reduction in manpower.
Improved performance.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Frequency (no. mo.)	Total Downtime	Downtime Frequency (no. mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Weight	Howe-Richardson Belt Scale			Est. 40	Est. 0.5	No	No	No	--	Little or none	Little or none	See below	Est. 2%	Integrator	Yes	Belt scale principally for sensing trends, estimating production. Good accuracy through frequent cleaning and calibration.
Oxygen (Flue Gas)	Hayes	(Large case)		Est. 160	Est. 8	No	NO	No	--	Est. 2%	Est. 2	Plugged sample lines	Good	--	--	Good instrument but high maintenance on sample piping.
BOD	Badger (Experimental)	Arthur type		High	Often	No	No	No	--	High	--	High maintenance	Poor	--	--	Experimental installation, rejected as unreliable, too much bother.
D.O.	Beckman			40	2	No	No	No	--	None	--	Fouling	2% (±0.1ppm)	None	Remote	Very little maintenance required for cleaning or calibration. Good agreement with YSI probe and Winkler analysis.
Level	Healey-Ruff	Float type		High	Often	No	No	No	--	High	Often	Float fouling	Poor			Floats N. G. for level control. Replaced with bubblers.
Control Valves	Phila. Gear (Limitorque)	Modutronic		High	Est. 0.5	No	No	No	--	Est. 10%	Est. 0.5	Electronic failures	--	--	--	High failure rate in electronic control circuit boards.
Flow	Foxboro (Magnetic)			Minor	On demand	No	No	No	--	Little or none	--	Probe fouling (see below)	Est. 4%	Zero-flow switch	Remote	Probe fouling due mostly to oversize inaccessible meter. Burn-off power applied to probes not successful.

* Corrosion, fouling, etc.
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

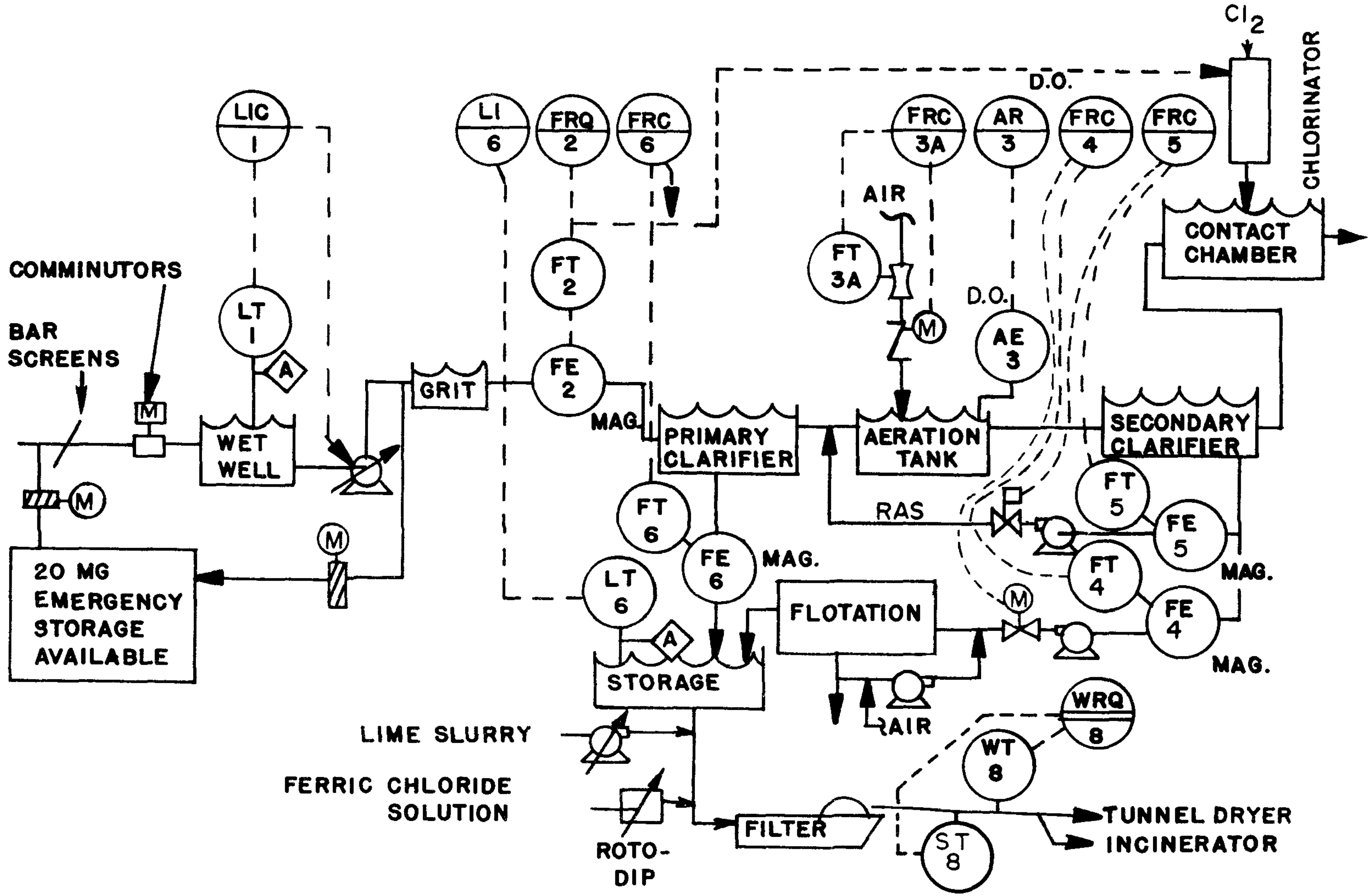
Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min.)	Manpower (mh/yr)	Utility (kW-hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no./mo.)	Comments
FE-4 FE-5	Sludge flow	4	Proport. plus reset	Electronic	Electric	Motorized sluice valves	2	6,000	No	Some	Yes	Improved	Est. 200	0.5	No	No	No	Valve failures	Est. 0.5	Abnormally high failure rate of valve actuator circuit boards.
LT-1	Wet well level	1	Proport. plus reset	Electric (Autocon)	Electric	Magnetic clutch	0.1	1,000	Minor	No	--	--	Est. 80	Est. 2	No	No	No	Little or none	--	Original Foxboro system replaced with Autocon.

* Control mode. relay, proportional, proportional plus reset, etc

** Types of controllers analog (pne., hyd or elec media) computer (supervisory direct digital or set analog)

*** Final control element pne. values, variable speed pump, etc.

FIGURE B-14.



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FT
6
FE
6
MAG.
LT
6
A
STORAGE
LIME SLURRY
FERRIC CHLORIDE
SOLUTION
ROTO-
DIP
FILTER
FLOTATION
AIR
FRC
3A
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FRC
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FRC
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D.O.
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AE
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AERATION
TANK
RAS
SECONDARY
CLARIFIER
FT
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FE
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MAG.
FT
4
FE
4
MAG.
M
Cl_2
CHLORINATOR
CONTACT
CHAMBER
WRQ
8
WT
8
ST
8
TUNNEL DRYER
INCINERATOR

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-15

Responsible Supervisor

Flow Rate Design (Average and Maximum) Average Design - 37.5 mgd, Peak Hydraulic Capacity - 120 mgd
Average Actual - 31.0 mgd

Storm Water Collection and Treatment None (separate system)

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Secondary, with activated sludge, step aeration in 4-pass system.

Performance Data (Individual Units and Overall) Suspended solids - Overall Removal: 97%, Primary Removal: 54%
BOD - Overall Removal: 88%

Year Built 1971 **Modifications (Year and Description)** 1973 - Facilities for addition of polymers in aeration tanks.

Original Cost $9M **Modification Cost** $25,000

Instrumentation

Equipment Mostly electric, some pneumatic.

Panels Central control panel and sub-panels at chlorination station, air compressor station, return sludge pumping station and influent sewage pumping station.

Installation and Start up Costs **Original Cost** **Total Cost** $350,000 - Robertshaw Control Co.

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
Method of control of return activated sludge flow.	1971	Changed control from sludge turbidity to sludge blanket level.			

Computer

Type Time sharing terminal console **Manufacturer** Teletype Corp. CSC-1108 computer **I O Devices** teletyper

Process Control None

Data Logging None at plant

Parameter Frequency	Parameter Frequency	Parameter Frequency	Parameter Frequency
Plant operating data are gathered, logged and transmitted once per day to main office. Plant flow, COD primary, COD secondary, waste activated sludge flow, suspended solids, MPN and other data.	Operations summary is prepared once per mo. and sent from main office to the plant. Incl. many useful parameters such as cell residence time, air rate per pound of COD.		

Storage
Memory bank in central computer

Software Description
Some programs are in process of being written.

Computer Cost **Software Cost** **Installation Cost** $100 per month total including installation and telephone costs for time sharing console.
$65.00 per mo. for time sharing console rental.

Central Control

Supervisory Control Return activated sludge flow, chlorination rate by adjusting set point, primary sludge valves, air compressors, waste activated sludge valve, and other processes are controlled from main control panel.

Alarm and Safety Systems Yes.

Automatic Emergency Program (e g , Power Failure) Standby generator for total plant load except for process air compressors; battery backup for control systems.

Maintenance and Calibration

Special Equipment Scope, test gauges, water manometer, precision milliamp detector, magnetic flow meter calibrator.

Down Time No plant downtime because there are spare units. Infrequent downtime to chlorinators and influent pump controls.

Special Operator Training Two hours per week for four men in the entire sanitation district.

Frequency (no mo) 0.17

Total In Plant Man Hours Year 1,500

Total Cost of Outside Service None

Estimate of Over all Benefits of Instrumentation and Automation Data logging and gathering, although manual, gives information to operate the plant better. Without instrumentation and automatic control, the same number of people would operate the plant less efficiently. Instrumentation and automation does not save manpower, but increases efficiency. Automatic control of air for activated sludge is very useful.

INSTRUMENT SURVEY FORM

Instrument: Parameter	Instrument: Manufacturer	Instrument: Model Number	Instrument: Equipment Cost	Operating Experience: In Plant Maintenance (mh/yr)	Operating Experience: Maintenance Frequency (no./mo.)	Operating Experience: Special Training	Operating Experience: Service by Contract ($ or mh/yr)	Operating Experience: On-Demand Service ($ or mh/yr)	Operating Experience: Frequency (no./mo.)	Operating Experience: Total Downtime	Operating Experience: Downtime Frequency (no./mo.)	Operating Experience: Problems*	Operating Experience: Accuracy	Peripheral Equipment: Auxiliary Devices**	Peripheral Equipment: Control panel; Recording Devices***	Comments
Influent Sewage Flow	Fischer & Porter Magnetic Flow Meters (4@ 30")	10D1430	$27,500 (1969-Incl. Auxil.)	18 (4-1/2 per meter)	0.3	Inhouse	None	None	None	Minor	0.04	None	Good	Alarms, indicators, totalizer, controller	Central control panel; Influent pump. panel	Very good meter. Calibration required once every 3 months.
Dissolved Oxygen	Beckman Probes (3)	735	Est.$1,000 (1969-Incl. Auxil.)	156 (52 per probe)	2 See below	Inhouse	None	None	None	Some for cleaning	2	Cleaning of probes and calibration 3 times/week	2%+	Alarms, indicators, switches, controller	Central control panel	The instrument is satisfactory provided the probes are cleaned once every 2 weeks; readings are tested 3 times per week with portable equipment; calibration is required.
Aeration Air Flow	Wallace & Tiernan Plastic insert (9@ 30") Dall-Venturi Meters	122	$28,000 (1969-Incl. Auxil.)	30	4	None	None	None	None	None	None	Auxiliaries Maintenance	Good	Alarms, indicators, totalizers, relays, switches, controller	Central control panel	Very good meter. The instrument is satisfacotry provided auxiliaries are maintained once per week.
Return Sludge Flow	Micrometer Propeller Meters (3@24" & 18 @10")	MC 0900	Est. $19,000 (1969-Incl. Auxil.)	32	1	None	None	None	None	Minor	0.08	Registers sometimes jam	3 - 4%	Alarms, indicators, transducers, controllers	None	Very good meter. Calibration required once per year.
Waste Sludge Flow	Micrometer Propeller Meter (1@6")	MC 0900	Est. $500 (1969-Incl. Auxil.)	4	0.3	None	None	None	None	None	None	None	Good	Alarms, indicators, totalizer, transducer, controller	Central control panel	Very good meter. Calibration required once per year.
Return Sludge Turbidity	Hach Falling Stream Turbidimeter	1031	--	Not used	Not used	None	None	None	None	Abandoned	Abandoned	Many problems; unworkable	Unknown	Alarms, sampling lines, airlift, etc.	None	Could not get the system to work. Turbidimeter received sample through 1-inch line pumped by air lift. The sample line kept plugging; there was foaming and pulsations in the system. Abandoned.
Chlorine Residual	Fischer & Porter Anachlor Analyzers (2)	17B3200	--	360 (180 each)	30	Inhouse	None	None	None	Some for cleaning	None (Alternat. units)	High maintenance	Est. 3%	Alarms, transducers, controllers	Chlorination control panel	High maintenance (clean probes and filters every day).

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In Plant Maintenance (mh/yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no mo)	Total Downtime	Downtime Frequency (no mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Effluent Sewage Turbidity	Hach Surface Scatter Turbidimeter	1889 B	$1,000± (1969 - Incl Auxil.)	1	0.25	None	None	None	None	None	None		5%±	Transducer	Central control panel	Very good meter. Calibration required 3 times per year.
Dissolved Oxygen	Weston & Stack Portable Probes	300	--	125	12	Inhouse	None	None	None	Not applicable (Two portable units on line)	--	High maintenance due to frequent cleaning of probes & calibration	2%+	None	None	The instrument is satisfactory provided it is calibrated 3 times per week and recharged every 2 weeks. Portable equipment is very useful to do DO profiles instead of installing and maintaining extensive, permanent, DO-probe system which is expensive to maintain.
Primary Sludge Pressure	Robertshaw Microsen (Bellows type)	115 B1 L1	--	None	None	None	None	None	None	None	None	Not sensitive enough	Unknown		Central control panel	The instrument is not satisfactory for this application because it does not have enough sensitivity to indicate pressure variations.

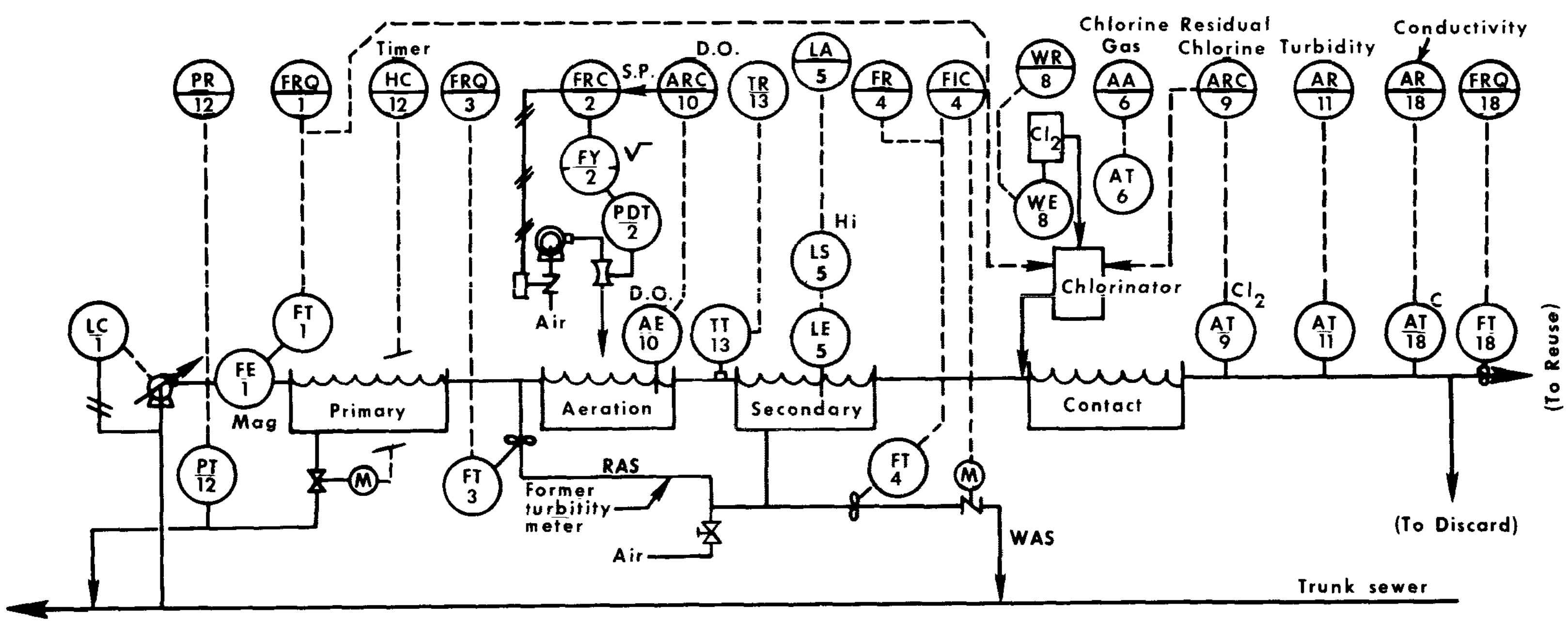
* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh yr)	Utility (kW hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no/mo)	Comments
AE-10	Aeration Air Flow	1	Proportional plus reset	Electric	Pneumatic	Valve	0.25	4380	None	None	Yes (BOD)	Reduces DO variations within 5% of set point	500 mh	15	Inhouse	None	None	None	2	Frequent cleaning of DO probes and calibration is required. The system is good and gives high operating efficiencies. The system is set up to operate as follows: DO control - used 50% time; Manual - not used; Flow Ratio Control - used 50% time; Programmed cam - not used.
AT-9	Chlorination	1	Proportional plus reset	Electric residual signal Vacuum flow signal	Pneumatic	Chlorinator	17	4380	None	Est. $40,000 (10% of total)	Yes (MPN)	1 to 2 mg/l	500 mh	30	Inhouse	None	None	None	--	Daily cleaning of Residual Chlorine probes is required. The system is good and gives close control on effluent residual chlorine.
FT-3	Return Sludge Flow	18	Proportional plus reset	Pneumatic	Pneumatic	Butterfly valve	0.25	Some	None	None	Yes (BOD)	Reduces flow variations	10[illegible] mh	2	None	None	None	Minor	0.08	Turbidity meter control was abandoned because sampling system wouldn't work. The present system of operation consists of reading sludge blanket level and manual control of valve position. The operation requires about 500 mh/yr.
FT-4	Waste Sludge Flow	1	Proportional plus reset	Electric	Pneumatic	Butterfly valve	0.25	Some	None	None	Minor	Reduces flow variations	10 mh	0.3	None	None	None	None	None	The system works well.
LC-1	Influent Sewage Flow (level)	1	Proportional plus reset	Electric	Electric (magnetic drives)	Variable-speed pump	0.03	8760	Some	None	Minor	Reduces influent level variations	50 mh	0.5	Inhouse	None	None	Minor	0.04	The system works well.
PT-12	Primary Sludge Flow	10	On-off (Timer)	Programmed open loop	Pneumatic	Gate valve	45	8760	None	None	Minor	Reduces drawing too thin sludge	70 mh	0.3	None	None	None	None	None	The system works well.

* Control mode relay, proportional proportional plus reset, etc.
** Types of controllers analog (pne , hyd or elec media), computer (supervisory, direct digital or set analog)
*** Final control element pne values, variable speed pump, etc

FIGURE B-15.



PR 12
FRQ 1
Timer
HC 12
FRQ 3
FRC 2
S.P.
D.O.
ARC 10
TR 13
LA 5
FR 4
FIC 4
WR 8
Chlorine Gas
AA 6
Chlorine Residual Chlorine
ARC 9
Turbidity
AR 11
Conductivity
AR 18
FRQ 18
FY 2
PDT 2
Cl2
WE 8
AT 6
Hi
LS 5
Chlorinator
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LC 1
FT 1
AE 10
TT 13
LE 5
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AT 18
FT 18
(To Reuse)
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Secondary
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PT 12
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FT 3
RAS
Former turbitity meter
Air
FT 4
M
WAS
(To Discard)
Trunk sewer

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GENERAL SURVEY QUESTIONNAIRE

STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-16

Responsible Supervisor

Flow Rate Design (Average and Maximum) Average flow rate - 23 mgd; Design flow rate - 44 mgd. The flow is highly seasonal, reaching design flow rate during the canning season.

Storm Water Collection and Treatment Separate system with high infiltration. Minor account of combined sewage.

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems.)
Secondary treatment plant with trickling filters.
Sludge thickening, digestion and trucking to land disposal.

Performance Data (Individual Units and Overall)
Overall removal - 87% suspended solids, 89% BOD

Year Built: 1964 **Modifications (Year and Description)** 1975; doubling plant capacity and adding Unox system of activated sludge treatment.

Original Cost 3.3 million **Modification Cost** 13.0 million (Future)

Instrumentation

Equipment Electrical mostly, some pneumatic.

Panels One main central control panel.

Installation and Start up Costs -- **Original Cost** -- **Total Cost** --

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
Influent gate-closure control.	1970	Standby engine			

Computer

Type None **Manufacturer** **I/O Devices**

Process Control

Data Logging

Parameter/Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost **Software Cost** **Installation Cost**

Central Control

Supervisory Control None

Alarm and Safety Systems Yes

Automatic Emergency Program (e.g., Power Failure) No plant standby generator. There is automatic by-pass in case of prolonged power failure. About 3 power failures per year. Gasoline standby generator to close influent gate automatically on power failure.

Maintenance and Calibration

Special Equipment None (Done by instrument suppliers) **Down Time** No downtime of plant due to instrument downtime.

Special Operator Training None (Service contract is under consideration for maintenance and calibration) **Frequency (no/mo)** No plant downtime (see below)

Total In-Plant Man Hours/Year 50

Total Cost of Outside Service $500 to $1,000 per year

Estimate of Over all Benefits of Instrumentation and Automation

When the systems are working well, they are very useful and the operators couldn't do without them. The most useful and important devices are high-water alarm and power-failure alarm.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		Comments
Parameter	Manufacturer	Model Number	Equipment Cost	In Plant Maintenance (mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Frequency (no./mo.)	Total Downtime	Downtime Frequency (no./mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Thickened Sludge Density	Ohmart Corp.	50G-144-40/10 MTR CS-137 MC 1000	$6,767 (For entire system in 1964	Very high. Instrument then abandoned.	Approx. 10	None	None	About $200 per day	10 called for; Inst. never satisfactory			Build-up of grease changes readings	Very poor due to build-up of grease	Delay timers, alternator, and alarms.	Local recorder, indicator/controller. Central recorder, indicator.	The operators don't like this density meter and have abandoned its use after the first few months of operation. Build-up of grease changes readings so that the accuracy is very poor. Too much trouble to keep it clean. Poor accuracy results in erroneous control of sludge pumps. They have changed to a manual reading of sludge blanket.
Thickened Sludge Flow	Fischer & Porter Magnetic Meter	10D1416D Series A-1 Jetflow Lining	$1,926 (For system in 1964)	None	None	None	None	None	None	None	None	None	Good	Also control of chlorinations and sampling pumps.	Central control panel recorder, indicator/integrator	The meter and the receiver work very well with no problems. The transmitter requires periodic cleaning, and occasional problems are experienced. The use of 24-hour charts is cumbersome.
Effluent (Final)	Hersey Sparling Propeller Meter	58042	$5,580 (For entire system in 1964 with some sampl. equip.)	3 hours: Meter: 0 Trans: 2 Rec vr: 1	.25: Meter: 0 Trans: .08 Rec vr: .08	None	None	$75: Meter: 0 Trans: 50 Rec vr: 25	0.11 per mo Meter: 0 Trans: .08 Rec vr: .03	None	None	No problems with meter. Condensate of local indicator. Rotary at transmitter shortout due to condensation.	Unknown	Transmitter alarms.	Local indicator/totalizer. Central control panel indicator/totalizer, recorder.	The meter works satisfactorily with very few problems. There are occasional minor problems with the transmitter and receiver. Condensation is a problem at the transmitter.
Sludge Gas Flow	BIF (Self contained Meter)	4KS-40473-1	Unknown	1.0	.04	None	None	None		None	None	Minor amt. of maintenance	Unknown	Local totalizer attached to meter	None	The meter works well.
Chlorine	Wallace & Tiernan: V-notch	A71113 JJ2390 A744013 JJ904	Unknown	36	.12	None	None	$500	.12	None	None	Electrical system failures. Replace switches, etc.	±5%	Alarms. transfer switches	Control Panel Recorder - Indicator/Totalizer	Except for electrical problems, the system works well. Chlorine gas metering is inaccurate. Operators use weight loss, instead of integrator and totalizer, to see what is left in chlorine tanks.

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

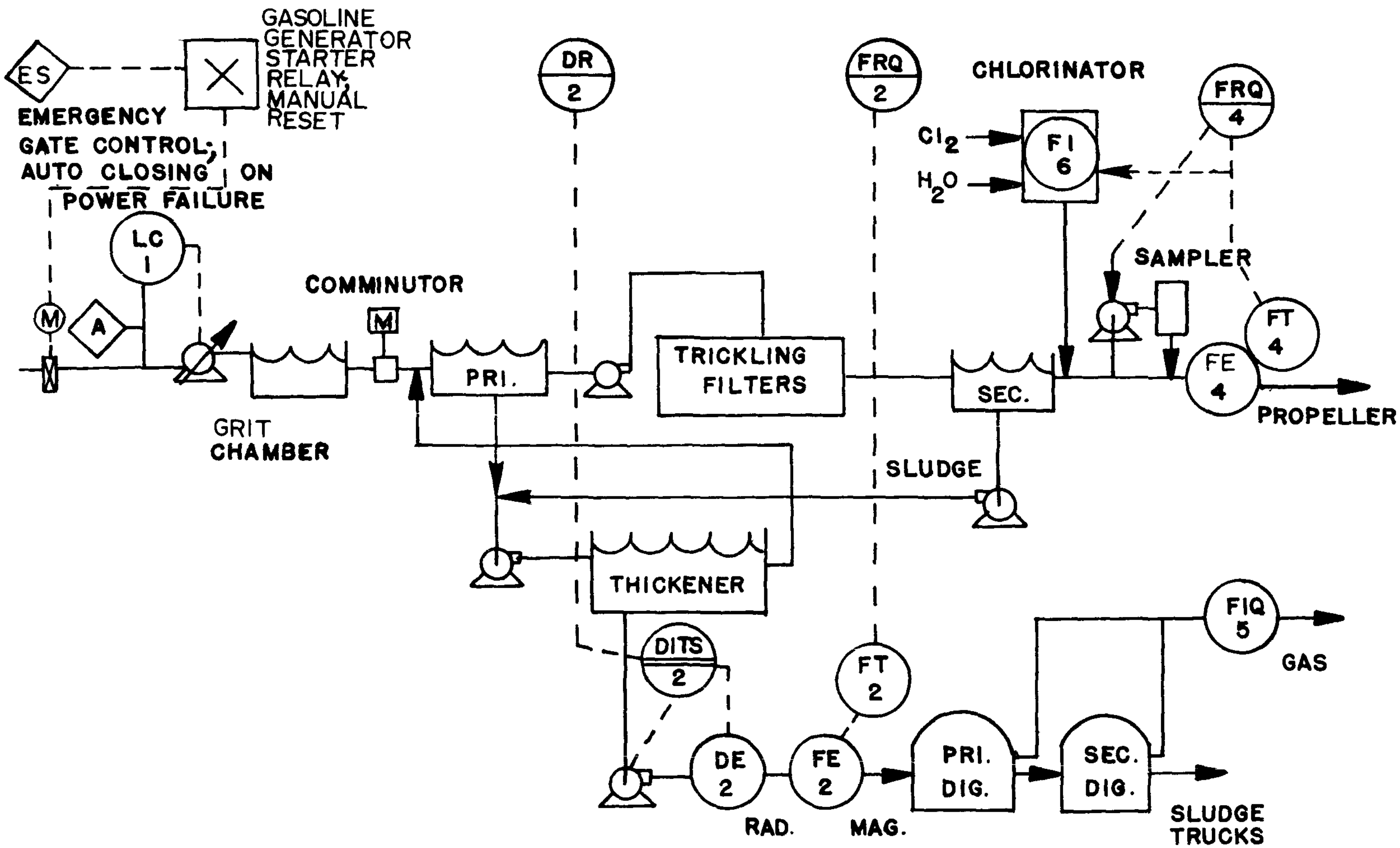
Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh yr)	Utility (kW hr yr)	Chemical (lbs yr)	Increase Removal (%)	Parameter Variance min, max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh yr)	Maintenance Frequency (no mo)	Special Training	Service by Contract ($ or mh yr)	On Demand Service ($ or mh yr)	Downtime (hrs yr)	Downtime Frequency (no mo)	Comments
DE-2	Thickened Sludge Pumping	2	Manually set on-off (min/hour)	Manually set electrical	Electric	Pump motor	Zero			None		Sludge density variation is reduced	None since density meter abandoned	None	None	None	None	None	None	The operator of a portable sonic device for a few minutes each day is easier, simpler and less costly in a small plant than maintenance and operation costs on a sludge density meter. (Determining sludge blanket level)
LC-1	Raw Sewage Pumping	2	Proportional control of speed	Flow-matcher BLV 6519 SN 65-07	Electric	Variable-speed of pumps from level.	±.2		None	None		Flow variation is reduced	1.5 mh/yr	.03	None	None	$100	None	None	The system works well.
FE-4	Chlorine Solution Feed Rate	2	Proportional to flowrate	Wallace & Tiernan V-notch chlorin.	Electric	Chlorinator	±.5		None	Some		Residual chlorine variation is reduced	36 mh/yr	0.12	None	None	$500	None	None	There have been some electrical maintenance and repair problems.

* Control mode relay, proportional, proportional plus reset, etc

** Types of controllers analog (pne hyd or elec media) computer (supervisory direct digital or set analog)

*** Final control element pne values, variable speed pump, etc

FIGURE B-16.



ES
EMERGENCY
GATE CONTROL;
AUTO CLOSING ON
POWER FAILURE
GASOLINE
GENERATOR
STARTER
RELAY,
MANUAL
RESET
LC
1
A
M
GRIT
CHAMBER
COMMINUTOR
M
PRI.
DR
2
TRICKLING
FILTERS
FRQ
2
SLUDGE
THICKENER
DITS
2
DE
2
RAD.
FE
2
MAG.
FT
2
PRI.
DIG.
SEC.
DIG.
SLUDGE
TRUCKS
FIQ
5
GAS
SEC.
CHLORINATOR
Cl2
H2O
FI
6
FRQ
4
SAMPLER
FT
4
FE
4
PROPELLER

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-17

Responsible Supervisor

Flow Rate Design (Average and Maximum) Av. 40, design 44 mgd, 80 mgd peak

Storm Water Collection and Treatment Most sewers combined

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Secondary (activated sludge), with sludge incineration and landfill. Phosphate removal (Ferric chloride and polymer).

Performance Data (Individual Units and Overall)
BOD Removal - 76%
SS Removal - 73%

Year Built 1929 Modifications (Year and Description) 1950's - Enlarged 1973 - Enlarged and revised

Original Cost $2 million Modification Cost $5 million

Instrumentation F & P, Brooks, Bristol, Etc. Process instrumentation being revised.

Equipment Pneumatic analogs being replaced with electronic for computer capability.

Panels Local

Installation and Start up Costs Original Cost Total Cost

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
Monitoring & Control	1973	computer with auxiliary	console		$800 K

Computer Not yet in service
Type Miniature, on-line
Manufacturer
I/O Devices Perf. Tape instructions
1 Memorex printer
4 #35 Teletypes
3 CRT/input stations

Process Control Direct Digital

Data Logging

Parameter Frequency	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency

Storage 8K 12 bit words (core)
520 K bit words (disc)

Software Description

Computer Cost Software Cost Installation Cost

Central Control Not yet

Supervisory Control Will be computer controlled

Alarm and Safety Systems Will be computer controlled

Automatic Emergency Program (e.g., Power Failure) Two ties, automatic switchover

Maintenance and Calibration Inst. Shop for inst's. computer accessories

Special Equipment Scope, Heath Standards, VOM, Pwr Spls., Freq. Gen. & Counter, Manometer.

Down Time None

Special Operator Training Electronic Technician

Frequency (no./mo.) -

Total In-Plant Man Hours Year 600

Total Cost of Outside Service None at present

Estimate of Over all Benefits of Instrumentation and Automation
Reduced manpower, especially for remote stations.
Uniform operation.

INSTRUMENT SURVEY FORM

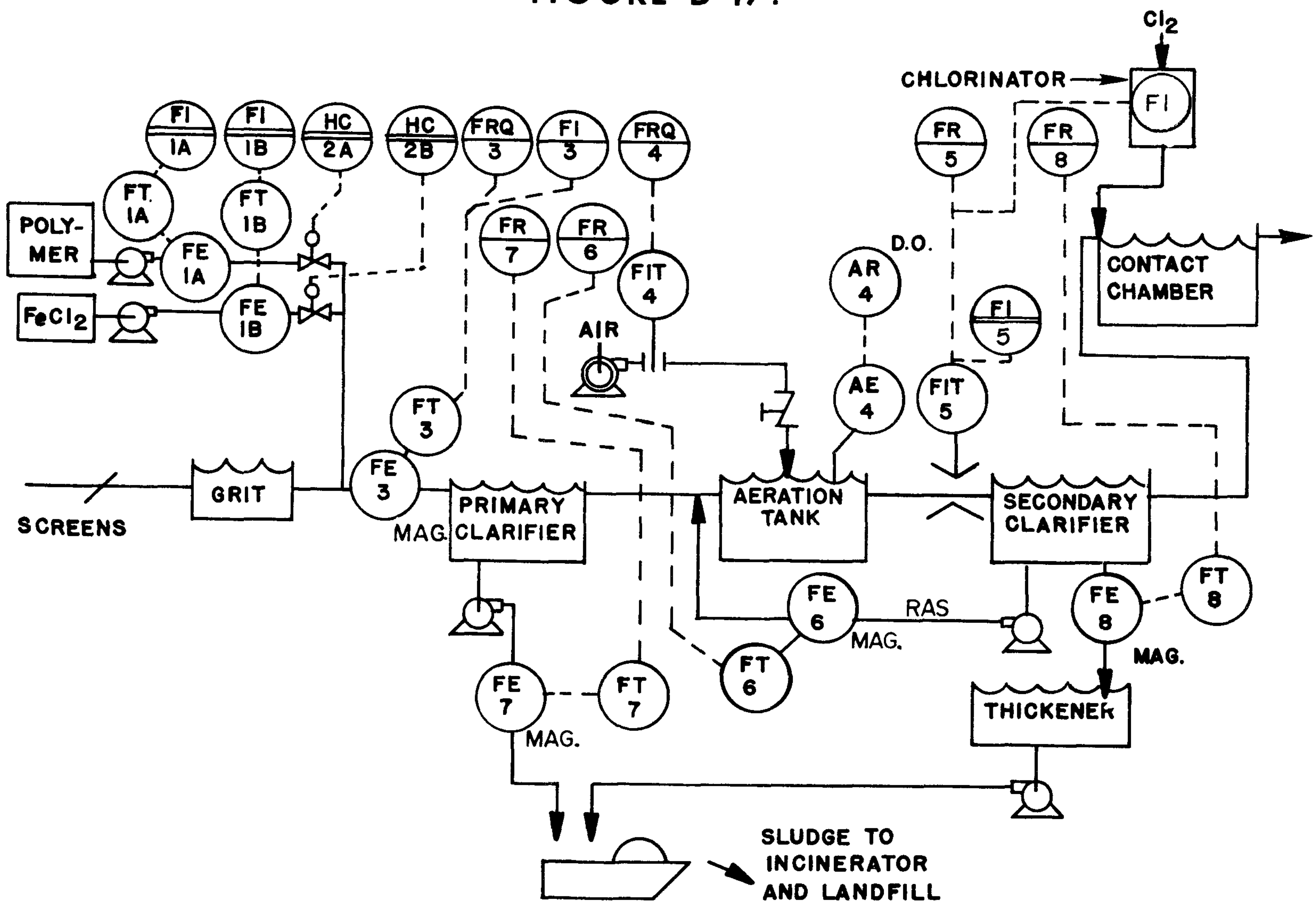
Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no./mo.)	Total Downtime	Downtime Frequency (no./mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Flow (Air)	Hayes					No	No	No						None	Remote	Obsolete (not computer compatible)
D.O.	Beckman			300	90	No	No	No	--	None	--	Probe Fouling	Good	None	Remote	Used for recording and guidance only. Checked monthly against air and Winkler with good results.
Flow	Parshall Flumes			--	--	No	No	No	--	None	--		Est. 20%		Remote	Meters essentially abandoned, while plant revisions are in progress (i.e., head is insufficient).
Flow	Brooks Mag. Meters	7300A2B-9C2AA		None to date	--	No	No	No	--	None	--	None to date	Unknown	Sonic Cleaner 5-272-E-247-AAA	Remote	On main flow and return secondary sludge. In use, with ultrasonic cleaning, for 12 months; no troubles to date.

* Corrosion, fouling, etc

** Limiters, alarms, ratio relays

*** Local and central

FIGURE B-17.



Cl2
CHLORINATOR
FI
FI 1A
FI 1B
HC 2A
HC 2B
FRQ 3
FI 3
FRQ 4
FR 5
FR 8
FT 1A
FT 1B
POLY-MER
FE 1A
FeCl2
FE 1B
FR 7
FR 6
FIT 4
AIR
D.O.
AR 4
FI 5
AE 4
FIT 5
CONTACT CHAMBER
FT 3
FE 3
SCREENS
GRIT
MAG.
PRIMARY CLARIFIER
AERATION TANK
SECONDARY CLARIFIER
FE 6
RAS
MAG.
FT 6
FE 8
FT 8
MAG.
FE 7
FT 7
MAG.
THICKENER
SLUDGE TO INCINERATOR AND LANDFILL

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-18

Responsible Supervisor

Flow Rate Design (Average and Maximum) 105 mgd Avg. dwf: 225 peak wwf.

Storm Water Collection and Treatment Combined system - no special provisions for stormwater

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems) Secondary treatment employing Krauss aeration process, chlorination, sludge digestion with drying beds; sludge sold commercially as a soil conditioner. Digester gas runs blowers and generators.

Performance Data (Individual Units and Overall)

Year Built 1964 (as is) Modifications (Year and Description) 1973, expansion to 150 mgd Avg. dwf.

Original Cost $\$29X10^6$ Modification Cost

Instrumentation Equipment Mostly Fischer & Porter pneumatic-type instruments; F&P magnetic flow meters; bubble-tube level indicators, with Flowmatcher liquid rheostat motor-speed controls; Wallace & Tiernan closed loop chlorination; Ohmart sludge density gauges; and temperature indicators and controllers.

Panels 20-Ft. panel in Blower Bldg.; 15-Ft. panel in sludge control building.

Installation and Start-up Costs Original Cost Total Cost

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
Replace Sludge Density Meters	1973	K-Ray			
D.O. Monitoring	1973	Beckman 735			
ORP Monitoring	1973	Beckman			
Computer Control	1973	F&P	CRT		
Lab TOC	1973	Beckman 1215			10K

Computer Not currently installed (see above)

Type Mini Computer Manufacturer Varian 620/L I/O Devices Printers, CRT, Teletype, Card Punch, Card Readers

Process Control DO, Digester loading, Activated Sludge Wasting

Data Logging Yes

Parameter/Frequency	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency
Hourly plant Data Acquisition	Daily Lab Data Acquisition		

Storage 16K core and 123K Disk

Software Description Data logging; three-mode control; alarms; CRT display programs

Computer Cost Software Cost Installation Cost

Central Control Although plant currently displays about 50% of its equipment status and process indication on two panels, there is virtually no remote control capabilities.

Supervisory Control No (less than 10% of adjustments can be made remotely).

Alarm and Safety Systems Torque alarms on mech. equipment; Hi-temp alarms; chlorine gas detector and alarm.

Automatic Emergency Program (e g., Power Failure) Facility generates its own power from digester gas, natural gas and oil.

Maintenance and Calibration

Special Equipment Press. test stand and calibration; O-scope; transistor checkers, signal generators, temp. test stand, diff. press. test stand.

Down Time Problem equipment abandoned

Special Operator Training Trained instrument technician

Frequency (no /mo)

Total In-Plant Man Hours/Year 4,000 man-hrs/yr

Total Cost of Outside Service

Estimate of Over all Benefits of Instrumentation and Automation
Sludge density meters abandoned because of poor accuracy and reliability - special AEC license for servicing; very poor blower control; automatic data logging being used. Since no process control instruments, other than flow monitoring and manual adjustment, this plant derives little or no benefits from I & A.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In Plant Maintenance (mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Frequency (no. mo.)	Total Downtime	Downtime Frequency (no./mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Res. Cl_2	Wallace & Tiernan	767		60 hrs/yr	Once every 6 weeks	None	--	--	--	50 hrs/yr	1 hr/wk	None	Good	Prop. Control	Local	Satisfactory performance, good reliability.
Flow	Fischer & Porter Mag. meter											Grease build-up [a]	10%		Strip Chart Recorder	a. Since facility has no by-pass on flow meters, they can't perform lock-up zero calibration.
Data Acquisition	Fischer & Porter	2000 Series														50-channel data logger with no storage capabilities, all output on hardcopy teletype. No value to plant personnel. Because of lack of interest, data logger abandoned.

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min.)	Manpower (mh/yr)	Utility (kW-hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In-Plant Personnel ($ or mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no./mo.)	Comments
LT-101	Level	4	PI	Pneumatic/ Electric	Electric	Variable-speed pump	Several min.	--	--	--	--	±1 Ft.	24 hrs/yr per loop	twice a year	Inst. Tech.	--	--	24 hrs/yr	1/yr	Reliable system, with no major maintenance problems. Essential for plant operation.
FE-102A FE-102B	Flow Distrib.	1	PI	Pneumatic	Pneumatic	Butterfly valve	5 min.	--	--	--	--	10% Variation	--	--	Inst. Tech.	--	--	--	--	Flow distribution control works satisfactorily (about 10% accuracy). All flow control systems maintained the desired set point.
PDT-12	Air Distrib.	12	Multiplier relay from press. cont.	Pneumatic	Pneumatic	Butterfly valve	Very long	--	--	--	--	About 30 - 50% offset	--	--	Inst. Tech.	--	--	--	--	Despite corrective programs, the air distribution control is unreliable and unacceptable: Usually 30-50% offset. Very poorly designed.
FT-209	Blower Control	--	PI	Pneumatic/ Electric	Electric	Variable-speed motor	2 min.	--	About 10%	--	--	None; maintains lbs/hr set point	--	--	Inst. Tech.	--	--	--	--	Satisfactory control system.
LIT-412	Digester Level	8	On-off	Electric	Electric	Pump	5-10 min.	--	--	--	--	±1 Ft	--	--	--	--	--	--	--	Occasionally cable jams, but usually level control is acceptable.
TT-411	Digester Temp.	8	On-off	Pneumatic	Electric	Solenoid valve	--	--	20%/year	--	--	±1° F	24 hrs/yr per loop	4/yr	Inst. Tech.	--	--	--	--	Temperature control holds the digester temp. relatively constant (±1%) No maintenance problems.
FE-406	Digester Loading	4	On-off	Sequence	Electric	Solenoid valve	--	0.5 mh/yr	--	--	--	--	16 hrs/yr per loop	1/yr	Inst. Tech.	--	--	--	--	Currently, loading control operated on timer (open loop, control), but has capability of switching to mass loading or flow loading. (see sludge density inst.).

* Control mode relay, proportional, proportional plus reset, etc
** Types of controllers analog (pne., hyd. or elec. media), computer (supervisory, direct digital or set analog)
*** Final control element pne. values, variable speed pump, etc

LOOP AND PROCESS CONTROL SURVEY FORM

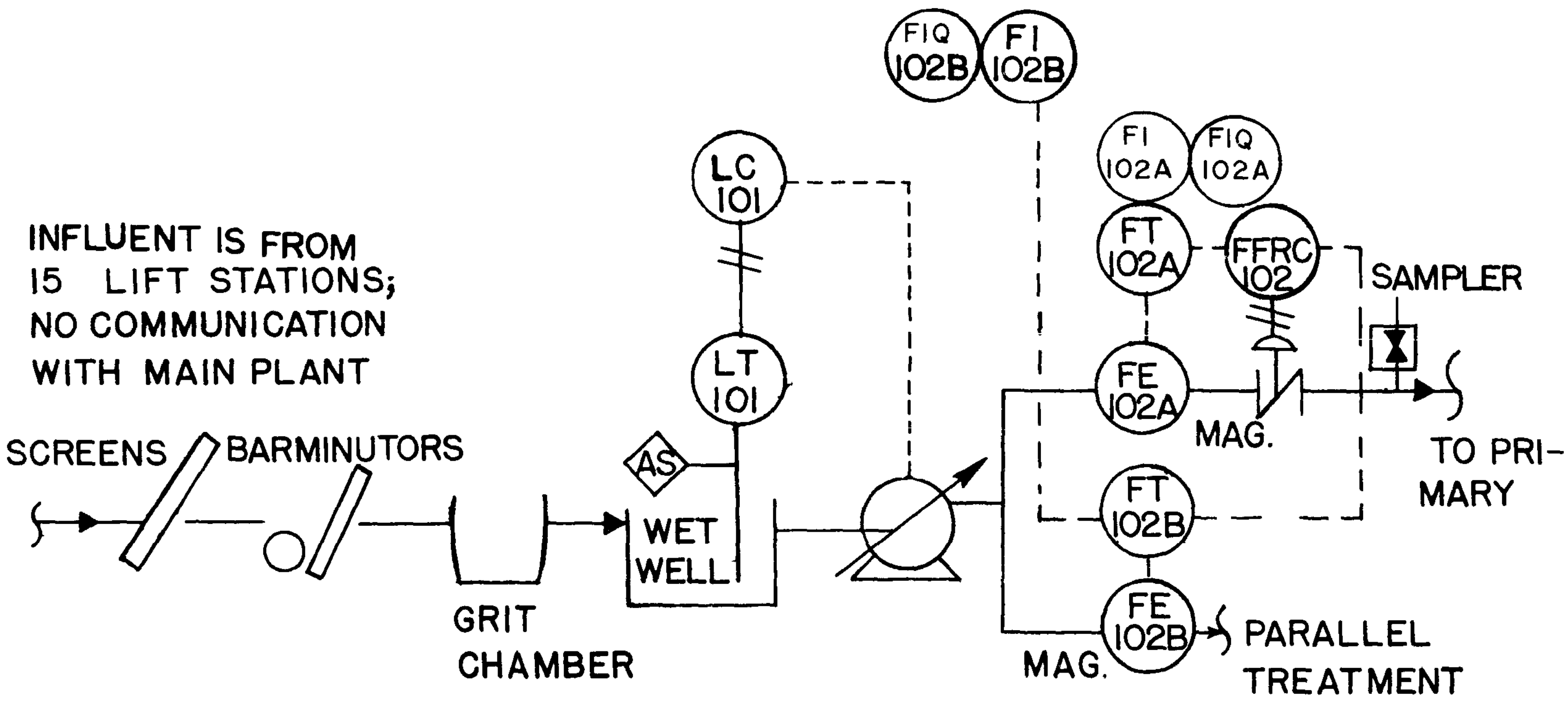
Control Techniques								Benefits					Operating Experience							Comments
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh yr)	Utility (kW hr yr)	Chemical (lbs yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh yr)	Downtime (hrs yr)	Downtime Frequency (no/mo)	
HC-207	RAS Flow	12	Manually adjusted	Manual operation	Pneumatic	Butterfly valve	Several hours	--	--	--	--	±20%	--	--	Inst. Tech.	--	--	--	--	Operated manually, but remotely adjusts valves to aeration tanks based on flow indications. This is the only supervisory control at this treatment plant.
AT-303	Chlorination	5	Prop. to Res. Cl_2	Analog Pneumatic Feedback	Vacuum	Diaphragm	4 min.	--	--	At least 30%	--	±1mg/liter 90% of time	(DETERMINED BY RES. Cl_2 ANALYZER)							Well behaved control system; no problems. Although facility has flow-prop. and Res. Cl_2 capabilities in their control system, only Res. Cl_2 mode used. Closed loop Cl_2 control is essential for operation, especially with forthcoming dechlorination requirement via SO_2.

* Control mode relay, proportional, proportional plus reset, etc.

** Types of controllers analog (pne hyd or elec media), computer (supervisory, direct digital or set analog)

*** Final control element pne values, variable speed pump, etc

FIGURE B-18(a). SECONDARY PLANT, PRETREATMENT SECTION



NOTE: NO INFORMATION TRANSMITTED TO CENTRAL LOCATION

FIGURE B-18(b).

SECONDARY PLANT,
PRIMARY & KRAUSS AERATION SECTION

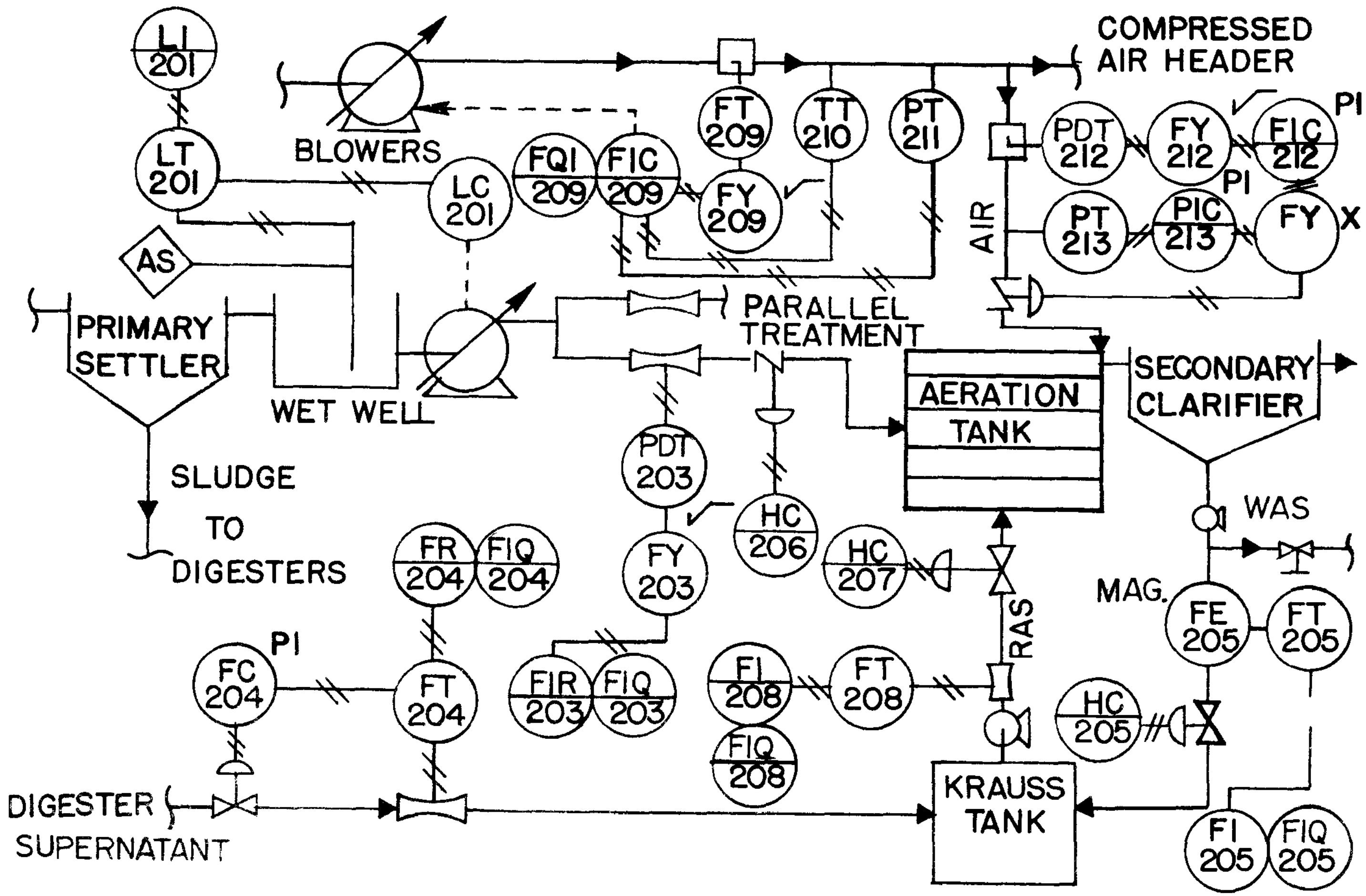


FIGURE B-18(c).

SECONDARY PLANT,
CHLORINATION SECTION

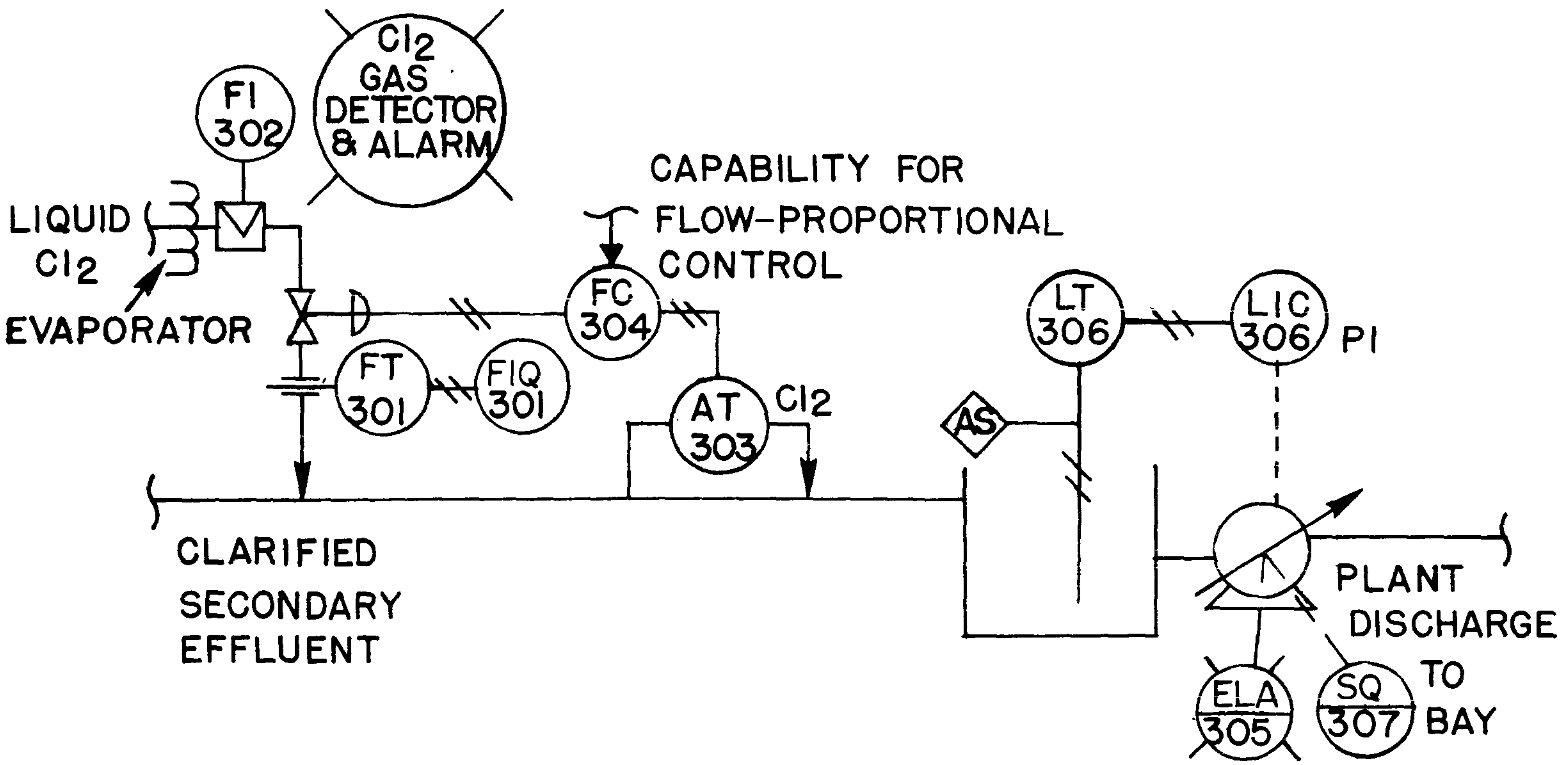
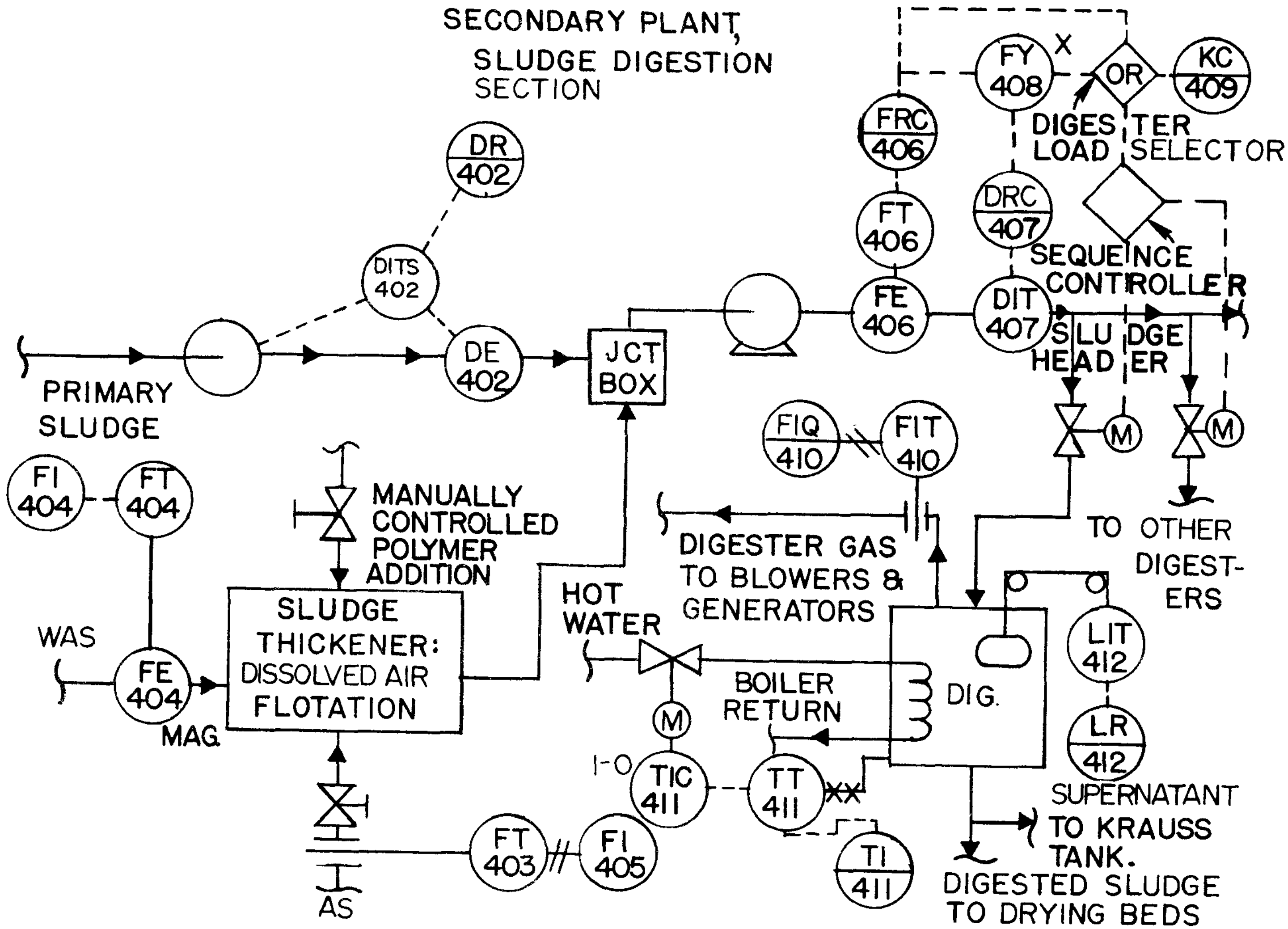


FIGURE B-18(d).


SECONDARY PLANT, SLUDGE DIGESTION SECTION
DR 402
DITS 402
DE 402
PRIMARY SLUDGE
JCT BOX
FRC 406
FT 406
FE 406
FY 408
X
OR
KC 409
DIGESTER LOAD SELECTOR
DRC 407
SEQUENCE CONTROLLER
DIT 407
SLUDGE HEADER
M
TO OTHER DIGESTERS
FIQ 410
FIT 410
DIGESTER GAS TO BLOWERS & GENERATORS
FI 404
FT 404
WAS
FE 404
MAG
MANUALLY CONTROLLED POLYMER ADDITION
SLUDGE THICKENER: DISSOLVED AIR FLOTATION
AS
FT 403
FI 405
HOT WATER
BOILER RETURN
I-O
TIC 411
TT 411
TI 411
DIG.
LIT 412
LR 412
SUPERNATANT TO KRAUSS TANK.
DIGESTED SLUDGE TO DRYING BEDS

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-19

Responsible Supervisor

Flow Rate Design (Average and Maximum) 130 av. 123 mgd design 200 mgd max.

Storm Water Collection and Treatment No. Combined system. Plant bypass to lake over 200 mgd.

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems.)

Secondary (activated sludge); sludge exported.

Performance Data (Individual Units and Overall) BOD removal 90% and more, neglecting occasional bypass.
SS removal 90% and more.

Year Built 1931-38 Modifications (Year and Description) 1973 expansion

Original Cost $9.5M Modification Cost $14M

Instrumentation Bailey Meter Company originally

Instrument air compressors
(Oil and water-free)

Equipment Mostly obsolete, but many mag. flow and sludge density meters

Panels Local

Installation and Start-up Costs Original Cost Total Cost

Instrumentation Modification 1972-73

Description	Year	Equipment	Panels	I & S	Total
Flow meter	1973	Bailey to BIF Differential meters			$0.5M

Computer
Type None Manufacturer I/O Devices

Process Control

Data Logging

Parameter/Frequency	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control Primary system only.

Supervisory Control

Alarm and Safety Systems Yes

Automatic Emergency Program (e.g., Power Failure) None. Gravity flow.

Maintenance and Calibration By meter group.

Special Equipment Mag. meter calibrator, loop tester, manometers. Down Time None

Special Operator Training Inst. mechanics must be licensed electricians. Frequency (no./mo.)

Total In-Plant Man Hours/Year 1000 mh

Total Cost of Outside Service None

Estimate of Over-all Benefits of Instrumentation and Automation

Minimal.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		Comments
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no./mo.)	Total Downtime	Downtime Frequency (no./mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	
Density	Indust. Nucleonics & Ohmart	Indust. Nucleonics "Accuray"	--	35 each	Should be 4	None	None	None	None	Little	None	Drift	+20 %	--	--	Correlation of solids vs. sp. gr. changes. Ohmart drifts. No longer calibrated for lack of manpower. Accuray preferred, but too expensive.
Pressure	Dresser PIT'S 0-80/3-15	40808	--	400	8	None	None	None	None	Large	0.5	Poorly Made	+5 %	--	--	Poor quality, poor design. Fell apart.
Flow	BIF Venturi & Bailey Mech. Diff. Pressure	CF 36	--	30	0.5	None	None	None	None	None	None	Phasing	+3 %	Selsyn Integrators and re-transmitters	Integral	Obsolete, no spares.
Auxiliary Flow	BIF 84" Venturi; F & P FIT (Time pulse)	F & P 60" 1451RB49	--	Min.	0.1	None	None	None	None	None	None	Occasional Cleaning, Purge Adjust.	+3 %		No	None. Old venturi w/piezometer, bayonets.
Main Flow	G.E. Venturi & Selsyn	2JRIB46	--	30 mh	0.5	None	None	None	None	None	None	Phasing, Clean Purges	+1 %	None	Indic.	Phasing troubles.
Channel Level	Foxboro	M40	--	4 mh	0.1	None	None	None	None	None	None	None	+2 %	Bubbler Air Sets	Recorder	None.
Sewage Flow	BIF (Venturi) & Bailey Meter Co.	CF 36	--	30 mh	1	None	None	None	None	0.2	0.2	Obsolete, and fouls	+ 2 %	Integrator	Yes (in same unit)	Obsolete. No spare parts. (Connecting lines tend to plug). Water purges not used.

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

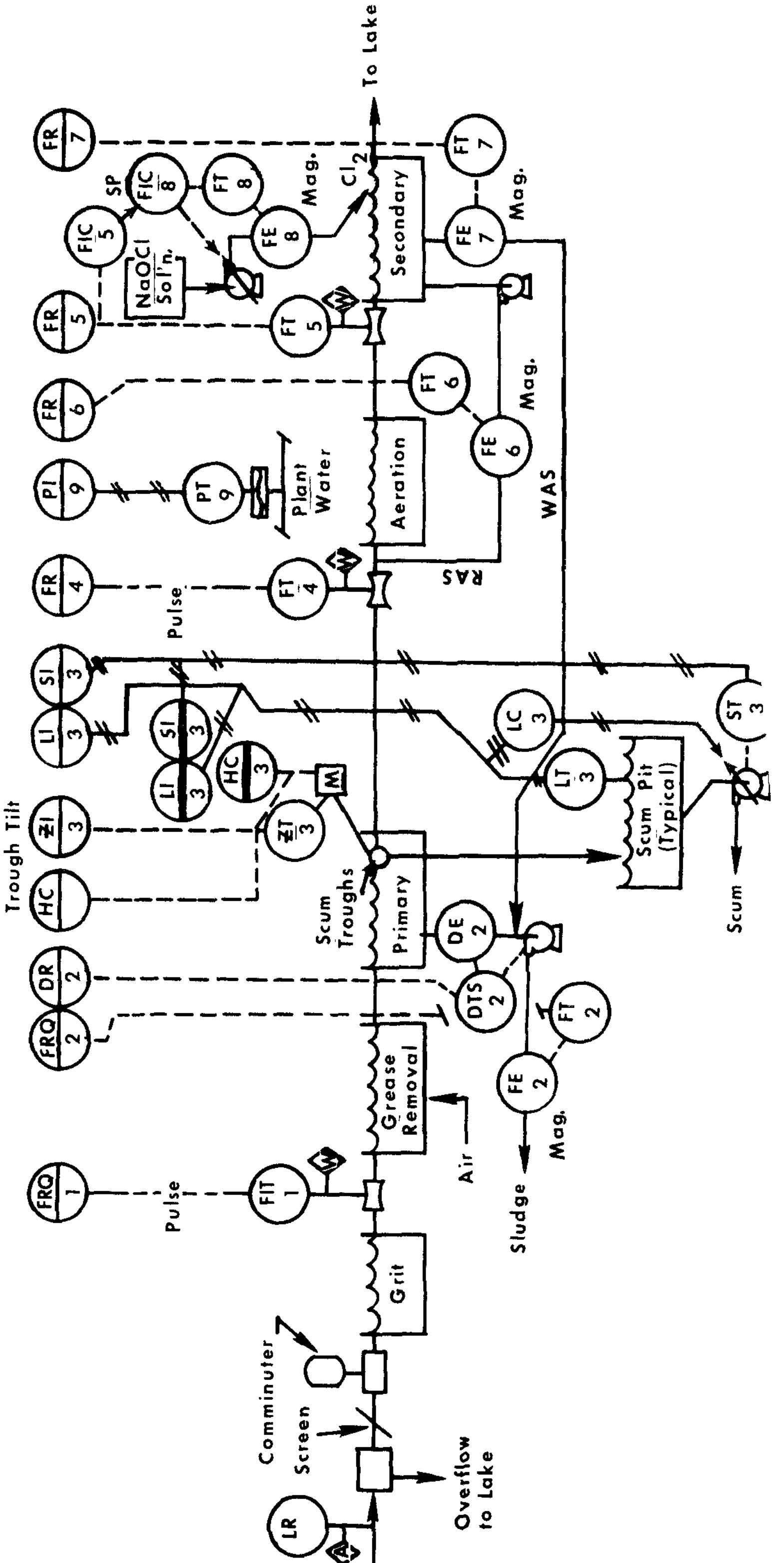
Control Techniques								Benefits					Operating Experience							Comments
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	*Control Mode**	Type of Controller**	Actuating Power	Final Control Element***	*Estimated Response* Time (min)	Manpower (mh/yr)	*Utility* (kW-hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	*Parameter Variance* min/max (mg/l)	Maintenance & Calibration by In-Plant Personnel ($ or mh/yr)	Maintenance Frequency (no mo.)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no /mo)	
HC-3	Tank Skimming	12	Remote	Manual	Electric switch	Skimmer Actuator	0.5	0	0	0	No		100	0.1	No	No	No	2 each	0.1	Misapplication. Poorly designed position transmission. Unworkable principle of skimming operation.
DE-2	Sludge Pumping by Density	6	Timed	On-off	Electric switch	Sludge Pump	0.1	1,000	Fair	Fair	Yes		300	4	No	No	No	50 each	4, for calibration	Even out of calibration, the density meters minimize unnecessary pumping of diluted sludge to digesters.

* *Control mode* relay, proportional, proportional plus reset, etc

** Types of controllers analog (pne hyd or elec media) computer (supervisory, direct digital or set analog)

*** Final control element pne values, variable speed pump, etc

FIGURE B-19.



To Lake
FR 7
FIC 5
SP
FIC 8
FT 8
Mag.
Cl_2
FE 8
NaOCl Sol'n.
FR 5
FT 5
Secondary
FE 7
FT 7
Mag.
FR 6
FT 6
Mag.
FE 6
PI 9
PT 9
Plant Water
Aeration
WAS
RAS
FR 4
Pulse
FT 4
SI 3
LI 3
SI 3
LI 3
HC 3
M
LC 3
ST 3
LT 3
Scum Pit (Typical)
Scum
Trough Tilt
ZI 3
ZT 3
HC
Scum Troughs
Primary
DE 2
DR 2
DTS 2
FT 2
FRQ 2
FE 2
Mag.
Sludge
Grease Removal
Air
FRQ 1
Pulse
FIT 1
Grit
Comminuter
Screen
LR
Overflow to Lake

GENERAL SURVEY QUESTIONNAIRE

Form approved
OMB No 158-S72005

STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-20

Responsible Supervisor

Flow Rate Design (Average and Maximum) Av. 50 mgd Peak Design 75 mgd

Storm Water Collection and Treatment No

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems.)

Performance Data (Individual Units and Overall)

Primary Removal	Primary & Secondary Treatment
SS 63%	Sec. Removal
VSS 65%	SS 66%
BOD 35%	VSS 58%
	BOD 73%

Year Built 1943 Modifications (Year and Description) Every year since 1957 to present

Original Cost -- Modification Cost Total value, both plants $43.1 Million

Instrumentation

Equipment Mech., Pneumatic and electronic; mag meters, etc.

Panels Centralized Control Panel and Building

Installation and Start-up Costs -- Original Cost -- Total Cost (Orig. 1943 plant had little instrumentation) since 1963, $600,000 (both plants)

Instrumentation Modification 1963

Description	Year	Equipment	Panels	I & S	Total
Control Center; mag meters and most all instrumentation	1963	See instrument sheet	Main Control panel and new building; 40' long panel	--	$600,000

Computer
Type None Manufacturer I O Devices

Process Control

Data Logging

Parameter/Frequency	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control Most plant functions indicated and recorded in manned control center.

Supervisory Control Some valves, etc.

Alarm and Safety Systems Yes - levels and pressures

Automatic Emergency Program (e g., Power Failure): Partial plant operation with generator, primarily for main pump.

Maintenance and Calibration

Special Equipment Manometers, V-O-M, digital multimeters, oscilloscope Down Time None

Special Operator Training General, plus 2 weeks F&P Instrumentation Service School Frequency (no /mo)

Total In-Plant Man Hours/Year 2400

Total Cost of Outside Service 1,000/yr.

Estimate of Over-all Benefits of Instrumentation and Automation

Central control of 2 plants (from Plant #1) highly effective. Instruments and control provide good manpower usage.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no./mo.)	Total Downtime	Downtime Frequency (no./mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
pH	Beckman	Model 940	$1,200	24	1	General	No	Available	--	24 hr/yr	1	Slight greasing of probes	Good	No	Yes	Much improved over previous model (Model J). A good probe and amplifier.
Digested Sludge Flow	Mag meter, F&P	10D-1418	$2,500	24	2	General	No	Available	--	24 hr/yr	2	--	2%	Yes	Yes	No problem.
Sludge Density	Ohmart	SGD-14TC-0/100	$4,000	50	4	General	No	None	--	50 hr/yr	4	Greasing	Question-able	Yes	Yes	Not as good as 2-section model made by Ohmart employed at Plant No. 2.
Incinerator Temp: Thermocouple	Supplied by Honeywell		$25	(50) Frequent Replacement	See Below				--			Over-temperature	3%	Yes	No	Thermocouple tends to burn up - may be caused by accidental over-ride of heat control.
Flow Rate: C12	Fischer & Porter Chlorinator	Type 70-1710	--	50	1	General	No	Available	--	--	--	General corrosion	--	No	No	
Magmeter: Raw Sludge Flow	F&P	10D 1418	$2,000+	48	4	General	No	Available	--	48 hr/yr	4		2%	Yes	Yes	Flow Recorder-Transmitter is a problem due to design and sulfide corrosion affecting electrical contacts.
Magmeter: Flow (Influent)	Foxboro & Fischer Porter	F&P 10D 1416	--	12	1	General	No	Available	--	12 hr/yr	1	Fouling and leaking probes	Question-able	No	Yes	No problems with either make, except for probes.

* Corrosion, fouling, etc

** Limiters, alarms, ratio relays

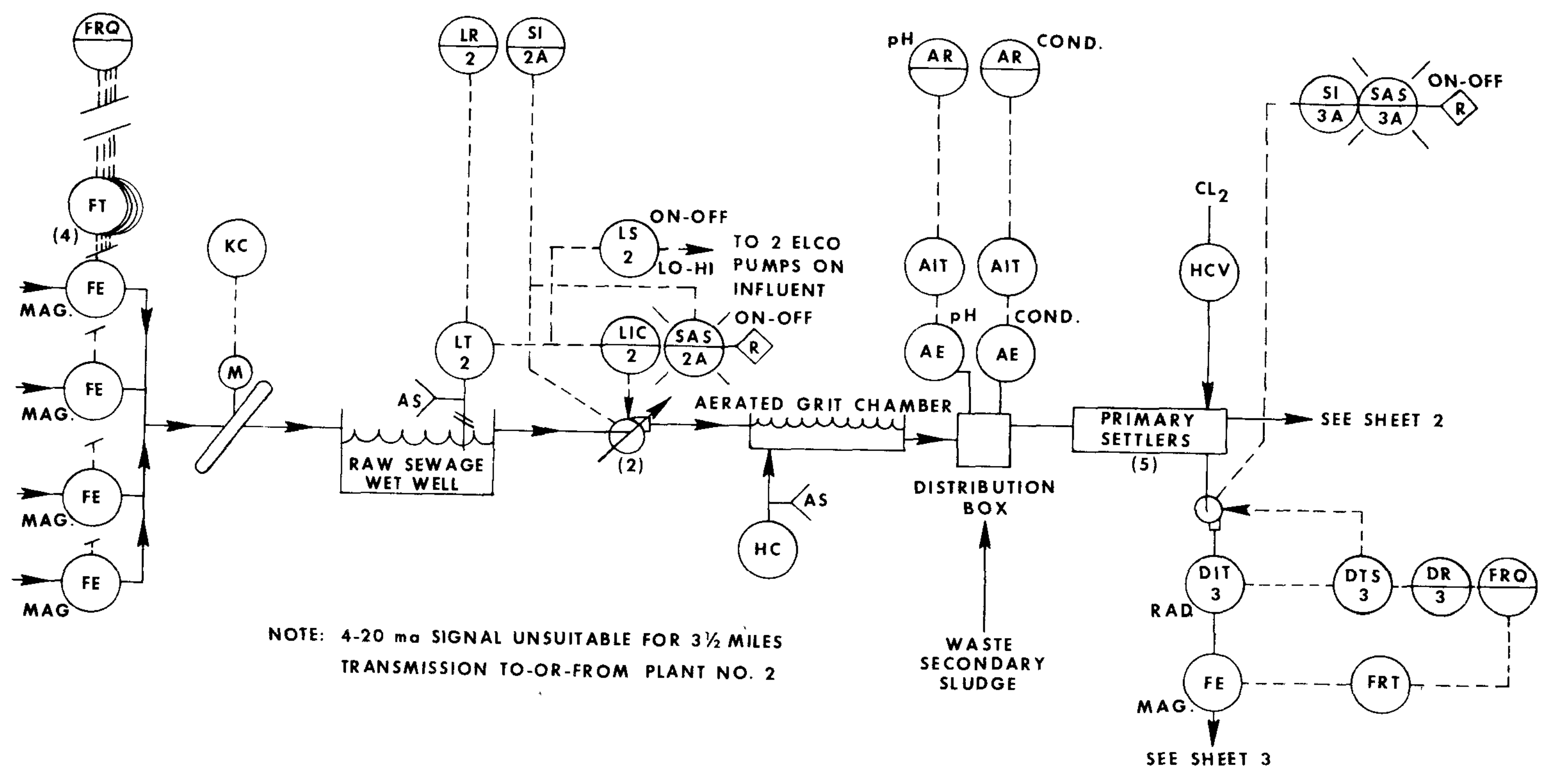
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW-hr yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In-Plant Personnel ($ or mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no./mo.)	Comments
LS-6	Secondary Wet Well Level	3	On-Off Relay	Electric Switch	Electric	Pump	0.25	--	--	--	--	--	Minimum	Minimum	General	No	None	Minimum	--	No problems.
FE-5	Digested Sludge Flow-Rate	1	Proportional Plus Reset	Analog Pneumatic	Pneumatic	Pneumatic Squeeze Valve	0.1	--	--	--	--	--	24 mh	.5	General	No	Available	24	.5	No problems.
TIC-4	Digester Temp. Control	8	Cascade	Analog Pneumatic	Pneumatic	Pneumatic Valve	2	--	--	--		--	24 mh ea.	.5 ea.	General	No	Available	24	.5	Works well.
DIT-3	Primary Sludge Density	3	On-Off Relay	Nuclear to Electronic	Electric	Pump	1	--	--	--	--	--	144 mh	4	General	No	None	72	4	Primary meter improperly designed - causes grease buildup due to low velocity through enlarged section at meter.
LT-2	Wet Well Level Control	1 loop	Proportional Plus Reset	Analog Pneumatic	Pneumatic	Variable-Speed Engine-Pump	1-4	--	--	--	--	--	50 mh	.5	General	No	Available	8	0.2	Bubble-tube clogging is main problem.
TT-1	Incinerator Temp.	1	Proportional with Reset	Electric to Pneumatic	Pneumatic	Pneumatic Valve (3-15 psi)	1	Unknown	--	--	--	--	50 mh	1	General	No	Yes	Unknown	Unknown	Thermocouple tends to burn up - cause may be manual override of gas into incinerator through by-pass valve creating excess temp. Being looked into at present. System Design could use more flame safety.

* Control mode relay, proportional, proportional plus reset, etc
** Types of controllers analog (pne., hyd. or elec. media), computer (supervisory, direct digital or set analog)
*** Final control element pne. values, variable speed pump, etc

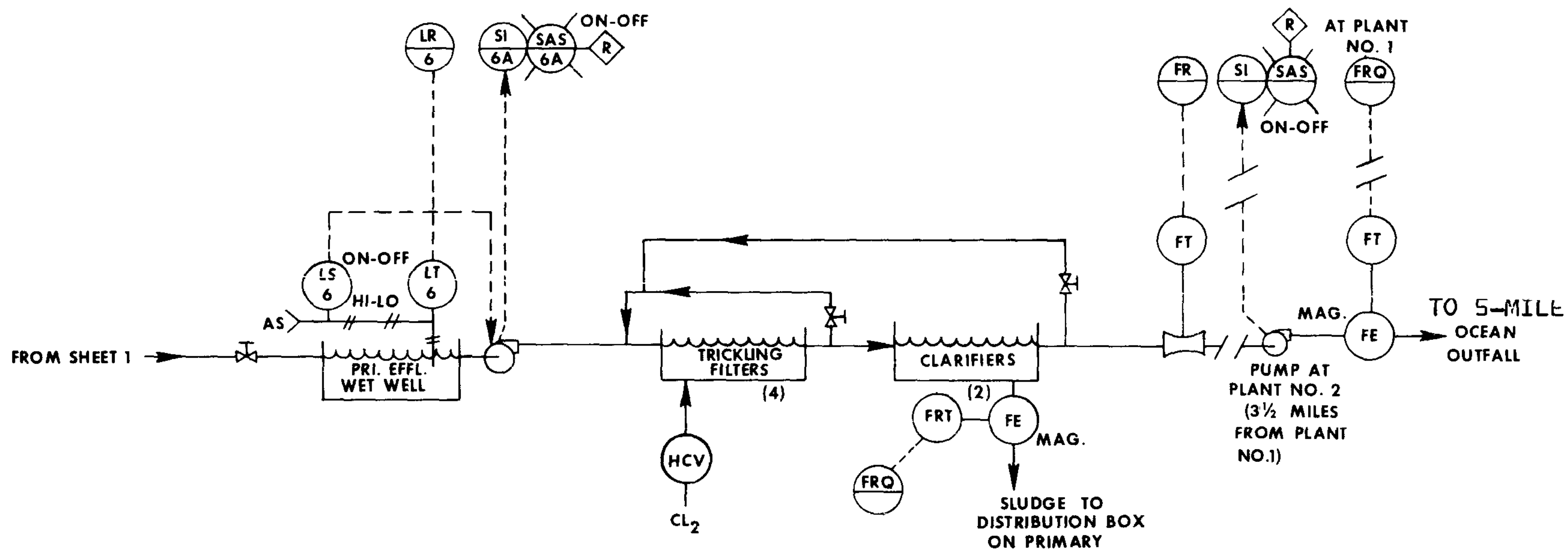
FIGURE B-20(a). PLANT NO.1



NOTE: 4-20 ma SIGNAL UNSUITABLE FOR 3½ MILES TRANSMISSION TO-OR-FROM PLANT NO. 2

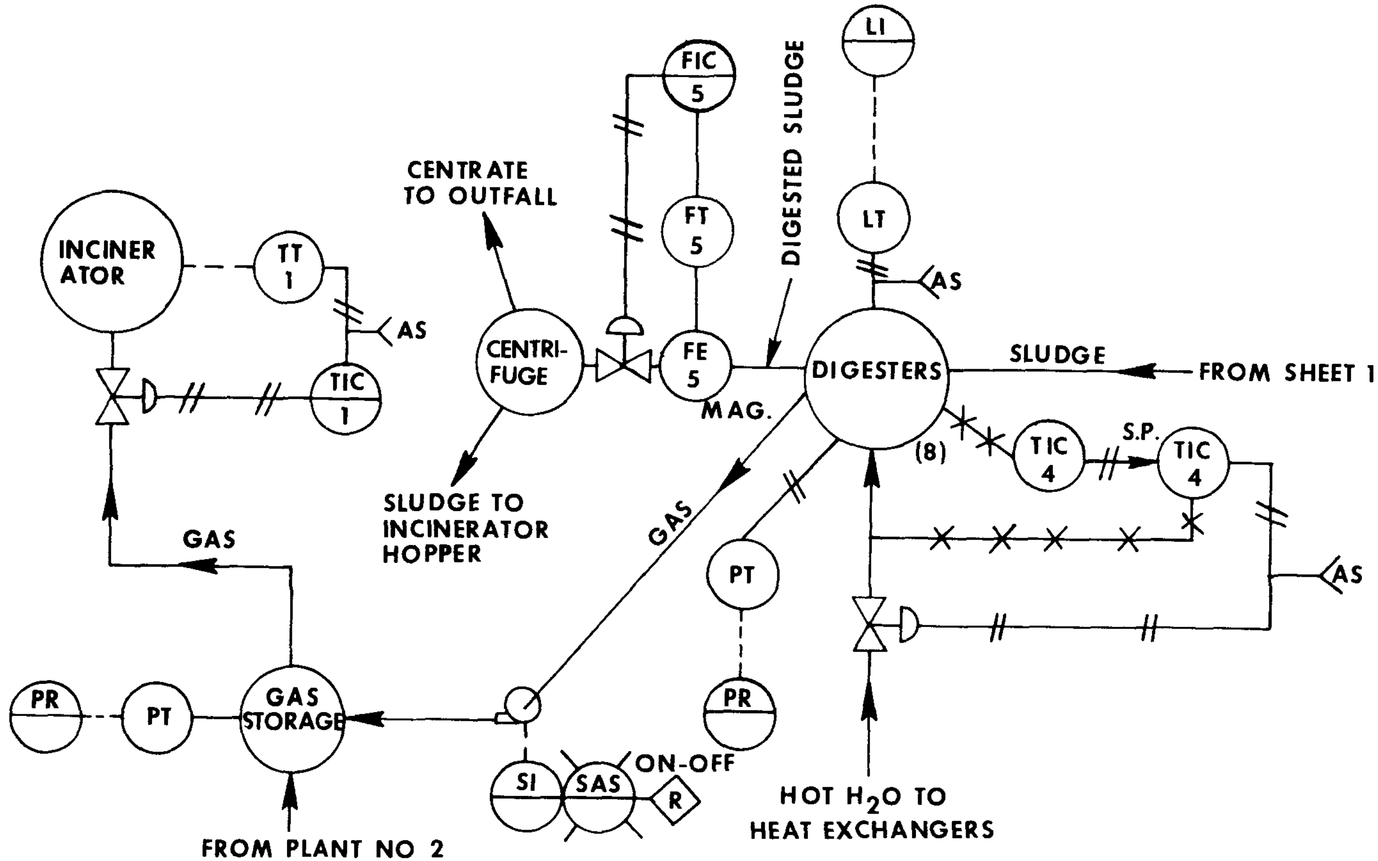
SHEET 1 OF 3

FIGURE B-20(b). PLANT NO.1



SHEET 2 OF 3

FIGURE B-20(c). PLANT NO. 1



SHEET 3 OF 3

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-20

Responsible Supervisor:

Flow Rate Design (Average and Maximum) Av. 100 mgd Peak 230 mgd

Storm Water Collection and Treatment No

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems) Primary

Performance Data (Individual Units and Overall)
SS 57% Removal
Volatile SS 60% Removal
BOD 24% (Low due to heavy industrial and oil field waste.)

Year Built 1968 Modifications (Year and Description)

Original Cost Modification Cost.
Total value of both plants (1 & 2) $43.1 Million

Instrumentation

Equipment Mechanical, Pneumatic and electronic; mag. meters, etc.

Panels Scattered through plant - main panel at Plant No. 1.

Installation and Start up Costs Original Cost Total Cost Since 1963 $600,000 both plants.

Instrumentation Modification 1963

Description	Year	Equipment	Panels	I & S	Total
Control Center; mag meters and most all formal instrumentation	1963		Main control panel at Plant No. 1	--	$600.000

Computer Type None Manufacturer I O Devices

Process Control

Data Logging

Parameter Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency

Storage.

Software Description

Computer Cost Software Cost Installation Cost

Central Control At Plant No. 1

Supervisory Control Some; close valves, etc.

Alarm and Safety Systems Yes, levels and pressures

Automatic Emergency Program (e.g., Power Failure) Partial plant operation with generator, primary for main pumps

Maintenance and Calibration

Special Equipment Manometers, digital multimeters, Oscilloscope, etc. Down Time

Special Operator Training General + 2 weeks F&P Instrumentation Service School Frequency (no./mo.)

Total In-Plant Man Hours/Year

Total Cost of Outside Service

Estimate of Over-all Benefits of Instrumentation and Automation

General operation permitting effective manpower use; however, it would also be good if some control were available at Plant No. 2 instead of all at Plant No. 1.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Frequency (no mo)	Total Downtime	Downtime Frequency (no/mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
pH	Beckman	Model "J"	$1,500	48	1	General	No	Available	--	48 hr/yr.	1	Slight greasing of probes	Good	--	Yes	Reference electrode and electronics not as good as Model 940 used at Plant No. 1.
Digested Sludge Flow	Magmeter, F & P	10D-1418	$2,500±	24	2	General	No	Available	--	24 hr/yr.	2	--	2%	Yes	Yes	None
Sludge Density	Ohmart	CS-3	$4,000	25	2	General	No	Available	--	--	--	None	Good	Yes	Yes	9 density meters are Ohmart's Model No. SDG-14TC-0/100 (like those at Plant No. 1) and give problems. Ohmart's Model No. CS-3 has given no problems during the 6 months it has been in service. No further operational experience on the Model No. CS-3 is available.
Incinerator Temp.	Honeywell	--	$25.00	--	--	No	No	Available		None	0		3%	Yes	No	No problem at Plant No. 2.
Flow Rate: Cl_2	F & P Chlorinator	Type 70-1710	--	50	1	General	No	Available	--	--	--	Corrosion	--	No	No	Some corrosion.
Magmeter: Raw Sludge Flow	F & P	10D 1418	$2,000±	48	4	General	No	Available	--	48 hr/yr.	4	--	2%	Yes	Yes	No problems.
Magnetic Flow Meter: Influent	Foxboro & F & P (Both makes)	F & P 10 D 1416	---	12	1	General	No	Available	--	12 hr/yr.	1	--	Good	No	Yes	No problems.

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Benefits: Annual Cost Savings: Manpower (mh/yr)	Utility (kW-hr/yr)	Chemical (lbs/yr)	Process Improvement: Increase Removal (%)	Parameter Variance min/max (mg/l)	Operating Experience: Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no./mo.)	Comments
LT-7, LIC-7A, LIC-7B	Main outfall pumps	1	Proportional and Reset	Analog Pneumatic	Pneumatic	Variable-speed effluent pumps	5	--	--	--	--	--	24 mh	0.5	General	No	Available	24	.5	Bubble-tube gives some problems due to clogging.
TIC-6	Digestor temp	13	Cascade	Analog Pneumatic	Pneumatic	Pneumatic valve	2+	--	--	--	--	--	24 mh	0.5/unit	General	No	Available	24	.5/unit	O.K.
FE-5	Primary sludge flowrate	4	Proportional and Reset	Analog Pneumatic	Pneumatic	Variable-speed sludge pump	0.1	--	--	--	--	--	50 mh	1	General	No	Available	50/unit	1	Generally fair control.
DE-4	Raw Sludge Density	10	On-off Relay	Nuclear and electric	Electric	Const. spd. sludge pumps	1	--	--	--	--	--	144 mh	4	General	No	None	72	4	1 meter (unlike Plant 1) does not have problem since velocity, due to smaller throat, is higher. Other 9 meters have same problem as at Plant No. 1 (low velocity causes grease build-up and, thus, serious calibration errors).
LT-3	Part of main inflow pump control	1	On-off	Pneumatic and electric	Electric	Solenoid to vent control line of pump actuator	0.1	--	--	--	--	--	12 mh	1	General	No	Available	1		Bubbler-tube clogs.
TT-2	Incinerator temp.	2	Proportional with Reset	Thermo-electric	Pneumatic	3-15 psi valve	1	--	--	--	--	--	50 mh	1	General	No	Available	Unknown	Unknown	System design could be improved safety-wise by addition of flame-sensing device.
LT-1A, LT-1B	Inflow pumping	1	Proportional and Reset	Analog Pneumatic	Pneumatic	Main influent variable-speed pumps	1-4	--	--	--	--	--	50 mh	0.5	General	No	Available	8	.2	Bubble-tube clogs (main problem).

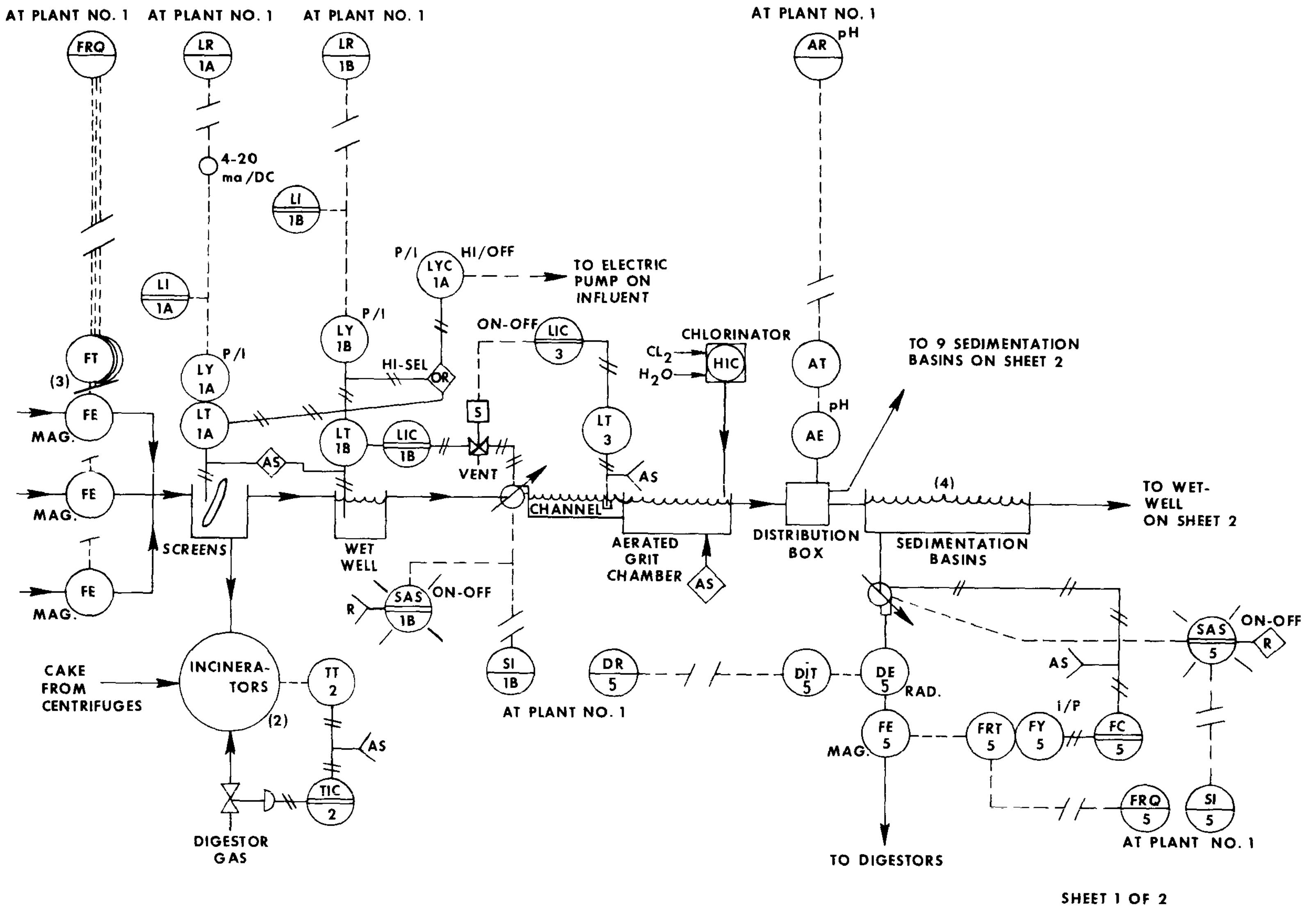
* Control mode relay, proportional, proportional plus reset, etc.
** Types of controllers analog (pne., hyd. or elec. media), computer (supervisory, direct digital or set analog)
*** Final control element: pne. values, variable speed pump, etc.

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no/mo)	Comments
FE-8	Digested Sludge Flow	1	Proportional and Reset	Analog Pneumatic	Pneumatic	Pneumatic squeeze valve	0.1	--	--	--	--	--	24 mh	.5	General	No	Available	24	0.5	No problems.

* Control mode relay, proportional, proportional plus reset, etc.
** Types of controllers analog (pne, hyd or elec media), computer (supervisory, direct digital or set analog)
*** Final control element pne. values, variable speed pump, etc

FIGURE B-20(d). PLANT NO. 2



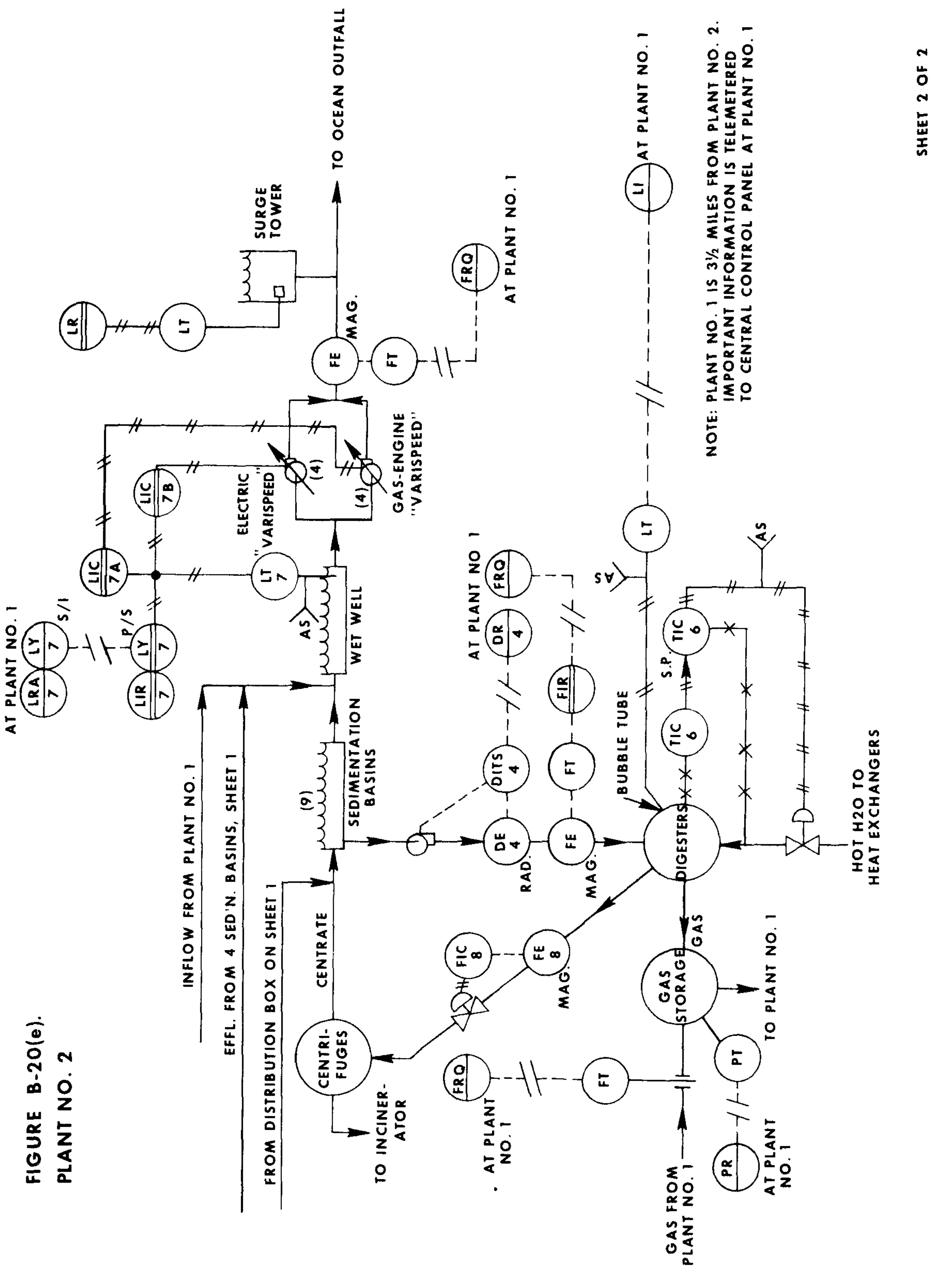


FIGURE B-20(e).
PLANT NO. 2

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-21

Responsible Supervisor

Flow Rate Design (Average and Maximum) Design: 180 mgd (max.). Present average: 260 mgd

Storm Water Collection and Treatment Only from combined sewers

Type of Plant Description of Treatment Process (*Attach schematic diagram for process monitoring and control systems*)
Secondary (Activated Sludge), with sludge disposal at sea.

Performance Data (Individual Units and Overall)
Est. 80% solids, 80% BOD removal

Year Built 1936 Modifications (Year and Description) 1975: Complete new instrument & data-logging system.

Original Cost $62 Million (1069 dollars) Modification Cost

Instrumentation Extensive mechanical instrumentation for level, flowrate. Mostly abandoned. No instrument-quality air available.

Equipment Venturis, mercury manometers, water columns, float and tape, selsyns, etc.

Panels Only for individual instruments

Installation and Start up Costs Unavailable Original Cost Total Cost Unavailable

Instrumentation Modification None

Description	Year	Equipment	Panels	I & S	Total

Computer Type None Manufacturer I O Devices

Process Control

Data Logging

Parameter/Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control Manual only (signal transmission for wet-well level). 11 Automatic recorders.

Supervisory Control

Alarm and Safety Systems

Automatic Emergency Program (e g., Power Failure)

Maintenance and Calibration

Special Equipment $7K Calibration Console Down Time None

Special Operator Training None Frequency (no /mo) --

Total In-Plant Man Hours/Year 700 (Est.)

Total Cost of Outside Service None

Estimate of Over-all Benefits of Instrumentation and Automation
Instrumentation provides remote indication of wet-well and sludge-storage levels. Plant influent rate recorded. Aeration air rate checked occasionally with existing venturis and portable manometers. Conclusion: 80% of original instrumentation abandoned. Manual data logging in addition to the inst.umentation being used is barely sufficient to sustain plant operations. Benefits from instrumentation care minimal, due to lack of plant and operator performance standards, inadequate initial installation and lack of funds for instrument improvement and/or maintenance

LAS, CE Maguire, 10/30/72 B-21

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In Plant Maintenance (mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Frequency (no. mo.)	Total Downtime	Downtime Frequency (no. mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Level	Simplex	Float & Cable (Selsyn)	Unavailable	25/loop (Est.)	1 (Est.)	None	No	No	--	12 hrs/yr. (Est.)	0.2 (Est.)	Obsolete, corrosion, excessive maint.	0.2 ft.	Water purges; Integrat.	Circular Chart	Measurement important, but instruments are obsolete (no spare parts from manufacturer); extra instruments cannibalized. Corrosion and synchronization problems are aggravated by unavailability of maintenance; only repair is available.
Flow	BIF	Manometer (Water Column)		25/loop (Est.)	1 (Est.)	None	No	No	--	25 hrs/yr. (Est.)	0.4 (Est.)	Obsolete, corrosion, excessive maint.	6% of full scale (Est.)	Water purges; Integrat.	Circular Chart	Most flow meters are venturis or venturi-type, with large displacement, purged, dP meters. Venturis still operable, (although tap design is poor). dP meters abandoned (Corrosion and no spare parts). Large water-sensor lines plugged too often, so they were also abandoned.

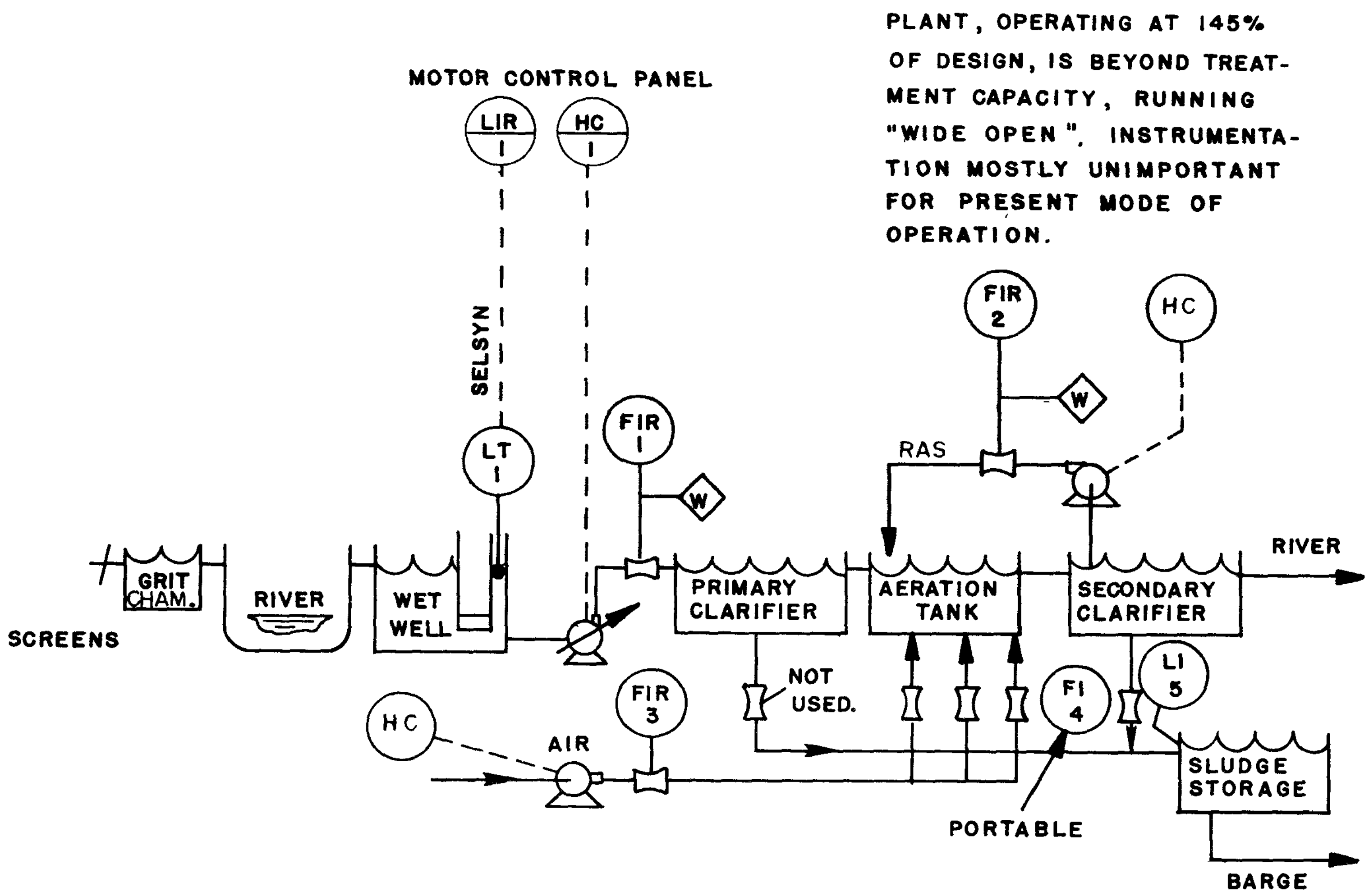
* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							Comments
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW-hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In-Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no/mo)	
LT-1	Level in Wet Well	2	-	Manual	Electric	Variable-speed pump	(20)						25 mh	1	No	No	No	12 (Est.)	0.2 (Est.)	No closed-loop control. Manual control only.

* Control mode relay, proportional, proportional plus reset, etc.
** Types of controllers analog (pne, hyd or elec media), computer (supervisory, direct digital or set analog)
*** Final control element pne values, variable speed pump, etc

FIGURE B-21.


PLANT, OPERATING AT 145% OF DESIGN, IS BEYOND TREATMENT CAPACITY, RUNNING "WIDE OPEN", INSTRUMENTATION MOSTLY UNIMPORTANT FOR PRESENT MODE OF OPERATION.
MOTOR CONTROL PANEL
LIR 1
HC 1
SELSYN
LT 1
FIR 1
W
FIR 2
W
HC
RAS
SCREENS
GRIT CHAM.
RIVER
WET WELL
PRIMARY CLARIFIER
AERATION TANK
SECONDARY CLARIFIER
RIVER
NOT USED.
HC
AIR
FIR 3
FI 4
LI 5
PORTABLE
SLUDGE STORAGE
BARGE

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-22

Responsible Supervisor

Flow Rate Design (Average and Maximum) 200 mgd design; 225 mgd peak

Storm Water Collection and Treatment Only by way of regulators and interceptors.

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Secondary, with fine-screening instead of primary sedimentation. Phosphate removal. Sludge drying.

Performance Data (Individual Units and Overall) 95-98% BOD and SS removal.

Year Built 1925 **Modifications (Year and Description)** 1932-expansion 1971-Phosphate removal

Original Cost $85M **Modification Cost** $115M

Instrumentation

Equipment Local flow controls, samplers, D.O. probes, chemical feeders.

Panels Few; scattered

Installation and Start up Costs **Original Cost** **Total Cost**

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
Added D.O. Probes					

Computer No

Type **Manufacturer** **I O Devices**

Process Control

Data Logging

Parameter Frequency	Parameter Frequency	Parameter Frequency	Parameter Frequency

Storage

Software Description

Computer Cost **Software Cost** **Installation Cost**

Central Control Only slightly.

Supervisory Control No.

Alarm and Safety Systems Slight

Automatic Emergency Program (e g , Power Failure) None (Plant generates own power)

Maintenance and Calibration

Special Equipment None **Down Time** None

Special Operator Training None **Frequency (no mo)**

Total In-Plant Man Hours Year 2100

Total Cost of Outside Service None

Estimate of Over all Benefits of Instrumentation and Automation

Manual solids determinations and flow ratioing maintain proper solids levels for fertilizer production. Liquid and air-flow metering, D.O. monitoring, chlorine and additive pacing all reduce manpower needs and help meet effluent quality standards.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Frequency (no./mo.)	Total Downtime	Downtime Frequency (no./mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Residual Chlorine	F & P	--	--	200*	Strainer-60 Vee-notch-30 Electrode-4	No	No	No	--	Shut down while sample is especially dirty.	--	Sample solids	Unknown	Sample System	No	Fine sample filter in analyzer plugs excessively, in spite of strainers in large sample line. Inst. shut-down. Chlorine dosage rate controlled manually. *Not counting sample system.
D.O.	Probe made On-site; YSI Receiver	--	--	--	(Check-4)	--	No	No	--	Little or none	--	Build-up on probe	Good			Probes are given weekly air calibration. Probe life is several years; no membrane replacement.
Chlorine Gas Detector	F & P	17E1100	--	50 Est.	1 (Check-4)	A few hrs.	No	No	--	Little none	--	Sample pump	Adequate	Sample Blower	No	Checked for operation monthly. Influent is mixture of air streams from 2 areas.
Turbidity	Hach.	Surface Scatter	--	30	4	No	No	No	--	Little or none	--	Sample dirt	Unknown		Yes	2 units in service 2 years on final effluent. Very good performance, but drained weekly.
Representative sample	Sonford Products	--	$2,000	6*	0.17* *Not counting lubrication	No	No	No	--	1 day/yr.	0.06	None	Adequate	Flow and timer controls	No	Simple, less expensive unit is reliable; produces representative sample. Must be maintained like other machines. Replaces dipper-on-chain type sampler. (Phipps & Bird).
Flow	Simplex (Venturi's) With retransmitting slide-wires	MO SN-36-222-7146	--	40	20	No	No	No	--	Little or none		Obsolete	$\pm$5% or better	Transmitting Slidewire added	Yes, local	Many units, properly installed, in use since 1925, 1936. Added slide-wires are quality design, but millivolt signal is noisy. Repair parts made on site. Conscientious, daily checks.
Flow	Badger (Sonic-flow Velocity) Bindicator (Sonic-level)	Bindicator LC-520	$7,000	Still being evaluated	Unknown	No	No	No	--	5 days in 1 year	0.3	Air bubbles, heavy solids	$\pm$ 10% Est.	Multiplier, Transmitter	Yes	Flow in rectangular channel is computed as product of velocity and level. Logic circuitry switches to level only when velocity signal is unacceptable. Performs well.

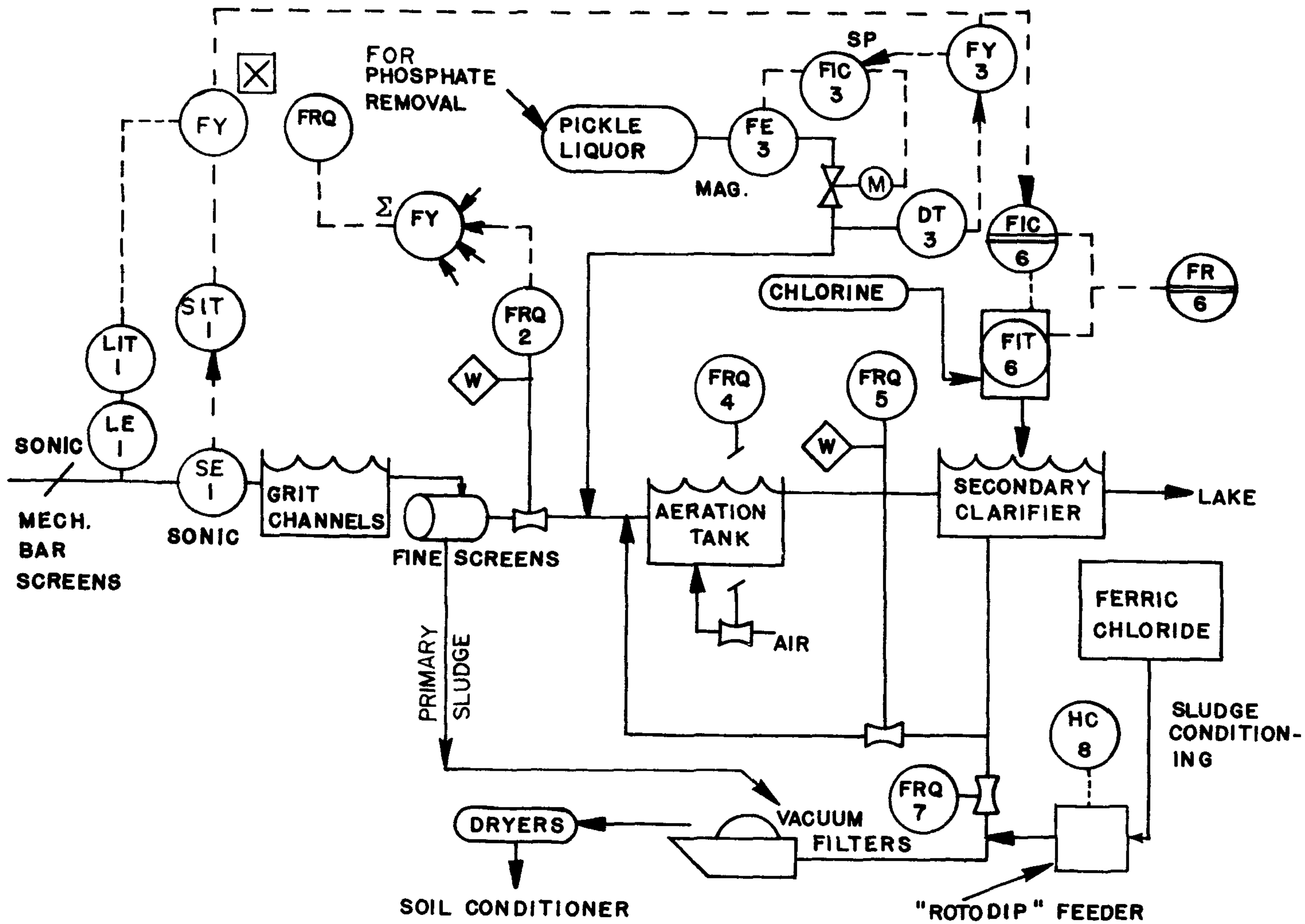
* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW-hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In-Plant Personnel ($ or mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no./mo.)	Comments
HC-8	Ferric Chloride Addition	2	-	Manual	Electric	Rotodip Feeder	0.05				(Better sludge)	(Better sludge)	30 mh/yr.	2	No	No	No	2	0.01	Ferric chloride, paced to sludge flow, improves filter cake. System has been in operation many years. Operator determines sludge solids with centrifuge.
SE-1	Pickle Liquor Addition	1	Cascade	Electronic	Electric	Motorized Valve (Jordan)	0.1	1000	--	10,000 Est.	Yes	Less release of soluble phosphate	200 mh/yr.	20	No	No	No	800	0.2	Pickle liquor is added in proportion to main flow, and the amount metered in is automatically compensated by density measurement. Improves phosphate removal. Freezing problems.

* Control mode relay proportional, proportional plus reset, etc
** Types of controllers analog (pne, hyd or elec media), computer (supervisory, direct digital or set analog)
*** Final control element pne values, variable speed pump, etc.

FIGURE B-22.



FOR
PHOSPHATE
REMOVAL
PICKLE
LIQUOR
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SECONDARY
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CHLORIDE
SLUDGE
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ING
HC
8
PRIMARY
SLUDGE
FRQ
7
VACUUM
FILTERS
DRYERS
SOIL CONDITIONER
"ROTODIP" FEEDER

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-23

Responsible Supervisor

Flow Rate Design (Average and Maximum) Design and Average
218 mgd - 290 mgd Peak (Excess bypassed to river)

Storm Water Collection and Treatment Combined

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems.)

Secondary: high-rate activated sludge.

Performance Data (Individual Units and Overall) BOD removal 74%
SS removal 83%

Year Built 1938 Modifications (Year and Description) 1960's - Secondary

Original Cost Plant $3.5 M
Interceptors $7.2 M
Modification Cost $28M

Instrumentation F & P, and others; pneumatic and electronic

Equipment Flow, level, weight, pH, etc.

Panels Centralized in pri., sec., and sludge disposal

Installation and Start up Costs Original Cost Total Cost

Instrumentation Modification No

Description	Year	Equipment	Panels	I & S	Total

Computer Type None (for running plant) Manufacturer I/O Devices

Process Control Stormwater control system utilizes computer; is located at Metro plant.

Data Logging

Parameter Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control

Supervisory Control Many control centers.

Alarm and Safety Systems Industrial types.

Automatic Emergency Program (e g , Power Failure)

Maintenance and Calibration

Special Equipment Extensive, pneumatic and electric Down Time None

Special Operator Training Extensive
(Probes maintained by lab. tech.)
Frequency (no /mo)

Total In-Plant Man Hours/Year 14,000

Total Cost of Outside Service Est. $1,200 in 1972

Estimate of Over-all Benefits of Instrumentation and Automation

Manpower reductions. Sustained performance.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no./mo.)	Total Downtime	Downtime Frequency (no./mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Oxygen Content	Hayes Flue Gas	631.10	$1000 Est.	30	1	On-site	No	No	--	No	--	None	Est. 0.5%	Water-cooled probe	Hays Rec. 771.1	Working well.
Temp.	Leeds & Northrup Thermo-couples	515 901 401	$1500	300	10	On-site and ven-dor's plant	No	No	--	100 mh/yr.	10	Ink systems and relays	Est. 1%			Multipoint recorder for incinerator thermocouples.
Flow (Air)	Honeywell Orifice	57511 07-DO	$545	104	4	On-site and ven-dor's plant	No	No	--	None due to failures	--	Valve Positioner				Orifices being replaced by Venturis to reduce noise.
Chlorine Residual	Fischer & Porter	53 EG 3000	$700	200	4	See below	No	No	--	60 mh/yr.	5	Cl_2 leaks and electronics	--	Sq.Rt.Relay; Cascade Controller	Remote	Cascaded 5 and 15-minute analyses readjust dosage based on plant thruput. Filters enlarged. Analyzer is maintained by lab. technician.
Flow (Dil. Water)	Foxboro Venturi	6245E	$650	48	1	On-site and ven-dor's plant	No	No	--	None	--	None	Est. 1%	Electronic Sq.Rt. Relay	Remote	
Flow (Mixed Liquor)	Honeywell Venturi	37612	$675	140	4	On-site and ven-dor's plant	No	No	--	None due to failures	--	Venturi taps	Est. 2%	Sq.Rt.Relay; P/I Relay; Integrator	Remote	Controls mixed liquor for step aeration.
Weight	Load Cells			30	1	No	No	No	--	None	--	Cumulative Calibration Drifts	Est. 1%	--	No	Used for measuring contents (or loads) of grit hoppers and filter cake conveyor belts. Good performance due to good design, frequent maintenance.

* Corrosion, fouling, etc.
** Limiters, alarms, ratio relays
*** Local and central.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In Plant Maintenance (mh/yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no /mo)	Total Downtime	Downtime Frequency (no /mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Grit flow	Gallagher Squeeze Valves			Est. 8	Est. 0.1	No	No	No	--	Little or none	--	Wear	--	Air for actuation	--	Valves handle grit from Dorrclones; perform well.
Secondary sludge density	Ohmart			Est. 60	Est. 2	No	None	None	--	None	--	Drift, Repeatability	Marginal		Yes	Performance fair in difficult application.
D.O.	Beckman			200	90	See below	No	No	--	None	--	Probes Fouling	Fair	See below	Remote (Rustrak)	Probes mounted in well-agitated section of aeration basin. Maintenance and calibration by lab. technician.
pH	Beckman Sludge Filtrate			150	30	See below	No	No	--	None	--	Probes Fouling	Good	Pressurized flow-thru cells	Remote	Probes are not exposed to vacuum. Maintenance and calibration by lab. technician.

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and [illegible]

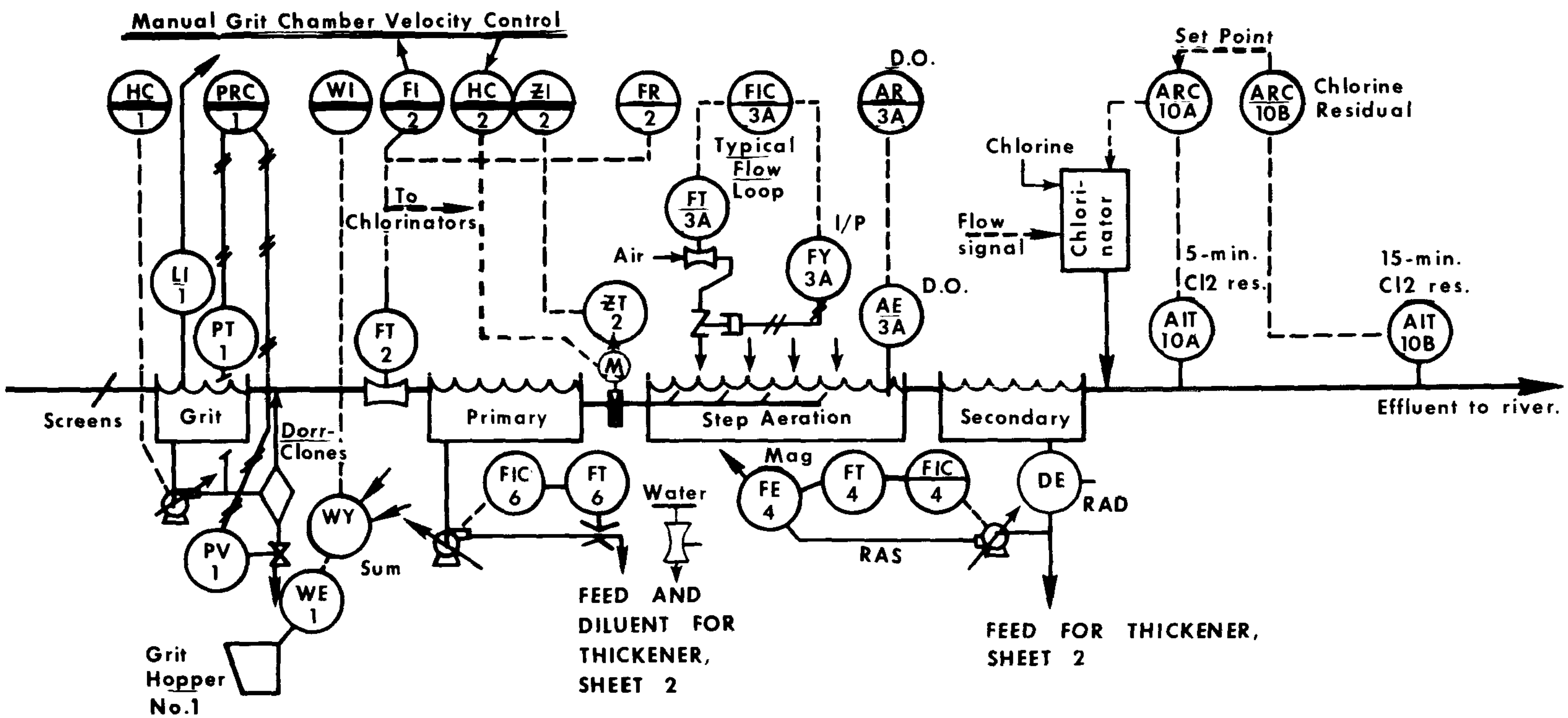
LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW-hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In-Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no/mo)	Comments
FT-3A	Step Aeration	32	Proportional plus Reset	Electronic	Pneumatic	Butterfly Valves	0.05	1200	Yes	No	Yes	Improved	Little or none	--	No	None	None	Little or none	--	
AIT-10A AIT-10B	Chlorine Residual	6	Proportional plus Reset (Cascade)	Electronic	Electric	Chlorinator	0.1 plus transport time	500	No	Yes (Chlorine)	No	Better Cl_2 Residual Control	300 mh	4	None; more desired	No	No	120	--	
LT-8	Filter Basin Level	20	Proportional plus Reset	Electronic	Electric	Var.-Speed Bucket Elevator	0.01	1500 each	Some	Yes	Yes	Better Filtration & Thruput	30 mh	2	No	No	No	60	4	Down often for mech. maintenance
FIC-6	Thickener Dilution Water	2	Proportional plus Reset	Electronic	Air	Control Valve	0.05	1000	Yes (Thickening)	Yes (Dilution)	Yes	Improved Separation	100 mh	1	No	No	No	3	0.08	
FT-5	Thickener Overflow	6	--	Remote Manual	Electric	Var.-Speed Pumps	0.03	1000	Yes (Pumping)	Yes (Dilution)	Yes	--	30 mh	1	No	No	No	720	1	Remote manual operation while controllers are being repaired at manufacturer's plant.
PT-1	Grit Separation	4	Proportional plus Reset	Pneumatic	Air	Callagher Squeeze Valve	0.01	2000	Yes (Pumping)	No	Yes	--	50 mh	0.17	No	No	No	2	0.08	
HC-2	Grit Chamber Velocity	2	Flow Prop. to A/L	Remote Manual	Electric	Motorized Sluice Gate	0.5	1000	No	No	Yes	--	100 mh Est.	0.5	No	No	No	None	--	

* Control mode relay, proportional, proportional plus reset, etc
** Types of controllers analog (pne, hyd. or elec media), computer (supervisory, direct digital or set analog)
*** Final control element pne. values, variable speed pump, etc

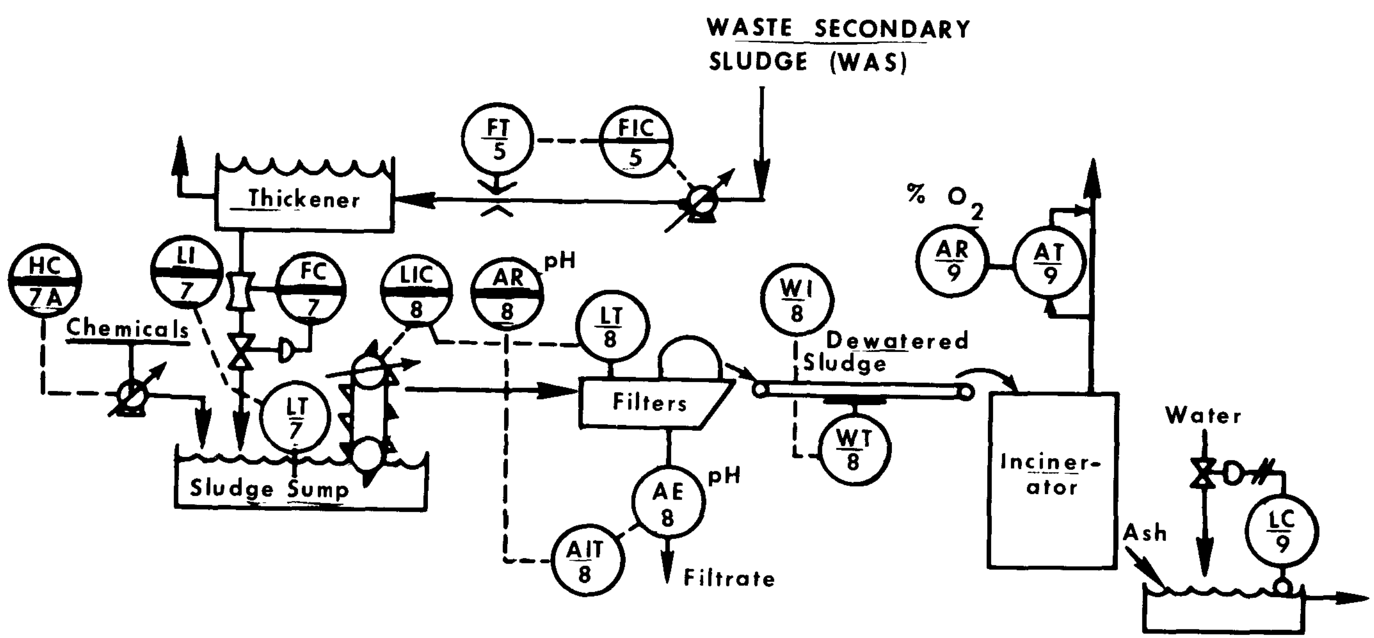
FIGURE B-23(a).

Note: This drawing is much simplified



SHEET 1 OF 2

FIGURE B-23(b).



SHEET 2 OF 2

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-24

Responsible Supervisor

Flow Rate Design (Average and Maximum) Primary Settling - 125 mgd Aeration --2-1/2 hr. detention
Final Settling - 175 mgd Max. Flow - 250 mgd, design maximum

Storm Water Collection and Treatment
Combined System

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)

Secondary, activated sludge.

Performance Data (Individual Units and Overall) 70-75% S.S. and 60-67% BOD removal

Year Built *Orig. Imhoff - 1923* Modifications (Year and Description) 1952 - $15,000,000 (Flow Meters)
1960 - $ 7,200,000 (General)
Original Cost Modification Cost 1965 - $ 5,000,000 (Est.) (General)

Instrumentation

Equipment Mechanical, pneumatic and electronic (see below)

Panels No centralized control before 1971, small panels throughout complex.

Installation and Start up Costs Original Cost Total Cost

Instrumentation Modification (General, starting about 1952)

Description	Year	Equipment	Panels	I & S	Total

Simplex - Flow (1952)
Foxboro - Flow, pressure, level instruments added (1960)
Bristol - Flow, level added (1965)
Honeywell - Sludge Heating & Scum Incineration added (1970 approx.)
(Panel added with Nichols incinerator)

Computer
Type Commercial, office type Manufacturer IBM 1130 I/O Devices Manual data reduction from log sheets at remote site.

Process Control None

Data Logging Manual

Parameter, Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency
Logs approximately 380-400 values/day			

Storage None Computer costs $4,000/mo. to rent and $35/hr. to run.

Software Description On cards

Computer Cost Rented Software Cost - Installation Cost -

Central Control No

Supervisory Control No

Alarm and Safety Systems Yes for levels, temperatures.

Automatic Emergency Program (e g, Power Failure) No auxiliary power; secondary treatment is bypassed during power failure.

Maintenance and Calibration
Special Equipment V-O-M, current, pressure, voltage, oscilloscope, millivoltmeter, wheatstone bridge, stand.gases, timers, electronic counters Down Time -

Special Operator Training See following sheets Frequency (no mo) Once every 3 mos., instrumentation is overhauled. Budget - $20,000/yr.

Total In-Plant Man Hours/Year 783

Total Cost of Outside Service -

Estimate of Over-all Benefits of Instrumentation and Automation
W/O instrumentation, plant could not operate effectively. Alarms prevent flooding and motor burnouts.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no /mo)	Total Downtime	Downtime Frequency (no /mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Scum burner	Nichols-Honeywell Supervisory System	--	--	--	3/mo.		None	None	None	None	None	--	--	--	--	Downtime occurs to clean flame rod - 1-2 times/week.
Digestor sludge+gas production	Foxboro, individual Venturis	613 DL 6B POR	$1,800 400	96	1/mo.	In shop	None	None	None	None	None	Moisture in gas produces condensation	Good	None	Yes	No moisture problems with electronics, but moisture in sensing lines gives false readings.
Sludge density	Ohmart	CP-WE	$4,000	48	0.08/mo., or less	Two days by mfr. in plant	None	None	None	None	None	Vandalism by kids	Very good	None	None (Indicates)	Measuring unit located outside protective fence.
Flammable Gas Detector	Honeywell	R4138A	300	208	4/mo.	In shop	None	None	None	None	None	Heater vibration -- req. constant maintenance	Very good	Alarm & controls for gas valve	--	Vibration in service causes internal components to loosen up and therefore to require constant maintenance. Unit is failsafe.
Sludge Flow	F&P Magnetic Flow Meter	1001416A	$4,000	10	0.3/mo.	On site	None	None	None	1.5 years	Abnormally high frequency	Coil burn-up	Good when operating	None	Local	Coils burn up shortly after installation, possibly due to high power requirements for heat cleaning. First burnout occurred within 9 months of start-up.
Dissolved oxygen	Union Carbide	1101	$1,400	10	Clean sensor, 9/mo.	On site	None	None	None	1 mo. in 4 years	N/A		Very poor below 0.4mg DO/1	Mechanical aerator control	Control bldg.	Works well if clean.
Grit chamber level	Sonar Guard by C.W. Stevens	Series 3000	$1,500	10	0.3/mo.	2 man-days in plant	None	None	None	None	None	Individual conduits required	Very good	Alarm	None	Several transmission lines in one shared conduit adversely affected each other.

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays.
*** Local and central

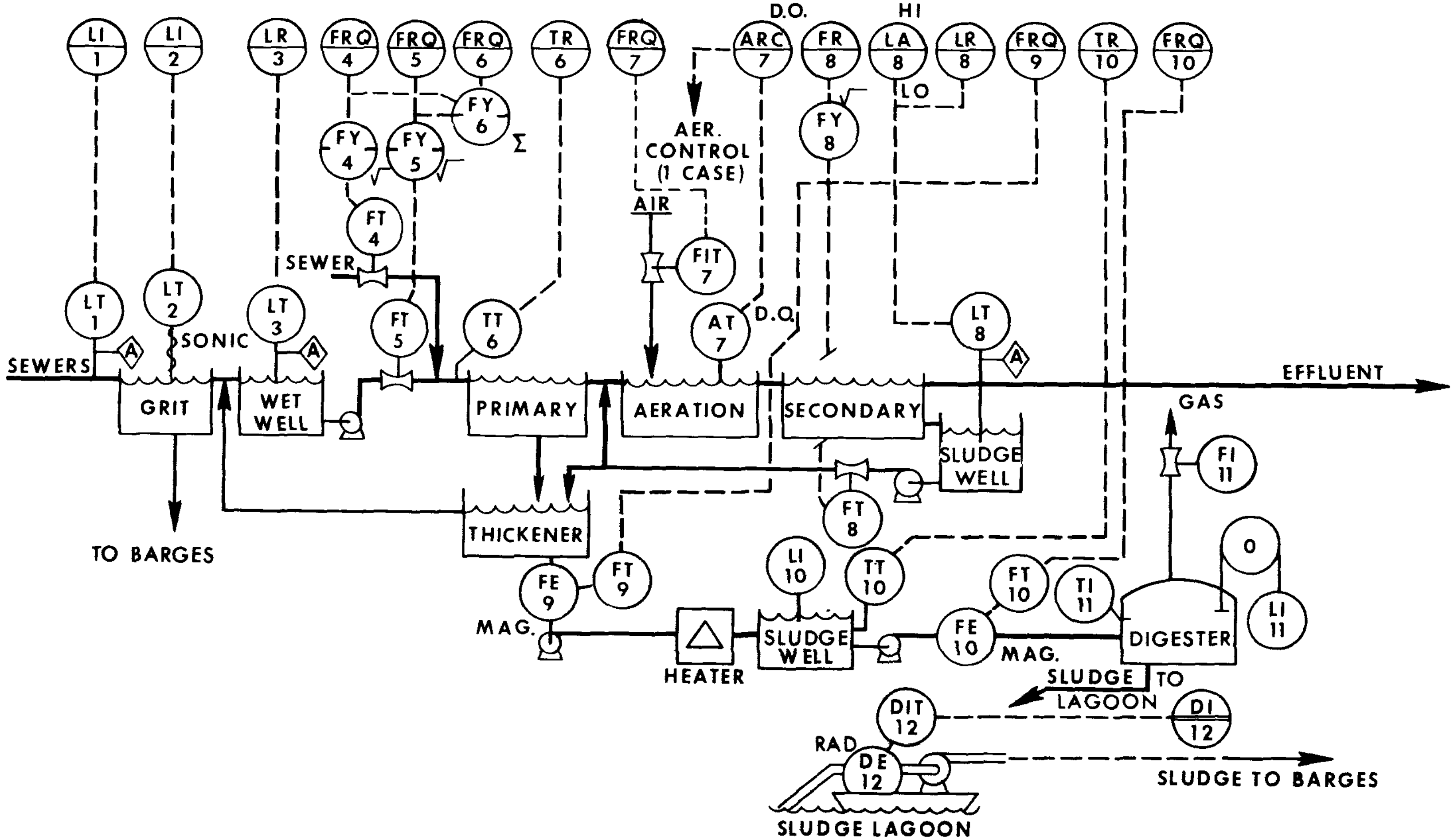
LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variation min/max (mg/l)	Maintenance & Calibration by In-Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no/mo)	Comments
AT-7	Mechanical aerators	2	On-off	DO Probe set to maintain 0.5-1.5mg/1	Electric	Mechanical aerator	Less than 0.1 min.	--	Est. 40% saving in power	--	--	0.5-1.5ppm maintained	10 mh/yr.	Clean sensor 2 times/wk.	None	None	None	1 Mos. in 4 yrs.	N/A	Only 20% of plant aeration is mechanical; 80% is diffused. D.O. probe control works well when sensor is kept clean.
DE-12	Lagooned sludge density	1	Manual	Dredge Operator	Gasoline engine(s)	Dredge	2-10	--	Est. 30% saving in power	--	Optimum density reduces pumping and barging costs.	--	48 mh/yr.	--	2 day by mfr.	None	None	None	None	Works well, aside from vandalism problem. (See previous sheet)

* Control mode relay, proportional, proportional plus reset etc
** Types of controllers analog (pne., hyd or elec media), computer (supervisory, direct digital or set analog)
*** Final control element pne values, variable speed pump, etc

FIGURE B-24

PHILADELPHIA NE STP



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GENERAL SURVEY QUESTIONNAIRE

STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-25

Responsible Supervisor

Flow Rate Design (Average and Maximum) 900 mgd, 900 Av., 1,080 peak

Storm Water Collection and Treatment Combined sewers

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)

Conventional secondary (Imhoff tank for primary sludge). Various methods for sludge disposal; considerable development going on.

Performance Data (Individual Units and Overall) 90% BOD+ suspended solids removal.

Year Built (Imhoff tank) 1930 Modifications (Year and Description) 1940 - Activated sludge, 1950 - Increased aeration 1961 - Zimpro, 1964 - Digesters

Original Cost Modification Cost

Instrumentation

Equipment Flow recording and telemetering, sewer levels, sludge-level controls, Hach turbidimeters.

Panels 1 large, hydraulic, recording panel. Local manual controls.

Installation and Start up Costs Original Cost Total Cost Relatively little.

Instrumentation Modification Miscellaneous operational developments.

Description	Year	Equipment	Panels	I & S	Total

Computer Type None Manufacturer I O Devices

Process Control

Data Logging

Parameter/Frequency	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control One central flow-control board

Supervisory Control No

Alarm and Safety Systems Few

Automatic Emergency Program (e g., Power Failure)

Maintenance and Calibration Experienced crew for process instruments.

Special Equipment Yes Down Time

Special Operator Training 2 weeks/man/year Frequency (no /mo)

Total In-Plant Man Hours/Year 14,000 mh

Total Cost of Outside Service. Negligible

Estimate of Over-all Benefits of Instrumentation and Automation

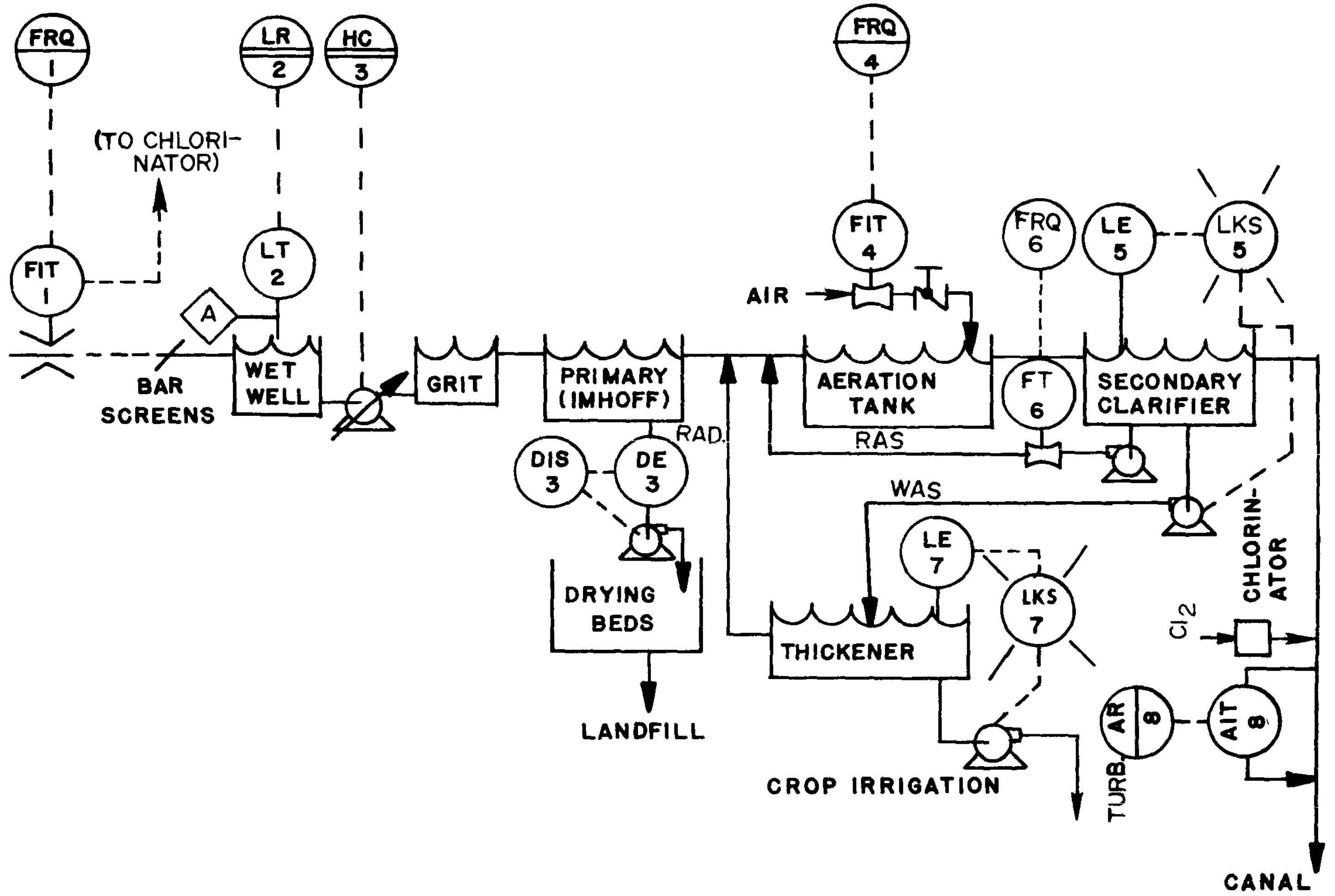
Instrumentation gives operational guidance.
Improved sludge separations.
Improvement over laboratory results (in accuracy and trend detection).

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no /mo)	Total Downtime	Downtime Frequency (no /mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Turbidity	Hach	Surface scatter		30	2	No	No	No	--	Little or none	--		± 10%	--	Remote	Seems good. In service about 5 years.
Flow (Air)	Ring Balance			20 Est.	0.5	No	No	No	--	Little or none	--	Plugged service lines	± 5%	Some air purges	Yes	Very well considered. In use many years.
Flow	BIF (Venturis)			60 Est.	0.1 Est.	No	No	No	--	Little or none	0.02 Est.	None	± 8% Est.	Water Purge, Pulse Transmitters	Remote	In use many years.
Sludge density	Ohmart			60 Est.	0.5 Est.	No	No	Factory Service	--	Approx. 50%	0.2	Defective electronics; excessive repairs.	Adequate	--	--	Excessive failure rate. Useful life is 6 months - 1 year. No preventive maintenance (except calibration).
Sludge interface	Keene	8200 SCCS		20	0.7	No	No	No	--	Little or none	0.08 Est.	Detector fouling; Manufacturing defects.	Adequate	10-minute lock-in timer		Four years experience in secondary sedimentation tanks. Some problems with factory defects, but well-received and widely used. (Approximately 30 units)

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

FIGURE B-25.



FRQ 1
FIT 1
(TO CHLORINATOR)
BAR SCREENS
A
LT 2
LR 2
HC 3
WET WELL
GRIT
PRIMARY (IMHOFF)
RAD.
DIS 3
DE 3
DRYING BEDS
LANDFILL
AIR
FRQ 4
FIT 4
AERATION TANK
RAS
WAS
FRQ 6
FT 6
LE 5
LKS 5
SECONDARY CLARIFIER
LE 7
LKS 7
THICKENER
CROP IRRIGATION
CHLORINATOR
Cl_2
AR 8
AIT 8
TURB
CANAL

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GENERAL SURVEY QUESTIONNAIRE

STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address B-26

Responsible Supervisor

Flow Rate Design (Average and Maximum) 6.0 mgd Average, 8.0 mgd Design, 18 peak

Storm Water Collection and Treatment Separate collection facilities. Excess flows go to oxidation pond or to stream.

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Primary settling, activated sludge treatment, final settling, sludge digestion, coagulation, sedimentation, sand filtration, micro straining.

Performance Data (Individual Units and Overall)

SS & BOD Removal:	Primary,	Pri. & Sec.,	Pri.-Sec.-Ter.
	30-35%	90%	98%

Year Built 1963 (2 mgd)

Modifications (Year and Description) 1964, Activated sludge plant; 1969, tertiary treatment; 1970, aeration of ox.-ponds; 1972, 4 mgd expansion.

Original Cost $146,000

Modification Cost $725,000, $1,126,000, $107,000, $2,778,000, resp.

Instrumentation Mostly F & P (Fischer & Porter)

Equipment Flow and level sensors, D.O. probes, turbidity indicators, etc.

Panels 1 control panel in the pump and blower house.
1 control panel in the tertiary building.

Installation and Start up Costs Original Cost Total Cost

Instrumentation Modification N/A

Description	Year	Equipment	Panels	I & S	Total

Computer Type None Manufacturer I/O Devices

Process Control

Data Logging

Parameter Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control Pump & Blower House control panel.

Supervisory Control One panel (control); one recording panel in tertiary building.

Alarm and Safety Systems Minor

Automatic Emergency Program (e g, Power Failure) Selected operation based on 1 of 2 lines. No standby; no spare tielines.

Maintenance and Calibration New instruments, still under warranty.

Special Equipment None (off-site) **Down Time** None

Special Operator Training Some **Frequency (no /mo)**

Total In-Plant Man Hours/Year Not yet established.

Total Cost of Outside Service None (warranty)

Estimate of Over-all Benefits of Instrumentation and Automation

Monitoring flow and treatment efficiency of medium-sized plant. Data will be used to help forecast future treatment requirements. Aids in gathering information pertaining to flow conditions, storm-weather flows, etc.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no/mo)	Total Downtime	Downtime Frequency (no/mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Sampling	N-Con	Sentinal		20	0.2	No	No	No	--	None	--			Sample pump	No	Performs well.
Turbidity	Hach (Surface scatter)	1889B		15	4	No	No	No	--	None	--	None to date	Good	Sample piping	Remote	Performs well. Used on secondary effluent. Four months service, so far.
Air & liq. flow	BIF (Venturi's and Dall flow tubes)	0301-07 B-TIR (Pulse)		8	0.2	No	No	No	--	None	--			Integrator	Remote	Performs well.
Liquid flow	Fischer & Porter (Magnetic)	1001430A		8	0.2	No	No	No	--	None	--	Some electrode fouling	Good	None	Remote	Performs well.
Dissolved Oxygen	Beckman	735		30	4	No	No	No	--	None	--	Probe fouling and drift	±15% (Adequate)		Yes	Performs poorly. Automatic D.O. control of aeration system is not used, but D.O. is recorded and used for guidance.
Combustible gas	MSA			20	1	No	No	No	--	Little if any	--	None	Adequate		No	Checked for operation monthly, or if showing a reading. Former AIRCO units abandoned as unworkable.
Sludge blanket level	Keene	8200 SCCS (Infra-red)		30	2	No	No	No	--	None	--	Fouling	Adequate	Timers, Lights	No	Limited experience (6 weeks); very well received.

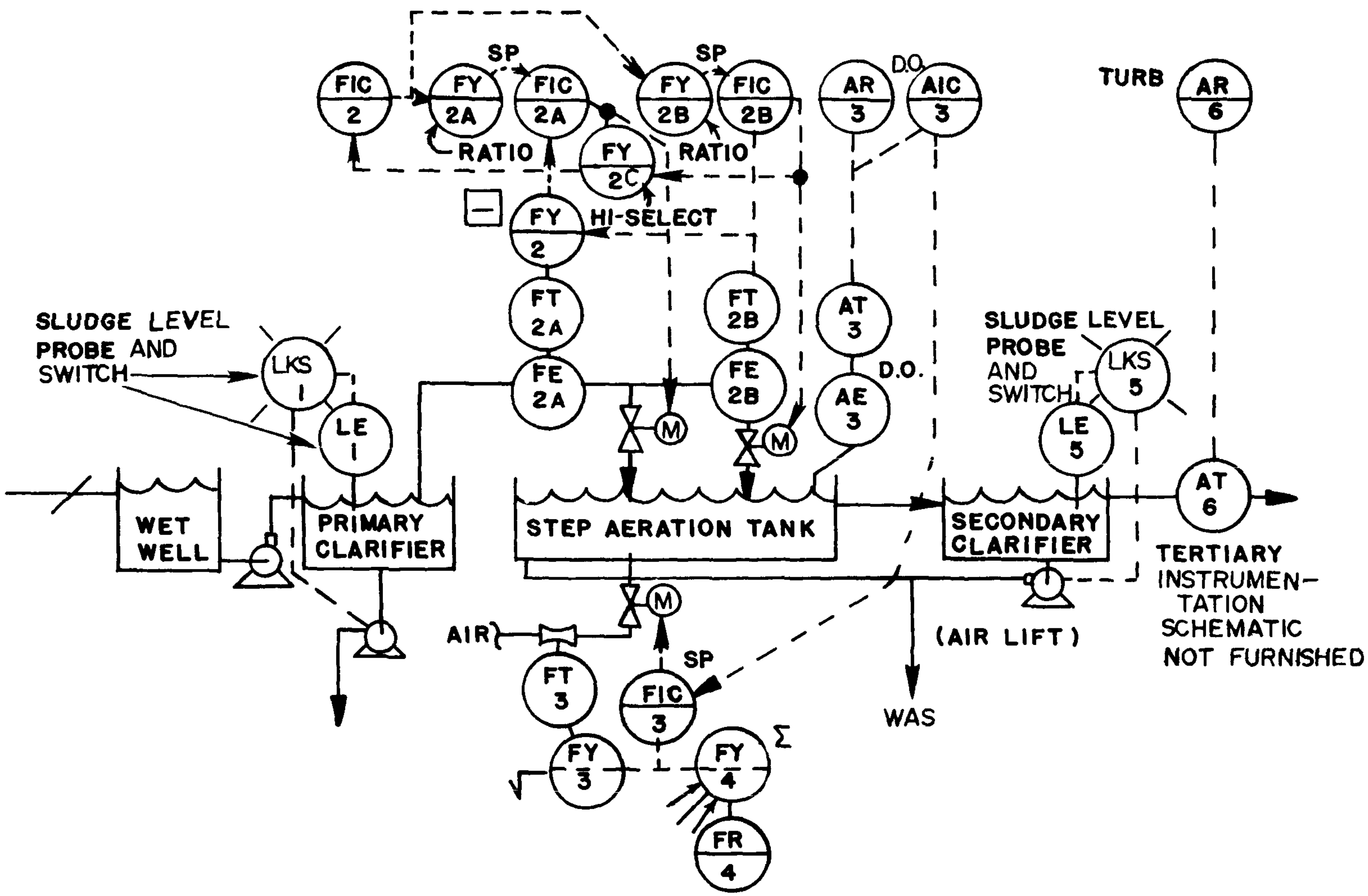
* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central.

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							Comments
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW-hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In-Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no/mo)	
LE-1	Sludge pumping	6	On-Off (Probe)	Relay	Electric	Sludge pump	--	800	10%	10%	Yes	--	20	2	No	No	No	None	--	Limited experience (6 weeks); works well.
FE-2A FE-2B	Primary effluent to aeration	8	Proportional and Reset	Electronic	Electric Motor	Sluice gate	0.5	800	--	Some	Yes	--		--	No	No	No	Temporarily out of service	--	Liquid flows maintained in ratio. High controller sensitivity at start-up wore out sluice-gate lead screws. Limitorque TR/SMB BIF Butterflies (M650), #663. Good.
FT-3	Air to aeration	8	Proportional and Reset	Electronic	Electric	Motorized valve	0.5	600	15%	No	No	Uniform aeration	200	4	No	No	No	Little or none	--	D.O. Probes not reliable. Results recorded but control is manual.

* Control mode relay, proportional, proportional plus reset, etc
** Types of controllers: analog (pne., hyd or elec media), computer (supervisory, direct digital or set analog)
*** Final control element pne values, variable speed pump, etc

FIGURE B-26.



FIC 2
FY 2A
FIC 2A
FY 2B
FIC 2B
SP
RATIO
FY 2C
HI-SELECT
FY 2
FT 2A
FE 2A
FT 2B
FE 2B
AR 3
AIC 3
D.O.
AT 3
AE 3
TURB
AR 6
AT 6
SLUDGE LEVEL PROBE AND SWITCH
LKS 1
LE 1
LKS 5
LE 5
WET WELL
PRIMARY CLARIFIER
STEP AERATION TANK
SECONDARY CLARIFIER
TERTIARY INSTRUMENTATION SCHEMATIC NOT FURNISHED
AIR
(AIR LIFT)
WAS
FT 3
FIC 3
FY 3
FY 4
FR 4
M
Σ

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GENERAL SURVEY QUESTIONNAIRE

STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address C-1

Responsible Supervisor

Flow Rate Design (Average and Maximum) 2 mgd (max.) Plant bypassed during rainy season.

Storm Water Collection and Treatment No. Sanitary, with infiltration.

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Tertiary: Activated sludge with microstrainer.

Performance Data (Individual Units and Overall)
98% removal, BOD and suspended solids.

Year Built 1971 **Modifications (Year and Description)**

Original Cost $3M **Modification Cost**

Instrumentation

Equipment BIF Telemetry, W & T chlorine equip., Union Carbide D.O. probes, etc.

Panels Central graphic, with local indicating instruments.

Installation and Start-up Costs **Original Cost** **Total Cost**

Instrumentation Modification None

Description	Year	Equipment	Panels	I & S	Total

Computer

Type No **Manufacturer** **I/O Devices**

Process Control

Data Logging

Parameter/Frequency	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost **Software Cost** **Installation Cost**

Central Control No. Indication, recording and alarms on central panel, but no control.

Supervisory Control No.

Alarm and Safety Systems Conventional industrial type.

Automatic Emergency Program (e g Power Failure) None

Maintenance and Calibration

Special Equipment None

Down Time None due to inst. failure

Special Operator Training None*

Frequency (no /mo)

Total In-Plant Man Hours/Year Not yet established

Total Cost of Outside Service Not yet established

*Superintendent, however, is particularly conscientious and experienced.

Estimate of Over-all Benefits of Instrumentation and Automation

Instrumentation essential for performance and labor savings.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no /mo.)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no /mo)	Total Downtime	Downtime Frequency (no /mo)	Problems*	Accuracy Range	Auxiliary Devices**	Recording Devices***	Comments
Dissolved Oxygen	Union Carbide	1131		250	Clean -30 Cal. -4	None	No	No	--	None	--	Slime build-up on probe	± 0.5mg O_2/1 over 0-10 mg/1	Automatic probe scanning	L & N Multi-point	Weston & Stack portable (with agitator) used to measure O_2 transfer. Winkler is the standard reference. Six Probes, one readout (D.O. & Temp), automatic scan.
Samplers	Chicago pump	BR (new design)		8 Est.	0.2 Est.	None	No	No	--	None	--	None	--	Sample pump	No	3-HP, non-clog, sample pump works well. Sample suction line (plant influent) is back-flushed weekly in winter with 160°F water to remove grease accumulation.
pH	Leeds & Northrup			40	1	None	No	No	--	None	--	Fouling, drift	Good		Yes	Probe in plant influent to detect indust. spills.
Temp.	BIF (Filled system)			4 Est.	.02 Est.	None	No	No	--	None	--	None	--		Yes	Probe in plant influent to detect indust. spills.
Chlorine gas detector	Wallace & Tiernan	Solvay		Slight	Slight	None	No	No	--	Unknown	--	Unknown	Unknown		No	Instrument given little attention.
Residual chlorine	Wallace & Tiernan	(Modified wet-chemical analyzer)														Works well.

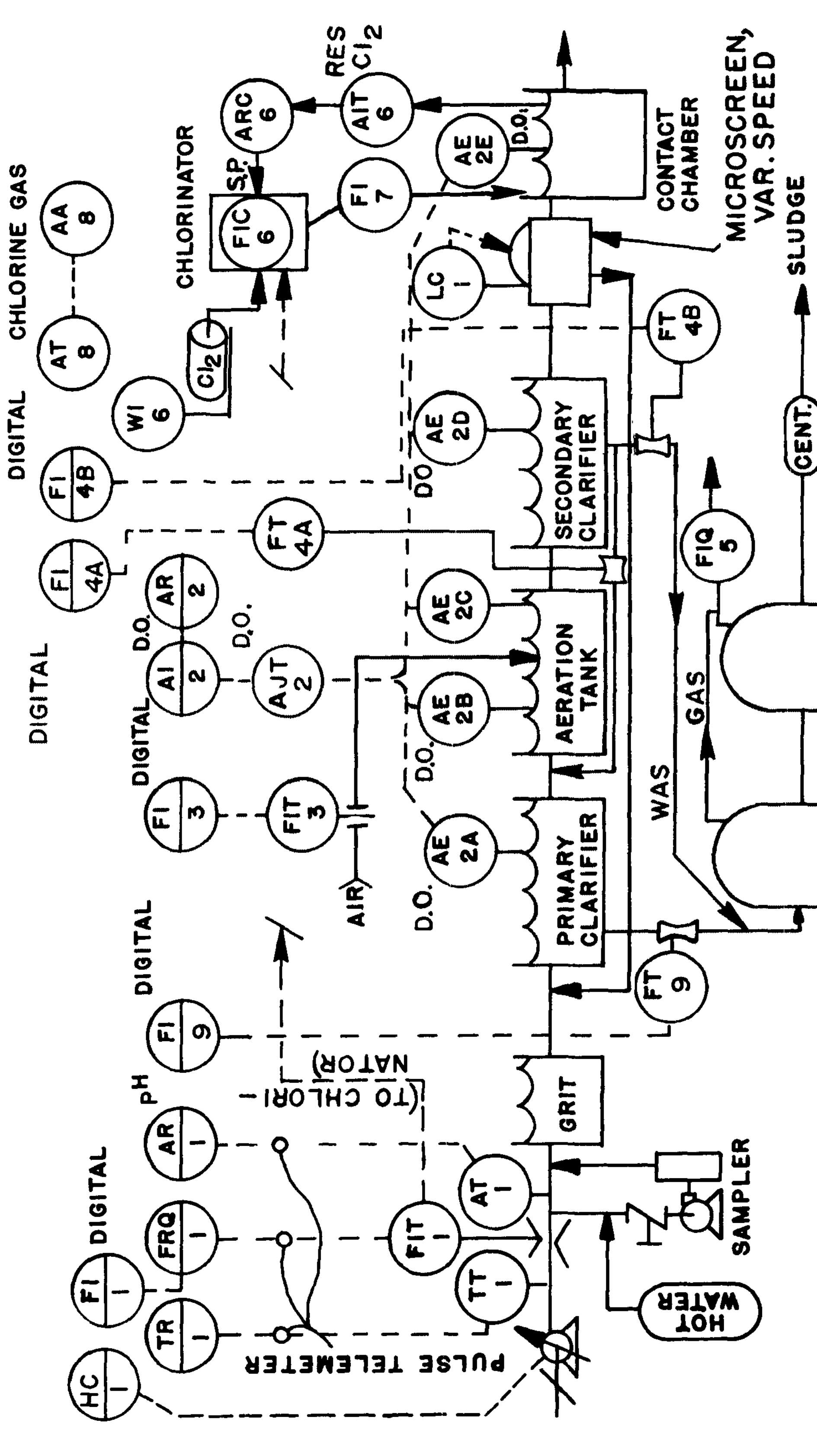
* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							Comments
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW hr/yr)	Chemical (lbs yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no./mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no/mo)	
AIT-6	Chlorine residual	1	Ratio with cascade trim	Electric analog	Air/Elect./ Water	Chlorinator	2			10%		±5% of 0.2 ppm	150 Est. mh/yr.	30	Personnel qualified by experience	No	No	None	-	W & T wet chem. analyzer modified (reagent pumps eliminated), bipolar on-off contacts drive chlorinator set-point motor. Works well.

* Control mode relay, proportional, proportional plus reset, etc
** Types of controllers analog (pne, hyd or elec media), computer (supervisory, direct digital or set analog)
*** Final control element, pne values, variable speed pump, etc

FIGURE C-1



HC 1
TR 1
FI 1
FRQ 1
DIGITAL
AR 1
pH
FI 9
DIGITAL
PULSE TELEMETER
(TO CHLORINATOR)
FIT 1
TT 1
AT 1
HOT WATER
SAMPLER
GRIT
FT 9
PRIMARY CLARIFIER
D.O.
AE 2A
AIR
FI 3
FIT 3
DIGITAL
AE 2B
D.O.
AI 2
AJT 2
D.O.
DIGITAL
AR 2
AERATION TANK
AE 2C
FI 4A
FT 4A
DIGITAL
FI 4B
SECONDARY CLARIFIER
AE 2D
DO
WI 6
Cl2
AT 8
AA 8
CHLORINE GAS
CHLORINATOR
FIC 6
S.P.
ARC 6
LC 1
FT 4B
FI 7
AE 2E
D.O.
AIT 6
RES Cl2
CONTACT CHAMBER
MICROSCREEN, VAR. SPEED
SLUDGE
CENT.
FIQ 5
GAS
WAS
PRIMARY DIGESTER
SECONDARY DIGESTER

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GENERAL SURVEY QUESTIONNAIRE

STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address C-2

Responsible Supervisor

Flow Rate Design (Average and Maximum) 3.9 mgd Avg.; Design Avg. 7.5 mgd; Design Peak 18 mgd

Storm Water Collection and Treatment None

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Conventional secondary treatment plus AWT - Lime pptn of PO_4, press. filtration, and act. carb adsorp. Effluent chlorinated and exported to Indian Creek Reservoir.

Performance Data (Individual Units and Overall)

Year Built 1965

Modifications (Year and Description) 1968 (Increased capacity to 17.5 mgd from 2.5 mgd)

Original Cost N/A

Total Cost $5.5X10^6$

Instrumentation Honeywell pne; Foxboro pne; and Beckman electric and pne.

Equipment Parshall Flume, turbine meter, equipment alarms, air flow indicators, pH monitors and control systems, turbidity analyzers, DP indicators, sludge density meters, recorders and totalizers.

Panels 10-ft. display in central control room (1); 5-ft. display in furnace bldg. (2); 10-ft. semigraphic in filter building (3)

Installation and Start up Costs

Original Cost

Total Cost $250,000 for AWT
$100,000 for CONV.

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
DO Monitoring	1973	Delta Scientific	-	-	$1,500/Unit

Computer
Type None

Manufacturer

I/O Devices

Process Control

Data Logging

Parameter/Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost

Software Cost

Installation Cost

Central Control

Supervisory Control Almost none (all adjustments are made directly on the equipment; all remotely operated equipment abandoned, with the exception of sludge wasting and filter back-washing).

Alarm and Safety Systems Several equipment alarms, alarms for pump station; no safety systems (i.e., no automatic process-shutdown devices, automatic relief valves, etc.)

Automatic Emergency Program (e.g. Power Failure) Stand-by generator for blowers, pumps, and lights.

Maintenance and Calibration

Special Equipment No in-plant Instr. service. All Inst. "M&C" done by Honeywell under contract.

Special Operator Training

Total In-Plant Man Hours/Year

Total Cost of Outside Service 20 K/yr. 2 days/week

Down Time All pH monitoring and control systems abandoned in 1970 due to poor accuracy and exceedingly poor reliability.

Frequency (no./mo.)

Most automatic equipment abandoned. Instruments serviced monthly by Honeywell.

Estimate of Over-all Benefits of Instrumentation and Automation Instrumentation & Automation has provided virtually no benefit to the Tahoe facility. All the on-line pH monitors, and subsequent automatic controls, have been completely abandoned because of poor control, reliability and accuracy. In fact, operators report that lime-pH adj. system never ran under automatic control for more than a single day, without major overhaul. Poor performance is attributed to incorrect design; fouled sensors; and the inability of the staff to maintain the Instruments and control systems. Flow-proportional lime control was abandoned for similarly poor performance; here the culprit is lagging and inaccurate flow measurements. With the exception of liquid level and filter-backwash flow regulation, this plant is operated manually via local adjustments.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no /mo)	Total Downtime	Downtime Frequency (no /mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
pH	Beckman	Industrial Model		Constant maint.	Hourly	None	Honeywell (N/A)	--	4/mo.	Instr. Abandoned		Constant fouling	Very poor	Lime control	Central	pH instruments performed unsatisfactorily due to excessive fouling of glass electrode; no provisions for automatic cleaning. Subsequently, on-line pH instruments were abandoned.
Flow	Parshall Flume	--		50 mh/yr.	1/mo.	None	Honeywell 50 mh/yr.	--	4/mo.	--	--	Debris clogs throat	Poor about ±10%	Flow-Prop. control	Central	Poor accuracy, usually about 10%
Flow	Hershey-Spaulding	--		40 mh/yr.	0.25/mo.	None	--	--	--	40 hrs/yr.	0.25/mo.	Excessive wear	Poor about +10%	Flow-Prop. control	Central	
Liquid level	Honeywell			Est. 8 mh/yr.	1/mo.	None	Honeywell 16 mh/yr.	--	--	0	--	None	Good	Pump control	None	
Turbidity	Hach	1720												Filter alarm	None	
Sludge density	Nuclear Chicago			--	--	AEC	Honeywell 100 mh/yr.	--	1/mo.	100 mh/yr.	1/mo.	Fouling	Fair (±5%)	Sludge wasting control	Central	Difficult to keep calibrated. Since no by-pass valves in sludge lines, zero check with water is impossible.

* Corrosion, fouling, etc.
** Limiters, alarms, ratio relays.
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min.)	Manpower (mh/yr)	Utility (kW hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In-Plant Personnel ($ or mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no./mo.)	Comments
AIC-101 AC-201	Lime addition	2	PI	Analog elect.	Elect.	Slaker & slurry valve	Very long ≈25 min.	None a	--	None a	None a	a	a	a	None	Honeywell a	--	Abandoned a	Abandoned a	(a) Because sample was pumped to control room, response time was very long (about 25 min.) due to transportation lag. Moreover, the pH probes constantly fouled, and the pH data was unreliable. Automatic pH control was abandoned shortly after start-up. Currently two-hour grab samples direct the lime addition.
FT-108	Excess sludge wasting	1	PI	Analog pneumatic	Pneumatic	Valve	5 min.	Est. 500 mh/yr.	None	None	--	±10%	None	--	--	≈200 mh/yr. Honeywell	None	--	--	
AT-204	Recarbonation	1	PI	Analog pneumatic	Pneumatic	Valve	5 min.	None b		None b	None b	b	b	b		Honeywell b		Abandoned b	Abandoned b	(b) Excessive fouling of pH probe led to abandoning automatic control of recarb. Currently, pH is measured once or twice a shift with manual adjustments made accordingly.
FE-304	Filter backwash	3	On-off	Analog pneumatic	Hydraulic	Valves	1 min.	N/A	--	--	--	--	--							Filter backwash can be automatically activated by excessive ΔP or by high turbidity, but plant operates by manual backwash once per shift unless high ΔP or turbidity-alarm conditions exist.
FE-303	Alum, with Polymer addition	3	P	Analog pneumatic	Pneumatic	Proportioning pump.	5 min.	--	--	20%	--	--	--	--	None	Honeywell	--	Very small ≈8 hrs/yr.	1/yr.	Chemical feed rate porportional to flowrate. This system provides reliable control of chemical additions.
	Flow regulation	10+	PI	Analog pneumatic	Pne/E/hyd.	Pump	1 min.	--	--	--	--	±5%	--	--	--	Honeywell	--	--	--	Hydraulically regulated control systems reliably maintain the desired flow rates and levels without any significant problems.

* Control mode relay, proportional, proportional plus reset, etc.
** Types of controllers analog (pne., hyd or elec. media), computer (supervisory, direct digital or set analog)
*** Final control element pne. values, variable speed pump, etc

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							Comments
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no./mo.)	
TIC-111	Incineration	10+	P & PI	Elect.	Elect.		5-10 min.	--	--	--	--	±1%	None	--	--	Manufacturer	--	--	--	Temp. and draft controls provide efficient regulation of important variables. To date, no operational problems.
FIT-312	Chlorination	1	P	Pneumatic	Pneumatic	Chlorinator's valving	1 min.			10-15%		±1mg/l	None	--	--	Honeywell, 50 mh/yr.	--	--	--	Flow-proportioned chlorination with no, continuous, residual Cl_2 measurements.

* Control mode relay, proportional, proportional plus reset, etc
** Types of controllers analog (pne., hyd or elec media); computer (supervisory, direct digital or set analog)
*** Final control element pne. values, variable speed pump, etc

FIGURE C-2 (a)
CONVENTIONAL TREATMENT
100 LOOP

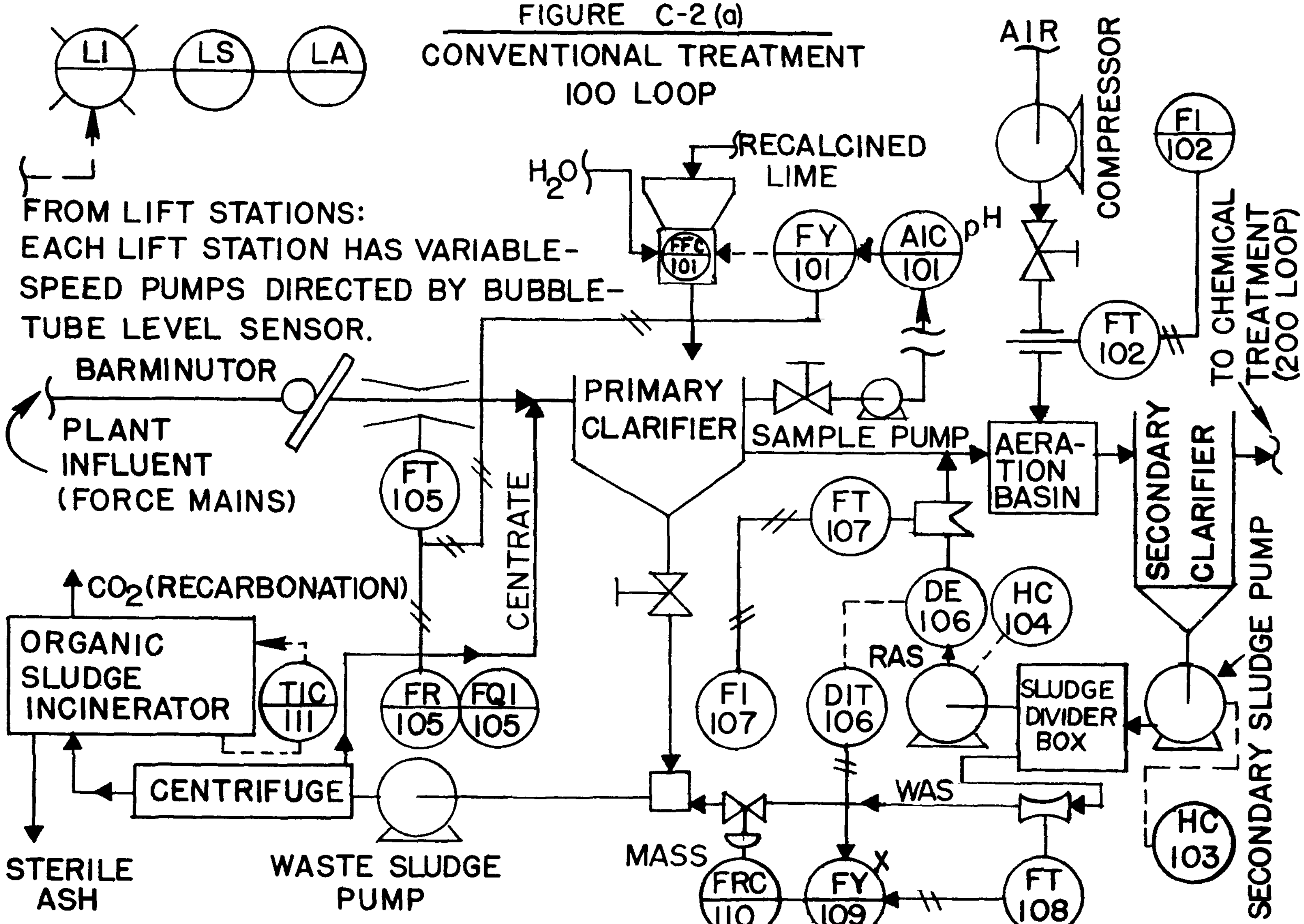


FIGURE C-2(b)
CHEMICAL TREATMENT, AMMONIA STRIPPING, AND RECARBONATION
200 LOOP

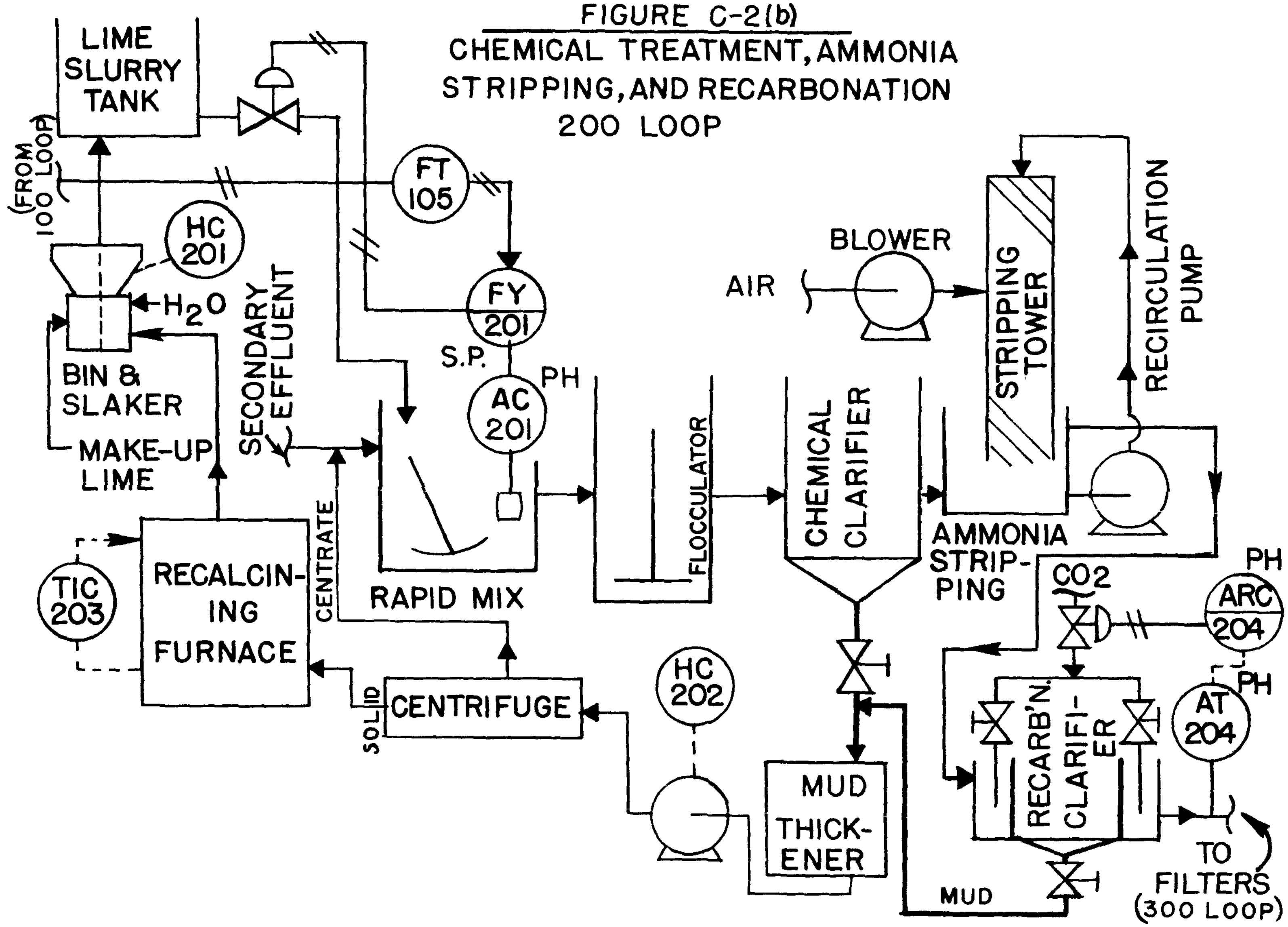
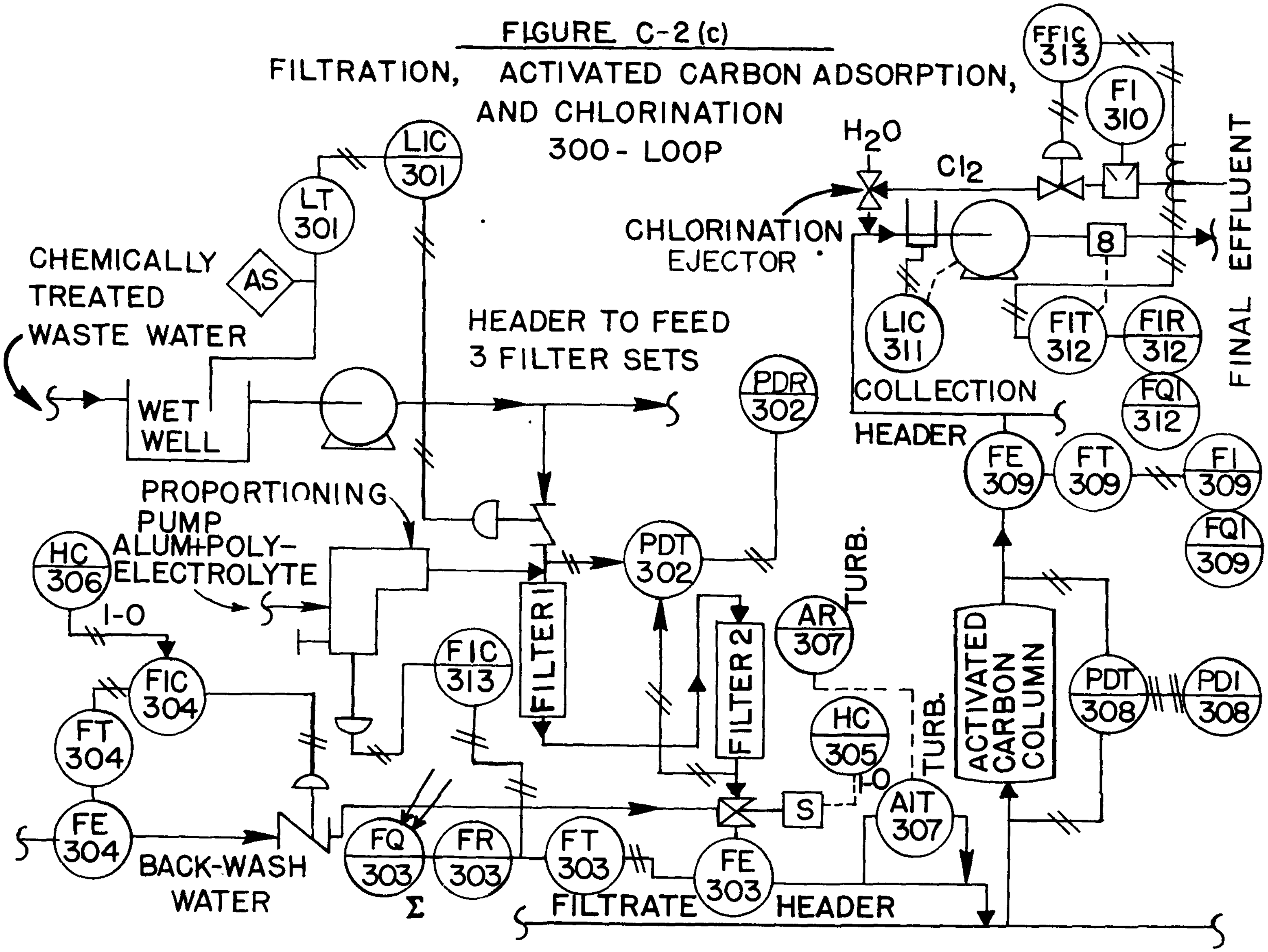


FIGURE C-2 (c)

FILTRATION, ACTIVATED CARBON ADSORPTION, AND CHLORINATION 300- LOOP



GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address

Responsible Supervisor

Flow Rate Design (Average and Maximum): 0.36 mgd (Avg.) Retention Tanks; 0.58 (Max.) Cyclator & Filter

Storm Water Collection and Treatment: None

Type of Plant. Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)

Cyanide destruction and silver recovery.

Performance Data (Individual Units and Overall)

Raw Waste - 40 ppm CN (Avg.) 25 ppm CNO (Avg.)
Effluent - less than 0.1 ppm CN; Zn 0.00 - .16 ppm; Cu 0.00 ppm; Ni 1.28 - 2.2 ppm

Year Built 1954 **Modifications (Year and Description)** Addition of sludge lagoon

Original Cost $1.0 Million **Modification Cost** $2,000

Instrumentation

Equipment Foxboro & Beckman and Honeywell

Panels Foxboro

Installation and Start-up Costs N.A. **Original Cost** $40,000 **Total Cost** N/A

Instrumentation Modification None

Description	Year	Equipment	Panels	I & S	Total

Computer None

Type **Manufacturer** **I/O Devices**

Process Control

Data Logging

Parameter/Frequency	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost **Software Cost** **Installation Cost**

Central Control Full graphic panel

Supervisory Control

Alarm and Safety Systems Shut-off influent, and switch tanks on batching system.

Automatic Emergency Program (e.g., Power Failure). None

Maintenance and Calibration

Special Equipment None **Down Time** 0

Special Operator Training 2 weeks at instrument school **Frequency (no./mo.)** 0

Total In-Plant Man Hours/Year Very little - (50-75 hrs./yr.)

Total Cost of Outside Service None

Estimate of Over-all Benefits of Instrumentation and Automation

Permits operating a complex treatment plant with 2 men on one shift. All collecting and batching operations are automatic. In the absence at controls, 1 man for each of 3 shifts and a utility man on day shift would be required. Plant operates 24 hrs./day and 6-1/2 days per week.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no /mo)	Total Downtime	Downtime Frequency (no /mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
pH	Beckman pH switch		N/A													6-pt. pH selector gave switch trouble with spurious signals from electrical equipment. Abandoned about 1957.
pH	Honeywell, & Beckman M/R	Y152P13B	N/A													Alkali Waste pH - actual operation proved that this instrument was not necessary - abandoned shortly after startup.
pH	Honeywell, & Beckman M/R	Y152P13B	N/A	1	Checked with button weekly	None	None	None	0	2 hr./yr.	1/6 mo.	None	Excellent	Pneumatic control	Circular chart	Cyclator final effluent pH.

* Corrosion, fouling, etc.
** Limiters, alarms, ratio relays.
*** Local and central.

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW-hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In-Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no/mo)	Comments
LIC-10	Level	3	Proportional	Analog Pneumatic	Comp. Air	Pneumatic valves														A full graphic panel, utilizing indicators in the flow plan and providing pump and valve actuation from the panel, operates the entire plant with the exception of a few, infrequently operated, local devices.
LC-8	Level	1	Relay	Analog Supervising	Electric	Pumps														
FT-6	Flow	2	Proportional and Reset	Analog Pneumatic	Comp. Air	Pneumatic valves														
LT-4	Level	1	Relay	Analog Supervising	Comp. Air	Alarm		Annual cost savings amount to 3 man-years/year					40 mh/year for all pneumatic equipment	1/mo.	2 weeks at Mfg. School	None	None	None	0	
LC-3	Level	1	Relay	Analog Supervising	Electirc	Pumps	Less than 1													
LTA-2	Level	3	Relay	Analog Supervising	Electric	Valves and pumps	Less than 1													
LT-1 LC-1	Level and Flow	1	Relay and Proportional	Analog Pneumatic	Comp. Air & Electric	Pneumatic valves and pumps	Less than 1													

* Control mode. relay, proportional, proportional plus reset, etc
** Types of controllers: analog (pne, hyd. or elec. media), computer (supervisory, direct digital or set analog)
*** Final control element pne. values, variable speed pump, etc.

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW-hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no/mo)	Comments
																				A full graphic panel, utilizing indicators in the flow plan and providing pump and valve actuation from the panel, operates the entire plant with the exception of a few, infrequently operated, local devices.
														1/mo.		None	None	None	0	
FT-11	Flow	1	Proportional and Reset	Analog Pneumatic	Comp. Air	Pneumatic valves	1./or less	Annual cost savings amount to	3 man-years/year for total system.				40 mh/year for all pneumatic equipment		2 weeks at mfg. school.					
FT-5	Flow	3	Proportional and Reset	Analog Pneumatic	Comp. Air	Pneumatic valves	1./or less													

* Control mode relay, proportional, proportional plus reset, etc

** Types of controllers analog (pne, hyd. or elec media), computer (supervisory, direct digital or set analog)

*** Final control element pne values, variable speed pump, etc

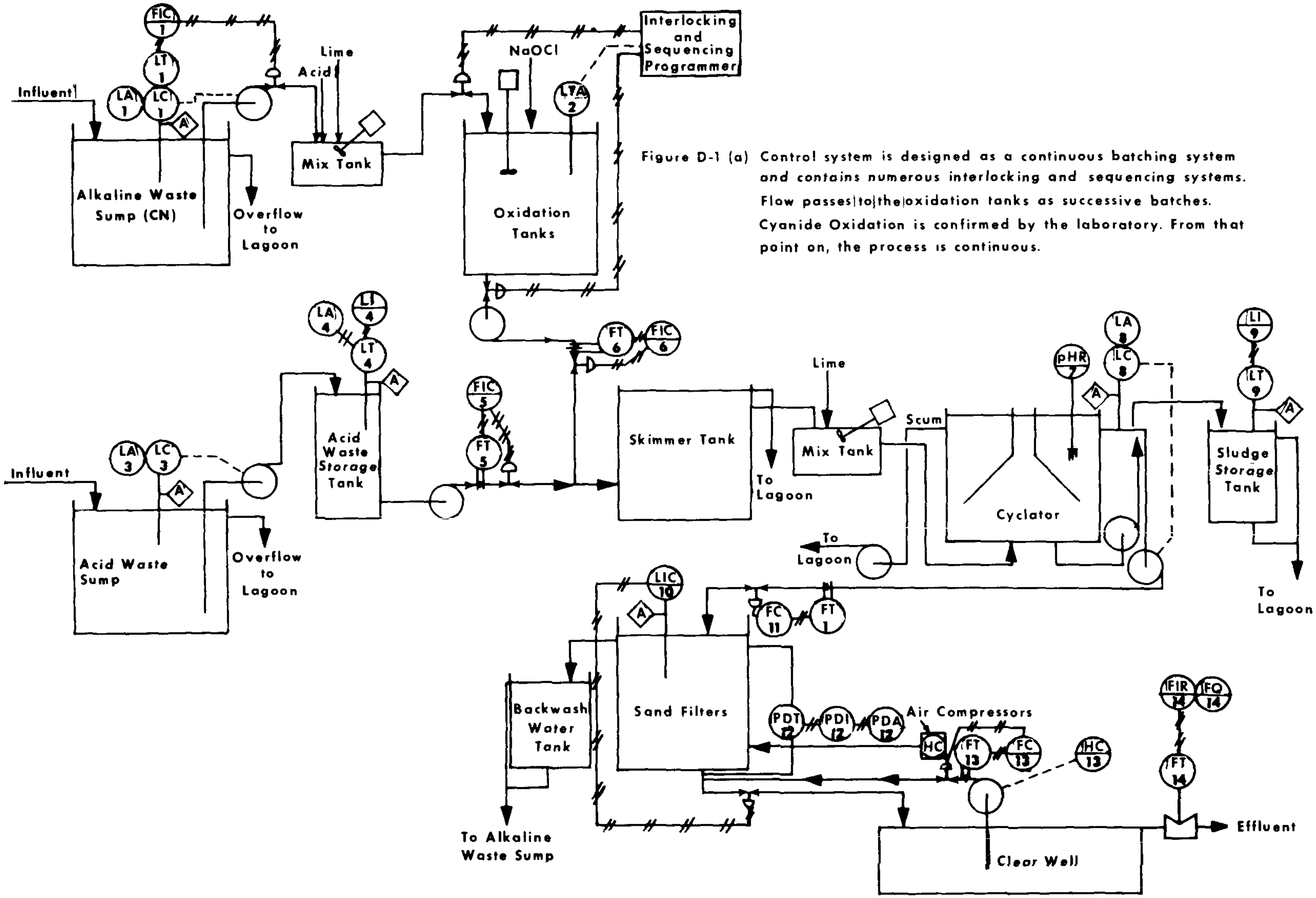

Figure D-1 (a) Control system is designed as a continuous batching system and contains numerous interlocking and sequencing systems. Flow passes to the oxidation tanks as successive batches. Cyanide Oxidation is confirmed by the laboratory. From that point on, the process is continuous.

(Sheet 1 of 2)

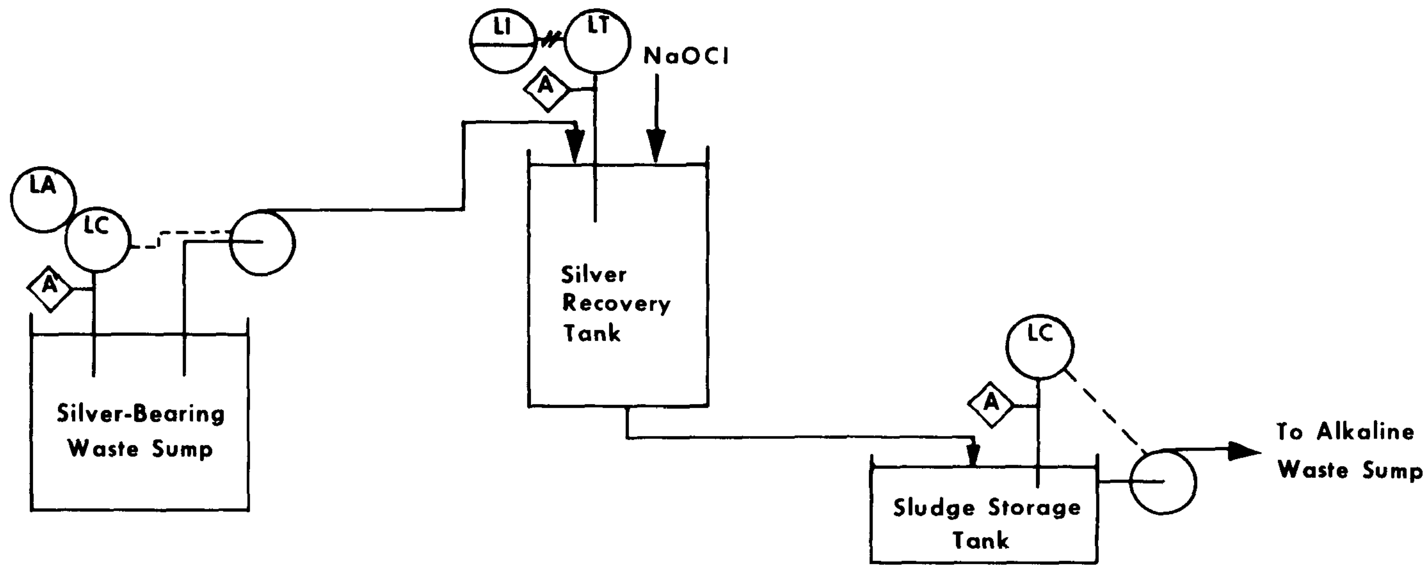

Figure D-1 (b) Silver recovery is a manual process occuring whenever the silver-bearing waste sump is full. This occurs about once a week.

(Sheet 2 of 2)

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address

Responsible Supervisor

Flow Rate Design (Average and Maximum) 2 mgd Avg., containing 10-15,000 lb/d suspended solids

Storm Water Collection and Treatment No

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)

Blending, neutralization, and activated sludge facility to handle nutritive, acidic, and hot wastes.

Performance Data (Individual Units and Overall)

97% solids, 95% BOD removal. (Suspended solids in effluent helc below 40 ppm.)

Year Built 1958 Modifications (Year and Description) General, to date

Original Cost $1.7M Modification Cost Present evaluation, approximately $5M

Instrumentation Pneumatic and electronic

Equipment Instruments to measure and control pH, temp., and TOC

Panels Centralized

Installation and Start up Costs Original Cost Total Cost

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
Continuing in-house development of TOC sampling system, etc.					

Computer

Type No Manufacturer I/O Devices

Process Control

Data Logging

Parameter/Frequency	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control Yes Instrument air is clean, dry and oil-free.

Supervisory Control

Alarm and Safety Systems Conventional industrial

Automatic Emergency Program (e g , Power Failure)

Maintenance and Calibration All the facilities of a large, modern, first-class chemical plant.

Special Equipment Down Time

Special Operator Training Frequency (no /mo)

Total In-Plant Man Hours/Year

Total Cost of Outside Service

Estimate of Over-all Benefits of Instrumentation and Automation

Instrumentation helps assure that plant effluent meets EPA and other effluent standards.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no. mo.)	Total Downtime	Downtime Frequency (no. mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
pH				10 (Est.)	0.1	No	No	No	--	None	No	Fouling and drift	±0.1 (1%)	Alarms	Yes	Flow-through probe holders; little or no grease in sample results in low fouling. Replacement of standard reference electrode with solid (Lazaran) electrode reduced probe maint. from 1/mo. to 1/yr.
TOC	(Total organic carbon) Ionics			200 (Est.)	30	No	No	No	--	Inst. still being developed	--	Sampling valve. Flash chamber	Good	Sample syst. alarms	Yes	Sampling system is based on taking a small fraction of a much larger sample. This seems to work well, but it is still being developed. In-house technicians are revising manufacturer's design.
D.O.	See comment					No	No	No					Unacceptable	Alarms	Yes	Use of D.O. probe was discontinued since none was found that could reliably measure below 0.5 ppm.

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays.
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							Comments
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no./mo)	
AT-2	Neutraliza-tion	1	Proportional and Reset	Pneumatic analog	Pneumatic	Lime slurry valve	2					±0.1, see comment	120 mh/yr. (Est.)	2 (Est.)	No	No	No	No	--	No downtime because system is maintained. (Slurry system requires maintenance) Tight control desired for pollution control.
HC-2	Storage	1	Manual	--			(200)					Yes, see comment	8 mh/yr.	.2	No	No	No	No	--	Operator gradually drains hold tanks, whenever possible, to maintain space to delay and blend spills. Manual control satisfactory.
TT-2	Cooling	1	Manual	--			(20)					Yes, see comment	4 mh/yr.	.1	No	No	No	No	--	Temperature change is usually so slow that manual coverage (which is normally maintained) can easily cope. Alarm for abnormal temp. is automatic.

* Control mode: relay, proportional, proportional plus reset, etc

** Types of controllers: analog (pne., hyd or elec media), computer (supervisory, direct digital or set analog)

*** Final control element: pne. values, variable speed pump, etc.

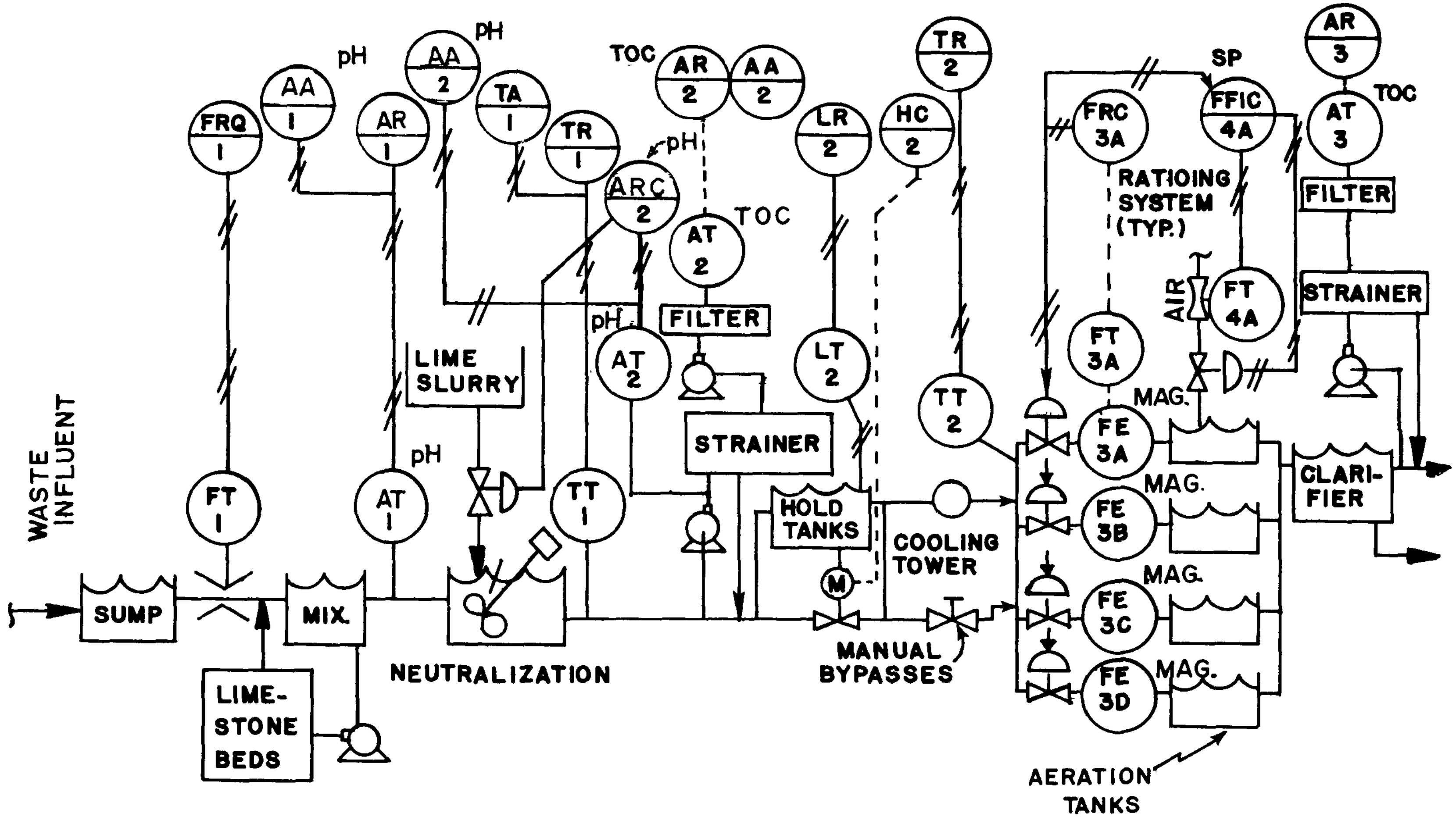

Figure D-2 RATIOING SYSTEM EQUALIZES FLOWS OF LIQUOR AND AIR TO FOUR PARALLEL AERATION TANKS

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address E-1

Responsible Supervisor

Flow Rate Design (Average and Maximum) Designed to treat 5-year-maximum storm flow of 233 mgd

Storm Water Collection and Treatment Treats combined stormwater overflows

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Combined stormwater screening, pumping, settling, chlorination

Performance Data (Individual Units and Overall)

Year Built May 1971 Modifications (Year and Description)

Original Cost $5,000,000 Modification Cost

Instrumentation

Equipment Pneumatic and electronic

Panels 10-ft. graphic, plus 5-ft. recording and misc.

Installation and Start up Costs (not broken out) Original Cost $125,000 Total Cost $125,000

Instrumentation Modification Start-up adjustments only

Description	Year	Equipment	Panels	I & S	Total

Computer
Type None Manufacturer I/O Devices

Process Control

Data Logging

Parameter/Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control Plant designed for automatic, unattended service. All essential controls on graphic panel located on pump room floor.

Supervisory Control

Alarm and Safety Systems 13 systems: Low & high levels, burglar, station start-up, engine malfunctions, etc.

Automatic Emergency Program (e.g., Power Failure) Standby generator for lights and chlorination (diesel-driven pumps); standby system checked out 1 per mos.

Maintenance and Calibration

Special Equipment Calibrating rods for flow meters (i.e., where flow is calculated from level data).

Down Time Flow meter lines clogged; 25 hrs. out of service. Station operation not affected.

Special Operator Training None

Frequency (no./mo.) Approx. 0.1/mo. (only flow meter)

Total In-Plant Man Hours/Year 50-100 (est.)

Total Cost of Outside Service

Estimate of Over all Benefits of Instrumentation and Automation
Station has been designed for complete unattended operation, giving approx. four-fold saving in manpower.

INSTRUMENT SURVEY FORM

Instrument: Parameter	Instrument: Manufacturer	Instrument: Model Number	Instrument: Equipment Cost	Operating Experience: In-Plant Maintenance (mh/yr)	Operating Experience: Maintenance Frequency (no /mo)	Operating Experience: Special Training	Operating Experience: Service by Contract ($ or mh/yr)	Operating Experience: On-Demand Service ($ or mh/yr)	Operating Experience: Frequency (no /mo)	Operating Experience: Total Downtime	Operating Experience: Downtime Frequency (no /mo)	Operating Experience: Problems*	Operating Experience: Accuracy	Peripheral Equipment: Auxiliary Devices**	Peripheral Equipment: Recording Devices***	Comments
Pump rate for NaOCl	Autocon	--	--	--	--	None	None	None	--	Station has never been shut down because of instrument trouble.	--	See Comments	See Comments	Sodium Hypochlorite System	Yes	Pump flow-matching control system is OK as flows increase. When influent flow decreases, pumps do not decrease pump rate. System is still being debugged.
Residual chlorine	BIF	870	--	33	3/mo.	None	None	None	--		--	See Comments	Good	Sodium Hypochlorite System	Yes	1) Mech'l sample-filter device is poor (sample extremely dirty, and filter too small). 2) Chlorine span (0-3 mg/1) is too small ; 0-10 mg/1 recommended, even though control level is 1-2 mg/1 . 3) Bad corrosion problem from conditions in area.
Flow	BIF Dall tube & diff. press. transmitter	231-22 (Chrono-flow)	--	25	3/mo.	None	None	None	--		--	See Comments	--	Sodium Hypochlorite System	Yes	Diff. press. sensing lines need rodding-out for cleaning. Owner is going to replace tubes with larger size pipes.
Wet-well level	BIF (Bubbler tube)	--	--	--	--	None	None	None	--		--	See Comments	Good	See Comments	None	Teleye probe (Model 4103) was replaced with bubbler system because unit was not self-cleaned in non-turbulent wet well.
Inlet structure level	BIF (contact probe)	4103	--	--	--	None	None	None	--		--	See Comments	Good	See Comments	None	1) Condensation in structure causes false actuation of station (i.e., short-outs). 2) Actuation alarm transmitted to remote pump station. 3) Probe needs flowing water to keep it clean. Therefore, unit is N.G. in wet well.

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

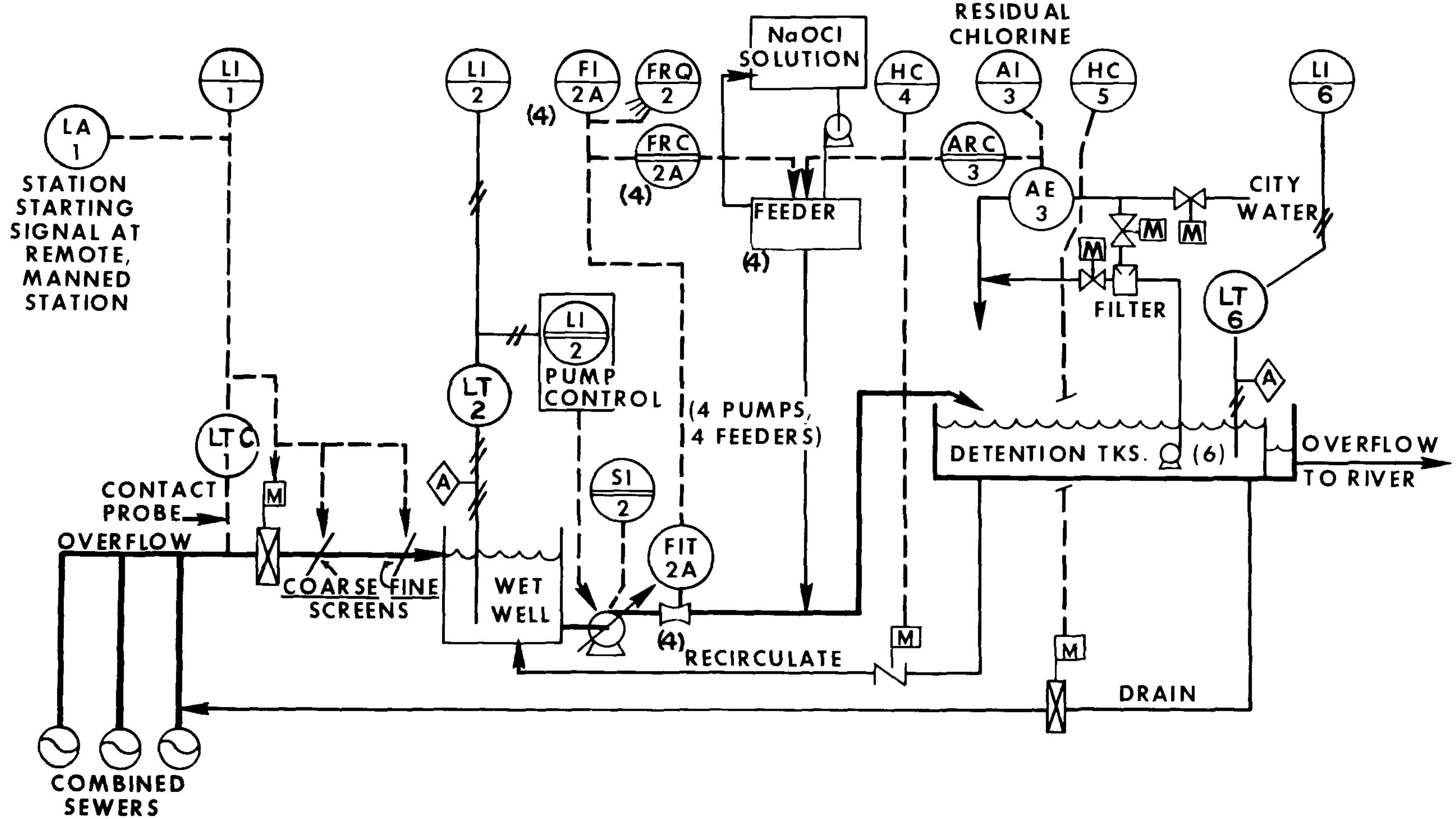
LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							Comments
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no/mo)	
AE-3 FIT-2A	Hypo-chlorination	1	Proportional to analysis and flow	Analog electric	Electric	BIF Rotodip Feeders	1-2 min.	800; could be approx. 1200	None	5,000 gal. 15% NaOCl per year	No	Undetermined	60 mh/yr.	3/mo.	None	No	No	None to date	--	Works well, requires frequent service; some materials of construction not suitable for operation in areas adjacent to NaOCl sol'ns.

* Control mode: relay, proportional, proportional plus reset, etc
** Types of controllers: analog (pne, hyd. or elec. media), computer (supervisory, direct digital or set analog)
*** Final control element: pne. values, variable speed pump, etc.

Figure E-1

STORMWATER DETENTION STATION



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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address E-2

Responsible Supervisor

Flow Rate Design (Average and Maximum) Design: 29 mgd, 29 mg storage (including interceptors)

Storm Water Collection and Treatment Yes - Facilities' sole function

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Stores and sterilizes overflow from storm and combined sewers. Any excess overflows to Jamaica Bay. Hypochlorination. Grit removed; sludge exported.

Performance Data (Individual Units and Overall)
Preliminary data (10-31-72) indicates good storage, sludge removal. Hypochlorination system being de-bugged.

Year Built. 1972 **Modifications (Year and Description)**

Original Cost $17 Million **Modification Cost**

Instrumentation Includes rainfall, flow, level, density, and residual chlorine measurements; dosage rate control and flow computed from level and velocity.

Equipment Mostly Fischer & Porter, pneumatic. See below.

Panels Main panel 6 x 6 ft., enclosed; 12 loops (mostly open). 29 Indic. or Record inst's. on 19-linear-foot panel.

Installation and Start up Costs Unavailable **Original Cost** $35K **Total Cost**

Instrumentation Modification None

Description	Year	Equipment	Panels	I & S	Total

Computer

Type None **Manufacturer** **I O Devices**

Process Control

Data Logging

Parameter/Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost **Software Cost** **Installation Cost**

Central Control Hypochlorination rate (Auto. or Manual). Extensive in-plant transmission. 7 automatic records.

Supervisory Control Alarms telemetered to remote supervisor.

Alarm and Safety Systems

Automatic Emergency Program (e g , Power Failure)

Maintenance and Calibration Plant start-up not yet complete

Note: Plant not yet fully operational (cannot control hypochlorination automatically); but plant only operates to handle stormwater overflows, is idle otherwise.

Special Equipment Residual Chlorine Titrator **Down Time**

Special Operator Training None **Frequency (no mo)**

Total In Plant Man Hours/Year 300 (Est.)

Total Cost of Outside Service

Estimate of Over all Benefits of Instrumentation and Automation

System for open-loop chlorination control not yet de-bugged. (10-31-72)
Expected benefits from reducing manpower requirements have not yet been realized.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Frequency (no mo)	Total Downtime	Downtime Frequency (no/mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Rainfall	Leopold & Stevens	Gauge-TB; Rec.-CAV-C		--	--	None	No	None	--	Not established	--	--	Est. ± 0.5" of precip'n	Digital ind., date stamp	Strip chart (reads totals)	Chart stamped automatically when inflow begins.
Stormwater Flow	Fischer & Porter Magnetic Flow Meter	10D1430A; 10F1430		--	--	None	No	None	--	Not established	--	--		I/p Transducer integrator	Miniature strip chart	Stormwater flow computed as product of velocity and level. Rotameters also used to verify total NaOCl flow.
Level	F & P	Bubblers, & 13D3495-J		--	--	None	No	None	--	None	--	--	Est. ± 1/4"	Air-flow-purge Ass'ys	Miniature strip chart	Excessive H_2S corrosion problem. Aluminum tubing and fittings (flared) don't corrode, but leak so badly that all Al will have to be replaced with plastic.
NaOCl Density (via diff. pressure)	F & P	Bubblers, & 14D34-95 F											Est. ±2% of range		None	(Same as Level)
Chlorine Residual	F & P	17B3201E; Series A-2 Sample Sys.		--	--	None	No	None	--	None	--	No available sample, 90% of the time	Est. ±0.2 ppm	Sampling system; calibrator	Miniature strip chart	Manual residual chlorine titrator (F&P17T1010) used for spot checks by operator. Sampling system included visual flow indication, motorized pump, and strainer.
Note: The following observation was made at two other plants in NYC area, regarding dissolved oxygen measurements.																
Dissolved Oxygen	Ionics (Formerly Union Carbide)			Clean & standardize, 100	4	None	None	None	--	Not established	--	Fouling & drift	Est. ±0.2 in 1-5 ppm range		Miniature strip chart	Comparative test of portables (Yellow Springs, Delta), Ionics, and Weston & Stack (without agitator) showed that Ionics unit was useful to indicate trends only. Success depends on constant salinity, no rags, and PREVENTIVE MAINTENANCE.

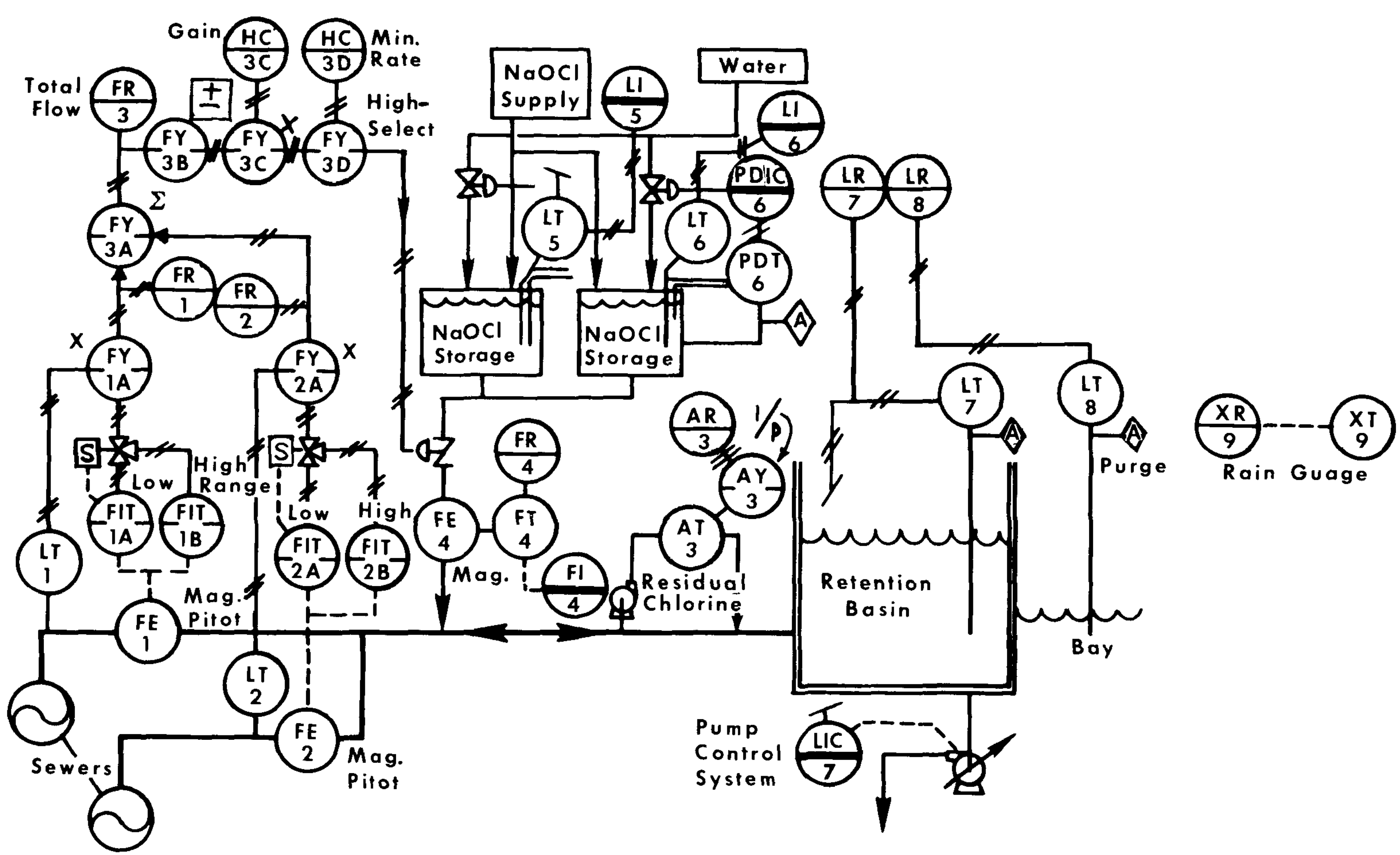
* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW-hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no/mo)	Comments
AT-3	Analysis	1 (open loop)	None	None	Electric	None	0.5	200 (Est.) analyst	0	Est. 20% over unmeasured		Probably at least a four-fold improvement in uniformity of disinfection.	Estimated 10/150hr.*	Estimated 1/month	None	Not established	Not established	Estimated 0.5/150*	Estimated .02	All operations aggravated by long idle periods between storms. *Nominal plant operating time is estimated at 150 hours actual running time per year.
LT-5 LT-6	Dilution of NaOCl concentrate	4	Closed loop ratio	Analog Pne.	Pneumatic	Valve	.02	0	0	--			Estimated 0.5/150hr.	Estimated 0.03/mo.	None	Not established	Not established	Estimated 0.3/150*	Estimated .01	
FE-1 FE-2	Disinfection	1 (open loop)	Open loop ratio	None	Pneumatic	Butterfly valve	.01	400 (Est.) operators	0	Est. 30%			Not established	Estimated 0.5/mo.	None	Not established	Not established	Estimated 3/150*	Estimated .05	

* Control mode relay, proportional, proportional plus reset, etc
** Types of controllers analog (pne, hyd or elec media), computer (supervisory, direct digital or set analog)
*** Final control element pne values, variable speed pump, etc

Figure E-2


Total Flow
FR 3
Gain
HC 3C
HC 3D
Min. Rate
High-Select
FY 3B
FY 3C
FY 3D
FY 3A
Σ
FR 1
FR 2
X
FY 1A
FY 2A
X
S
Low
High Range
FIT 1A
FIT 1B
LT 1
FE 1
Mag. Pitot
S
Low
High
FIT 2A
FIT 2B
LT 2
FE 2
Mag. Pitot
Sewers
NaOCl Supply
LI 5
Water
LI 6
PDIC 6
LT 5
LT 6
PDT 6
A
NaOCl Storage
NaOCl Storage
FR 4
FE 4
FT 4
Mag.
FI 4
AR 3
I/P
AY 3
AT 3
Residual Chlorine
LR 7
LR 8
LT 7
LT 8
A
A
Purge
XR 9
XT 9
Rain Guage
Retention Basin
Bay
Pump Control System
LIC 7

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address E-3

Responsible Supervisor

Flow Rate Design (Average and Maximum) 24 mgd; drains 240 acres

Storm Water Collection and Treatment Yes, plant treats overflow from combined system during wet weather.

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems.) Wet-weather satellite plant: combined overflow chlorinated and subjected to dissolved air flotation with the aid of alum, caustic and polyelectrolytes. Sludge pumped to North Point MWT plant.

Performance Data (Individual Units and Overall) TSS=90% @ 1,000gpd/FT^2; = 15% @ 5,000gpd/FT^2. This data was obtained from Eng. Sci. but Plant Engineer doubts the validity of this information. *No operational data.*

Year Built 1970 Modifications (Year and Description) Corrective measures

Original Cost $2.1X10^6 Modification Cost 1972

Instrumentation

Equipment All-electric instruments and controls, mostly F & P; Flow-control loops; open-loop flow-proportioned chemical addition.

Panels 10-ft. operator console.

Installation and Start-up Costs N/A Original Cost $75,000 Total Cost

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
Changes to correct faults in original design.	1972	Bubble-type level detectors	-		30K
	1972	Automatic samplers. Telemetry	-		

Computer
Type None Manufacturer I/O Devices

Process Control

Data Logging

Parameter/Frequency	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control In-plant (satellite plant only)

Supervisory Control No

Alarm and Safety Systems Equipment status - panel alarms

Automatic Emergency Program (e.g., Power Failure) Stand-by generator for lights and hydraulic gates - no process power

Maintenance and Calibration

Special Equipment Down Time 100%,until needed; can be operated manually.

Special Operator Training Instrument tech. (by contract) Frequency (no./mo.)

Total In-Plant Man Hours/Year

Total Cost of Outside Service

Estimate of Over all Benefits of Instrumentation and Automation Notwithstanding the designers' intention of unmanned operation, automatic start-up and other control devices are not reliable enough for unattended operation of the Baker St. facility. In fact, this facility never automatically responded to overflow events. As a last resort, 3 operators have been assigned to a 24-hr., 3-shift watch during the rainy season (about 6 mo.); operators manually control this plant. With the exception of plant meters, none of the instruments have operated acceptably. Moreover, the plant was not properly maintained. *The plant supervisor doubts the soundness of dissolved air flotation for solving this* plant's operational problems.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Frequency (no /mo)	Total Downtime	Downtime Frequency (no /mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Level	B & W	Conductance probe		180 mhrs/yr.	1/mo.	None						Corrosion & fouling of contacts	Poor	Initiates plant activity	Alarms	Extremely poor reliability
Flow	F & P Mag Meter												Good	Flow-proport. controls		Ultrasonic probe cleaning; yearly zero calibration.

* Corrosion, fouling, etc

** Limiters, alarms, ratio relays.

*** Local and central.

LOOP AND PROCESS CONTROL SURVEY FORM

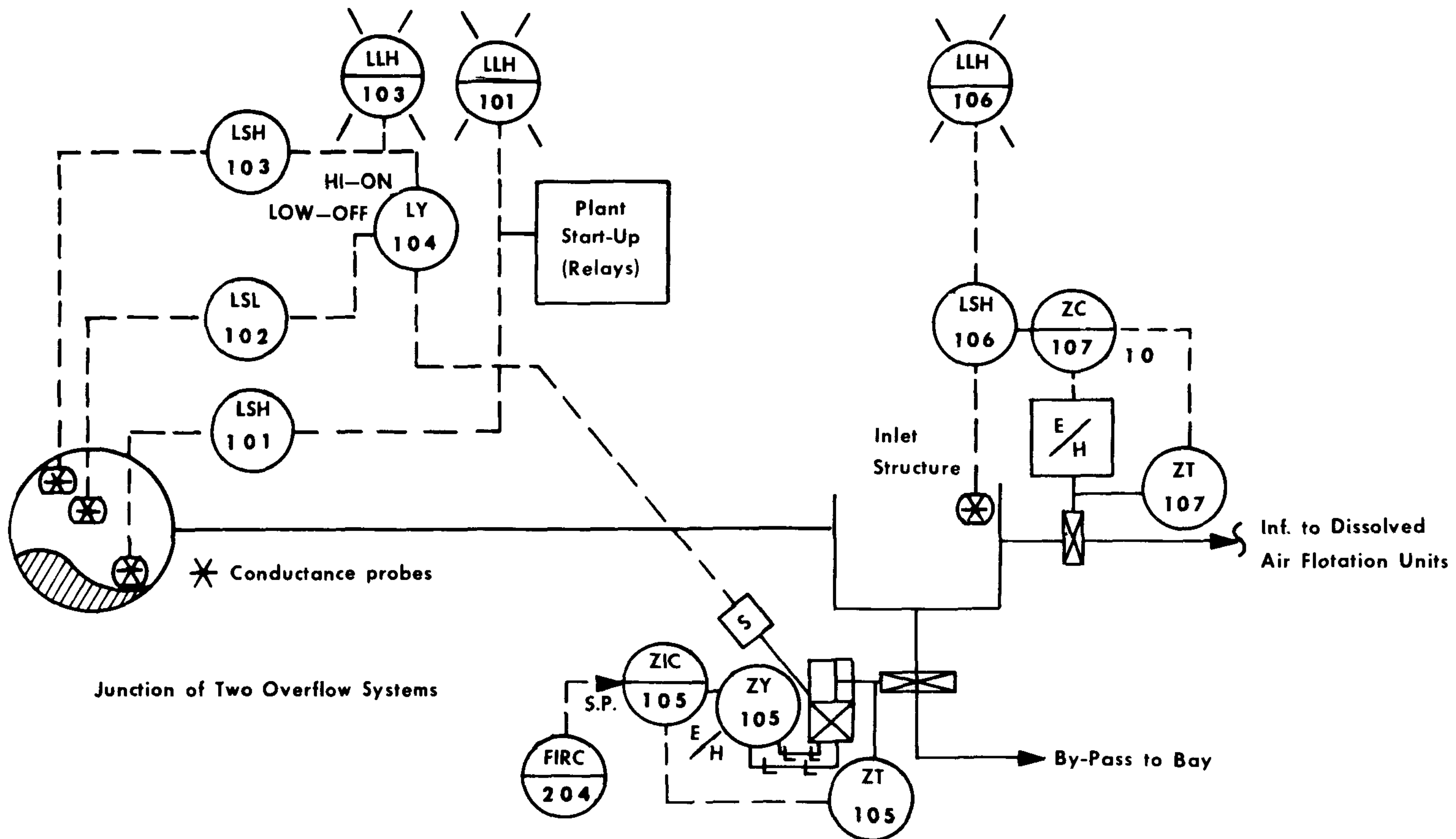
Control Techniques								Benefits					Operating Experience							Comments
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW hr/yr)	Chemical (lbs yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no mo)	
LSH-101	Start-up		Relay	Analog elect.	Elect.	Switches	--	--	--	--	--	--	--	--	--			Abandoned	Always	Plant cannot start-up automatically.
FE-201A FE-201B	By-pass	2	Relay	Analog elect.	Hyd.	Gates	Less than 1 min.													Never tested or used.
FE-201B FE-201A	Chemical addition	4	Flow Proportional	Elect.	Elect.	Variable-speed pump	About 2 min.		NO		INFORMATION		AVAILABLE							Trouble-free operation; but accuracy never tested. In investigator's opinion, chemical costs are reduced about 40-50%.
LSH-106	Flow control	4	Proportional	Elect.	Elect.	Butterfly valve	About 1 min.		NO		INFORMATION		AVAILABLE							Since plant overdesigned, flow control never practiced.

* Control mode relay, proportional, proportional plus reset, etc

** Types of controllers analog (pne, hyd or elec media) computer (supervisory direct digital or set analog)

*** Final control element pne values, variable speed pump, etc.

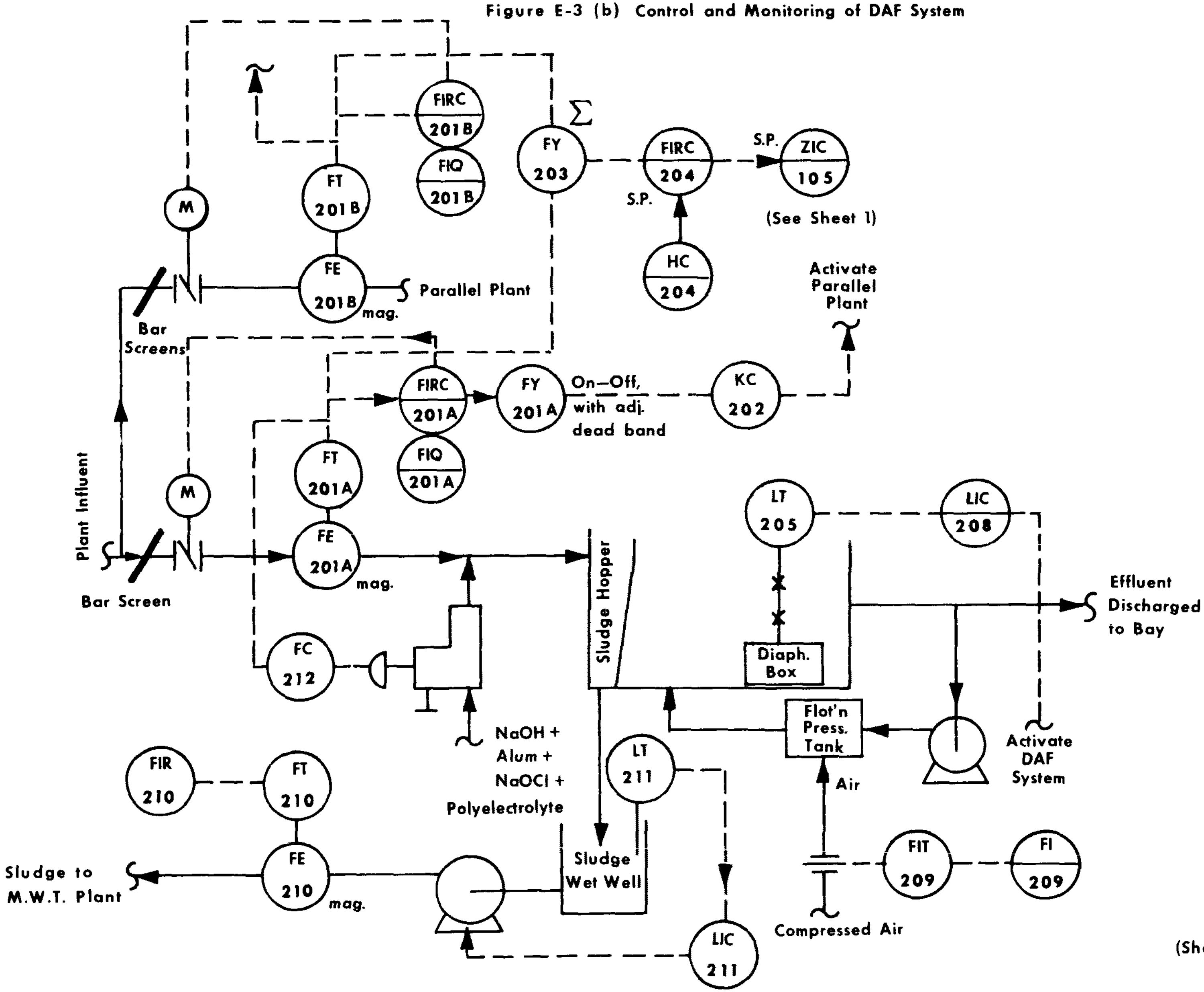
Figure E-3 (a) Control and Monitoring of Influent System



(See Sheet 2)

(Sheet 1 of 2)

Figure E-3 (b) Control and Monitoring of DAF System



(Sheet 2 of 2)

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address E-4

Responsible Supervisor

Flow Rate Design (Average and Maximum) Up to 28 mgd per installation (4), to achieve 0.1 to 2.0 ppm Cl_2 residual

Storm Water Collection and Treatment Sole function - EPA demonstration.

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)

Demonstration stormwater sterilization system; adds hypochlorite to canal at manually controlled rate; measures and records chlorine residual.

Performance Data (Individual Units and Overall)

Year Built 1970 Modifications (Year and Description) Mothballed, 1972 (lack of operating funds)

Original Cost $1.5 Million Modification Cost

Instrumentation Electric analog - see tables and sketch.

Equipment

Panels 1 console, each installation

Installation and Start up Costs Original Cost Total Cost

Instrumentation Modification None

Description	Year	Equipment	Panels	I & S	Total

Computer

Type None Manufacturer I/O Devices

Process Control

Data Logging

Parameter/Frequency	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control Special console in pump house

Supervisory Control No

Alarm and Safety Systems Minimal

Automatic Emergency Program (e g , Power Failure) None

Maintenance and Calibration

Special Equipment Amperometric analyzer Down Time Unknown portion of project's operating time

Special Operator Training None Frequency (no /mo)

Total In-Plant Man Hours/Year 300 per installation

Total Cost of Outside Service None

Estimate of Over all Benefits of Instrumentation and Automation

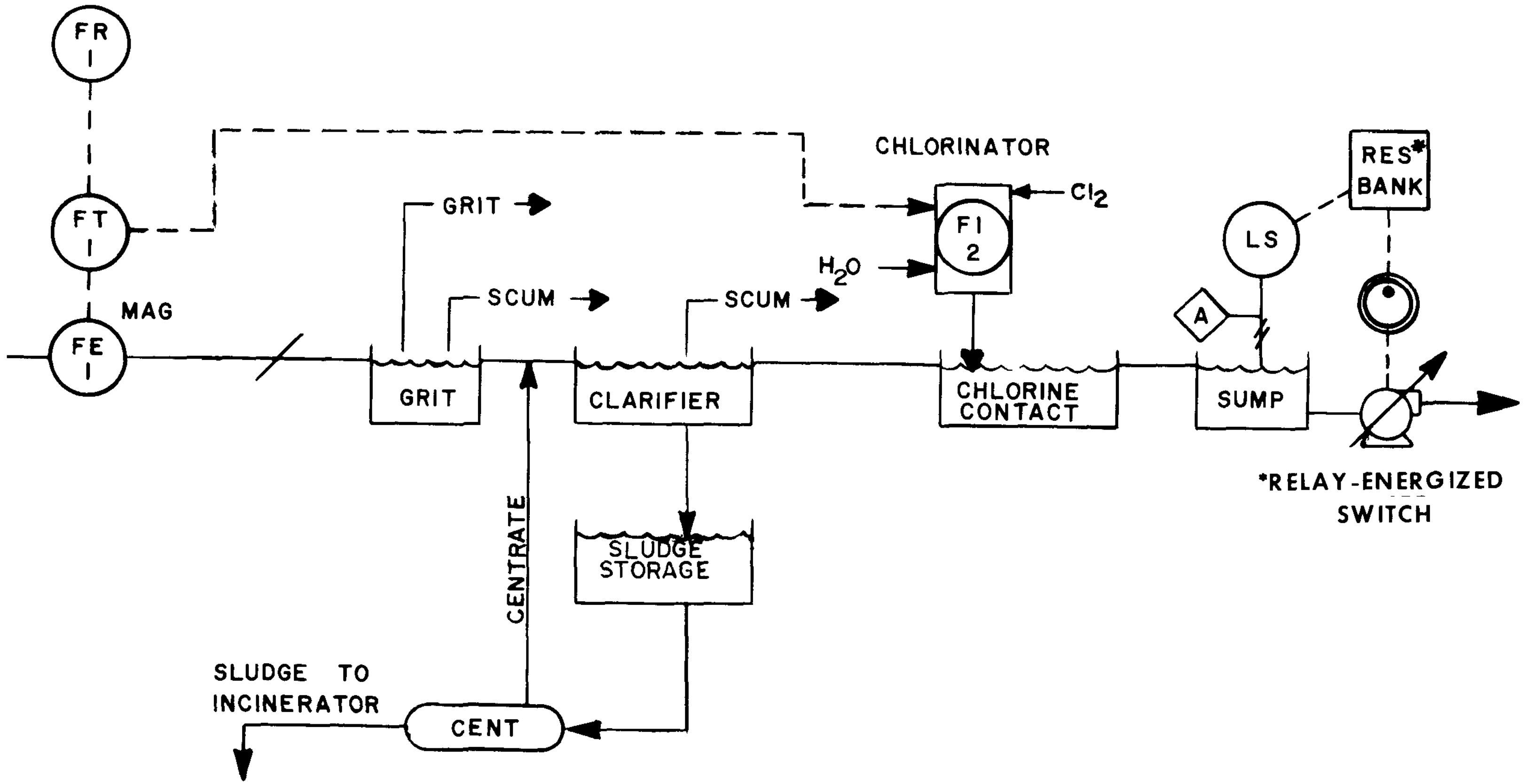
Allowed one man to handle sterilization as well as run pumping operation.
Provided permanent records of treatment and result.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no/mo)	Total Downtime	Downtime Frequency (no/mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Remote control	Ramcon (Elgin, Ill.)			8 Est.	Not over 0.1	No	None	None		None		None	±4% (adequate)	No	No	*Worked well for 2-year service period.*
Chlorine residual	Wallace & Tiernan A780021, NN25789; A780021, PP2438			240 Est.	10 Est.	1 day (Est.) on-site	No	No		10% of running time	Est. 1	Sample and reagent pumps	Good when calibrated	Sample and calibration systems	Yes	Sample pump (Oberdorfer-gear) leaked; sample head in canal occasionally damaged; instrument's reagent pumps failed; instrument drifted, had to be recalibrated often.
Flow	Fischer & Porter (Mag-Meter)			4 Est.	Not over 0.1	No	No	No		None		External corrosion	Good	None	Yes	Very satisfactory.
Level	Local		Not over $50. Installed	10 Est.	0.5	No	No	No	--	Unknown		Mech. wear and corrosion	±2% (adequate)	No	No	Home-made temporary U-tube manometer made from plastic tubing and yardsticks. *Inadequate for anything beyond temporary use.*

* Corrosion, fouling, etc.
** Limiters, alarms, ratio relays.
*** Local and central

Figure E-4 (a)


FR
FT
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H_2O
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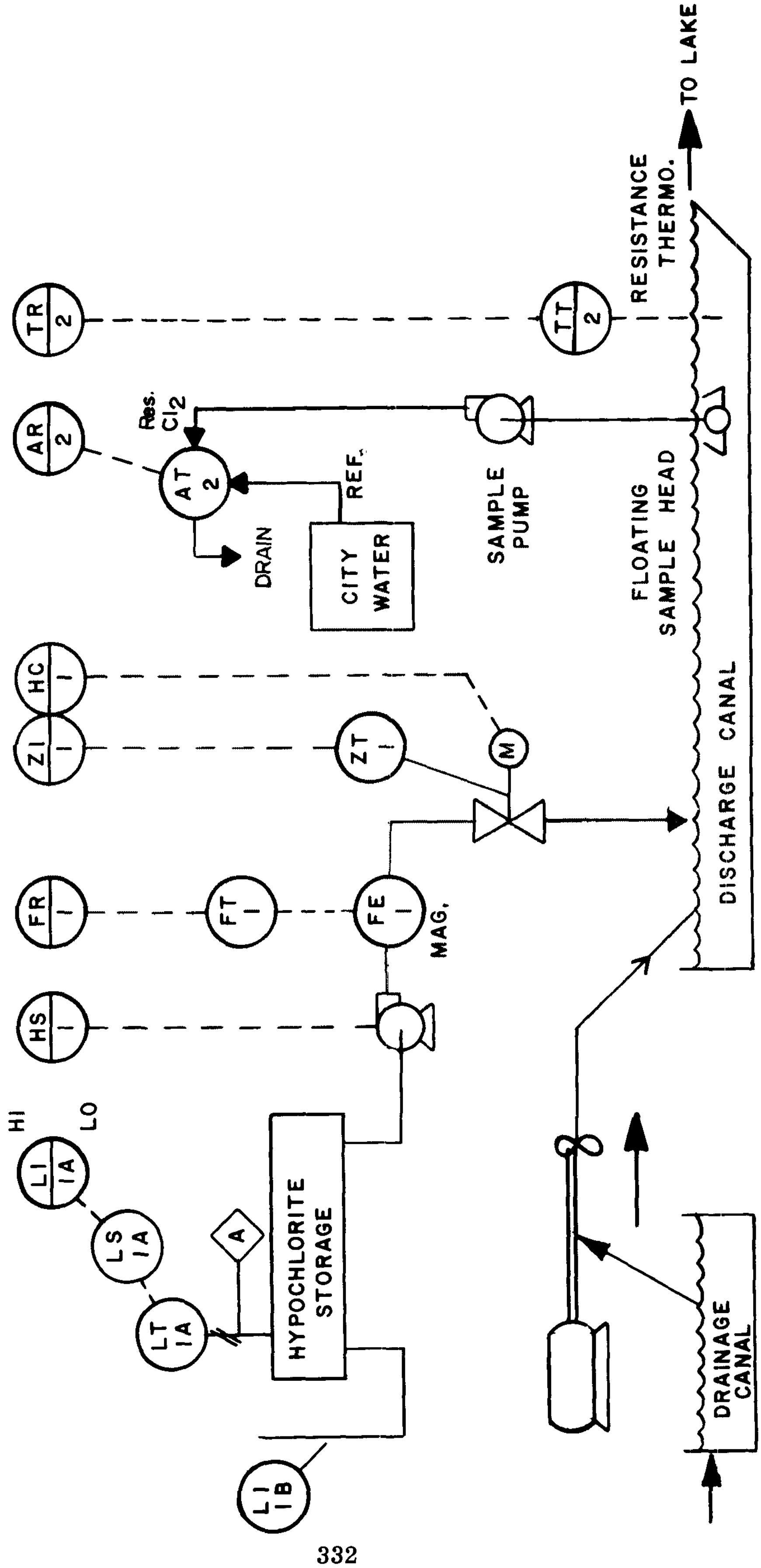
RES* BANK
*RELAY-ENERGIZED SWITCH
CENTRATE
SLUDGE STORAGE
CENT
SLUDGE TO INCINERATOR


LI 1B
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HS 1
FE 1
MAG.
FT 1
FR 1
ZT 1
ZI 1
HC 1
M
DISCHARGE CANAL
DRAINAGE CANAL
CITY WATER
REF.
DRAIN
AT 2
AR 2
Res. Cl2
SAMPLE PUMP
FLOATING SAMPLE HEAD
TT 2
TR 2
RESISTANCE THERMO.
TO LAKE

Figure E-4 (b)

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address F-1

Responsible Supervisor

Flow Rate Design (Average and Maximum) Not applicable

Storm Water Collection and Treatment Combined Sewerage Retention System.

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems.)
Computer-directed system to utilize maximum storage within trunks and interceptors of combined sewerage. The system includes regulator stations, pumping stations, river and sewer quality-monitoring stations, and rain gauges. Central digital computer with telemetry network to remote terminals.

Performance Data (Individual Units and Overall)
Average reduction of overflow volume - 52%.

Year Built
1971 - Installation
1972 - Programming & debugging
1973 - Automatic operation

Modifications (Year and Description)

Original Cost $3.1 Million (1.4 Million EPA Demonstration Grant) Does not include cost of pump stations and regulator.

Modification Cost

Instrumentation

Equipment Electronic (Telemetering over leased telephone lines); some pneumatic and mechanical.

Panels
Central control panel at Metro office.
Sub-panels at two STP's within the controlled area.
Sub-panels at pumping stations, regulators, and quality-monitoring stations.

Installation and Start up Costs 2-man years to tune in equipment. $700,000 for programming.
Original Cost
Total Cost $3.1 Million Philco-Ford Contract and interfacing.

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
Fire Monitoring System	1973				$20,000
Addition of one STP Computer Console	1973	Time sharing computer console	Local sub-panel		$31,000

Computer Sigma II Computer
Type 16-bit word machine
Manufacturer Xerox Data Systems

I/O Devices Cathode Ray tubes. Digital inputs and contact outputs. Peripheral equipment: card punch, card reader, paper tape punch, paper tape reader, line printer, off-line card punch, off-line card verifier, off-line tape preparation unit, plotter, operator's console. Remote treatment plant keyboard input, printed display, telemetering. Remote data collection and log-to-digital converters, multiplex units, telemetering units, etc.

Process Control Speed control of pumps at pumping stations and gates at regulator stations.

Data Logging Extensive data logging of alarms, operating data, and quality data. 2 treatment plants and 35 remote monitoring stations.

Parameter/Frequency	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency
Alarm functions: once every hour logged date, time, where, what. Also repair status. Scanned, 1-min. intervals.	Operating data: once per hour logged date, time, where, what. Levels, flows, set points, gate positions, storage volumes, rainfall, pump speeds, explosion hazard.	Quality data: once per hour logged date, time, where, what, temp. pH, D.O. solar radiation	Control data: At the time of set point adjustments — Date, time, where, what. Effluent level for speed control of pumps. Overflow quantity for operation of regulator gates.

Storage (Cards & 45K core memory; (1.5-million word bulk memory.

Software Description Alarms, operating data gathering; quality data gathering; central console operation; satellite terminal operation, supervisory commanding, events recording.

Remote Treatment Plant Terminal	$25,090
Remote Data Collection Terminal	$43,470
Operator's Console------------	$16,165
Spare Parts-------------------	$33,000

Computer Cost $156,349
Software Cost $147,108
Installation Cost $11,237 (Included in prices, except for installation engineer)
Input-Output Terminals $64,164
Peripheral Equipment $111,268
Telemetering Equipment $238,187

Central Control

Supervisory Control Remote control of influent level adjusts set point signal for automatic speed control of pumps; remote control of overflow quality adjusts set point for automatic operation of regulator gates.

Alarm and Safety Systems Yes

Automatic Emergency Program (e g , Power Failure) System will restart automatically after power failure; no standby power. (may be added later)

Maintenance and Calibration

Special Equipment TCU simulators, oscilloscope, digital voltmeter, photoelectric digital rpm counter, electronic test, pressure gauges, etc.

Down Time Very little

Special Operator Training In-house programs at treatment plants. Instrument training school in Yamamo, Wash. Resident inspectors trained for maintenance by Metropolitan Engineers.

Frequency (no mo) 1 to 2 times per year.

Total In-Plant Man Hours/Year 8,320 man-hours (2 men - full time from each of 2 Divisions) (Total operation and maintenance cost - $200,000 per year)

Total Cost of Outside Service $2,000 per year.

Estimate of Over all Benefits of Instrumentation and Automation
Reduction in pollution from overflows of combined sewerage system.
Eliminated manpower overtime by automatic speed control of pumps.
Quicker response to alarms in order to make repairs.
Uniform flow to sewage treatment plants, thus improving treatment, postponing expansion, and furnishing better information and accumulated data for engineers.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In Plant Maintenance (mh/yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Frequency (no /mo)	Total Downtime	Downtime Frequency (no mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Telemetry	RFL and local phone co., under Philco-Ford Contract	--	w/remote terminals, $300k	4,000	30+	Factory and on-site	$2,000	80 mh	1	About 1%	0.16	Noise and distortion	Good	CRT's, A/D's, D/A's, consols, multiplexers.	Local, with central cards, tapes, graphs	RF noise is a problem in transmission; spurious commands have occurred from noise bursts. Filters, capacitors and shields only partially successful. Frequency-shift type, telemetered, supervisory system to augment auxiliary control units gave good performance, but noise still a problem. Original 3 scans in 45 seconds doubled (to 6 in 45), but slowness is unwieldy; some false alarms still occur.
Sluice gate position	Limitorque actuator, modified (see below)	--	--	Minor	Minor	None	None	"	"	"	"	"	+ 5%	--	Analog and remote digital	Transmitting slidewire and anti-blacklash gearing installed by plant personnel. Measures actuator, not gate, but is quite satisfactory except for minor slope and poor resolution.
Water level	Foxboro bubbler and level (dP) trans.	d/P cell	--	Minor	Minor	None	None	"	"	"	"	"	Good	Air meters, blow-down valves	Analog and remote digital	The system works well in about 20 stations, all self-controlling; some capable of remote supervisory control via CATAD System with fail-safe backup.
Stream monitors	(T, Cond., D.O. & pH) Esterline-Angus and Sirco	E.A.: 6704 Sirco: ST-vs/45 &/46	--	1500 mh at pump stations & regulators. Minor	30+ (pH, Cond.; T req. 9)	None	None	"	"	Very large	Frequent	Pump couplings, line plugs, humid., ice, dirt	Question-able	Alarms, indicators, telemeters	Local analog; remote digital storage	Turbid. sensor installed, not used. Probes (especially D.O.) require frequent cleaning. Algae and solids caused problems. *Membrane-type D.O.* probes.
Rainfall	Weather measure and local (Tilting-bucket) rain gauge	--	$150 + (Gauge only) --	Minor	Minor	None	None	"	"	7 hrs/yr.	0.16	Utility power failures	Good	Contacts, *photo-coupler*, clock, etc.	Tape recorder, translator, computer	Information also telemetered. Photo-coupler driven by bucket contacts resolved noise problem.

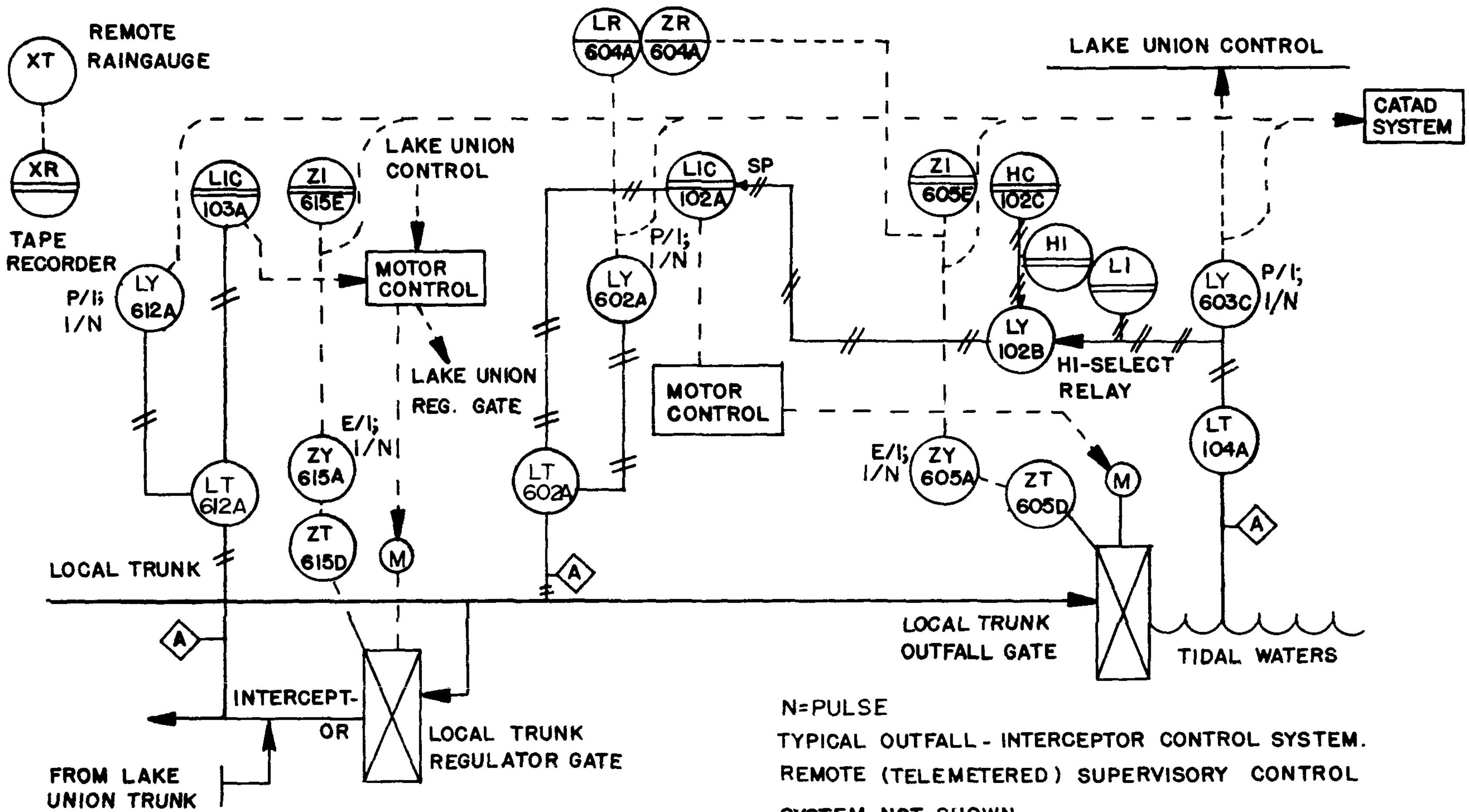
* Corrosion, fouling, etc
** Limiters, alarms, ratio relays.
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In-Plant Personnel ($ or mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no./mo.)	Comments
Control Techniques								Benefits: Annual Cost Savings			Benefits: Process Improvement		Operating Experience							
LT-602A	Gravity flow	1	Proportional plus Reset	Pneumatic analog plus computer. Supervisory control of set point.	Pneumatic-electric	Variable-speed pump	1/2	8,760	Some	None	Yes; more flow	Not applicable	120 mh	0.5	In-house and factory for maintenance personnel.	None	None	None	None	Typical pump system; works very well. There are 19 pumping stations within the system; all are similar but differ in details.
LT-612A	Gravity flow	2	Proportional plus Peset		Pneumatic-electric	Sluice gate opening	1	4,380	None	None	Yes; by diverting to treatment	Not applicable	30 mh	0.16		None	None	None	None	Typical gate system; works very well. There are 15 regulator stations within the system; all are similar but differ in details.
																				NOTE: Pneumatic instruments were converted to electronic, starting in 1968, to be compatible with CATAD system (especially telemetry) and avoid excessive air consumption.
																				System designers feel that pneumatic instruments (from a few, highly reputable manufacturers) are more reliable than electronic inst's., where manufacturers are apt to be less qualified.
	METRO area wastewater	34+	Remote Supervisory	Digital telemetry	Pulse to electric	Sluices or variable-speed pumps	2	200,000±	Some	None	52% annual decrease by bypassing	--	4,000±	Est. 20	Extensive	35K/yr. with Philco-Ford	(Infrequent, included above)	10	0.3	System not yet fully engaged, but it successfully monitors, controls, collects data. Scheduled to be fully on-line, mid-'73, with final report in August, 1973.

* Control mode relay, proportional, proportional plus reset, etc
** Types of controllers analog (pne, hyd or elec media), computer (supervisory, direct digital or set analog)
*** Final control element pne values, variable speed pump, etc

FIGURE F-1



N=PULSE

TYPICAL OUTFALL - INTERCEPTOR CONTROL SYSTEM.

REMOTE (TELEMETERED) SUPERVISORY CONTROL SYSTEM NOT SHOWN.

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address F-2

Responsible Supervisor

Flow Rate Design (Average and Maximum) Wastewater: 750 mgd DWF; up to 12 mgd in storms

Storm Water Collection and Treatment No. Water and wastewater system monitoring

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Central monitoring and control station for metropolitan sewage system monitors rainfalls, sewer levels, pumps, overflows, and pump stations; controls pumps, sluice gates.

Performance Data (Individual Units and Overall)

General reduction in manpower and in overflows to the river.

Year Built 1969-1970 Modifications (Year and Description) 1972-1973, Replaced computer; extended system to control more locations.

Original Cost $2.1M Modification Cost $1.5M

Instrumentation Level cells, rain gauges, proximity switches, electrodes, transmitters, scanners.

Equipment

Panels One, central (by Quindar)

Installation and Start up Costs Original Cost Total Cost

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
Modified computer	Under construction		Control Data SC-1700; Hazeltine CRT, Disc Data Logging (2.4M word)		

New emergency system will allow local stations to override remote control on communications failure.

Computer
Type PDP-8 (being replaced) Manufacturer Digital Equip. Corp. I O Devices Input - FSK telemetry and teletype; Output - Teletype, alarms, and analog recorders

Process Control

Data Logging

Parameter Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency
Levels, every 5 minutes	Rainfall, every 5 minutes	Status - on occurrence	Functional scan — continuous

Storage 4K in core, 32K on disc.

Software Description Scaling, alarms, logging

Computer Cost $118K (Total) Software Cost -- Installation Cost --

Central Control At downtown Water Board Building

Supervisory Control Remote control of pumps and sluice gates.

Alarm and Safety Systems High-low and trend alarms, plus alarms from functional scanner.

Automatic Emergency Program (e g , Power Failure) None

Maintenance and Calibration Automatic checks for time and tone.

Special Equipment Scanner tester, telemeter tester, etc. Down Time 25% (9-month CPU outage)

Special Operator Training 2 2-week courses (Quindar, Acco) Frequency (no /mo) 0.2%, otherwise

Total In Plant Man Hours Year 4,000

Total Cost of Outside Service Some - varies

Estimate of Over-all Benefits of Instrumentation and Automation
Major benefit is in manpower savings. Decided reduction in overflows. Demonstrated feasibility of centralized monitoring and control.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no /mo)	Total Downtime	Downtime Frequency (no /mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Sewer levels	Bristol Company Press. Trans. / Home-made Diaph. Box	Bristol Metameter Series	$550 each	None	0.17		None	None	None	Insignificant	None	Occasional replacement of timing motors.	±0.1 ft.		Bristol (Strip chart series)	Pulse-duration transmission.
Rainfall	Belfort Instrument Company (Tipping Bucket)		$1,500 each	None	0.17	One two-week course on Bristol equipment and one two-week course on Quindar equipment	None	None	None	Insignificant	None	Some premature signals due to wind.	Accurate for operations only ±.04"		No	Line noise degrades output. Heaters with thermostats being installed.
Gate & dam status	Honeywell Proximity Sensors; B & W Controller Corporation ~~Electrodes~~		$150 & $25 / $1,000 installed	None	0.17		None	None	None	None	None	Some fouling of electrodes	N/A	Telemeter system	No	
Function scanners	Quindar Multiplexer	QSR-R-X	$3010 each		4		None	None	None	1 day/mo.	1	Slight	N/A	Alarm-system output	No	
Signal transmitters	Quindar (Pulse duration, analog, and on-off)	QT-17 QT-10 (AM Keying)	$660 each	2000 mh (2-3 mh/unit)	4		None	None	None	Insignificant	Insignificant	Some failure of mercury switches	± 1% on analog. Poor for on-off	Dry-contact interposing relays	No	Min. downtime due to rapid card replacement.

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays.
*** Local and central.

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							Comments
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh yr)	Utility (kW hr yr)	Chemical (lbs yr)	Increase Removal (%)	Parameter Variance min max (mg l)	Maintenance & Calibration by In Plant Personnel ($ or mh yr)	Maintenance Frequency (no mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh yr)	Downtime (hrs yr)	Downtime Frequency (no mo)	
	Pumps and sluice gates	Approx. 15 open loops	Switch on control panel	Manual	Starter, (Hyd. or elec.)	Pump, hyd. system, or motor	3 min., pumps; 12 min., sluice gates	80,000	Reduced heat and light for seven stations	N/A	N/A	N/A	30,000 mh	0.16	None	None	None	--	--	7 pump stations, 5 gate stations; system highly successful.

* Control mode relay, proportional, proportional plus reset, etc
** Types of controllers analog (pne , hyd or elec media), computer (supervisory, direct digital or set analog)
*** Final control element pne values, variable speed pump, etc

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GENERAL SURVEY QUESTIONNAIRE

STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address F-3

Responsible Supervisor

Flow Rate Design (Average and Maximum)

Storm Water Collection and Treatment

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)

Rain gauge network and movable level transmitters are used to gather data on various parts of the city.

Performance Data (Individual Units and Overall)

Data collection only, for off-site reduction and refinement of $140 K run-off model.

Year Built — Modifications (Year and Description)

Original Cost — Modification Cost

Instrumentation

Equipment Raingauges, level transmitters, telemetry system, and cata-gathering computer.

Panels No

Installation and Start-up Costs — Original Cost — Total Cost

Instrumentation Modification Minor

Description	Year	Equipment	Panels	I & S	Total

Computer

Type. — Manufacturer GE-PAC-30 — I/O Devices 0-5V, via variable tone (Quindar). Punched tape output, plus optional teletype.

Process Control No.

Data Logging:

	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency
12 rain gauges 12 sewer levels	Rainfall; Once every 45 seconds	Sewer Level (fair weather): 1 per hour	Sewer Level (storms): 6 per hour	Rainfall trip point: 0.45"

Storage: 8 K

Software Description Developed on-site for $100 K hydrograph model by Watermation (Batelle)

Computer Cost — Software Cost — Installation Cost

Central Control No

Supervisory Control No

Alarm and Safety Systems No

Automatic Emergency Program (e g , Power Failure) None

Maintenance and Calibration

Special Equipment Elect. & pneu. (for bubblers) — Down Time None

Special Operator Training No — Frequency (no /mo)

Total In-Plant Man Hours/Year Est. $1,000

Total Cost of Outside Service Est. $2,000

Estimate of Over-all Benefits of Instrumentation and Automation

Provides accurate hydrographs, checks on storm-drain capacities, helps upgrade model of area.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no/mo.)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no/mo)	Total Downtime	Downtime Frequency (no/mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Data	GE computer	GE-PAC 30		None	--	No	Yes	No	2	None	--	Few (Contract Maint.)	High	FM Rec., tape punch	Teletype #35 and tape recorder	Programmed in assembly language to scan, condition, and record rain and sewer levels vs. time. Output typed and plotted on TT, tape stored as reference. Purpose of computer is to prepare conditioned data.
Sewer level	Home-made bubbler system			6 each (12 units)	0.5 (calibrate)	No	No	No	--	None	--	Mostly in phone lines	1.4%	P.S.; FM trans.; air supply; timed purge.	No	Pressure converted to level by straight-line plot for each installation in computer program. Portable, temporary bubbler system.
Rainfall	Belfort (Weighing type)			20 each (12 units)	1 to 4 (to empty bucket)	No	No	No	--	None	--		2%	Pwr. Sup.; FM Trans.	No	Rainfall measured as accumulated weight in bucket.

* Corrosion, fouling, etc.
** Limiters, alarms, ratio relays.
*** Local and central

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address F-2

Responsible Supervisor

Flow Rate Design (Average and Maximum)

Storm Water Collection and Treatment See EPA 11020 FAW 03/71 - "Dispatching System for Control of Combined Sewer Losses."

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Collects data on rainfall, sewer levels, river quality and gate positions; controls sewer regulators and dams; collects data on alarms. Also performs off-line computations, prepares graphs, etc.

Performance Data (Individual Units and Overall)
Reduced run-off to the river by 51%

Year Built 1969 Modifications (Year and Description)

Original Cost $1.7M Modification Cost

Instrumentation

Equipment Raingauges, level transmitters, regulators, and "Fabridams"

Panels No

Installation and Start up Costs Original Cost Total Cost

Instrumentation Modification Continuing improvements.

Description Year Equipment Panels I & S Total

DEC mag. tape preferred to disc as more trouble-free, more flexible.

Computer

Type PDP-9 Manufacturer Digital Equip. Corp. I O Devices Paper tape reader and punch; numbers 33 and 35 teletypes; line printer; magnetic disc and tape systems; analog recorders.

Process Control

Data Logging

Parameter Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency
Rainfall: 1 per hr. (dry) 12 per hr. (rain)	Levels and dams: 1 per hr. (dry)	Control: Manual	Fabridam Pressures: 1 per 3 hrs. (fair or rain)

Storage 24K words in core
2.5M words on discs

Software Description Fortran and assembly

Computer Cost Software Cost Installation Cost

Central Control

Supervisory Control At main treatment plant

Alarm and Safety Systems No

Automatic Emergency Program (e g Power Failure) No

Maintenance and Calibration

Special Equipment Routine elect. and pneumatic. Down Time 8.5% (1 mo. in 1 year)

Special Operator Training No Frequency (no mo) 0.1

Total In-Plant Man Hours/Year 6,000

Total Cost of Outside Service Est. $3K

Estimate of Over-all Benefits of Instrumentation and Automation

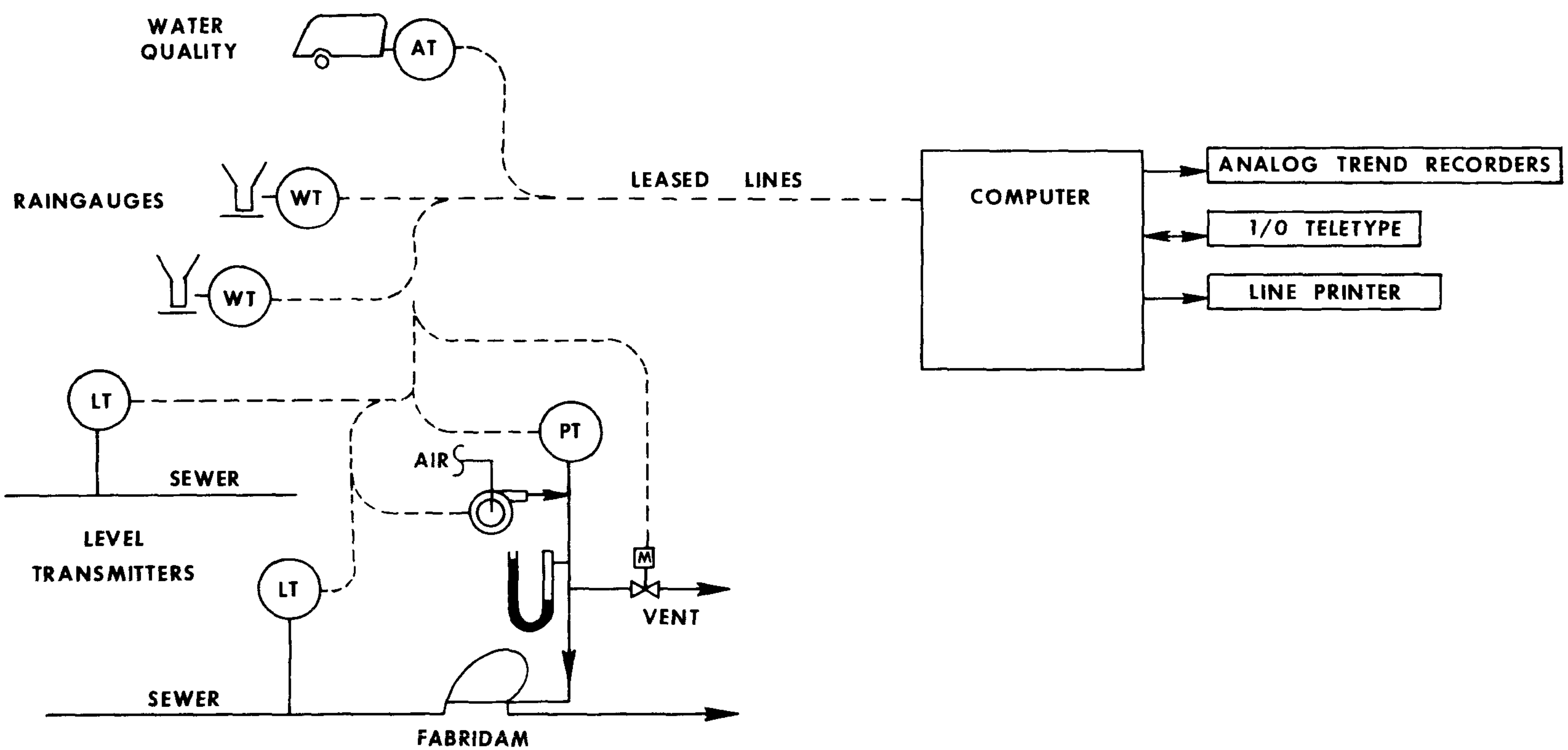
Reduced run-off to river ($1.75M investment equivalent to $200M plant).
Produced workable hydrograph model for area.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In Plant Maintenance (mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no/mo)	Total Downtime	Downtime Frequency (no/mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Inflatable dam	Firestone	"Fabridam"		400 each	0.16	No	No	No	--	0.02	0.002	None	--	Air source, safeties, etc.	No	Very good, corrosion-resistant, inexpensive, on-off weir.
River quality	Fairchild (Beckman D.O. probes)			120 per st'n	8 (in summer)	No	No	No	--	High	High	Pumps and calibration: see below	Fair	Sampling system	No	Works fairly well on river water when maintained. D.O., pH, temp., and conductivity o.k.; chlorine and ORP N.G.
Sewer level	Robertshaw (P/I transducers)	Microsen Model 115		8	0.3	No	No	No	--	4	.05	None	1%	Bubbler system	No	Very reliable system.
Rainfall	Belfort, w/Bourns Potentio-meter	5915		Est. 20	0.16	No	No	No	--	8	.1	Delicate potentio-meter	2%	Fuses	No	
Telemetry	Badger/ Noller and 'Phone Co.			240 mh x 25 sites	Est. 2 (varies)	No	No	No	--	Est. 5%	Unknown	Spare parts, 'phone lines.	Adequate when maintained	--	--	Crew monitors system continuously. Main problem is leased line quality (noise).

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

FIGURE F-4.


WATER
QUALITY
AT
RAINGAUGES
WT
WT
LEASED LINES
COMPUTER
ANALOG TREND RECORDERS
1/0 TELETYPE
LINE PRINTER
LT
SEWER
LEVEL
TRANSMITTERS
LT
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AIR
M
VENT
SEWER
FABRIDAM

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GENERAL SURVEY QUESTIONNAIRE

STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address

Responsible Supervisor

Flow Rate Design (Average and Maximum) 250 mgd av., 600 max.

Storm Water Collection and Treatment No

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)

System monitors and totalizes sewage flow into the area.

Performance Data (Individual Units and Overall)

3 to 5% overall accuracy achieved for billing purposes.

Year Built 1970 Modifications (Year and Description)

Original Cost Modification Cost

Instrumentation

Equipment Local flow transmitters, telemetry system, computer

Panels No

Installation and Start up Costs Original Cost Total Cost

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total

Computer
Type MH 316 (CSI-2000) Manufacturer Control Systems Industries I/O Devices Data Concentrators (Telemetry) Data storage disc ASR 33 Teletype

Process Control No

Data Logging (15-second pulses received by computer as priority interrupts).

Parameter/Frequency	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency

Storage 16 K words in core
756 K words in each disc

Software Description
Assembly language, with diagnostic routines, off-line capabilities.

Computer Cost Software Cost Installation Cost
$350K

Central Control No

Supervisory Control

Alarm and Safety Systems

Automatic Emergency Program (e.g., Power Failure) None

Maintenance and Calibration

Special Equipment Down Time 22 days in first year

Special Operator Training Frequency (no mo) 0.5

Total In Plant Man Hours Year

Total Cost of Outside Service Still on warranty

Estimate of Over all Benefits of Instrumentation and Automation

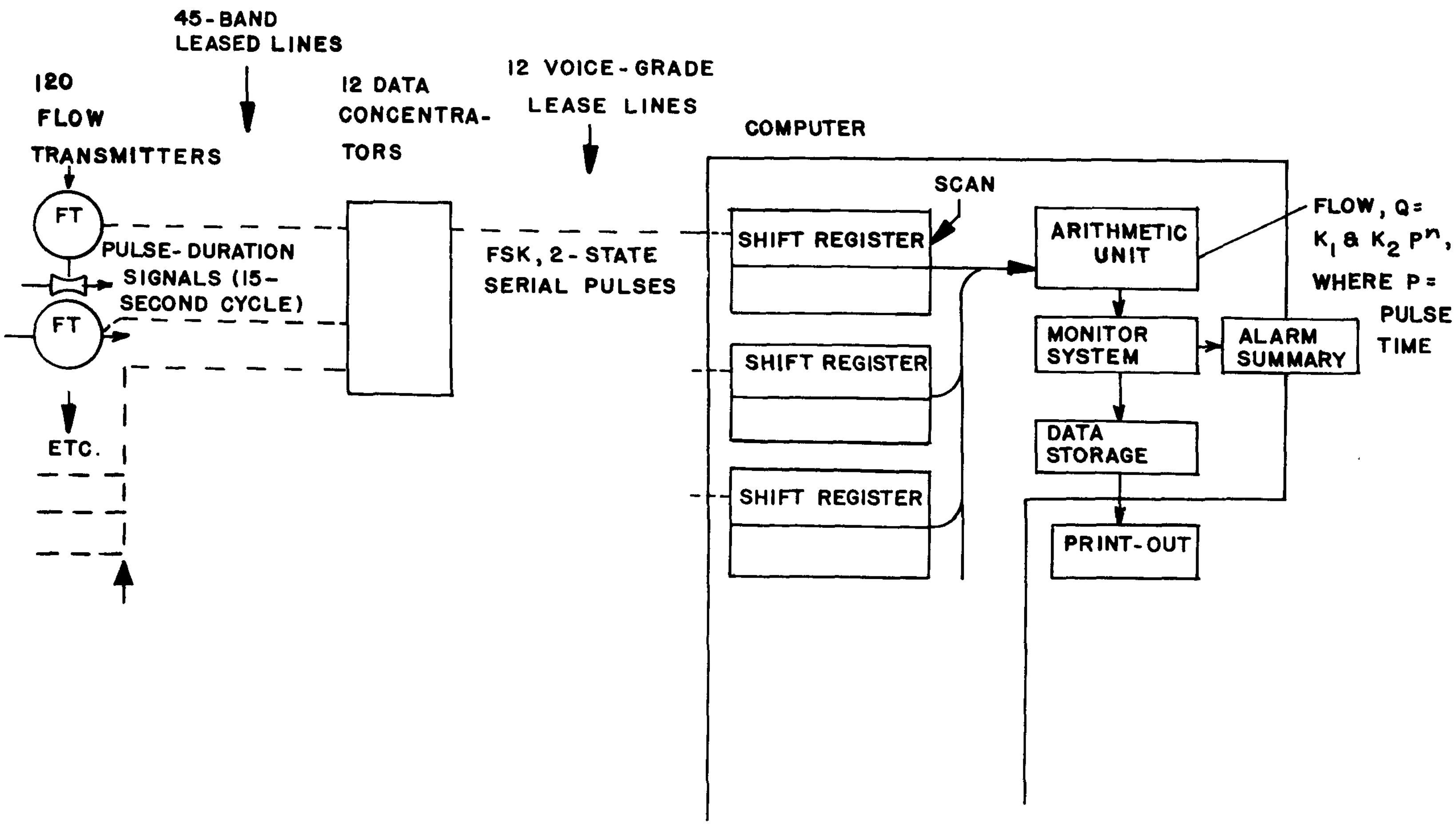
Automatically and accurately collects area sewage-flow data for billing outlying areas.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		Comments
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no./mo.)	Total Downtime	Downtime Frequency (no./mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	
Printout	Teletype	ASR 33 ASR 35		No	--	No	Est. 50 mh	Available	2	None	--	Maintenance	High		--	
Data Storage	Disc			30	1	No	Yes	Available	0.25	2 days (first yr.)	0.25	Few	High		--	One disc used on-line; other disc stores data, is removed annually
Computer	Control Systems Industries	MH 316		No	--	Yes	Yes	Available	0.16	20 days (first yr.)	0.16	Few	High		--	
Multiplexing	LFE (Control Systems Div.), Data Concentrators			--	--	No	No	No	--	None	--	Leased line quality	Good		--	
Flow	Venturi's, Mag. meters Kennison Nozzles			--	--	No	No	No	--	Little or none	--	Mag. meters foul on raw sewage	3-5%		--	Typical flow transmitters are reliable, not too accurate.

* Corrosion, fouling, etc.
** Limiters, alarms, ratio relays.
*** Local and central

FIGURE F-5.


120
FLOW
TRANSMITTERS
45-BAND
LEASED LINES
12 DATA
CONCENTRA-
TORS
12 VOICE-GRADE
LEASE LINES
COMPUTER
SCAN
FT
FT
PULSE-DURATION
SIGNALS (15-
SECOND CYCLE)
ETC.
FSK, 2-STATE
SERIAL PULSES
SHIFT REGISTER
SHIFT REGISTER
SHIFT REGISTER
ARITHMETIC
UNIT
MONITOR
SYSTEM
ALARM
SUMMARY
DATA
STORAGE
PRINT-OUT
FLOW, Q=
K_1 & K_2 P^n,
WHERE P=
PULSE
TIME

GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address G-1

Responsible Supervisor

Flow Rate Design (Average and Maximum) 450 gpm (Avg.)

Storm Water Collection and Treatment Treats Combined Storm Water from 11-acre site at a Pilot Test Plant.

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Pilot Plant for treating combined stormwater by microstraining and chlorination.

Performance Data (Individual Units and Overall) 2 Study Phases have been conducted for EPA. Unit has reduced Sus. Solids from 80 to 40 mg/l, and from 700 mg/l to 10 mg/l (performance of this facility is heavily dependent upon the nature of the influent.)

Year Built 1968 Modifications (Year and Description)

Original Cost $120,000 Modification Cost

Instrumentation

Equipment Pneumatic

Panels Instruments are installed on do-it-yourself type of plywood panels.

Installation and Start-up Costs Original Cost $6,000 Total Cost

---

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
Honeywell to Bristol	1971	Circular charts to strip charts	-	-	$4,000

Computer

Type None Manufacturer I O Devices

Process Control

Data Logging

Parameter/Frequency	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost Software Cost Installation Cost

Central Control 1) Rise in stream level actuates pumps, microstrainer motor, sampling units.

Supervisory Control 2) Difference in pressure across microstrainer controls microstrainer speed.

Alarm and Safety Systems Signal sent to main municipal STP.

Automatic Emergency Program (e g , Power Failure) None

Maintenance and Calibration None

Special Equipment Down Time

Special Operator Training Frequency (no mo)

Total In-Plant Man Hours/Year

Total Cost of Outside Service

Estimate of Over all Benefits of Instrumentation and Automation

Essential - impossible to do without instrumentation.
High-speed strip charts (8"/hr.) produce better short-term results than circular charts.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no./mo.)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no./mo.)	Total Downtime	Downtime Frequency (no./mo.)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Level	Bristol: Stripchart Recorder and transmitter	(Bubbler tube)	$2,000	--	(Maintenance Frequency is approximate) 4/mo. when pilot plant is being used.	None	--	--	--	(Whenever Facility is	not being used)	Pneumatic system is not good for installations that do not operate continuously. Maintenance of compressor is frequent.	Good	(See Comments)	Strip charg	Rise in level actuates influent pumps, microstrainer and sampler. Alarm signal sent to main municipal STP to indicate that microstrainer is in operation.
Head loss thru micro-strainer	Honeywell: dP transmitter and recording controller	DPT-369296-1 Rec-702X26014 (Bubbler)		--		None	--	--	--				Good		2-pen circ. chart	Differential pressure governs microstrainer drum speed. Recorder: 1) differential pressure 2) drum speed
Flow meters	Penn: Venturis	--		--		None	--	--	--				Good	None	Round & strip chart	
Flow	Bristol: Venturis and strip-chart recorders.	--				None	--	--	--				Good	--	--	
Flow	Honeywell: Venturis and round-chart recorders.	22XIC2 dP trans.				None	--	--	--				Good	--	--	

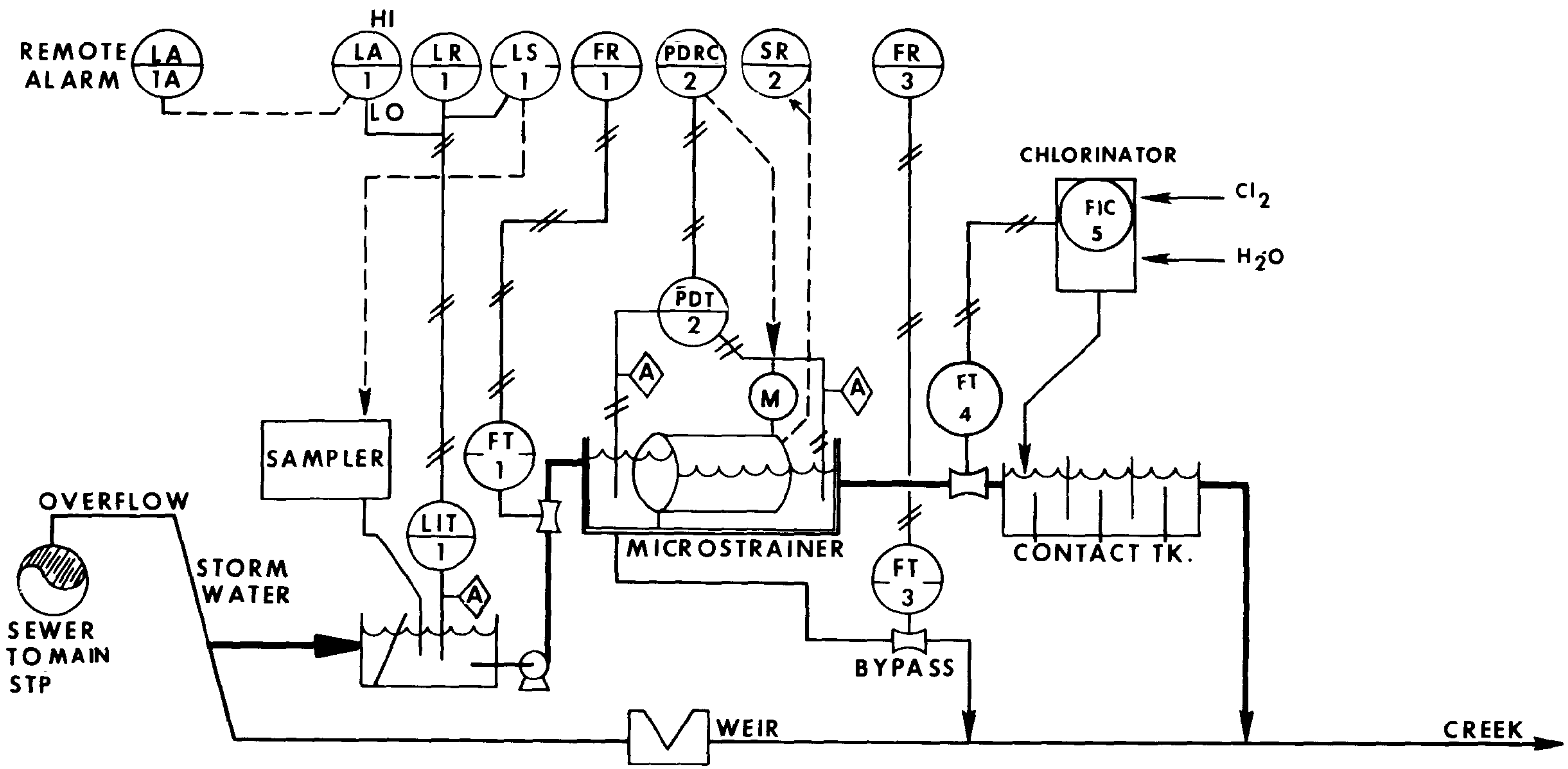
* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no mo)	Comments
PDT-2	Micro-strainer speed	1	Proportional	Pneumatic analog	Electric	Varispeed drive	less than 1 min.	--	--	--	See note	See note	30 mh/yr.	4/mo. (when used)	None	No	No	--	--	Speed control essential to effective operation. Performance good for pilot-plant service in which used.
																				NOTE: Pneumatic system unsatisfactory, mostly because dirty air accentuated problems with intermittent use.

* *Control mode*   *relay, proportional, proportional plus reset, etc*
** Types of controllers analog (pne , hyd. or elec media), computer (supervisory direct digital or set analog)
*** Final control element pne values, variable speed pump, etc.

Figure G-1 (MICROSTRAINER INSTALLATION)



GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Facility Ownership and Address G-2

Responsible Supervisor

Flow Rate Design (Average and Maximum) 100,000 gpd

Storm Water Collection and Treatment None

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems.)

Pilot Plant with complete physical chemical and completely mixed actived sludge capabilities.

Performance Data (Individual Units and Overall)

Year Built

Modifications (Year and Description)

Original Cost

Modification Cost

Instrumentation pH, D.O., magnetic flow meters, NH_3 & PO_4 analyzers, free residual chlorine, total residual chlorine.

Equipment Alarms, status indicators

Panels Central control for physical chemical plant; no control panel for biological system.

Installation and Start up Costs: Original Cost Total Cost

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total

Computer Mini-Process computer

Type IBM System/7 Manufacturer IBM I/O Devices Teletype and magnetic tape cassette

Process Control Yes

Data Logging Yes

Parameter/Frequency	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency
(development in progress)			

Storage None

Software Description Chemical control algorithms

Computer Cost $100K Software Cost $75K Installation Cost

Central Control Yes; one panel for P.C. treatment (no panel for biological treatment).

Supervisory Control

Alarm and Safety Systems

Automatic Emergency Program (e.g., Power Failure) None

Maintenance and Calibration

Special Equipment Full pneumatic and analytical instr. shop Down Time

Special Operator Training Instrument Engineer and Technician Frequency (no. mo.)

Total In Plant Man Hours/Year 4,000

Total Cost of Outside Service

Estimate of Over-all Benefits of Instrumentation and Automation

The automatic control and instrumentation of Physical Chemical treatment permits close control and supervision over the routine chemical processes; process control is absolutely essential for breakpoint chlorination. Next year's plans call for automating the biological processes.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Frequency (no/mo)	Total Downtime	Downtime Frequency (no/mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
pH	Uni-Loc	1000	$1,000	50 mh/yr.	Once every 3 days	None	--	--	--	Cleaning time only	--	Leaking submersion assembly	$\pm$0.1 pH		Strip chart	Uni-lock was the only analyzer that performed satisfactorily at high pH's (i.e., > 11).
Flow	Brooks (Mag. flow meter)	7200 short form	$1,000	50 mh/yr.	4/mo	Instr. tech.	--	--	--	--	--	Leaking cases	$\pm$2%		Strip chart	Ultrasonic cleaner necessary for good operation on sludge and raw wastewater.
NH_3	Technicon	Monitor IV	$7,500	Very high: 500 mh/yr.	Daily	Instr. tech.	--	--	--	--	--	Plugging; corrosion	$\pm$1%		Strip chart	Technicons are designed for laboratory use, not for process application. Successful operation demands continuous maintenance by trained personnel. Output signal not suitable for analog control because of non-linearities.
Free Cl_2	Technicon															Same as Technicon's NH_3 analyzer. Technicon does not sell their free chlorine analyzer to the general market.
NO_3	Technicon															Same as Technicon's NH_3 analyzer.
PO_4	Technicon															Same as Technicon's NH_3 analyzer.
DO	Beckman	--	$735	50 mh/yr.	4/mo.	None	--	--	--			Poor accuracy; poor reliability.	$\pm$10%		Strip chart	Because of poor reliability, the Beckman analyzers were abandoned.

* Corrosion, fouling, etc.
** Limiters, alarms, ratio relays.
*** Local and central

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Frequency (no/mo)	Total Downtime	Downtime Frequency (no/mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
D.O.	Delta	--	$900	24 mh/yr.	2/mo.	None	--	--	--	Rare	--	None	0.5 mg/1		Strip chart recorders	
Sludge density	Ohmart		$3,000	*	*	AEC license	--	--	--	(Abandoned)	--	Poor reliability	Poor		Strip chart recorders	* Sludge density meter abandoned because of poor reliability and accuracy. Additionally, recalibration was very time-consuming.
Free chlorine	F & P	--	$3,000	90 mh/yr.	4/month	Instrument technician	--	--	--	40 hours	1/yr.	Occasional plugging	Fair ($\pm$1.5 mg/1)		Strip chart recorders	
Turbidity	Hach	1032	$1,000	180 mh/yr.	Daily	None	--	--	--			Clogging	Question-able			Difficult to calibrate the Hach falling stream turbidity meter. Additionally, the choice of available turbidity ranges is somewhat unsuitable for AWT-process monitoring and/or control.
Turbidity	Segriest	983	$2,000	40 mh/yr.	Daily	None	--	--	--	--	--	--	Good		Strip chart recorders	Dual beam optical measurement.

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays
*** Local and central

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							Comments
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW-hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no/mo)	
FE-101 AIT-102	Lime ppt'n.	1	PI (feed-forward flow plus feed-back pH)	Analog or DDC	Electric	Dry feeder	1.5-5 min. to 90% completion	600 mh/yr.	--	20%	10%	pH=±0.05 pH=±0.1	60 mh/yr.	10/mo.	Instr. tech	--	--	10-20 hrs./yr.	Yearly	Computer monitors wt. of lime added to primary clarifier. Satisfactory analog control; excellent DDC. Slakers require much more maintenance, usually about 700 mh/yr.
AIT-203	Recarbon-ation	1	PI (feed-fwd. flow plus feed-back pH)	Analog or DDC	Electric	Valve	5 minutes to 90% completion	0-6hrs/day	--	20%	--	±0.2pH	365 mh/yr	30/mo.	Instr. tech	--	--	None	--	Since recarbonation follows lime ppt, its performance depends on the stability of the upstream pH-adjusting processes.
	$FeCl_3$ addition	1	P (feed-forward flow)	Analog or DDC	Electric	on-off + variable-speed pump	1 minute	--	--	25%	--	--	--	--	--	--	--	--	--	No special maintenance.
AIT-302 FIE-303 AIT-305	Break pt. Chlorination	1	PI feed-fwd flow + NH_3 concen.; feed-back pH/free Cl_2	Analog or DDC	Electric	Chlorinator valves	5 minutes to 90% completion	*	--	*	*	± 7mg/l NH_3	2000 mh/yr.	Continuous attention	Instr. tech & chemist	--	--	--	--	*Automatic control is essential for effective breakpoint chlorination. Most plant operators could not manually control this process. Analog control of break point chlorination yields marginal performance; DDC improved break point control.
FTE-306 AIT-309 AIT-308	↑																			~~Principal problems are slow, unreliable,~~ analytical sensors - see NH_3, Free Cl_2.

* Control mode relay, proportional, proportional plus reset etc.
** Types of controllers analog (pne , hyd or elec media), computer (supervisory direct digital or set analog)
*** Final control element pne values, variable speed pump, etc

Figure G-2 (a). Lime Precipitation Loop

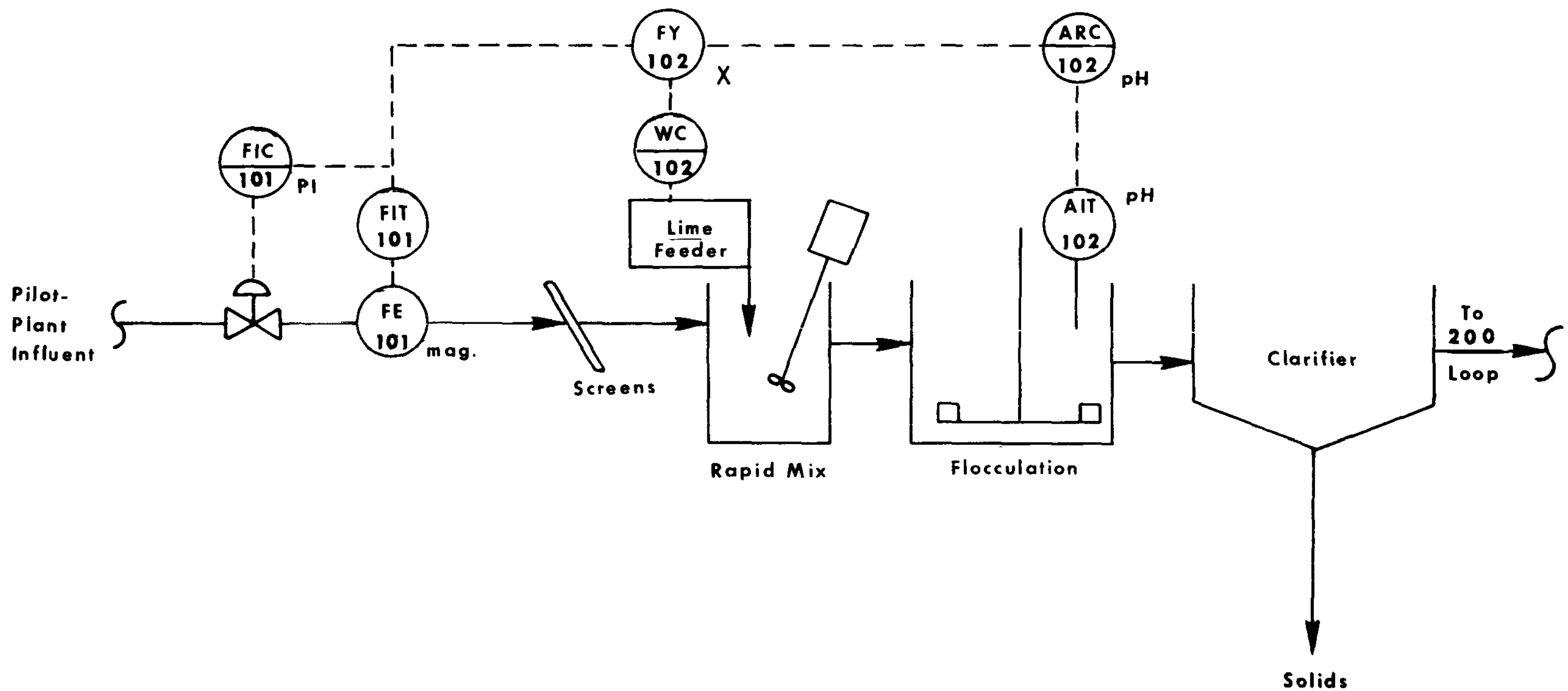


Figure G-2 (b). Recarbonation Loop

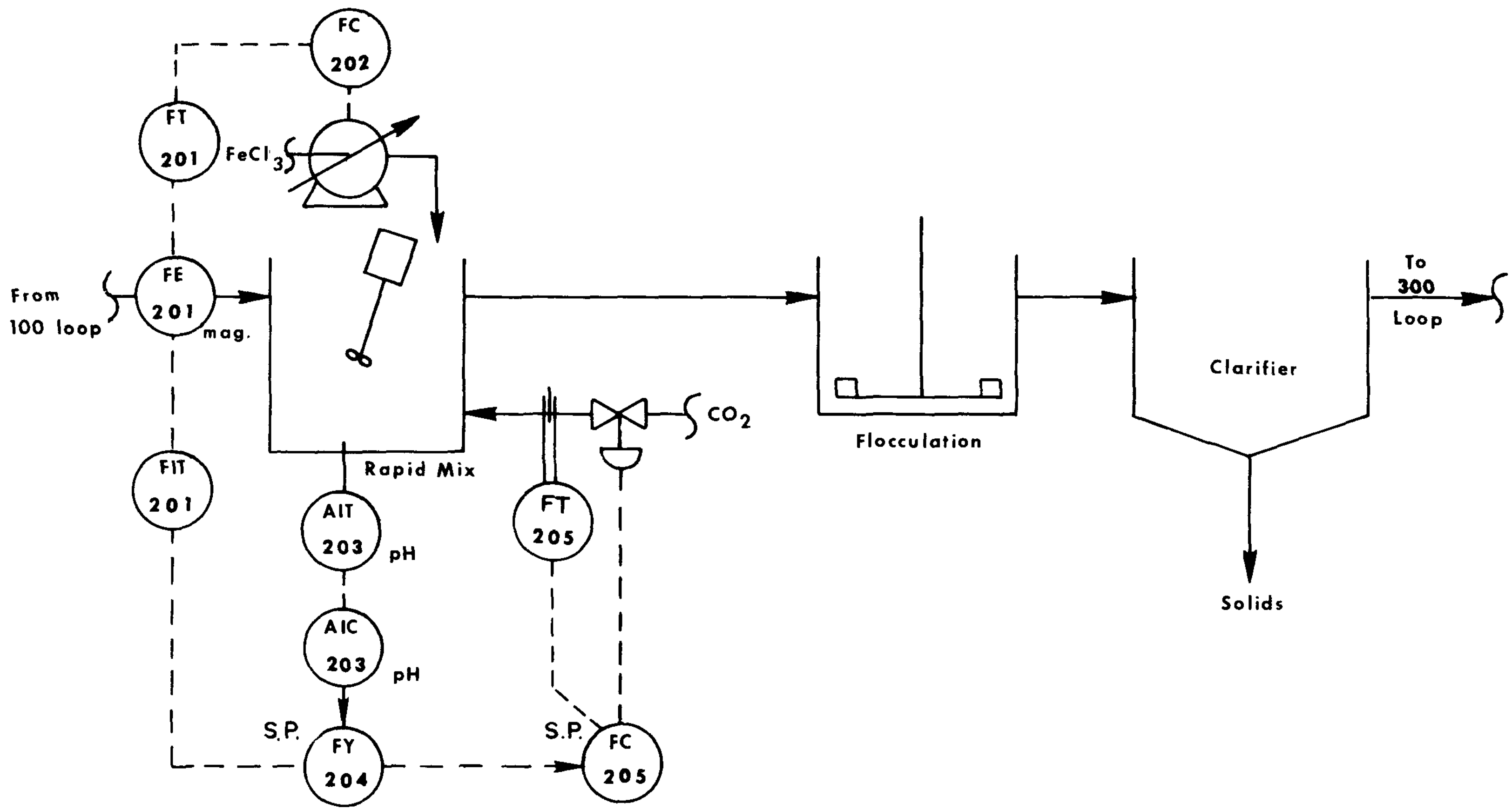
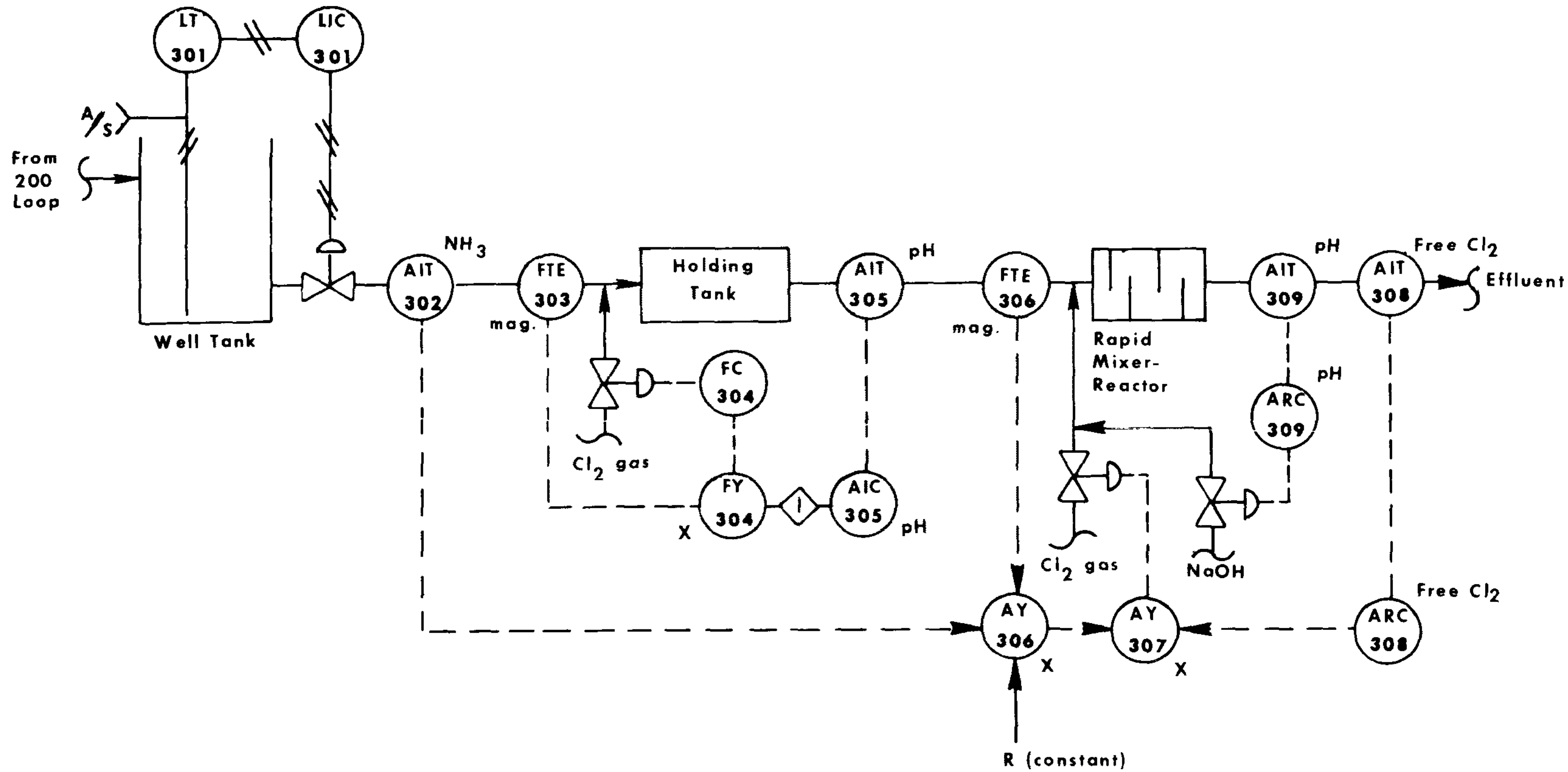


Figure G-2 (c). Breakpoint Chlorination Loop



GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION

Preliminary Survey *

Facility Ownership and Address H-1

Responsible Supervisor

Flow Rate Design (Average and Maximum) 15 mgd max. and avg.

Storm Water Collection and Treatment Principal function

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)

Stormwater-treatment demonstration plant.

Performance Data (Individual Units and Overall)

N/A

Year Built Under constr. during 1973
Expected completion 1974

Modifications (Year and Description) *Plant designed, construction in progress.

Original Cost $442,000

Modification Cost

Instrumentation

Equipment Brooks, Bristol

Panels

Installation and Start up Costs Est. Original Cost $27,251 Total Cost

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
	N/A				

Computer No, but see below.
Type. Manufacturer I/O Devices

Process Control Each measurement of flow produces tape for future analysis.

Data Logging

Parameter/Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency

Storage Tapes will be fed into office IBM 1130

Software Description

Computer Cost Software Cost Installation Cost

Central Control

Supervisory Control N/A

Alarm and Safety Systems

Automatic Emergency Program (e g , Power Failure)

Maintenance and Calibration

Special Equipment N/A Down Time

Special Operator Training Frequency (no /mo)

Total In Plant Man Hours/Year

Total Cost of Outside Service

Estimate of Over all Benefits of Instrumentation and Automation

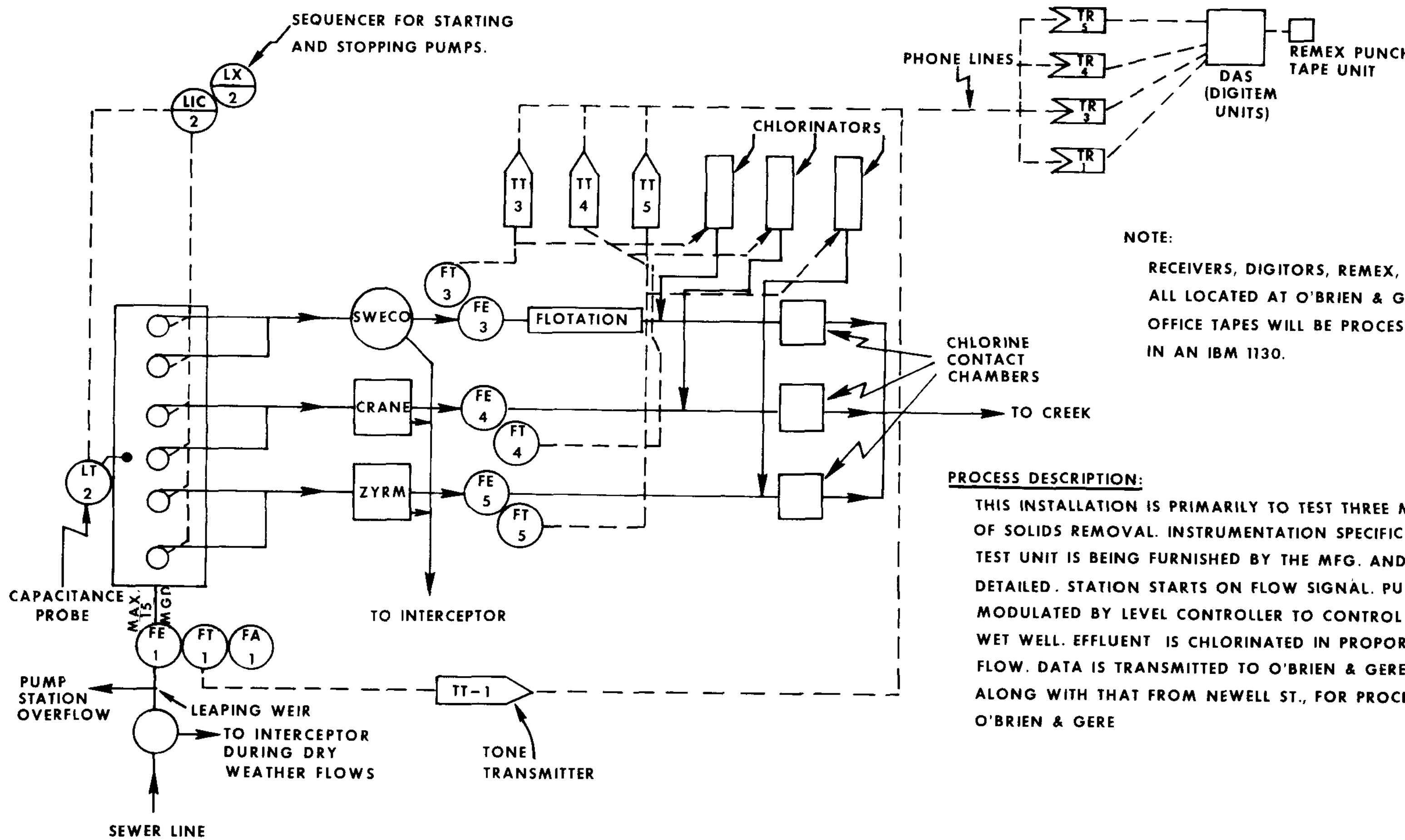
Permits evaluation of three different stormwater-treatment methods. Station is designed to be operated unattended.

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW-hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no /mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no mo)	Comments
	Flow measurement only	1	On-off	Relay	Electric	Alarm & contact closure	Less than 1 min.	See comment												Installation designed to start and operate unattended.
	Level	1	Proportional	Analog	Electric	Variable-speed pumps	Less than 1 min.													Wet well level to be measured continuously by proposed capacitance probe.
	Chlorination	3	Open loop	Analog	Vacuum and Electric	Chlorinator	Less than 1 min.													Flow signal paces chlorine feeder in usual manner.

* Control mode relay, proportional, proportional plus reset, etc
** Types of controllers analog (pne , hyd or elec media), computer (supervisory, direct digital or set analog)
*** Final control element pne values, variable speed pump etc.

Figure H-1. (WET WEATHER TREATMENT PLANT)



NOTE:

RECEIVERS, DIGITORS, REMEX, ALL LOCATED AT O'BRIEN & GERE. OFFICE TAPES WILL BE PROCESSED IN AN IBM 1130.

PROCESS DESCRIPTION:

THIS INSTALLATION IS PRIMARILY TO TEST THREE METHODS OF SOLIDS REMOVAL. INSTRUMENTATION SPECIFIC TO EACH TEST UNIT IS BEING FURNISHED BY THE MFG. AND IS NOT DETAILED. STATION STARTS ON FLOW SIGNAL. PUMPS ARE MODULATED BY LEVEL CONTROLLER TO CONTROL LEVEL IN WET WELL. EFFLUENT IS CHLORINATED IN PROPORTION TO FLOW. DATA IS TRANSMITTED TO O'BRIEN & GERE OFFICE, ALONG WITH THAT FROM NEWELL ST., FOR PROCESSING BY O'BRIEN & GERE

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GENERAL SURVEY QUESTIONNAIRE

STATE OF THE ART
INSTRUMENTATION AND AUTOMATION — Preliminary Survey *

Facility Ownership and Address H-2

Responsible Supervisor

Flow Rate Design (Average and Maximum): 7.7 mgd max. and avg. — O'Brien & Gere, Syracuse

Storm Water Collection and Treatment Principal function

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)
Swirl chamber for stormwater treatment

Performance Data (Individual Units and Overall)

N/A

Year Built Under const. during 1973
Expected completion 4/73
Modifications (Year and Description)
*Plant designed, construction in progress.

Original Cost $65,600
Modification Cost

Instrumentation

Equipment Bristol, Brooks

Panels

Installation and Start up Costs Est. **Original Cost** $12,287 **Total Cost** Output and recording equipment included in cost estimate.

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
N/A					

Computer None directly involved. Process data is collected for later reduction in remote engineering office.
Type **Manufacturer** **I/O Devices**

Process Control Each measurement of flow produces a punched tape for future analysis. Digital readout.

Data Logging

Parameter/Frequency	Parameter Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description Tapes will be fed into office IBM 1130 located in O'Brien & Gere office.

Computer Cost **Software Cost** **Installation Cost**

Central Control

Supervisory Control

Alarm and Safety Systems N/A

Automatic Emergency Program (e g., Power Failure)

Maintenance and Calibration

Special Equipment N/A **Down Time**

Special Operator Training **Frequency (no /mo)**

Total In-Plant Man Hours/Year

Total Cost of Outside Service

Estimate of Over-all Benefits of Instrumentation and Automation

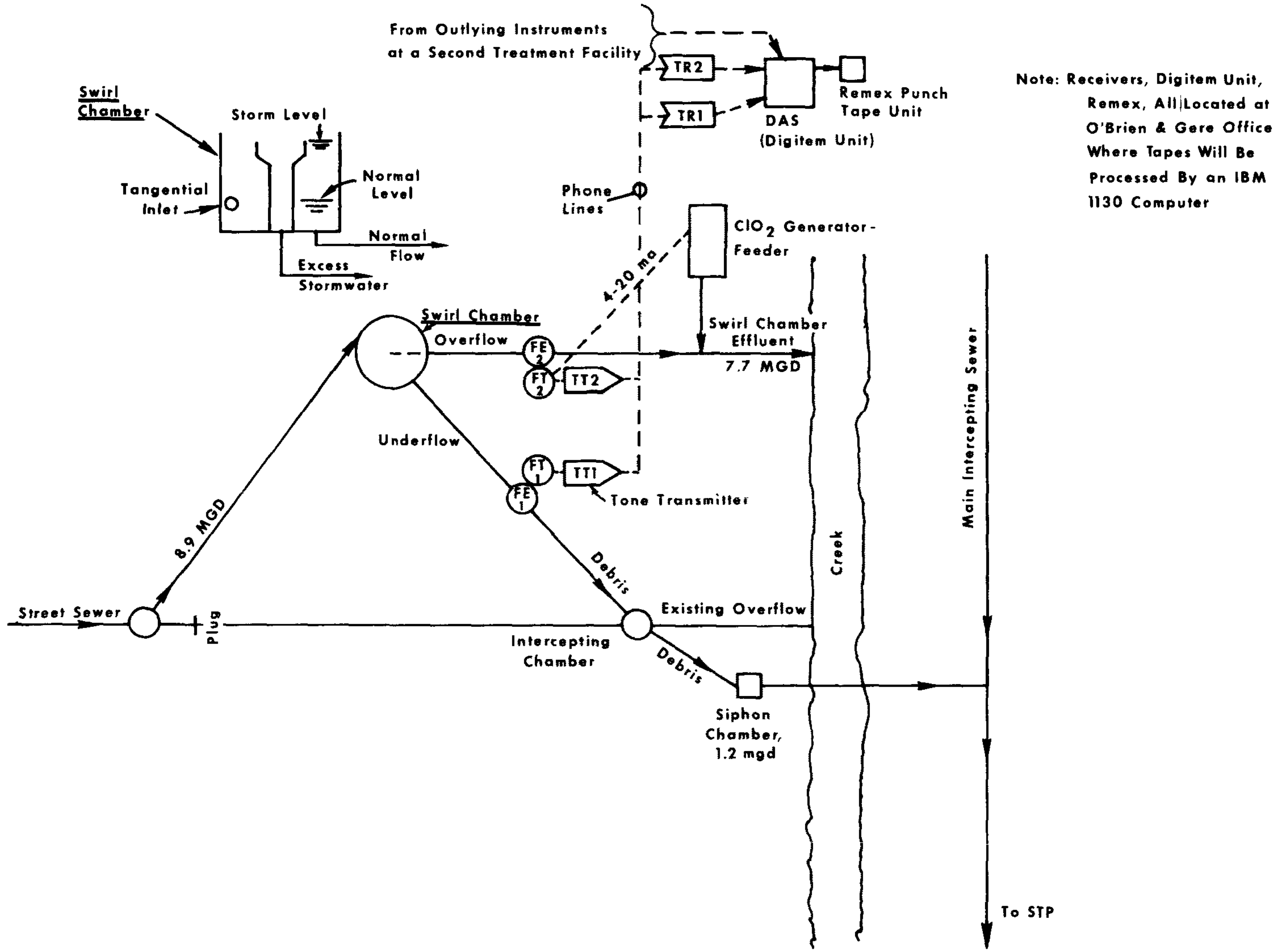
Design data obtained by measuring overflow effluent and debris effluent.
Disinfection control has aided in meeting effluent health requirements.

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min)	Manpower (mh/yr)	Utility (kW hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min max (mg/l)	Maintenance & Calibration by In Plant Personnel ($ or mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no/mo)	Comments
FE-1	Flow measurement only	1	Open loop	--	--	--														To be maintained by County personnel. Data reads out on Digitem unit, and a punched tape is generated.
FE-2	Disinfection	1	Open loop	--	--	ClO_2 Generator feeder														Typical open-loop treatment proportional to flow. Proprietary design undisclosed.

* Control mode relay, proportional, proportional plus reset, etc
** Types of controllers analog (pne, hyd or elec media) computer (supervisory, direct digital or set analog)
*** Final control element pne values, variable speed pump, etc

Figure H-2 SWIRL CHAMBER



GENERAL SURVEY QUESTIONNAIRE

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STATE OF THE ART
INSTRUMENTATION AND AUTOMATION — Preliminary Survey *

Facility Ownership and Address. H-3

Responsible Supervisor:

Flow Rate Design (Average and Maximum): N/A

Storm Water Collection and Treatment Sole function

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems.)

Performance Data (Individual Units and Overall) Stormwater overflow treatment and control.

Year Built Anticipated completion 1974 (late)

Modifications (Year and Description) *System designed, construction in progress. N.B.: Not yet accepted by client. Do not release without OK from F. Drehwing-O'Brien & Gere

Original Cost Est. cost $650,000

Modification Cost

Instrumentation

Equipment Badger Respirometer (BOD), Badger S.S. unit (not yet released for sale), 12 Badger Ultrasonic Flow Meters (12 represent about 80% of overflow)

Panels Possible use of technicians for C.O.D., etc.

Installation and Start-up Costs — Original Cost — Total Cost

Instrumentation Modification

Description	Year	Equipment	Panels	I & S	Total
None					

Computer

Type Logger Not selected as yet — Manufacturer — I/O Devices.

Process Control

Data Logging

Parameter/Frequency	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency

Storage: Principal use as Logger and Alarm

Software Description

Computer Cost — Software Cost — Installation Cost

Central Control

Supervisory Control N/A

Alarm and Safety Systems

Automatic Emergency Program (e g , Power Failure).

Maintenance and Calibration

Special Equipment — Down Time

Special Operator Training Included in cost of purchase — Frequency (no /mo)

Total In-Plant Man Hours/Year

Total Cost of Outside Service

Estimate of Over-all Benefits of Instrumentation and Automation:

Instrumentation will be used to evaluate storm loading and determine the ability of the treatment plant to accept the BOD & SS from stormwater.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no/mo)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Frequency (no/mo)	Total Downtime	Downtime Frequency (no/mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
BOD by respirometry		N/A	N/A													Proposed installation still under design. Very little information available.
S.S.	Badger (not released for sale as yet)	N/A	N/A													Proposed installation still under design. Very little information available.
Flow (12 units)	Badger Ultrasonic	N/A	N/A													Proposed installation still under design. Very little information available.
COD: Total P and N series	(Technicians may be used for these analyses)															Proposed installation still under design. Very little information available.

* Corrosion, fouling, etc
** Limiters, alarms, ratio relays.
*** Local and central

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GENERAL SURVEY QUESTIONNAIRE

STATE OF THE ART
INSTRUMENTATION AND AUTOMATION — Preliminary Survey *

Facility Ownership and Address: H-4

Responsible Supervisor

Flow Rate Design (Average and Maximum): 100 mgd (1-yr. storm) — 240 hrs. operation per year
300 mgd (25-yr. storm)

Storm Water Collection and Treatment: Principle function

Type of Plant Description of Treatment Process (Attach schematic diagram for process monitoring and control systems)

Storm water screening and sterilization.

Performance Data (Individual Units and Overall)

Design (1-yr. storm): 99% coliform removal - 10% sus. solids removal
15% BOD removal

Year Built: 1973 — Modifications (Year and Description) — *The project is being built; expected to start mid-1973.

Original Cost: $500K — Modification Cost

Instrumentation: Flow and sterilization

Equipment: Flow, level, and analysis measurement; pump-delivery controls.

Panels: One (central)

Installation and Start-up Costs — Original Cost — Total Cost

Instrumentation Modification: None

Description	Year	Equipment	Panels	I & S	Total

Computer

Type: None — Manufacturer — I/O Devices

Process Control

Data Logging

Parameter/Frequency	Parameter/Frequency	Parameter/Frequency	Parameter/Frequency

Storage

Software Description

Computer Cost — Software Cost — Installation Cost

Central Control: Yes

Supervisory Control: No

Alarm and Safety Systems: No

Automatic Emergency Program (e.g., Power Failure): None

Maintenance and Calibration: None

Special Equipment — Down Time

Special Operator Training — Frequency (no./mo.)

Total In-Plant Man Hours/Year

Total Cost of Outside Service

Estimate of Over-all Benefits of Instrumentation and Automation

Automatically controls sterilization and cleaning of overflow to Mystic River basin.

Provides pollution protection at reasonable labor costs.

INSTRUMENT SURVEY FORM

Instrument				Operating Experience										Peripheral Equipment		
Parameter	Manufacturer	Model Number	Equipment Cost	In-Plant Maintenance (mh/yr)	Maintenance Frequency (no /mo.)	Special Training	Service by Contract ($ or mh/yr)	On-Demand Service ($ or mh/yr)	Frequency (no./mo)	Total Downtime	Downtime Frequency (no /mo)	Problems*	Accuracy	Auxiliary Devices**	Recording Devices***	Comments
Flow direction														Sensing vane, heater, alarm	No	Pivoted vane in stream closes contact when stream reverses.
Residual chlorine	Fischer and Porter	17B3201												Sample system	Yes	Sample pump and sampling system specified.
Level	Fischer and Porter	SOEP1011-ACSA												Diaphragm box	Yes	Bubbler
Flow (Velocity)	Fischer and Porter	50SF2221-A11												Mult. relay	(After correction) Yes	Open channel flow is approximated by product of stream velocity and approp. function of channel depth.

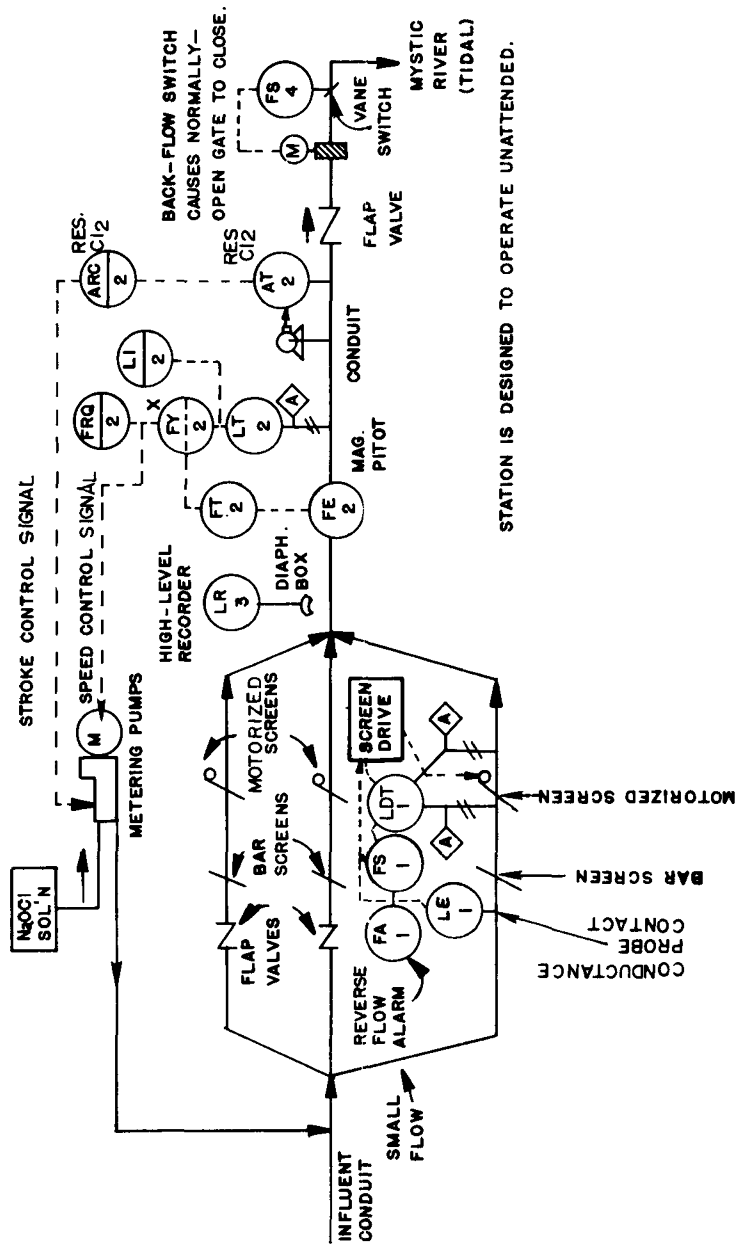
* Corrosion, fouling, etc.
** Limiters, alarms, ratio relays
*** Local and central.

LOOP AND PROCESS CONTROL SURVEY FORM

Control Techniques								Benefits					Operating Experience							Comments
								Annual Cost Savings			Process Improvement									
Code Number (Schematic Diagram)	Process Being Controlled	Number of Loops	Control Mode*	Type of Controller**	Actuating Power	Final Control Element***	Estimated Response Time (min.)	Manpower (mh/yr)	Utility (kW-hr/yr)	Chemical (lbs/yr)	Increase Removal (%)	Parameter Variance min/max (mg/l)	Maintenance & Calibration by In-Plant Personnel ($ or mh/yr)	Maintenance Frequency (no. mo.)	Special Training	Service by Contract ($ or mh/yr)	On Demand Service ($ or mh/yr)	Downtime (hrs/yr)	Downtime Frequency (no. mo.)	Comments
FE-2	Channel flow	1	On-off	Switch	Electric	Sluice gate	1	Plant protection												Protects station from high tides. See other sheet.
AT-2	Stream steriliza-tion	1	Flow prop. with feed-back trim	Analog electric	Electric	Var.-speed Var.-stroke pumps	2					Est. 1+0.5								Closed-loop control, with inner loop controlling pump speed proportional to channel flow and outer (trim) loop controlling pump stroke inv. propor-tional to res. chlorine.

* Control mode relay, proportional, proportional plus reset, etc
** Types of controllers analog (pne., hyd. or elec. media), computer (supervisory, direct digital or set analog)
*** Final control element pne. values, variable speed pump, etc

Figure H-4


STROKE CONTROL SIGNAL
SPEED CONTROL SIGNAL
NaOCl SOL'N
METERING PUMPS
M
FRQ 2
FY 2
X
LI 2
ARC 2
RES. Cl2
BACK-FLOW SWITCH CAUSES NORMALLY-OPEN GATE TO CLOSE.
FS 4
M
VANE SWITCH
MYSTIC RIVER (TIDAL)
FLAP VALVE
RES Cl2
AT 2
CONDUIT
LT 2
A
MAG. PITOT
FT 2
FE 2
DIAPH. BOX
LR 3
HIGH-LEVEL RECORDER
MOTORIZED SCREENS
SCREEN DRIVE
BAR SCREENS
FLAP VALVES
LDT 1
FS 1
FA 1
LE 1
MOTORIZED SCREEN
BAR SCREEN
CONDUCTANCE PROBE CONTACT
REVERSE FLOW ALARM
SMALL FLOW
INFLUENT CONDUIT
STATION IS DESIGNED TO OPERATE UNATTENDED.

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4. TITLE AND SUBTITLE Instrumentation and Automation Experiences in Wastewater-Treatment Facilities		5. REPORT DATE October 1976 (Issuing Date) 6. PERFORMING ORGANIZATION CODE
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15. SUPPLEMENTARY NOTES See also EPA-600/2-76-276, "Selected Applications of Instrumentation and Automation in Wastewater-Treatment Facilities"		

16. ABSTRACT

This report describes the results of a nationwide survey of instrumentation and automation experiences in fifty wastewater-treatment plants. The data show that the average wastewater-treatment plant spent about 3% of the construction costs for installed instruments. This is about half the instrument utilization rates of water supply and chemical process plants. Sensors measuring mechanical or physical properties showed satisfactory performance records and were very popular. Sensors measuring chemical parameters tended to be unreliable and were subject to continued fouling from solids deposition, slime buildup and precipitation. Automatic process control is only occasionally utilized in wastewater treatment, but it performs well with sensors that have good performance records. Approximately 20% of the visited facilities were used for data-logging computers, and 90% of these facilities were satisfied with their systems. Process and supervisory control computers are not well established in dry weather treatment plants, but computers are being effectively utilized in stormwater control centers.

17. KEY WORDS AND DOCUMENT ANALYSIS		
a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
*Automation, Automatic Control, Automatic Control Equipment, Data Processing, Digital Computers, *Instruments, *Waste Treatment, Wastewater, Process Control, Centralized Control	Activated Sludge, Process Control Theory	13B
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