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5 January 2000

LESSONS LEARNED

OPERATOR ASSISTANCE PROGRAM

WASTEWATER TREATMENT

Public Works Technical Bulletins are published by the U.S. Army Corps of Engineers, 441 G Street, NW, Washington, DC, 20314-1000. They are intended to provide information on specific topics in areas of Facilities Engineering and Public Works. They are not intended to establish new DA policy.

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WASTEWATER TREATMENT OPERATOR ASSISTANCE PROGRAM: LESSONS LEARNED

1. Purpose. This Public Works Technical Bulletin (PWTB) transmits the Wastewater Treatment Plant Operator Assistance Program Lessons Learned Document. The lessons learned improve maintenance, efficiency, reliability, system life and safety of treatment plant personnel.

2. Applicability. This PWTB applies to all U.S. Army Public Works activities responsible for operating and maintaining wastewater treatment plants.

3. References.

   a. Army Regulation 420-49, Facilities Engineering, Utility Services, April 1997.

   b. MIL-HDBK-1138, DoD Handbook, Operations and Maintenance: Wastewater Treatment Systems Augmenting Handbook, Department of the Army, Navy, and the Air Force, October 1997.

4. Discussion. In 1984 the Army responded to recommendations in a Government Accounting Office (GAO) report, "DoD Can Make further Progress in Controlling Pollution From Its Sewage Treatment Plants" by initiating the Operator Assistance Program (OAP). The OAP was developed to assist Directors of Public Works (DPW) in improving wastewater treatment plant operation and maintenance, thereby improving treatment plant efficiency and compliance with regulatory requirements. Although many installations have benefited from the program, many continue to face compliance problems with new and more demanding federal and state operating and discharge standards. One of the most common problems is the need for modernization. Resources are so limited that even when plant upgrades are approved, long time delays are normal before modernization occurs. This problem negatively impacts the environment and creates environmental liability for the Army. To assist the DPW to further improve wastewater treatment operations, a list of lessons learned in wastewater treatment plant operation and maintenance over a 10year period has been assembled to indicate the most common problems and their solutions. The Lessons Learned is attached as an appendix.

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EXECUTIVE SUMMARY

This report is a summary of the *Lessons Learned* from the conduct of the US Army, Corps of Engineers Center for Public Works, Operator Assistance Program (OAP) at Army wastewater treatment plants during the period 1994 to 19947 The information used to produce this report was taken from facility and plant specific OAP reports, prepared by contractor personnel, documenting on-site evaluations of the condition and operation of wastewater treatment plants an collection systems. Below is shown a synopsis of the "Lesson" and a summary of the potential actions that can be taken to make full use of what has been "Learned."

Lesson	**Remedy**
Wastewater Facility Modernization Many military wastewater treatment plants are in need of modernization. Resources are so limited that, even when plant upgrades are approved, long time delays are normal before modernization occurs. This problem impacts the environment negatively and creates environmental liability for the Army.	<u>Operations</u> Make contact with local municipal and private wastewater system operators and managers. Optimize existing plant operation. <u>Management</u> Investigate participation in regional system and privatization and maintain existing facility.
Inflow and Infiltration (I/I) Collection system inflow and infiltration cause significant problems at many Army wastewater treatment plants and, with some exceptions, are not being addressed adequately.	<u>Operations</u> Discover and monitor the magnitude and nature of the I/I problem. <u>Management</u> Insist on annual report and evaluation of the I/I problem and a plan for the next year.
Operator Training Progress has been made in increasing the number of certified operators at military wastewater plants. However, the training needs of wastewater treatment plant operators are changing and increasing and are not being met with existing training programs.	<u>Operations</u> Create a training plan and budget that husbands resources but provides training opportunity. <u>Management</u> Insist on formal reporting of the status of training, certification and training needs.

Management Support

Military wastewater treatment facilities have not usually been a high priority of facilities managers. This issue, coupled with decreasing resources, has resulted in a decline in the morale of operating personnel. Low morale is a major cause for poor operating, maintenance and house keeping practices and concomitant degradation of treatment plant performance.

Operations
Seek opportunities to brief management on the operation status of the treatment works, and report fully and in detail all aspects of deficient operation or maintenance.

Management
Require detailed reports on the status of operation and maintenance an visit the plant more frequently.

Plant Maintenance

Preventative maintenance on mechanical and electrical equipment is not routinely performed and long delays often occur before critical equipment is repaired. There are few formal preventive maintenance systems and/or critical spare parts inventory systems in place and plant performance suffers from these failures.

Operations
Create, implement and enforce a maintenance plan and a critical inventory program.

Management
Require formal and frequent reporting of equipment failure rates and spare parts inventory.

Plant Safety

Safety programs at military wastewater treatment facilities are frequently incomplete and/or inadequate. The result is the exposure of employees and others to unsafe conditions which may lead to subsequent operator injury or ill health.

Operations
Create, implement and enforce a safety plan as well as an up-to-date inventory of safety equipment and supplies. Make sure that the plant safety program is part of the facility safety program.

Management
Require frequent reporting of status of safety program, e.g., accidents, training, etc. and formally inspect the wastewater treatment plant several times per year.

Treatment Process Control

Insufficient, and often inappropriate, sampling and testing is being performed on military wastewater treatment facilities. This inadequate monitoring cannot produce sufficient data to allow operators to modify individual unit processes and, thereby, optimize total plant performance.

Operations
Create, implement and enforce and intra-process sampling and testing plan and review all monitoring data with management and supervision.

Management
Carefully review monthly operations reports, particularly the laboratory and NPDES reports. Look for anomalies.

Water Treatment Chemicals

Wastewater chemicals are often used inappropriately because operators frequently do not understand the chemistry involved nor the calibration and adjustment of the chemical feed equipment. Operators need supplemental "update" training on the chemistry of wastewater and the proper application of treatment chemicals.

Operations
Conduct frequent training on wastewater chemistry and chemical feed systems and practice quality changes and chemical feed responses.

Management
Require reporting of chemical usage vs. NPDES daily values an compare results on a month-to-month or year-to-year basis.

Sludge Handling/Treatment/Disposal

Army wastewater treatment plant operators are not well trained concerning the chemistry, process control or economics of the sludge handling equipment under their control.

Operations
Additional operator training, process monitoring and improved operating/ procedures manuals.

Management
Require monthly operation summary and review and control process by monitoring costs on month-to-month basis.

Trickling Filters

Upgrading existing Army trickling filter performance can often be accomplished by relatively simple piping and equipment modifications.

The distributor arm is the most maintenance sensitive portion of the trickling filter. Maintenance of the bearing and nozzles is crucial an should not be neglected.

Odor and filter fly problems can be caused by poor operation and maintenance of tricking filter plants. The resulting difficulties can cause problems for the entire military facility. Managers and supervisors must ensure that procedures and the impact of improper operation are clearly understood by operating personnel and that they are carried out with the correct frequency.

Operations and Management
As the benefits of this process modification are high and the costs low, all of the Army facilities should design and schedule a modification to allow for recirculation of the trickling filter effluent at the earliest possible budget cycle.

Make certain that operators understand the operating and maintenance requirements of trickling filters and the appropriate remedies for specific problems such as distributor arm bearings, filter flies and odors. Provide maintenance benchmarks to wastewater plant managers and operators, e.g., average bearing replacement frequency. Inspect the plant frequently to assure that appropriate operating conditions are being maintained.

ACTIVATED SLUDGE SYSTEMS

The Process Control of activated sludge wastewater treatment plants requires more attention and better trained operators than is the case for trickling filter plants which are the majority of plants presently being used by the Army.

Operations
Operators of activated sludge treatment plants require training aimed directly at the process control issues.

Management
In order to provide excellent operation of activated sludge plants, management must focus on improvement of training and process control.

Package wastewater treatment plants have the same operating requirements as larger facilities. The small size of these plants can justify a smaller maintenance staff, but the operating and analytical requirement is the same as much larger systems. A full-time dedicated operating staff for package plants is frequently undersized or nonexistent even though they have NPDES permits and the same regulatory requirements and liability of much larger plants.

Operations and Management
Package plants should be operated by either hired contract operators or as satellites of larger plants located in close geographical proximity. The facilities manager must treat the package wastewater plant as a standard wastewater facility, regardless of its relative small size.

ROTATING BIOLOGICAL CONTACTORS

RBC plants are not difficult to operate and will produce a good effluent provided the operator inspects the equipment regularly, tests the influent and effluent, observes the media, and takes appropriate corrective actions when necessary.

Operations
Create a maintenance plan and budget and keep an up-to-date inventory of necessary spare parts. Make sure that routine inspection and lubrication is completed.

Management
Require annual reporting of equipment failure rates and spare parts inventory. Formally inspect the wastewater treatment plant several times per year.

CONTINUOUS LOOP REACTOR PLANTS

The general experience, inside and outside of the Army, is that these plants are somewhat easier to operate due to their ability to sustain shock loadings and their high degree of resistance to toxicity. However, the key to good plant operation is still high quality process control.

Operations
Operators require training aimed directly at the process control issues. The sampling and analytical scheme must be designed to give the operator the information required to make changes in a timely fashion.

Management
Management must focus on these issues of training and process sampling and testing and assure that they are accomplished correctly.

LESSONS LEARNED
OPERATOR ASSISTANCE PROGRAM
WASTEWATER

I. INTRODUCTION

I.1. PURPOSE AND SCOPE OF REPORT

This report is a summary of the "Lessons Learned" from the conduct of theUS Army Corps of Engineers, Center for Public Works world-wide Operator Assistance Program (OAP) at approximately 50 Army wastewater treatment plants during the period 1984 to 1994. The information used to produce this report was taken from the site-specific OAP reports, prepared by contractor personnel, documenting on-site evaluations of the conditions and operation of wastewater treatment plants and collection systems. Each Lesson is presented with a synopsis of observations of the OAP contractors, a general discussion of the problem, existing Army guidance (if available), examples of the problems for different types of treatment equipment and facilities as well as recommended actions where appropriate.

Each *lesson* is additionally a summary of related or associated OAP findings and covers relatively large topic areas such as plant operation, maintenance, management, training and safety. The discussion provided in each section is intended to provide the reader with a sense of the magnitude and significance of each type of problem as it affects different types of equipment, unit processes or facilities. Comparisons between different treatment facilities are difficult to perform, due to size and varying regulatory conventions among other issues, and are generally not included in this document. However, summary data has been included when available and if it provided illumination to the nature or extent of the problem.

The intent of the OAP program is to identify site (or treatment plant) specific problems or weaknesses and to suggest methods of correction or remediation. The format does not lend itself to identification of program elements that are performed well, nor does it permit highlighting routine and satisfactory facility operation, which is the norm for these facilities. Therefore, this document does not contain much information about the positive aspects of the Army wastewater collection and treatment facilities. The reader is cautioned not to generalize the negative aspects of this report. The OAP has also shown that there are many instances of excellent operation at military wastewater treatment facilities and many of these have been developed or enhanced by the site specific assistance provided by this program.

I.2. BACKGROUND

In 1984, the Government Accounting Office issued the report, "DoD Can Make Further Progress in Controlling Pollution From Its Sewage Treatment Plants", which found 11 of the 17 DoD plants evaluated, representing all of the armed services, did not consistently meet The National Pollution Discharge Elimination System (NPDES) discharge limitations contained in their permits. As a result of these findings, GAO recommended to the Secretary of Defense that each armed service provide more specific guidance to installation commanders to ensure that adequate treatment plant operation and maintenance are practiced, thereby improving compliance with NPDES permit requirements. The Army responded to the recommendation by initiating the Operator Assistance Program (OAP) in 1984 to identify and correct problems at specific installations. Many installations have benefited from the technical help provided under the OAP. However, with the recent and continuing imposition of new and more demanding federal and state operating and discharge standards, the ability of the Army wastewater treatment plants to consistently comply with the regulations continues to be challenged.

I.3. OAP CONCEPT

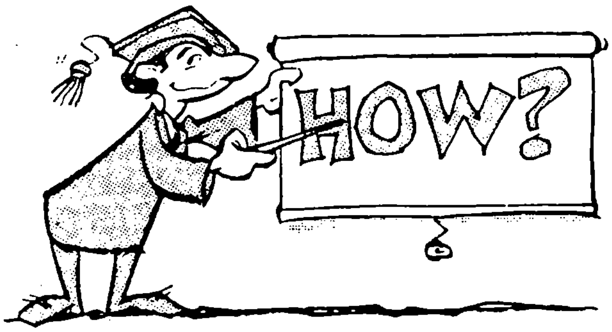
The OAP has evolved as a three phase program managed by the **Army Center For Public Works** located at Fort Belvoir, Virginia. In general, the program involves the (1) identification and analysis of wastewater treatment plant deficiencies, (2) direct hands-on assistance and training to begin to address operational deficiencies, and (3) the presentation of longer term recommendations or strategies designed to correct maintenance and structural deficiencies and/or other infrastructure problems. The specific elements of each program phase are elaborated below:

IDENTIFICATION AND ANALYSIS (Phase I): Phase I consists of an on-site diagnostic evaluation of a treatment plant to determine if the process consistently produces a process effluent that meets the current applicable NPDES permit requirements, and if not, why not. This requires the contractor's assistance team to evaluate the effectiveness of each unit treatment process as well as the overall treatment system. In addition, wastewater sampling and laboratory testing procedures are observed and evaluated, and all recent records and reports, submitted to state and federal regulatory agencies, are examined as part of this diagnostic evaluation. The results of this evaluation is summarized in a OAP Phase I report which is submitted to the Center for Public Works and the management team of the facility for comment and correction of errors, omissions or misconceptions. When finalized, this Phase I Report is the working basis of the next two steps in the OAP process.

TRAINING AND OPERATIONAL IMPROVEMENT (Phase II): This segment of the OAP is largely devoted to conducting hands-on training for plant operators and Laboratory technicians. The type and amount of this training is determined by the deficiencies and problems identified during Phase I. Also at this stage, suggestions and assistance are provided to modify operational procedures that are being done incorrectly or do not reflect best practices. Much of this training and operational modification is captured and memorialized in a revised Operating Manual which is prepared for each individual treatment plant based on information and data collected during Phase I. The on-site visits for training in Phase II are used to validate the contents of a Operation and Maintenance (O&M) Manual and assure that it provides exactly the information needed by the operating personnel.

LONG TERM IMPROVEMENT STRATEGY (Phase III): This segment of the OAP involves a follow-up site visit accomplished some months after the Phase II activities and is intended to evaluate the amount of improvement that has been accomplished in plant operation and maintenance resulting from other program phases, to tailor any short term improvement strategies that have not proved to be effective and to determine what additional assistance, if any, may be required. The product of this last phase is a document that itemizes the problems of the facility and suggest short and long term strategies or programs that can potentially remediate these problems. This report is a blueprint for incrementally improving the operation of the facility and also serves as a basis and explanation for whatever capital improvement program might ultimately be required.

The work that has been done in this program has been excellent. It also has been cost effective. It has allowed seasoned engineers and operators to concentrate attention on one facility for a short period of time and develop very effective programs for problem resolution at each specific facility. What follows is a collection of the *Lessons* that have been hard won in this decade long improvement process.



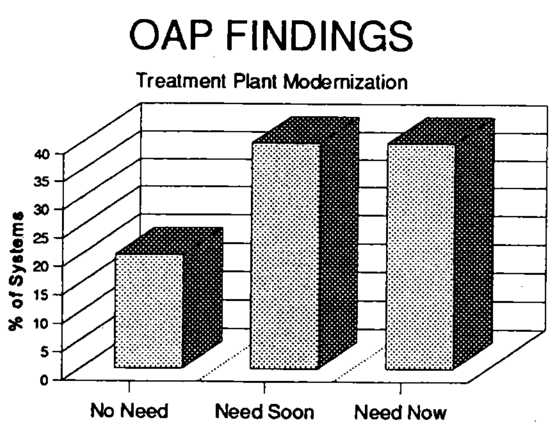
II. LESSONS

II. 1. MODERNIZATION AND UPGRADE OF TREATMENT FACILITIES

Lesson *Many military wastewater treatment plants are in need of modernization. Resources are so severely constrained that, even when plant upgrades are approved, long time delays are normal before modernization occurs. This problem creates potential negative environmental impacts and liability for the Army.*

> ***Modernization . . .***
> *. . . many plants in need . . .*
> *long delays . . . limited resources. . .*
> *consider other options . . .*
>
> *contract operations. . . regionalization*

II.1.1. OAP Finding: Many, if not most, military wastewater treatment facilities are in need of modernization. Principal causes of this are the age of the plants and the more lenient regulatory standards that were in effect at the time of the plant's design and construction. Other problems include poor equipment reliability, difficulty in obtaining spare parts, problems with the integration of interim process modifications and increases (or decreases) in the treated flow. A more recent problem is the slow down in normal replacement cycles related to the Base Realignment and Closure (BRAC) program, i.e., the postponement of expenditures where facility closure or realignment may be anticipated. Regulatory targets have been in motion making Army engineers very reluctant to predict design requirements. Also, the high cost of plant upgrading and the time and effort required in both design and regulatory involvement mitigates against plant upgrades in the necessary and competing facility priorities. These issues are creating a large backlog of design and construction activities for plant modifications that cannot be reduced quickly. Conversely, regulators are becoming less sympathetic to the plight of Army facility managers and are more insistent upon strict and consistent compliance with all of the environmental statutes.



II.1.2. Discussion: Almost every Army installation at one time or another has been served by its own wastewater treatment plant. However, none of these treatment facilities have been large in comparison with typical municipal plants. A good number of these facilities are old, having been built in the 1940's. Some older plants have been replaced and others have been modified in order to meet discharge standards. Nearly all Army wastewater plants meet regulatory requirements with some degree of consistency. As the wastewater effluent regulations increase in stringency, however,

many presently marginal facilities will require modernization and or upgrade. Most recently, the downsizing trend and BRAC activities have created situations where existing wastewater treatment facilities have excess capacity. This inadvertent oversizing often results in inefficient operation and, in some situations, operational failures. The age of the treatment plants causes them to be relatively labor intensive to operate and often more technically complex due to the absence of modern automation and computer assisted control. The relatively small size of these facilities (average 1 to 3 mgd) does not create economies of scale for the purchase of chemicals, supplies or materials and often makes it difficult for the Army to support contract operators or to recruit and retain qualified operators. These issues, and others related to the same underlying factors, suggest the need for a large and ever growing capital improvement program for the military if other alternatives are not utilized, e.g., regionalization and privatization. The Army has recognized this problem and has encouraged facility engineers to seek out potential alternatives and the Army has specifically encouraged privatization where BRAC actions are contemplated. These later initiatives have been hampered by the absence of privatization and or regionalization expertise at the facility level and the potential privatizer's impression of the age, condition and operating capacity of the relevant military wastewater plant/s.

II.1.3 Existing Army Guidance: **Army Regulation 420-49**, Facilities Engineering, Utility Services, 28 April 1997, Chapter 2, Utility Services, page 2-1., **Army Policy.**

a. Army policy is to obtain utility services from local, municipal or regional (public or private) authorities rather than expand, build or operate and maintain Army-owned utility systems.

b. In providing utility services, Army installations will comply with all applicable Federal laws and regulations.

See also **Army Regulation 200-1**, Paragraph 2-4.

II.1.4. Summary: Many Army treatment plants are in need modernization and upgrade. In general, resources are limited to make the capital investment required in the time frame necessary. Managers need to continually review their present situation and seek out opportunities for regionalization, privatization and contract operations. Similarly, facility engineers should move forward to modernize and update plants where alternatives are not available, and, in any event, optimum operation of the operation of any Army wastewater treatment facility should be the norm.

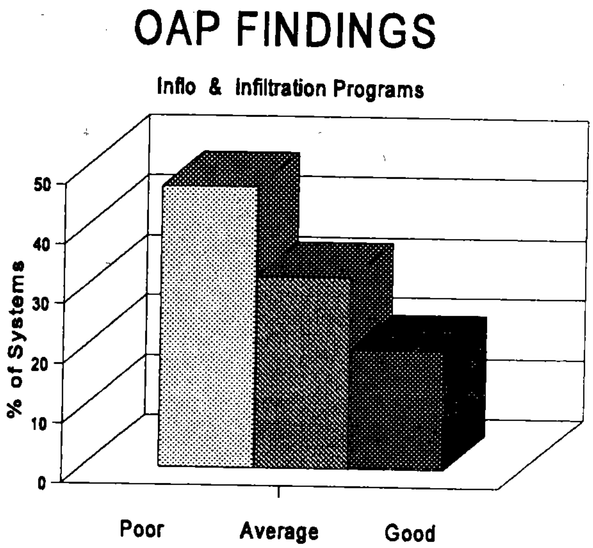
II.1.5. Recommended Actions:

System Operators and Managers
- o Make contact with local system operators and managers.
- o Optimize existing plant operation.

Base Commanders, Facility Managers and Public Works Managers
- o Investigate participation in regional system and privatization.
- o Pursue contract operation opportunities.

II.2. COLLECTION SYSTEM INFLOW AND INFILTRATION

Lesson: *Collection system inflow and infiltration causes significant problems at many Army wastewater treatment plants and, with some exceptions, is not adequately addressed .*



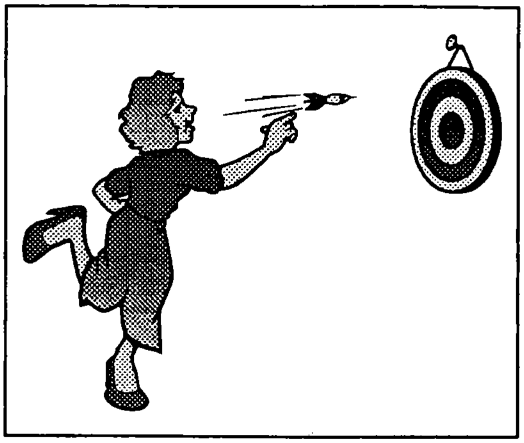
II.2.1. OAP Findings: A program of checking sewer collection lines for cracks and breaks has been initiated at some Army installations. The data to the left shows that only 20% of the bases that were evaluated in the OAP Program have fully implemented I/I programs. However, 32% more had begun this work at some level. Among all systems that were implementing the program, smoke tests are the most common testing method for inflow (rainwater) as well as identifying illegal downspout connections. TV inspections are preferred for infiltration (ground water) as well as inspection of the general condition of the sewer lines and house connections. When leaks or breaks are detected, repair work is seldom initiated due to the high cost and disruptive nature of excavating and repairing sewer lines. Moreover, each individual leak or infiltration site may be a small part of the total flow in the sewer system. Additionally, wastewater plants have other demands and priorities which can often be of more immediate importance than the intermittent inflow problems or the lower level and more uniform infiltration issue. Installations have been experiencing reductions in the resident populations which tends to obscure the effects of I/I problems. Also, I/I repair work is a likely candidate for postponement in any budget cycle due to the expense and inconvenience and the lack of immediate penalties for not performing the work.

II.2.2. Discussion: Most Army wastewater collection systems were installed when the military cantonments were first built. As a result of use, settlement and age, essentially all of these systems have developed cracks or small breaks that permit infiltration and inflow, to penetrate manholes and piping and subsequently enter the treatment plant. This problem can also affect newer systems if care was not given to pipe laying and joining processes or if individual connections to the collection system were not constructed properly. The volume of wastewater from these sources often upsets the treatment process, or even overtaxes the plant capacity. For Army owned treatment facilities, these high flows and resulting process upsets may cause instances of noncompliance with the NPDES permit requirements or similar state regulations. These non-compliant incidents may result in fines and, in some cases, criminal prosecution (See Federal Facilities Compliance Act, Appendix

> ***Inflow and Infiltration . . .***
>
> *cause of many problems at plants . . .*
>
> *not being addressed adequately.*

A). However, even when excess flows do not cause upsets, extra costs are incurred for chemicals and unnecessary equipment wear and tear. For installations exporting wastewater to *Publicly Owned Treatment Works* (POTWs) additional costs are incurred since infiltration and inflow waters would be part of the measured, *and therefore billed*, flow from the facility to the POTW. These excess flows from inflow and infiltration are a problem for Army facilities and for all other wastewater plants. However, they do not get addressed due to the high cost of repair and the mostly intermittent nature of the problem.

II.2.3.Existing Army Guidance: Army Document TM 5-665,*"Operation and Maintenance Of Domestic And Industrial Wastewater Systems", Jan. 1982*, Chapter 2. Wastewater Collection Systems, Section 3. Maintenance of Collection Systems, page 2-9: 2.3.2.1. Infiltration and Inflow. Breaks and leaks which cause infiltration most often occur at joints or manholes. To find out how bad the problem is a comparison of the flow at peak and low periods should be made. If storm water is getting into the wastewater sewer, heavy rainfall will cause an increase in the flow rate. To find out where the storm water is getting into the system, the flow rates from one manhole to another can be compared. . . .



II.2.4. Summary: *"The results of inadequate I/I programs for individual facilities can include year to year increases in operating and maintenance costs, a decreasing operational buffer between conpliance and non-compliance, posible requirements for plant expansion, an ever increasing risk of penalties and negative publicity and the growing probability of catastrophic failures due to both infiltration and exfiltration into and from the sewer system.*

II.2.5. Recommended Actions

System Operators and Managers

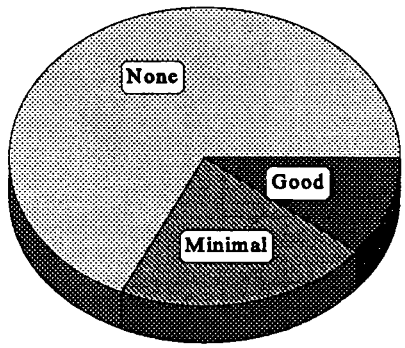
- o Begin any way you can to discover the magnitude and nature of the I/I problem
  - Review production records for excess flows after rainfall events
  - Carefully review historic flow data in relationship to base population and annual rainfall
  - Choose a representative manhole and monitor the flow every other week for one year
  - Try out plastic manhole cover seals in a well defined area of the collection system

Base Commanders, Facility Managers and Public Works Managers

- o Insist on annual reporting of the magnitude and trend of the I/I problem

II.3. OPERATOR TRAINING

Lesson: *Progress has been made in increasing the number of certified operators at military wastewater plants. However, the training needs of wastewater treatment plant operators are changing and increasing and are not being met with existing training programs.*



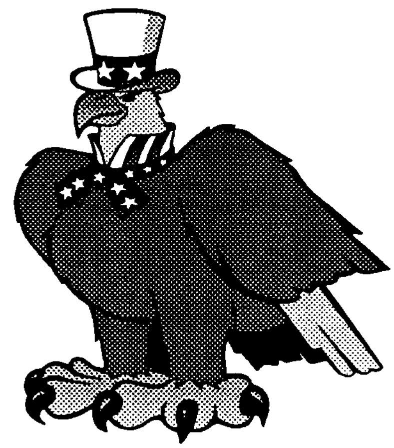
II.3.1 OAP Observation: Wastewater treatment plant operation is often unpleasant and stressful. Process upsets are common due to highly variable influent characteristics, but effluent quality must be consistently excellent. Performance failure has consequences above the norm in the form of potential civil and criminal penalties. Satisfying these demands requires the operator to have an intimate knowledge of all aspects of the wastewater treatment plant. To that end, very few certified operators of wastewater treatment plants benefit significantly from off-post re-certification training courses. The summary findings from the OAP programs performed to date indicate that 88% of all operators interviewed had some form of formal wastewater training and 71% were certified at some level. However, operator morale and productivity, excluding modern facilities, were less than optimum. Failure to provide training and communication opportunities, as noted above, is part of this problem. Other contributors include lack of management attention to the work environment and failure to provide appropriate motivation in the form of management attention, performance definition and recognition.

> **Operator Training**
>
> *"Progress has been made . . .*
> *. . . most operators now certified . . .*
>
> *new needs . . .*
> *not being met by existing programs."*

II.3.2. Discussion: In most states, the permits that govern the operation of the wastewater facilities require that monitoring and testing be done or supervised by certified operators. Previous training programs were geared to allow operators to satisfy certification requirements. This need has largely been met and essentially all military wastewater facilities are in compliance with this regulatory requirement. However, regulatory emphasis has changed and now centers on enforcement of NPDES permit requirements as well as other elements of the *Clean Water Act, as most recently amended.* This has created the need for new and additional operator information and training. These new subjects include regulatory updates as well as military guidance and policy, regulatory driven training such as OSHA, TOSCA, HAZWOPER, RCRA and others as well as specific safety training and administrative and procedural instruction. Experience conclusively

conclusively shows "plant-specific hands-on training", such as given under the OAP, satisfies a portion of these needs. However, implementation and maintenance of a training/information program that supports and improves operator performance is ultimately dependent upon management support.

II.3.3. Existing Army Guidance: Army Document TM 5-665,*"Operation and Maintenance Of Domestic And Industrial Wastewater Systems," Jan. 1982*, Chapter 1. Introduction to Wastewater Treatment, Section 1. General, page 1-2: "1.1.5. Operator Training.: Sanitary engineers as early as 1903 wrote, "Any plant requires intelligent and diligent care. It will not run itself, no matter what the design." Our vast expenditures for treatment plants will be useless if plants are poorly operated or maintained. An effective training program may be the most important element or a well managed and operated plant.



II.3.4. Summary: *The many negative work factors associated with wastewater treatment plant operation can cause a downward spiral of performance and performance expectation unless there is conscious management intervention. Principal and most effective among these interventions is training of all types with job and plant specific training leading the list. Other interventions are important and include administrative, morale and motivation related activities.*

II.3.5. Recommended Action

System Operators and Managers

- o Create a training plan and budget that maximizes available resources while providing training opportunities
- o Seek innovative training situations and vehicles such as teleconferencing and videos
- o Plan once a year open house as part of earth week or other base activity
- o Make connections with industry groups or societies and budget for participation
- o Make contact with operators of local municipal, regional or industrial treatment plants

Base Commanders, Installation Managers and Public Works Managers

- o Insist on annual reporting of the status of training, certification and training needs
- o Formally inspect the wastewater treatment plant several times per year
- o Insist on a monthly "red flag" report of the top two or three problems facing the plant
- o Participate in the OAP evaluation and training program
- o Support training and professional activities for operators and publicly recognize excellence

II.4. MANAGEMENT SUPPORT

Lesson: Military waste water treatment facilities have not usually been a high priority of facility managers. This management inattention, coupled with decreasing resources, has resulted in a decline in the morale of operating personnel and the perpetuation of poor operating, maintenance and house keeping practices and the concomitant degradation of treatment plant performance.

II.4.1. OAP Observations: The consequences of the lack of support at the management level can be a Notice of Noncompliance (NON). This usually results in bad publicity when covered by the local press.

> ***OAP Findings***
>
> *Management inattention can lead to . . .*
>
> *reduced morale . . .*
>
> *and poor plant operating performance.*

The following Table summarizes improvements in plant support activities as a result of conducting the OAP at 47 Army wastewater treatment plants from 1984 to 1994. The small percent of increase between Phase I and the later Phases can only be attributed, to lack of management support and supervision.

Water and Wastewater Treatment Plant
Support Functions
Installations with Formal or Active Programs
(percent)

	Phase I	Phase II or III	% Increase
Maintenance Plan	38	50	12
Safety Plan	37	48	11
Process Control	<1	<5	4
Laboratory Quality Control	<1	<1	0
Spill Control	42	55	13
Sludge Management	30	39	9
Operator Training	<10	<10	0
Computerized Records Keeping	9	11	2

II.4.2. Discussion: Within an installation commander's staff, knowledge and interest in wastewater treatment is limited outside the Directorates of Public Works or Engineering and Housing until there is a citation for violating regulatory standards. Seldom, if ever, do members of the senior staff visit a plant because of it's remote location and as well as the plant's function, which is not usually of great interest to a professional military person. Also, the expenditure of funds for training and for the purchase of repair parts and replacement equipment generally receives low priority. Downtime

of inoperable or maladjusted equipment often lasts for months or in some instances for years. There has been a general perception that state regulators would be reluctant to take enforcement actions against federal facilities and that wastewater treatment maintenance could wait on available resources; the same as other military installation maintenance. All of these issues have produced a management environment that places low priority on wastewater treatment plant operation and maintenance and has engendered a malaise among plant operators and supervisors concerning the need for quality operation and maintenance. The result is degradation in the performance of the plants.

II.4.3. Existing Army Guidance: Army Regulation 420-49, Facilities Engineering, Utility Services, 28 April 1998, Chapter 1, Introduction, paragraph 1-4. Responsibilities, a. The Assistant Secretary of the Army for Installations, Logistics, and Environment (ASA (I, L, & E)) establishes policy and provides program direction and guidance for utility services. . . . e. Installation Commanders . . . The installation commander is responsible for providing utility services in compliance with applicable standards, laws and regulations. f. Director of Public Works (DPW). . . (1) Provide safe, efficient, reliable and life-cycle cost effective utility services that provide for the health and well-being of soldiers and their families, and other assigned personnel . . .

II.4.4. Summary: *Excellent performance in any venture requires that the operating personnel have clear guidelines from their management about what, when and how their responsibility is to be accomplished. Additionally, employees need to know that what they do contributes to the effort and mission of the command and that they are valued contributors. Lastly, they need to know that what they do is visible to management and that management cares and is watching. When these elements exist, employees can be expected to perform predictably and well. When any of these elements are absence, the opposite is true. For most Army wastewater treatment plants, the latter is the norm.*

II.4.5. Recommended Actions

<u>System Operators and Managers</u>

- o Seek opportunities to brief management on the operation status of the treatment works.
- o Report fully and in detail all aspects of deficient operation or maintenance.
- o Sponsor once per year open house as well as hosting school trips.

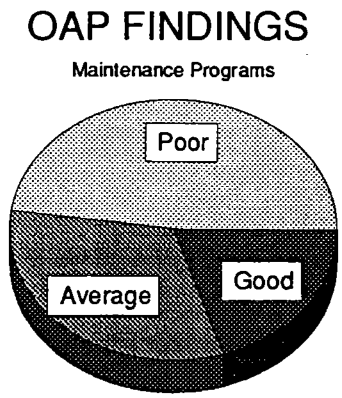
<u>Base Commanders, Installation Managers and Public Works Managers</u>

- o Require detailed reports on the status of operation and maintenance.
- o Get "red flag" reports on critical maintenance items.
- o Visit the plant with some realistic frequency.

II.5. PLANT MAINTENANCE

Lesson: *Preventative maintenance on mechanical and electrical equipment is not routinely performed and long delays often occur before critical equipment is repaired. There are few formal preventative maintenance systems and/or critical spare parts inventory systems in place and plant performance suffers form these failures.*

II.5.1 OAP Observations: Any approach to treatment plant maintenance requires a written program that includes maintenance schedules and records keeping. OAP visits found very few plants had such formalized maintenance programs and, even when plans had been written, they were often outdated and/or ignored. Additionally, OAP reviews determined that, at many locations, insufficient, inappropriate or nonexistent spare parts precluded rapid repair of critical equipment. Delays in effecting repairs were also found to be caused by cumbersome procurement procedures. Frequently job descriptions precluded operators from doing maintenance, including painting and lubrication. The plant rules and/or union agreements required that such work be done by trade specialists, e.g., painter, mechanic, electrician, etc. Other findings included the following:



1. General housekeeping practices were poor.
2. Routine inspection and lubrication of equipment was often ignored.
3. Maintenance record keeping was inconsistent and incomplete.
4. Maintenance and maintenance safety training was absent.
5. Equipment and maintenance manuals for equipment was often absent.
6. Reliance on operators to maintain the treatment plant ground.

II.5.2. Discussion: Wastewater treatment plant maintenance has always been the "step child" of public works. The nature of the processes involved in wastewater treatment requires that the equipment be very sturdy to withstand the grit and chemicals routinely encountered. This necessity causes the equipment to be very expensive, e.g., special materials for pump impellers and explosion proof motors. Procurement practices intended for non-emergency situations cannot be manipulated to

Preventive Maintenance . . .

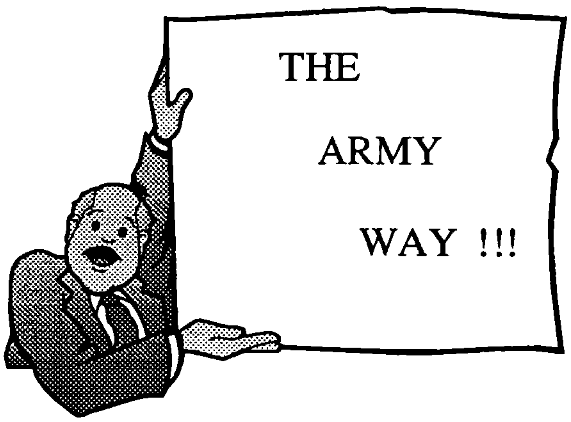
. . . not routinely performed . . .

. . . long delays before critical equipment is repaired . . .

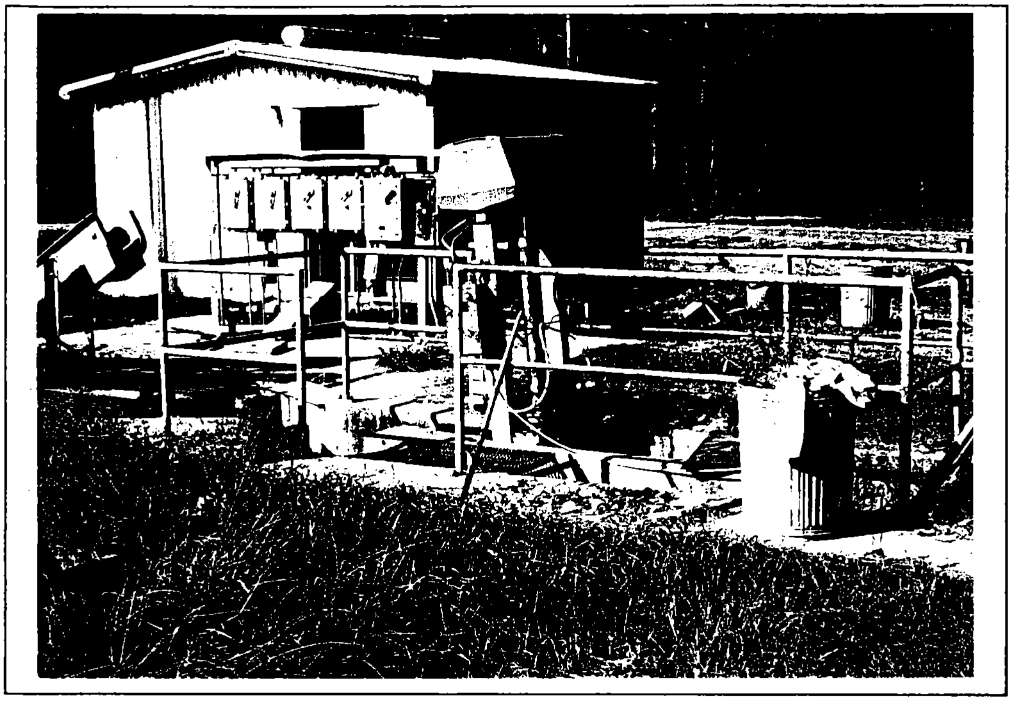
few formal . . . systems in place

provide overnight delivery of expensive parts or equipment. Additionally, equipment repair is often a dirty, dangerous and unpleasant process. Traditionally, broken equipment has even been considered an acceptable excuse for effluent violations. However, the attitude of regulators is rapidly changing and past maintenance practices will not be acceptable in the future. Specifically, NPDES violations caused by maintenance failures may not be treated the same as other types of process failures. Specifically, regulatory penalties may be very severe if the facility is perceived to have diverted budgeted funds away from needed maintenance. Therefore, postponing maintenance or process failures caused by inadequate maintenance programs or procedures may create unacceptable liabilities for the facility, the Army and the individuals involved.

II.5.3. Existing Army Guidance: Army Document TM5-665, "Operation and Maintenance of Domestic and Industrial Wastewater Systems," Jan. 1982, Chapter 1. Introduction to Wastewater Treatment, Section 6. Maintenance, page 1-21: 1.6.1. ROUTINE MAINTENANCE. A well designed and constructed military wastewater plant will experience problems if not properly maintained. Maintenance policy should schedule planned operations and maintenance procedures to keep "break down" maintenance to less than 20% of all maintenance activity. The responsibility for maintenance must be clearly defined and given to competent personnel. Proper tools, spare parts, test instruments, and maintenance shop facilities will allow preventive maintenance to be planned and carried out. Finally, an adequate system of written records and reports must be used for control over the program.



II.5.4. Summary: *The creation and implementation of an excellent maintenance program for a military wastewater facility requires a good plan which includes schedules for maintenance on all plant equipment and contingency planning for major repair work. Additional requirements include adequately trained maintenance people, good record keeping, continued maintenance training, an emphasis on good housekeeping, adequate spare parts and appropriate procurement practices. Nevertheless, the most important component is management attention to the maintenance program.*



IMPROPERLY DISPOSED OF TRASH AND POOR GROUNDS MAINTENANCE

II.5.5 Recommended Actions

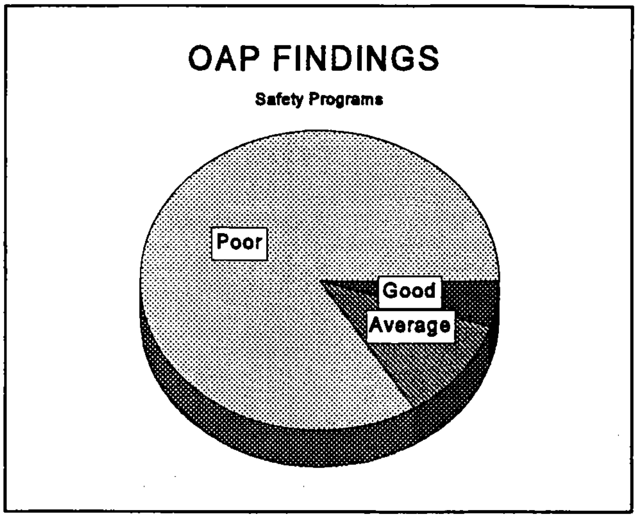
<u>System Operators and Managers</u>
- o Create a maintenance plan and budget
- o Keep an up to date inventory of necessary spare parts and keep it full
- o Take advantage of vendor information and training opportunities
- o Make sure that routine inspection and lubrication of equipment is completed
- o Take advantage of vendor information and training opportunities
- o Investigate the use of PC based maintenance programs

<u>Base Commanders, Facility Managers and Public Works Managers</u>
- o Require annual reporting of equipment failure rates and spare parts inventory
- o Formally inspect the wastewater treatment plant several times per year
- o Require a monthly "red flag" report of the top maintenance problems

II.6. PLANT SAFETY

Lesson: *Safety programs at military wastewater treatment facilities are frequently incomplete and or inadequate. The result is the exposure of employees and others to unsafe conditions and subsequent injury or ill health.*

II.6.1. OAP Observations: The wastewater treatment plant is often not included in the overall installation safety program. As a result, few military wastewater treatment plants hold regular or formal safety meetings, and plants are seldom visited by installation safety inspectors. Frequently, no plant safety officer has been designated so that, even well designed programs, were frequently ineffective. Other important findings included the absence of regular practice on the use of safety equipment, e.g., self contained breathing apparatus. Operators were often frequently unfamiliar with the "Right to Know" program that is OSHA mandated for every workplace. Written procedures on contingency plans for spills and other emergencies were either absent or not in use. Consequently, operators often did not take proper precautions when handling chemicals or dealing with chemical spills. Equipment safety guards were missing, ladders and catwalks were hazardous, exposed wires were common, housekeeping practices were poor. The OAP visits have revealed that there is a direct positive correlation between good housekeeping practices and good safety performance. Lack of management attention to safety and safety procedures has created a demoralizing sense of frustration among employees.



II.6.2. Discussion: A meaningful and technically correct safety program requires the following as a minimum:

- o the conduct of regular and formal safety meetings,
- o showering and laundering facilities,
- o periodic training on;
  - self contained breathing apparatus,
  - Chlorine Institute cylinder repair kits,
  - chemical handling and safety,
  - leak detection equipment, and
  - "right-to-know" and contingency plans,
  - confined space entry.
- o correction of safety hazards, a safety coordinator, and management time and attention.

> ***Plant Safety . . .***
>
> *inadequate and incomplete programs . . .*
>
> *exposure to . . . unsafe conditions . . .*
>
> *management focus required . . .*

Safety has always been "good business" due to the savings that result from reduced lost time and lower medical expenses. High quality safety programs demonstrate management's concern for the well being of the employees and have important and positive effects on morale and performance. Unfortunately, the converse is true. Moreover, with the passage of the Occupational Safety and Health Act (OSHA), good safety practices are now the law. Accordingly, while the principal motivation for safety programs should always be the health of the employees, istallation management should not forget that they expose themselves and the Army to significant liability by not insisting upon very aggresive and high quality safety programs.

II.6.3. Existing Army Guidance: Army Document TM5-665, *"Operation and Maintenance of Domestic and Industrial Wastewater Systems," Jan. 1982,* Chapter 17. SAFETY AND HEALTH, Section 1. GENERAL INTRODUCTION, page 17-11: "17.1.1. SAFETY REGULATIONS AND MANAGEMENT RESPONSIBILITIES. The Occupational Safety and Health Act of 1970 (OSHA) first became law on April 28, 1971, and has been amended by administrative interpretation several times since that date. The purpose of the Act is to identify, eliminate or rectify hazardous and unhealthy conditions. Corrections of these conditions will save lives, provide better health and protect property. Wastewater utility management and other safety organizations need to be aware that OSHA recommendations are compatible with good management practices. ...

17.1.2. O.S.H.A. This Act specifies that individual workers are personally responsible to follow safe procedures, properly use the safety equipment provided, and to perform their tasks in a safe manner.

17.1.3. GOOD MANAGEMENT PRACTICE. Good management practice requires an effective safety program. ...

II.6.4. Summary: *The OAP Phase I inspections found that, in general, wastewater teatment plant safety was well below industry standards and clearly not in conformance with Army guidance. Significant unacceptable findings included inadequate training of personnel, infrequent safety meetings, serious deficiencies in safety equipment and supplies, few periodic inspections, little contingency planning, and poor housekeeping. This situation represents serious liability for the Army and the installation management.*

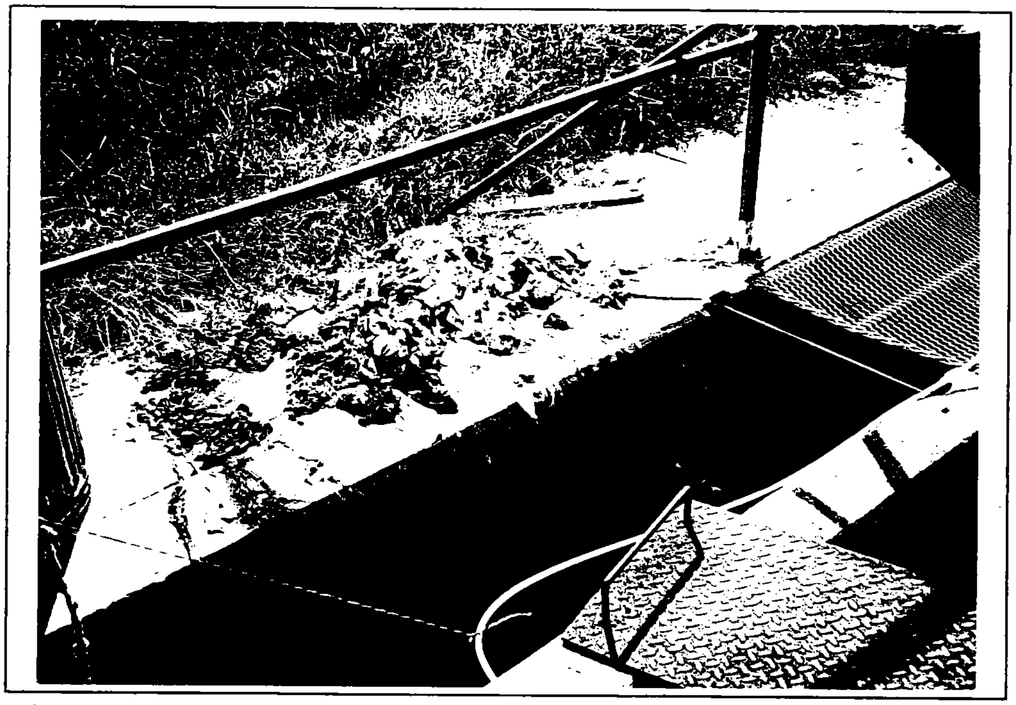
II.6.5 Recommended Action

System Operators and Managers

- o Create a safety plan and budget
- o Keep an up to date inventory of safety equipment and supplies
- o Iinspection and practice with safety equipment should be routine
- o Take advantage of facility and contract training opportunities
- o Good housekeeping !

Base Commanders, Facility Managers and Public Works Managers

- o Require frequent reporting of status of safety program, e.g., accidents, training, etc.
- o Formally inspect the wastewater treatment plant several times per year
- o Pay attention, attend some safety meetings, communicate your belief in the importance of safety programs and training



SAFETY HAZARDS - GRIT CHAMBER WITHOUR PROTECTIVE GRATE AND IMPROPERLY DISPOSED OF SCREENINGS

II.7 TREATMENT PROCESS CONTROL

Lesson: *Insufficient, and often inappropriate, intraplant sampling and testing is being accomplished at military wastewater treatment facilities. Inadequate monitoring cannot produce sufficient data to allow operators to modify individual unit processes when required and, thereby, optimize total plant performance.*

II.7.1. OAP Observations: Process control involves the collection and analysis of samples at intermediate locations in the treatment sequence to determine the efficiency and effectiveness of key unit processes. *The specific sampling locations and tests must be determined individually for each facility.* At most military plants, testing is limited to the final effluent since the primary concern has been to satisfy NPDES permit requirements. Despite operational benefits of unit process control, testing unit processes to determine performance efficiencies is not being required by those in management. Supervisory and management personnel do not usually consider the additional work and expense to be justified as long as the NPDES permit requirements are met. As a result, operators refrain from performing this type of testing due to lack of materials, fear of censure and to avoid additional work. Therefore, military operators run their plants by "rule of thumb" rather than by procedures based on sound technical principles and good analytical data.. This results in violations of the NPDES permit requirements and the concomitant liability for management.

Process Control

Insufficient . . . sampling and testing . . .

Operators . . . cannot . . .
modify unit processes . . .or
. . . optimize plant performance.

II.7.2 Discussion: Wastewater sampling and testing are performed routinely on plant effluent to verify plant performance because it is an NPDES permit requirement. However, the same actions are seldom, if ever, taken to check the plant influent or the influent and effluent from individual treatment units, such as clarifiers and trickling filters. Only when intraplant sampling and analysis is routinely performed is it possible to determine the effectiveness of each treatment process and to make timely adjustments before the plant effluent fails to meet prescribed standards.

Additionally, when sampling and testing are limited to monitoring the plant effluent, there is all too frequently a tendency to withhold test results from the operators. This is especially true when the sampling and testing is done by an outside contract laboratory, but the same pattern was observed for in-house sampling and analysis. As a result of this lack of information, operators tend to lose interest in their work and are often not motivated to improve plant performance.

II.7.3. Existing Army Guidance: Army Document TM5-665, *"Operation and Maintenance of Domestic and Industrial Wastewater Systems," Jan. 1982,* Chapter 16. LABORATORY SAMPLING, TESTING AND RECORDS, Section 1. SAMPLE COLLECTION, page 16-2: "16.2.1. USING LAB TEST RESULTS. Lab results are useful in the operation of a waste water treatment plant. The operator can use lab test results to keep the plant working its best and to give early warning of operating problems. Lab testing programs vary with the type of treatment, size of the plant, local water quality requirements and the NPDES permit requirements. Some of the most common lab tests for wastewater treatment plants are shown in Table 16-3 and will be discussed more in this chapter. . . Lab test required by NPDES are determined for each treatment plant and are cited in the discharge permit."

Section 3. LABORATORY RECORDS, page 16-22: "16.3.2.3.d. Using Performance Records to Check the Plant. The performance records at a treatment plant can provide good process control data to the operator. Results of lab tests which differ a lot from previous records may reflect an equipment breakdown, an industrial waste discharge or a break in the collection system. Table 16-6 shows some changes from normal values and some causes for these changes."

II.7.4. Summary: *Process control sampling and testing, above that required for NPDES reporting, should be made standard practice at every plant to ensure optimum control over treatment processes. This practice will increase the operator's understanding of the treatment facility and will markedly improve morale and performance.*

II.7.5. Recommended Actions

System Operators and Managers

- o Create an intraplant sampling and testing plan
- o Review all sampling, monitoring and testing data with operators frequently
- o Take advantage of vendor information and training opportunities

Base Commanders, Installation Managers and Public Works Managers

- o Benchmark your plant with other nearby plants for NPDES compliance and analytical program
- o Review the sampling and analysis plan of the plant and review the monthly results

II.8 USE OF WASTEWATER TREATMENT CHEMICALS

Lesson Learned: *Wastewater chemicals are often used inappropriately. Operators most often do not understand the chemistry involved nor the calibration and adjustment of the chemical feed equipment. Operators need supplemental training in the chemistry of wastewater and the application of treatment chemicals.*

OAP Findings

Wastewater treatment chemicals . . .

inadequate sampling and analysis . . .

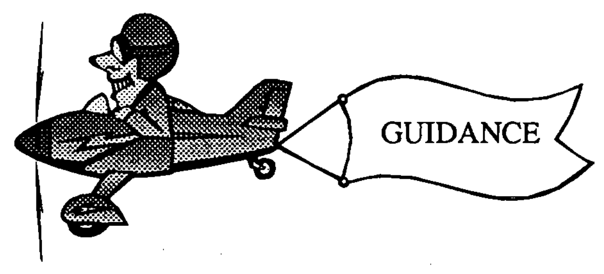
provides insufficient data for operators . . .

resulting poor performance of plant at times of quality changes.

II.8.1. OAP Observations: Most operators have not been given adequate instruction on the chemistry of wastewater treatment. Operators frequently do not understand how to adjust feed rates on chemical feed equipment. Often the plant O&M Manual does not adequately cover adjustment and calibration procedures for chemical feed equipment. The effect of these deficiencies is that adjustments are frequently incorrect with too much or too little chemical being applied. Additionally, chemical feed adjustments are not always based on the information provided by plant instrumentation and laboratory test results. At many plants, instrumentation was unreliable due to calibration, repair and replacement issues (see Maintenance) and laboratory testing and analysis was either not available or not understood by the operators. Lastly, chemical inventory data was usually unreliable or non-existent.

II.8.2. Discussion: Chemical feed rates for coagulation and pH adjustment chemicals, such as alum or lime, are rarely modified after the feed equipment has been installed. Nevertheless, changes are required when there are major problems with effluent quality. Even in the face of deteriorating effluent quality, operators are loath to change settings because of limited understanding of the chemical and physical processes which will be affected. Additionally, good operational control procedure requires the performance and evaluation of laboratory tests. Review of laboratory data will indicate which chemicals, if any, require dose changes. Also the review of chemical inventory data can confirm the chemical usage and highlight any feed adjustment problems. An operator's lack of understanding and or training usually results in

chemical feed adjustments that are made by trial and error or hit or miss. The result are potentially catastrophic in terms of treatment costs, sludge generation, permit compliance, effluent quality and impact upon the receiving stream. Each operator must have sufficient training in the chemical treatment of wastewater and have access to an operating manual that sets out simple and unambiguous algorithms for the calibration and adjustment of chemical feed systems. Frequent in-house update training on this subject is required.



II.8.3. Existing Army Guidance: Army Document TM 5-665. *"Operation and Maintenance of Domestic and Industrial Wastewater Systems," Jan. 1982,* Chapter 1. INTRODUCTION TO WASTEWATER TREATMENT, Section 1. GENERAL, page 1-3, 1.1.5.2. Objectives of Training. Operator training should stress the application of useful information directly relating to the skills needed to operate a particular plant or type of equipment. It should focus on concepts essential to the operator's job performance. For example, the training material should allow the operator an understanding of the physical, chemical, and biological processes involved in plant operation. Specific laboratory, maintenance, safety and operational tasks should be covered. . .

Chapter 16. LABORATORY SAMPLING, TESTING AND RECORDS, Section 2. LABORATORY TESTS, page 16-2, 16.2.1 USING LAB TEST RESULTS. Lab results are useful in the operation of a wastewater treatment plant. The operator can use lab test results to keep the plant working its best and to give early warning of operating problems. Lab testing programs vary with the type of treatment, size of the plant, local water quality requirements and the NPDES permit requirements. . .

page 16-22, 16.3.2.3. Performance Records. Paragraph d. Using Performance Records to Check the Plant. The performance records at a treatment plant can provide good process control data to the operator. . .

II.8.4. Summary: *The lack of training and, consequently, understanding of wastewater chemistry and the dynamics of process changes caused by chemical additions, results in operators creating or "rule-of-thumb" procedures for the setting of chemical feed equipment. This problem is exacerbated by lack of training on the calibration, setting and adjusting of chemical feed equipment as well as chemical handling safety. The results are 1) water quality discontinuities and potential permit violations, 2) excessive costs due to over feeding of chemicals as well as the time and materials required to stabilize the plant, and potentially hazardous conditions for the operators.*

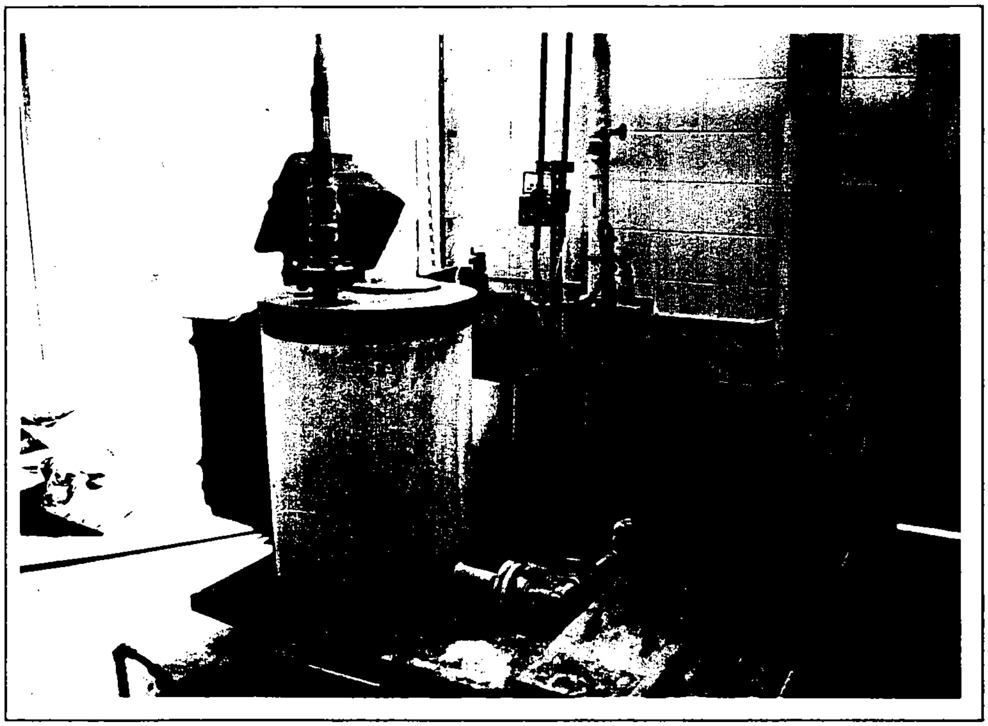
II.8.5. Recommended Actions:

System Operators and Managers

- o Keep an up to date inventory of treatment chemicals - review it frequently.
- o Emphasize wastewater chemistry and chemical feed systems.
- o Practice quality changes and chemical feed responses.

Base Commanders, Installation Managers and Public Works Managers

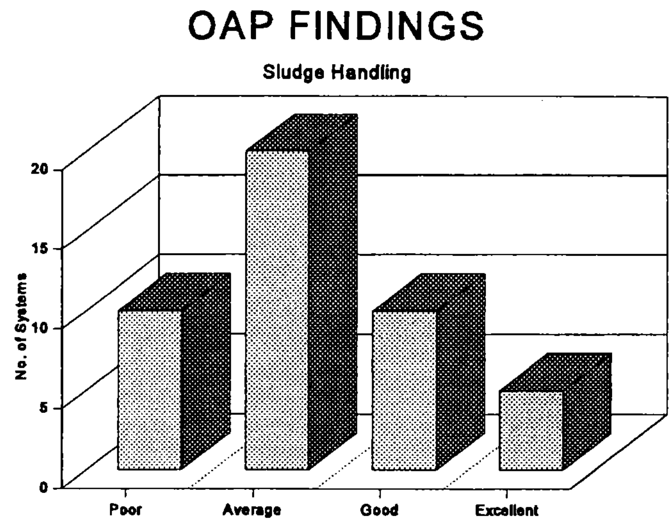
- o Require reporting of chemical usage vs. NPDES daily values.
  - Compare month to month and year to year.



TYPICAL CHEMICAL FEED SYSTEM

II.9. SLUDGE HANDLING / TREATMENT / DISPOSAL

Lesson Learned: *Army wastewater treatment plant operators are generally not well trained concerning the chemistry, process control or economics of the sludge handling equipment under their control.*



II.9.1 OAP Finding: The wastewater treatment facilities of the Army represent a wide variety of sludge or biosolids handling equipment. Processes range from simple pumping of clarifier sludge by septage haulers and sand drying bed sludge cake removal to very complex digestion systems and mechanical dewatering systems. Universally, operators are not well informed about the sludge handling/treatment/disposal processes at their plants. Operators are often unclear as to how these processes worked, e.g., factors affecting gas production at digesters, sludge withdrawal rate impacts on activated sludge, sludge stabilization techniques, etc. Plant personnel seldom sample for, or try to interpret the results of analytical tests for, parameters such as temperature, volatile acid/alkalinity ratios, CO_2 content of digester gas or sludge age. Operators reported that they had been given an operational scheme, e.g., sludge feed and withdrawal rates and valve and pump settings, and they did not understand the technical basis of the scheme nor did they know how to make modifications to reflect changing plant conditions. Operators need to be trained in sludge handling theory, practice and "trouble shooting", with primary emphasis given to the operation of the specific equipment at each individual plant. Other deficiencies were noted such as poor handling of screenings and scum and inadequate attention to drying beds. These later deficiencies are not solely the fault of training and can and should be corrected by more vigilant supervision.

II.9.2. Discussion: Due to differences in construction, specific state regulations and local conditions, the Army has a wide range of solids handling equipment. For those reasons, the operational requirements vary significantly between plants and facilities. The disposal methods and requirements are practically unique to each facility and differ due to climate, geology and demographics of the region. Furthermore, the solids/sludge handling processes can be complex and technically different from the remainder of the wastewater unit processes, e.g., gas production from an anaerobic have a clear understanding of the process theory. It also requires an operational scheme that is based upon continuous monitoring of the physical parameters involved and review of analytical testing. Moreover, sludge operations almost always require the maintenance of good records and continual trend plotting of significant control values. Equipment maintenance is critical to quality operation. When these elements are missing or inadequate, the operation of sludge handling and disposal equipment is usually inefficient. In the circumstance of changing process characteristics, operators fall back on "rules of thumb" which may not be thoroughly understood and which may not be appropriate or efficacious. The most frequent outcome of these situations is the degradation of the sludge handling capability of the plant, often requiring Herculean efforts to reverse or improve. Another result can be an effluent quality discontinuity caused by the need to hold sludge longer than usual or to recirculate more sludge than the design allows. In any event, outcomes may be negative for the facility in either cost or compliance. Better and more frequent training and greater management involvement with plant operations are required to improve this situation.

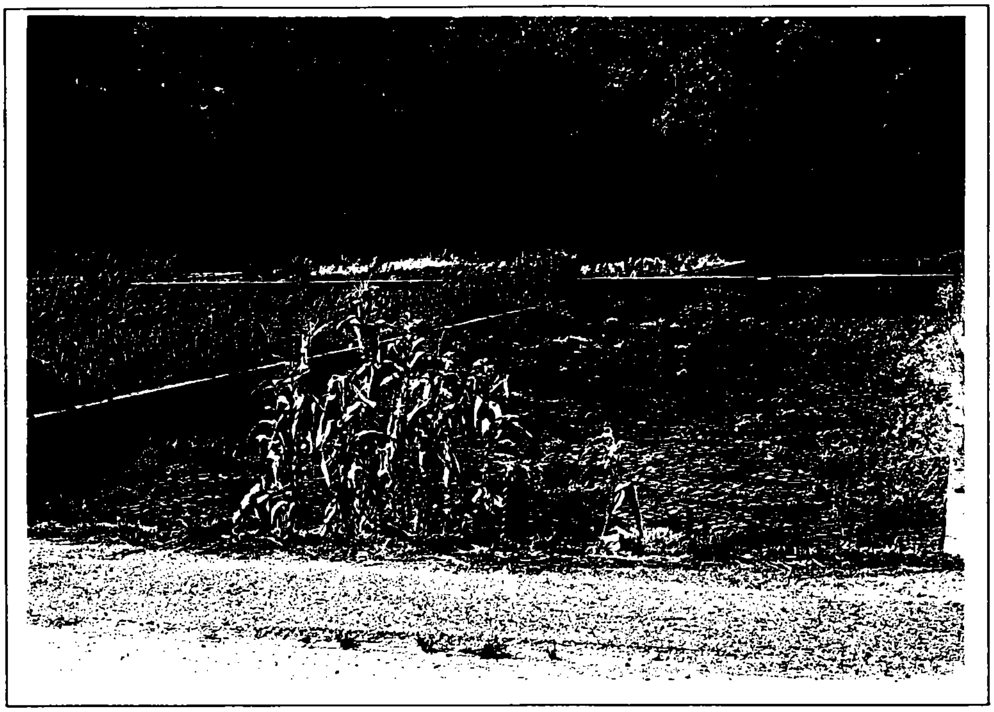
Sludge Handling . . .
problems . . .

wide range of equipment . . .
little monitoring . . .poor maintenance . . .
rule of thumb operation . . .

degraded effluent . . . excess costs.

II.9.3 Existing Army Guidance: Army Document TM 5-665, *"Operation and Maintenance of Domestic and Industrial Wastewater Systems," Jan. 1982,* Chapter 13. SLUDGE HANDLING, TREATMENT AND DISPOSAL, Section 1. PUMPING SLUDGE, page 13-1, 13.1.1 SLUDGE. . . . For plant operators to plan for sludge pumping, they must figure the rate at which solids build up and the total amount per day that must be treated. Changes in temperature, storm flows and other *process items* must be thought about *(AND PLANNED FOR)* if a primary or secondary settling tank, a sludge thickener or other unit is to work right. . . .

II.9.4 Summary: *Wastewater sludge handling, treatment and disposal are technically challenging and expensive. The unit processes involved must be managed carefully using careful process monitoring and a comprehensive operating scheme. Presently, wastewater treatment plant operators at Army facilities are not adequately prepared to assure consistently high quality solids handling and disposal. The effects of this deficiency are process upsets, inefficient operation, excess costs and potential compliance difficulties. Additional operator training and close management and supervision are required.*



CORN AND WEEDS GROWING IN SLUDGE DRYING BEDS

II.9.5. Recommended Actions:

System Operators and Managers

- o Additional operator training - unit process specific
- o Additional process monitoring
- o Improve operating procedures/manuals
- o Maintain adequate recorsds

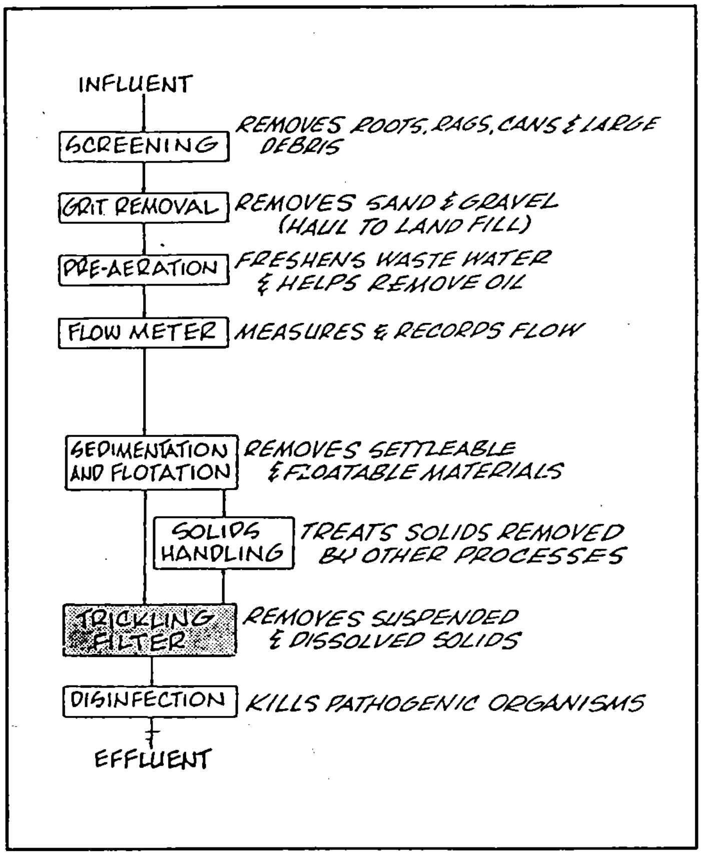
Base Commanders, Installation Managers and Public Works Managers

- o Formally inspect the wastewater treatment plant several times per year
- o Require periodic operational summaries
- o Control process by monitoring costs on month to month basis

III. PROCESS SPECIFIC LESSONS

III.1 TRICKLING FILTER PLANT OPERATION

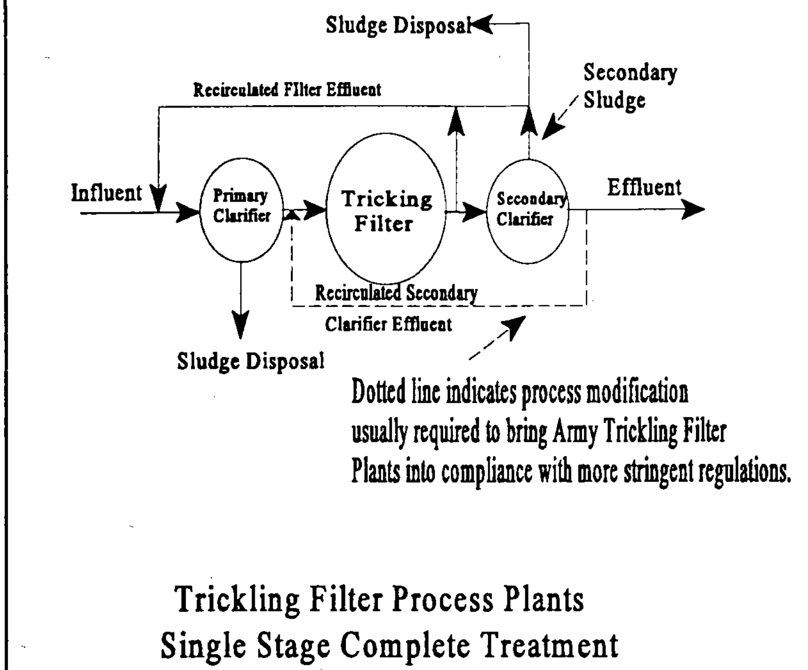
III.1.1. Overview of Treatment Process: Trickling Filters are large-diameter, shallow, cylindrical structures filled with stone or other media and having an overhead distributor designed to distribute wastewater evenly over the surface of the filter. When natural media (stones) are used, the trickling filter is usually cylindrical with a shallow bed; when synthetic media (usually plastic) are used, the filter could be cylindrical or rectangular with a much deeper bed. Square or rectangular filters have been constructed with fixed nozzles or sprinklers to distribute the waste water. Indeed, many variations in design have been used and the Army systems have a good cross-section of this diversity.



TRICKLING FILTER PROCESS SCHEMATIC

The media provide a large surface area upon which a biological slime growth develops. This slime growth, sometimes called a *zoogleal film*, contains the living organisms that break down the organic material. The media should be of such sizes and stacked in such a fashion to provide empty spaces (voids) for air to ventilate the filter and keep conditions aerobic. The media must be uniform in size to create a maximum void volume. The media depth ranges form about three to eight feet. Important process issues include the amount and distribution of oxygen in the filter, keeping the voids open, the quantity and frequency of wastewater loading, the temperature and chemical composition of the wastewater and the degree and efficiency of the primary clarifier.

Trickling filter plants are the most common method of treating wastewater in the Army. About 75% of the plants in operation today are of this type. These plants are relatively simple to operate, and are less susceptible to upset from shock loads than other methods of treatment. However, their performance, secondary treatment as originally designed, will not generally meet the newer and more stringent effluent discharge standards. Where the more stringent discharge standards have been imposed by state regulatory authorities, modifications of the basic treatment process have become necessary as discussed and shown below.



TRICKLING FILTER EFFLUENT RECIRCULATION

III.1.2.RECIRCULATING THE TRICKLING FILTER EFFLUENT

III.1.2.1. Lesson: *Existing Army trickling filter plants can often be upgraded by simple piping and equipment modifications.*

III.1.2.2. OAP Findings: Trickling filter plants that do not now permit recirculation of filter effluent can be readily modified by the installation of simple piping and a variable speed pump. Biological Oxygen Demand (BOD) removal would be increased by this procedure, and this in turn could assist meeting plant discharge limitations for this pollutant

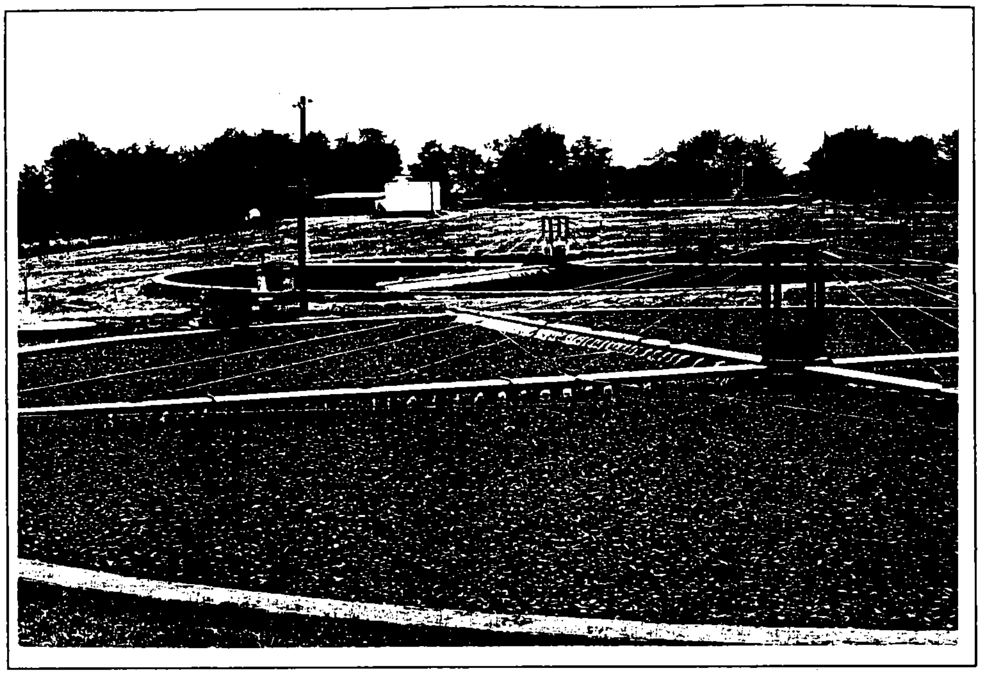
III.1.2.3. Discussion: In the design of those trickling filter plants installed in the early 1940s, as many of the Army plant were, the concept was to pass wastewater through the filter once on its way to the final clarifier. Subsequently, sanitary engineers determined organics removal would be improved by recirculating filter effluent and or secondary clarifier effluent through the filter. Some, but not all, of the Army's trickling filter plants have been modified to permit this recirculation.

III.1.2.4. Recommended Actions: As the benefits of this process modification are high and the costs low, all of the Army facilities should design and schedule a modification to allow for recirculation of the trickling filter effluent at the earliest possible budget cycle.

III.1.3. DISTRIBUTOR BEARING MAINTENANCE

III.1.3.1 Lesson: *The distributor arm is the most maintenance sensitive portion of the trickling filter. Maintenance of the bearing and nozzles is crucial and should not be neglected.*

III.1.3.2. OAP Finding: Routine maintenance of the distributor arms was often delinquent at Army trickling filter plants. OAP contractors found examples of failure to flush the end dump-gates on the distributor arms, infrequent or no cleaning of debris from the filter, absence of cleaning of the nozzle openings and infrequent observation of the arm for clogging and rate of rotation. The oil in distributor bearings was usually not checked as called for in the plant maintenance schedule and routine maintenance of the filter was frequently delayed or not done at all.



TYPICAL TRICKLING FILTER IN OPERATION SHOWING DISTRIBUTOR ARM DOSING THE FILTER

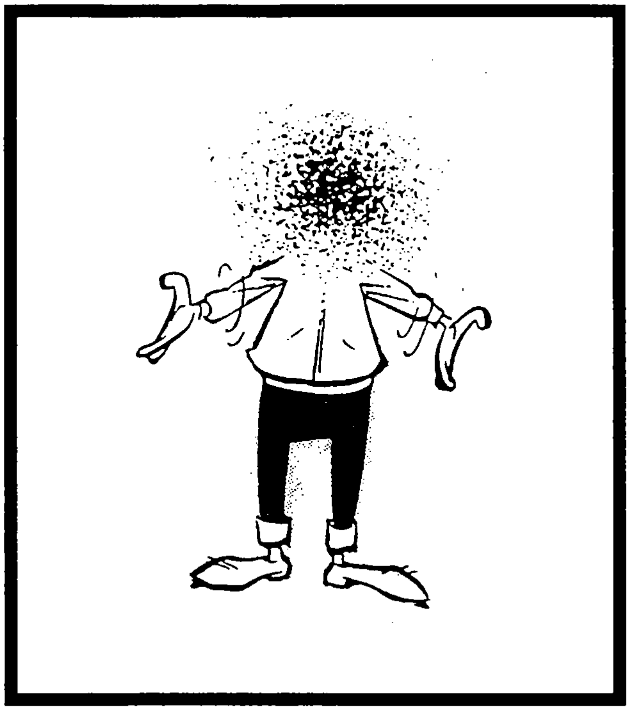
III.1.3.3. Discussion: Primary clarifier effluent is distributed over the filter media by a rotating distributor arm which operates periodically depending on releases from the dosing siphon. Maintenance of the distributor is relatively simple, only requiring periodic lubrication of the central pivot bearing and unclogging distributor arm ports. However, failure to check bearing oil may allow water or foreign matter to accumulate and can quickly reduce the lubricating value of the oil. Similarly, not adjusting the support turnbuckles can cause the arm to distribute wastewater unevenly or at too slow of a speed, thereby, reducing the efficiency of the process and risking compliance failures. The preventative maintenance for this device is simple and not time consuming. On the other hand, major repairs to the arm are labor intensive and costly and put the filter out of service for extended periods of time. This maintenance should not be neglected or overlooked.

III.1.3.4. Recommended Actions: The required maintenance and monitoring of the trickling filter and distributor arm must be made clear to the operating personnel and the supervisor must insure that it is done correctly and at the right frequency. The Army should provide maintenance benchmarks to wastewater plant managers and operators, e.g., average bearing replacement frequency.

III.1.4. ODOR AND FLY CONTROL

III.1.4.1. Lesson: *Odor and filter fly problems can be caused by poor operation and maintenance of tricking filter plants. The resulting difficulties can cause problems for the entire military facility.*

Managers and supervisors must insure that procedures are clearly understood by operating personnel and that they are carried out with the proper frequency.



III.1.4.2. OAP Finding: A well maintained trickling filter plant is relatively simple to operate and is generally quite efficient.. There is, however, a tendency for the trickling filters themselves to become a source of odor and a breeding place for filter flies. These conditions can be avoided by proper maintenance of the filters and routine monitoring followed by appropriate action by the operator. The OAP contractors found many instances of inadequate or inappropriate maintenance and operational procedures. The results of these operations and maintenance failures included bad smelling and nuisance plants as well as significant filter fly problems.

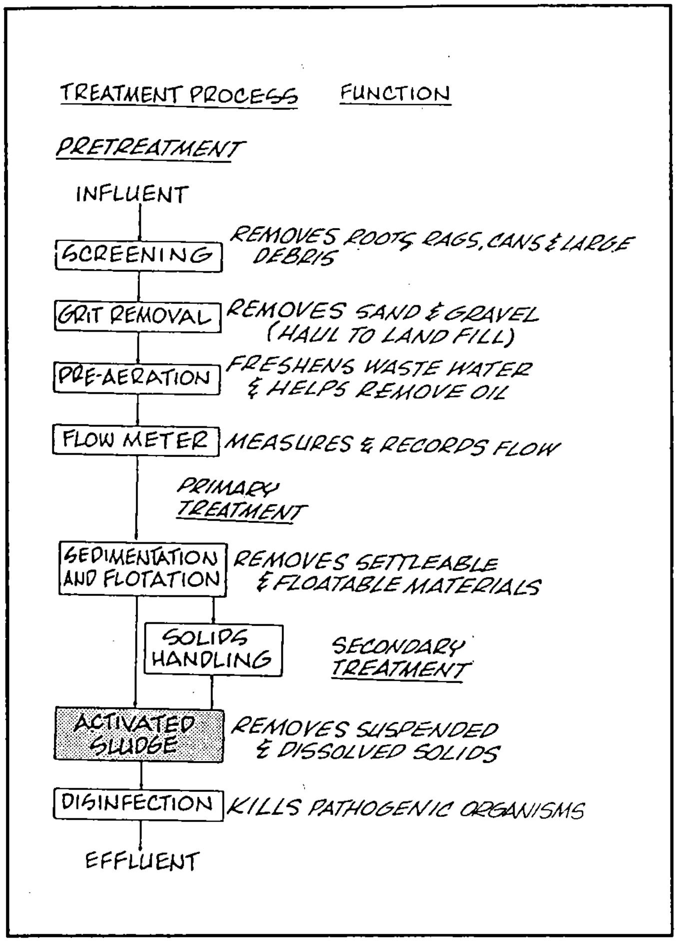
III.1.4.3. Discussion: The tiny, gnat-sized filter fly (psychoda) is the primary nuisance insect connected with trickling-filter operations. There are a number of methods for the control of filter flies including increasing the hydraulic loading rate, chlorination and insecticides. However, in general fly control is best achieved by periodically flooding the filter, for a period of 24 hours, in order to prevent completion of the life cycle, which is as short as seven days in warm weather.

The best solution to the odor problem is to do everything possible (such as prechlorination or preaeration) to maintain aerobic conditions in the sewer collection system and in the primary treatment units. In addition, ventilation in the filter should be checked frequently to insure that the underdrain system has not become clogged by heavy biological growths or other obstructions. When this clogging occurs, air flow to the filter is partially interrupted or blocked and will interfere with the maintenance of aerobic conditions. Similarly, the surface of the filter should be inspected frequently to insure that the application of wastewater in not being obstructed by leaves, plastic or other materials.

III.1.4.4. Recommended Actions: Make certain that operators understand the operating and maintenance requirements of trickling filters and the appropriate remedies for specific problems such as filter flies and odors. Inspect the plant frequently to assure that appropriate operating conditions are being maintained.

III.2. ACTIVATED SLUDGE TREATMENT PLANTS

III.2.1. Overview of Treatment Process: The activated sludge treatment process is aimed at oxidation and removal of soluble or finely divided suspended materials that were not removed by preliminary treatments. (see process schematic below) Aerobic organisms stabilize soluble or finely divided suspended solids by partial oxidation forming carbon dioxide, water, and compounds of sulfur and nitrogen among others. The remaining solids are changed to a form that can be settled and removed as sludge during ensuing sedimentation.



ACTIVATED SLUDGE TREATMENT PROCESS SCHEMATIC

When wastewater enters the aeration tanks of an activated sludge plant, it is mixed with a portion of the previously settled sludge to form a mixture of sludge, carrier water, and influent solids. The activated sludge which is added (return activated sludge) contains many different types of helpful living organisms that were grown during its previous contact with wastewater. These organisms will use additional food contained in the incoming wastewater in treating the wastes. The activated sludge also forms a lacy network of floc mass that entraps many materials not used as food. The key to successful operation of activated sludge plants is maintaining the proper balance between the organisms and waste organic material in the aeration basins as well as maintaining the optimum environment for the organisms to decompose the waste material found in the incoming wastewater.

Activated sludge plants make up about 15% of the Army's inventory of treatment facilities, and most of them are small package plants that range in size from 0.04 MGD to 1.0 MGD. These plants are more difficult to operate than trickling filter plants because they require continuous monitoring and adjustment and are less resilient to variability in plant influent quality. There are many variations of the conventional activated sludge process, but they all involve the same basic principles.

III.2.2. PROCESS CONTROL

III.2.2.1. Lesson: *Activated sludge wastewater treatment plants require more attention and better trained operators than is the case for other types of treatment plants presently being used by the Army.*

III.2.2.2. OAP Finding: Control of these facilities consists of maintaining the proper solids concentration in the aerator for the waste inflow by adjusting the waste sludge pumping rate and regulating the oxygen supply to maintain a satisfactory level of dissolved oxygen in the process. Operators of activated sludge plants require intensive instruction and hands-on training in operational techniques and analytical testing and interpretation to operate these plants adequately To avoid the analytical work load that is normally associated with these plants, many Army operators and managers have used the "*rate of wasting of return activated sludge*" as the principal, and sometimes only, process control parameter. This simplified operating procedure will only work when the influent chemical and biological characteristics are consistent day to day. However, operators who depend solely on this "rule of thumb" for wasting sludge will not have a clear understanding of the many and complex physical, biological and chemical processes that interact in the activated sludge process technology. When process upsets occur, these operators have few operational or analytic tools to use in correcting the problem. The result is too often very erratic operations, and in the event of an upset due to a shock loading, the plant is frequently not returned to normal and proper operating condition for extended periods of time. The a OAP engineers uniformly believed that this situation was too common and constituted a high degree of environmental liability for the Army and the facility management.

III.2.2.3. Discussion: The activated sludge process is a complex process technology. It involves the balance of raw wastewater, oxygen, agitation, water chemistry and biology with the maintenance of a large mechanical plant with many operating systems. The analytical tools required for this control of this process include regular determination of settleability of the activated sludge, the oxygen content of the aeration basin, solids and volatile solids content of the sludge, amount of sludge being wasted as well as composite parameters such as the food/microorganism ratio, sludge age, pH and total suspended solids and chlorine residual of the effluent. Small changes in the oxygen content or the ration of return sludge to incoming wastewater can cause significant deterioration in the quality of the wastewater process effluent. Likewise, changes in the physical and chemical characteristics of the incoming wastewater can cause the same results. Avoidance of such deterioration requires constant vigilance of the process and the ability to interpret the physical and chemical testing results. Operators will not learn these skills

quickly and many will need additional preparation in chemistry and microbiology in order to fully understand all the elements of this process. Owner of activated sludge process plants have come to understand that operator training for process control is a necessary investment of both time and money and that failure to make that investment can have catastrophic results, e.g., fish kills, odors, stream degradation and resulting negative regulatory actions and public relations. The Army (facility managers) has, to this date, either chosen to not make such an investment or believes that such an investment can be avoided.

III.2.2.4. Recommended Actions: Operators of activated sludge treatment plants require training aimed directly at the process control issues inherent in the operation of this type of plant. Additionally, the sampling and analytical scheme at these plants must be designed to give the operator the information he/she requires to operate the plant correctly and to make changes in a timely fashion. In order to provide excellent operation of activated sludge plants, management must focus on these issues of training and process sampling and testing.

III.2.3. PACKAGE PLANTS

III.2.3.1. Lesson: Package wastewater treatment plants have the same operating requirements as larger facilities (activated sludge process - see above). The small size of these plants can justify a smaller maintenance staff, but the operating and analytical requirement is the same as much larger systems. The operating staff of Army package plants is frequently undersized or nonexistent.

III.2.3.2. OAP Finding: The OAP training of package plant operators requires as much time and effort as is required at the larger plants. Considerable attention has to be given to sampling the various unit processes and to the interpretation of test results. The latter is often made difficult due to the limited laboratory capability provided at the small training-oriented installations.

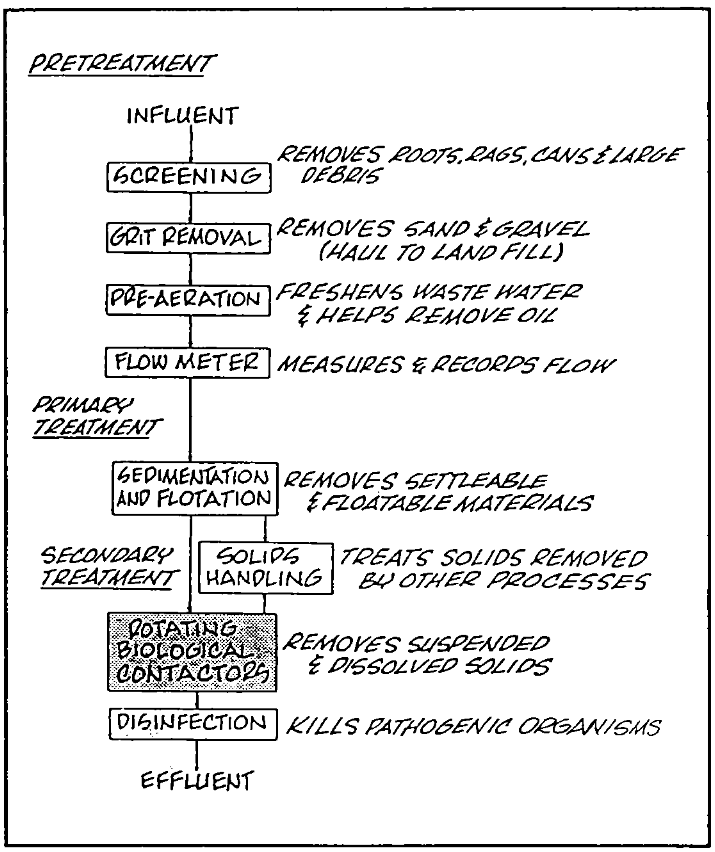
III.2.3.3 Discussion: Small capacity package plants that employ the activated sludge treatment process are commonly found at installations that host Reserve and National Guard training. Control over the treatment process is oftentimes difficult due to the periodic fluctuations in population. Weather can also affect their operation because package plants are commonly above ground, where they are susceptible to temperature extremes which can adversely affect the biological processes. Furthermore, these plants which commonly have rated capacities of between 50,000 and 100,000 gallons per day, are operated with minimal-size crews, making the hiring and retention of proficient operators very difficult. Providing insufficient operation and supervision personnel due to the small size of the facility

III.2.3.4. Recommended Actions: Package plants should be operated by either hired contract operators or as satellites of larger plant located in close geographical proximity. If neither of these options are available, the facility manager must treat the wastewater plant as a standard wastewater facility and staff it appropriately.

III.3 ROTATING BIOLOGICAL CONTACTOR PLANT OPERATION

III.3.1 Overview of Treatment Process: Rotating Biological Contactors (RBCs) are secondary biological treatment process for domestic and biodegradable industrial wastes. RBCs have a rotating shaft surrounded by plastic discs called the "media"; together, the shaft and media are referred to as the "drum." This type of plant is basically a variation of the trickling filter plant where the rotating media of the RBC has been substituted for the stationary media of the trickling filter. However, in the RBC, the drum is submerged half way into the sewage and allows the biological growth on the media to rotate into the settled wastewater and then into the atmosphere to provide oxygen for the organisms.

The media rotate while approximately 40 percent of the medial surface is immersed in the wastewater. In this fashion, the media pick up a thin layer of wastewater which flows over the biological growth on the drum. The organisms on the drum are thereby alternately presented with new organic matter from the wastewater for food and dissolved oxygen from the air, thus removing wastewater from the water being treated. Additionally, as the biological growth is submerged, a small percentage is sloughed off of the media and subsequently captured in a secondary clarifier.



RBC PROCESS SCHEMATIC

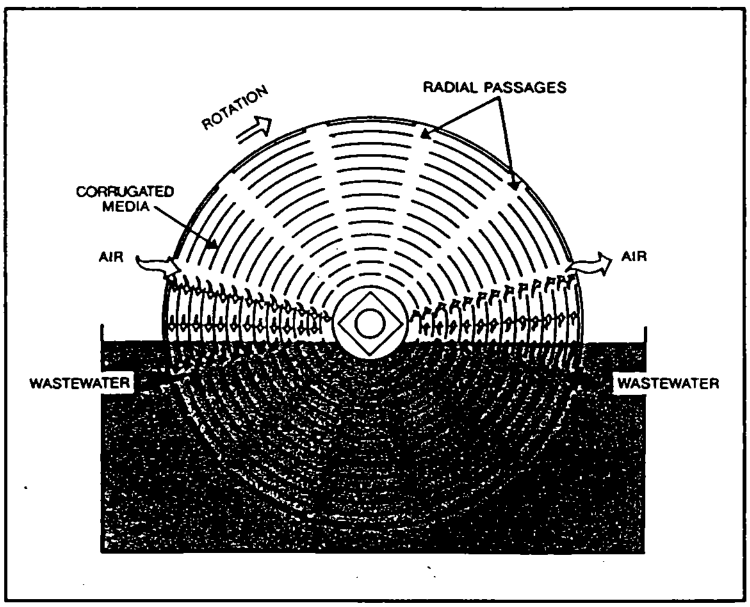
About 5% of the Army-owned treatment plants use (RBCs). Many of those in operation today are small capacity plants and are found on U.S. Army posts in South Korea. The rotating contactor is a relatively new device, that found early favor in the Army. It was believed that RBCs could be retrofitted to older plants at low cost and with a much improved effluent quality. However, installations experienced mechanical problems, primarily shaft breakage due to the heavy weight and/or uneven distribution of the biological growth. These frequent equipment failures have caused RBCs to fall into disfavor, and no more RBCs are to be built by the Army.

III.3.2 PROCESS FAILURE

III.3.2.1. Lesson: *RBC plants are not difficult to operate and will produce a good effluent provided the operator inspects the equipment regularly, tests the influent and effluent, observes the media, maintains the equipment and takes appropriate corrective actions when necessary.*

III.3.2.2. OAP Finding: RBCs require only minimal water quality analysis to monitor and control daily performance. OAP engineers found that often even these simple analytical requirements were not being met on RBC plants. Additionally, failure-free operation of a RBC plant is dependent on a well implemented maintenance program and a selective inventory of high failure frequency and difficult to obtain parts. Maintenance and parts inventory programs were substandard on the RBC plants observed. Specific attention should be addressed to drive components, i.e., chain drives, belt drives, sprockets, rotating shafts, as well as motors and speed reducers. *The frequent breaking of shafts was experienced when the RBCs were initially installed. However, redesign of drive units and the installation of heavier shafts by the equipment manufacturers have essentially eliminated this problem.*

III.3.2.3. Discussion: A desirable characteristic of RBCs is the low level of analytical monitoring that is generally required, i.e., biological oxygen demand, suspended solids, pH and dissolved oxygen. pH and dissolved oxygen can be done quickly on-site, while biological oxygen demand and suspended solids can be done on a daily composite sample. When this data is made redily available to the operator, the plant can be monitored and controlled easily. Unfortunately, in the plants observed by OAP engineers, managers and supervisors either did not require testing with sufficient frequency or did not use, or make availabel, the data generated by off-site/contract laboratories. The result of this deficiency can be the degredation in effluent quality. This can ultimately cause a failure in meeting the effluent requirements and this type of failure tends to last for prolonged periods of time as RBCs need time to build new biological growth.



ENDVIEW OF DRUM ILLUSTRATING THE EXCHANGE OF AIR AND WASTEWATER

In the operation of RBCs it is critical that the drum and the mediabe observed/inspected frequently. Similar to other wastewater plants, RBCs can be upset by heavy hydraulic or organic loading, reduced temperatrue, high or low pH values and toxic or inhibitory substances in the influent. The first indication of these problems will be the color, odor and physical appearance of the bilogical growth on the drum.

Additionally, RBCS are specifically subject to problems related to drum rotation which include improper speed, irregular speed, shaft lubrication and breakage as well as power outages. Nevertheless, conscientious maintenance of drive components to include chain drives, belt drives, sprockets, rotating shafts, motors and speed reducers can ensure trouble free operation. The lubrication and adjustment procedures are those prescribed by the equipment manufacturer, and should be conscientiously incorporated into the plant maintenance program.

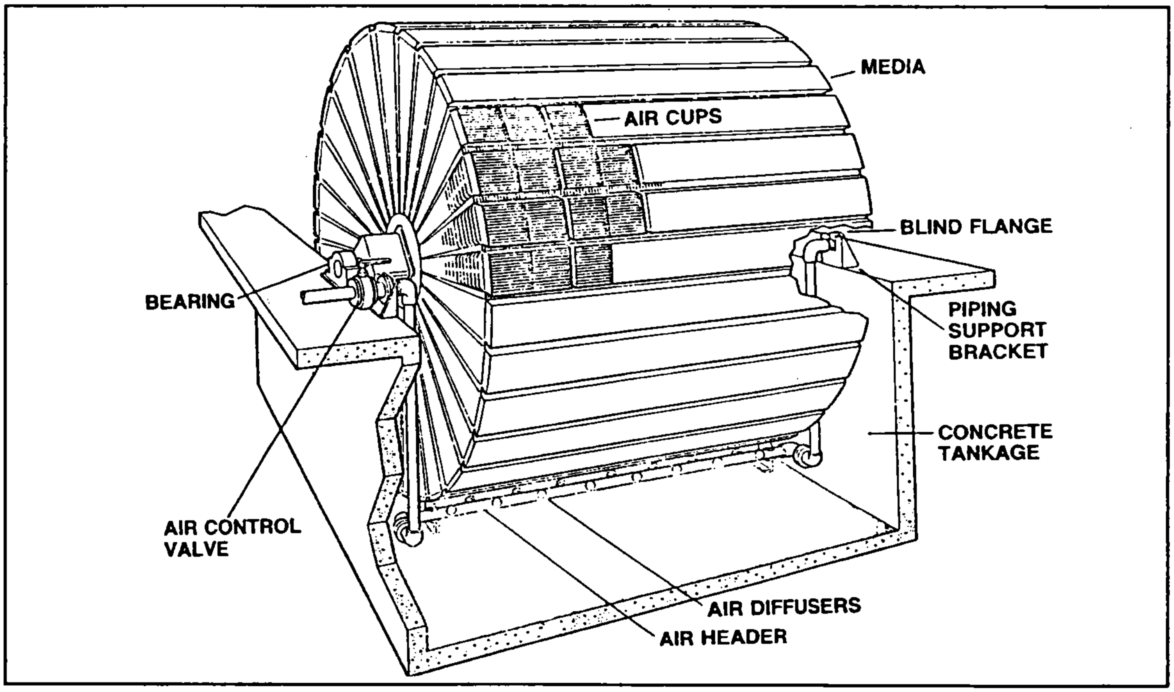
III.3.2.4. Recommended Actions:

System Operators and Managers

- o Create a maintenance plan and budget
- o Keep an up to date inventory of necessary spare parts and keep it full
- o Make sure that routine inspection and lubrication of equipment is completed

Base Commanders, Facility Managers and Public Works Managers

- o Require annual reporting of equipment failure rates and spare parts inventory
- o Formally inspect the wastewater treatment plant several times per year



ROTATING BIOLOGICAL CONTACTOR

III.4 CONTINUOUS LOOP REACTORS

III.4.1. Overview of Treatment Process: The continuous loop reactor (CLR), or oxidation ditch as it sometimes called, is a modified form of the activated sludge process and is usually operated in the extended aeration mode. The main parts of the CLR, *illustrated in the figure below*, include the aeration basin, which generally consists of two parallel channels connected at the ends to produce a continuous loop, a brush rotor assembly to entrain oxygen into the wastewater, settling tank, return sludge pump, and excess sludge handling facilities.

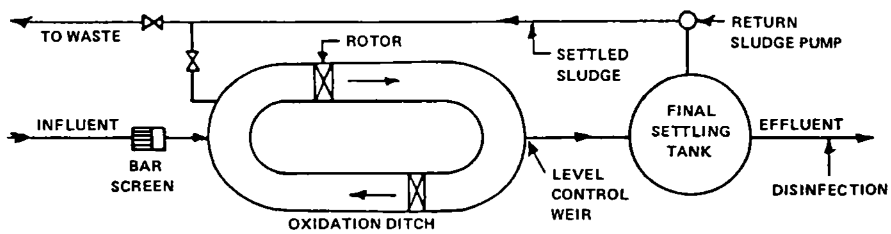
> **The key is process control . . .**
>
> requires frequent sampling and testing . . .
>
> optimum oxygen level . . .
>
> balance between organic matter and organisms.

There is usually no primary settling tank or grit removal system used in this process. Inorganic solids such as sand and silt are captured in the oxidation ditch a d removed during sludge wasting or cleaning operation. Raw wastewater passes directly through a bar screen or comminutor into the oxidation ditch. The oxidation ditch forms the aeration basin and here the raw wastewater is mixed with previously formed active organisms. The brush aerator (rotor) is the aeration device that entrains the necessary oxygen in to the liquid for microbial life and keeps the contents of the ditch mixed and moving The velocity of the liquid in the ditch must be maintained to prevent settling of solids, normally 1 to 1½ feet per second (0.3 to 0.45 m/sec).

The mixture of new wastewater and recirculated sludge flows from the ditch to a clarifier for separation. Settled sludge is removed form the bottom of the clarifier by a pump and is returned to the ditch. The amount of suspended solids, particularly the volatile suspended solids, will gradually increase to the point where it will become necessary to waste some of the sludge. The waste sludge can be put on sand drying beds or held in tanks or lagoons for later disposal at larger sewage facilities or to approved landfills. A very high suspended solids concentration is maintained in these plants in relationship to other activated sludge plants, e.g. 2000 to 6000 mg/l. This high solids concentration creates an operational buffer that allows improved handling of shock loads and peak hydraulic loads as well as providing somewhat better cold weather performance. Important operating criteria include:

- flow
- F/M Ratio
- Sludge Age
- Velocity
- Liquid Level
- BOD Loading
- MLSS concentration
- Ditch Detention Time
- DO Levels
- Temperature

The CLR/ oxidation ditch is a relatively new configuration in wastewater treatment facilities, and is generally used where there are large volumes of wastewater. The first installation of this type in the Army was made at Fort Bragg, NC, where two CLRs having a design capacity of 5.0 MGD were constructed. This plant is reported to be performing well and is producing the quality of effluent required by the NPDES permit.



CONTINUOUS LOOP REACTOR SCHEMATIC

III.4.2. PROCESS CONTROL

III.4.2.1. Lesson: As there is only one of these plants in service, a compilation of Lessons Learned cannot be done at this time. However, experience to date suggests that the *Lessons* are much like those of activated sludge plants (see **Section III.2.2.**). The general experience, inside and outside of the Army, is that these plants are somewhat easier to operate due to their ability to sustain shock loadings and their high degree of resistance to toxicity. However, the key to good plant operation is still high quality process control.

III.4.2.2. OAP Finding: As noted above, there is presently only one of these plants in service with the Army. The present experience with these facilities, both inside and outside the military, is very good. Other issues include ice problems in cold regions, bank erosion, underpowered brush aerators, lack of grinders or comminutors, inadequate laboratory and maintenance facilities and difficulty with sludge handling. Newer plants have fewer problems and designers for the Army are encouraged to visit a number of these plants before completing designs for Army facilities. Similarly, if designs are contracted, the contract officers are encouraged to perform similar plant visits and inspections to clearly understand all of the requirements of these plants. Lastly, these plants have been both under and overestimated in their operating complexity and resistance to shock loadings. It must be remembered that these plants are, in the last analysis, modifications of the activated sludge process and will be subject to most of the problems that plague those treatment plants. The operation is much the same but with fewer moving parts. That is a benefit, but monitoring and testing must be done frequently and the operator must be well trained. Similarly, the high level of suspended solids carried by these plants will buffer shock loads to some extent. However, they are subject to upsets like any sewage plant and operators must keep on top of effluent and influent changes in order to maintain compliance with all of the plant permits.

III.4.2.3. Discussion: Also as noted above, these plants are very forgiving due to the high level of solids carried in the mixed liquor. However, there are some operational issues that are unique to these facilities and must receive attention. Ice is more of a problem during cold weather operation that for other types of plants. Specifically, the brush aerators prevent icing in the area close to the aerator, but ice can build up in other areas and cause a variety of problems. In regions where cold is a problem, ancillary aeration equipment may be required. Even with comminutors and bar screens, floating materials can cause problems of unsightliness and odor. Daily inspection of the CLR and manual removal of floating material is required. One benefit of these systems is the small number of moving parts, i.e., the aerators. However, when an aerator fails, the plant begins to go septic and will very quickly exceed it's discharge permit. Replacement parts or entire units are required as spares on-site unless contracts can be written to assure that the equipment can be kept in service continuously. Additionally, grit and sludge removal can be difficult and will require dewatering portions of the plant. At the time of design, sludge removal issues should be addressed and provisions made to accommodate this important unit operation. Despite the relative ease of operation and the reduced amount of maintenance, these plants must be monitored frequently to give the operator the ability to modify operating parameters to meet potentially changing conditions. Lastly, when designing these facilities, engineers have sometimes overlooked some housekeeping issues that can be very important. For example, bathroom and shower facilities still must be provided for the operator and laborers, storage must be provided for treatment chemicals and for spare parts as well as shop facilities and laboratory capability. These needs should be addressed by the construction of an operations building in close proximity to the CLR. The OAP engineers believe that this type of plant provides some advantages to the Army, particularly where existing plants must be upgraded significantly. However, optimum operation of these plants will still require high quality operation, good maintenance as well as management attention and concern.

III.4.2.4. Recommended Actions:

<u>Operations</u>

o Operators require training aimed directly at the process control issues inherent in this type of plant.

o The sampling and analytical scheme must be designed to give the operator the information required to make changes in a timely fashion.

<u>Management</u>

o Management must focus on these issues of training and process sampling and testing and assure that they are accomplished correctly.

IV. RECOMMENDATIONS - NEXT STEPS

IV.1 Interpretation of the Lessons: As noted in the introduction, a casual reader of this document might come to the conclusion that the operation of Army wastewater treatment plants is uniformly bad. That is not a correct conclusion. There are examples of exemplary operation and the large majority of operators are hard working and dedicated to doing a good job. Furthermore, it should be noted again that the majority of Army wastewater treatment plants routinely produce treated effluent that meets the NPDES discharge limitations.

Furthermore, the OAP program has brought about very significant improvements and continues to be a major force for positive change in the Army water and wastewater plants. However, as the Lessons demonstrate, there is room for improvement and institutional and economic incentives to make these improvements. For the sake of an overall look, the lessons are greatly summarized below.

IV.2 LESSONS:

IV.2.1. General Lessons

- Many plants need upgrades or modernization.
- Inflow and Infiltration is a universal problem.
- Operator training needs should be refocused on operation and process control.
- Insufficient management support and attention continues to cause problems.
- Plant maintenance is a significant problem that is causing considerable liability.
- Plant safety needs attention
- Treatment process control is not done well

Water treatment chemicals are both over and underfed and frequently handled improperly.

IV.2.2. Process Specific Lessons:

- Most trickling filters suffer from inadequate maintenance, housekeeping problems and have not been upgraded as required.
- Activated sludge plants, including package plants, need better trained operators and monitoring schemes that improve the operators ability to control the plant.
- Rotating Biological Contactor plants require better maintenance and surveillance.
- Continuous Loop Reactor Plants (Oxidation Ditches) are relatively new, but appear to promise improved operation with potentially less maintenance and operation.

These lessons suggest specific remedies as shown in the individual sections and the executive summary. However, some very fundamental problems seem to persist with the facility management system of the Army. These fundamental problems are:

- Lack of capital and engineering resources to update wastewater options as required.

- Lack of capital and operating resources to aggressively address the inflow and infiltration problems of wastewater collection systems.

- Insufficient management understanding and support of system operations and military requirements, leading to

  Inadequate training for:

  Process Control
  System Requirements
  Safety
  Chemical Handling
  Others

- Inadequate and often inappropriate maintenance and inventory systems that lead to long repair times and degraded plant performance.

  1. Trickling Filters
     Maintenance
     Housekeeping
     Upgrades

  2. Activated Sludge/RBC's
     Improved operator training
     Better maintenance

  3. Oxidation Ditches
     Operator training
     Maintenance

IV.3 REMEDIES

These reflect either resource deficiencies or training and supervision problems.

The potential remedies are similarly installation specific and can be seen in each of the individual sections and the Executive Summary. However, they can be summarized into a small number of initiatives that will have many sub-initiatives at the implementation staff. In the last analysis, these initiatives will require the Army to make a determination of how wastewater plants will be operated and how the Army will be judged as a steward of our national resources, i.e., the Army Environmental mission states, "The Army will be a national leader in environmental and natural resource stewardship for present and future generations as an integral part of our mission."

The Lessons and the Remedies suggest that there is progress needed to begin to approach the reality of this Mission. Specifically, the OAP program is an integral part of achieving the elements of the Army vision. However, as we have noted throughout this document, implementation of OAP recommendations have been very slow. Indeed, often those recommendations have been ignored. The OAP recommendations are always based upon achievement of compliance with environmental law and regulations. Therefore, the slowness or absence of implementation increases the risk of non-compliance and degradation of resources. Our evaluation is that greater acceptability must be