SEWER SYSTEM EVALUATION FOR INFILTRATION/INFLOW

Prepared for

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
TECHNOLOGY TRANSFER PROGRAM

Prepared By

AMERICAN CONSULTING SERVICES, INC.
Minneapolis, Minnesota

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INTRODUCTION

In past years, infiltration and inflow of extraneous waters into sewer systems were not of much concern to the engineer or municipal official. Some of the major reasons which trigger desperate corrective measures to solve the extraneous water intrusion problem are:

(1) Flooded basements during period of intensive rainfall

(2) Excessive power costs for pumping

(3) Overtaxing of lift station facilities often resulting in frequent electric motor replacements

(4) Overloading of treatment plant facilities

(5) Excessive costs of sewage treatment including meter charges levied by sanitary districts or other jurisdictional authorities

(6) Obnoxious odors and health hazards caused with by-passing of raw sewage

(7) A pumping-up action of downstream sewers when excessive heads and surcharging of manholes occur. When the surcharging stops and the head over the pipe is relieved through defective joints, a fine sugar sand enters the pipe with the water. A loss of pipe overburden occurs and the street eventually settles or collapses.

In addition to the above motivators for correction, there are many other sewer system inadequacies which concern the engineer and the municipal official. Problems of infiltration/inflow are often relieved by the construction of relief sewers, larger lift stations and treatment plants, and the use of sewage by-passes throughout the system. Unfortunately, however, this approach results in untreated sewage flows being discharged into rivers, streams, lakes and open ditches. In past years the engineer concerned himself with the best economical design choice of a system which would serve the needs of the community 90 to 95 per cent of the time. On those rare occasions where the flows were excessive, relief facilities and by-passes provided a convenient solution to the problem.

What were acceptable standards of sewage treatment in the past are not sufficient to meet the sophisticated requirements of treatment today. The upgrading of federal and state standards for the

type and degree of sewage treatment, has resulted in new problems that the engineer must now face. "Zero discharge" is a new term in the environmental lexicon of today.

New federal legislation proposes a zero discharge standard as a national goal. The objective is to eliminate all pollutant discharge to open ditches, lakes, streams, rivers and navigable waters.

The engineer is now faced with the problem of handling all of the wastewater. The problems connected with infiltration/inflow and overloaded sewer systems must be faced. There is no choice. Past practices of constructing relief sewers and by-pass facilities will not solve the problem. Therefore, we must go to the source of the infiltration/inflow problem ... the sewer system itself.

Unfortunately, we have to live with our existing collection systems. We cannot trade them in on new ones. We have huge sums of money invested in our underground sewers and the street surfaces above them. The replacement cost of the existing sewers would far exceed what we paid to install them. Complete sewer replacement would not only be too costly but in most cases would not solve the infiltration/inflow problem.

Intrusion of ground water or storm water into the sewer system

via house laterals and other service connections compound the problem. Often the major contributions to the clear water problem are faulty service connections and direct connections of footing drain tile to the sanitary sewer. Any sewer system evaluation must differentiate between the extraneous water contribution from service connections and those extraneous flows contributed through irregularities or deficiencies in the municipal sewer system. Correction of service connection problems are political in nature and must be handled judiciously. The technology for correcting these problems is also different from that used to correct infiltration/inflow problems in the larger sewer mains. Replacement of municipal sewer mains or grouting sewer joints in the main will not solve the service connection problem.

What can we do with our existing sewer systems? We must evaluate these systems and formulate programs to solve the infiltration/inflow problems. One may ask, where do we start? How do we do it? Who is going to do it? How much will it cost? How long will it take? How are we going to finance it? What assurance do we have that any program will solve the infiltration/inflow problems? What are the alternatives? These and other questions can boggle the mind. The burden is on the engineer and public official to provide answers and solve the problem. This is the real subject of this presentation ... SEWER SYSTEM EVALUATION.

THE NEW FEDERAL LAW

ON OCTOBER 18, 1972 THE 92ND CONGRESS OF THE UNITED STATES OVERWHELMINGLY PASSED PUBLIC LAW 92-500 WHICH IS CITED AS THE "FEDERAL WATER POLLUTION CONTROL ACT AMENDMENTS OF 1972." IT IS SUGGESTED THAT ANY ENGINEER OR PUBLIC OFFICIAL CONCERNED WITH THE DESIGN, IMPROVEMENT OR OPERATION OF SEWAGE TREATMENT PLANTS AND/OR SEWAGE COLLECTION SYSTEMS SECURE A COPY OF THE NEW LAW. MANY CHANGES IN REQUIREMENTS AND ELIGIBILITIES FOR FEDERAL GRANT ASSISTANCE HAVE BEEN MADE.

The new act recognizes that sewer problems can relate to the sewage treatment needs. AMONG THE MANY NEW PROVISIONS IS ONE WHICH PROVIDES FOR FEDERAL FINANCIAL ASSISTANCE TO SPECIFICALLY DEAL WITH INFILTRATION/INFLOW IN EXISTING SEWER SYSTEMS. Excerpts from Title II of the federal Water Pollution Control Act Amendments of 1972 are included in the Appendix of this presentation.

If you read the excerpts, you will note that it is now mandatory to identify the extraneous water problems and to determine whether the sewer system is subject to excessive infiltration/inflow. Federal grant assistance is available to study the problem and, in turn, to correct or accommodate it provided that all such work is performed in "accordance with rules and regulations promulgated by the Administrator", (EPA). Copies of the EPA rules and regulations are available from each regional EPA office.

SEWER SYSTEM EVALUATION ... WHAT IT IS

For the purpose of this discussion, we will define sewer system evaluation or system analysis as a systematic approach to evaluating a sewer system which will enable the engineer to:

(1) Identify the scope and nature of the infiltration/inflow problem.

(2) Establish an end objective. (The amount of infiltration/inflow that can be economically eliminated)

(3) Isolate those general sections of the sewer system where infiltration/inflow is occurring.

(4) Formulate a plan which can be economically justified for investigating and locating specific areas from which the major infiltration/inflow emanates.

(5) Formulate a plan which will assure correction of the infiltration/inflow problem along with alternatives for rehabilitation and a prediction of the end results that can be expected.

(6) Establish hydraulic parameters for sewage treatment plant design.

FEDERAL STUDY AND MANUAL OF PRACTICE

What are the causes, effects and means of correcting excessive extraneous water entering public sewer systems as a result of infiltration and inflow? A very detailed and exhaustive national study examining these factors and their economic impact in the

United States has been conducted by the Research Foundation of the American Public Works Association, under contract and in concert with the water quality office of the Environmental Protection Agency. The study involved many public agencies, the American Public Works Association, the American Society of Civil Engineers, the Water Pollution Control Federation, an Industrial Advisory Panel, the Associated General Contractors of America and consulting engineering firms.

AS A RESULT OF THIS JOINT EFFORT, TWO DOCUMENTS WERE PUBLISHED. THE FIRST DOCUMENT IS ENTITLED, CONTROL OF INFILTRATION AND INFLOW INTO SEWER SYSTEMS (NO. 11022 EFF 12/70). THIS REPORT IS A TABULATION AND ANALYSIS OF INTENSIVE FIELD INVESTIGATIONS CARRIED OUT BY THE FULL TIME STAFF OF APWA.

THE SECOND DOCUMENT IS ENTITLED, PREVENTION AND CORRECTION OF EXCESSIVE INFILTRATION AND INFLOW INTO SEWER SYSTEMS ... A MANUAL OF PRACTICE (NO. 11022 EFF 01/71). THIS REPORT CONTAINS THE SUGGESTED METHODS, GUIDELINES AND PRACTICES PERTAINING TO THE CONSTRUCTION, TESTING AND ACCEPTANCE OF NEW SEWER FACILITIES AS WELL AS DEALING WITH THE PROBLEMS OF INFILTRATION/INFLOW INTO EXISTING SEWER SYSTEMS. BOTH PUBLICATIONS ARE AVAILABLE FROM THE SUPERINTENDENT OF DOCUMENTS, U.S. GOVERNMENT PRINTING OFFICE, WASHINGTON D.C. 20402 AT A COST OF $1.25 EACH.

THE REPORTS ARE PART OF THE WATER POLLUTION CONTROL RESEARCH SERIES OF THE WATER QUALITY OFFICE OF THE ENVIRONMENTAL PROTECTION AGENCY. ANYONE WHO IS DIRECTLY RESPONSIBLE FOR THE DESIGN,INSTALLATION OR MAINTENANCE OF SEWER SYSTEMS IS ENCOURAGED TO PURCHASE THESE TIMELY EPA DOCUMENTS AND TO READ THEM THOROUGHLY. THE INFORMATION WILL PROVIDE YOU WITH SOME NEW IDEAS FOR DEALING WITH YOUR OWN SEWER PROBLEMS.

THE METHODOLOGY OF SEWER SYSTEM EVALUATION

Figure 1 shows the general considerations of an orderly programmed approach to evaluating a sewer system. Each phase of the program will be discussed separately. The following presentation should facilitate the understanding of the federal Guidelines for Control of Infiltration/Inflow in Sewer Systems. Phase I deals with the work involved under the Infiltration/Inflow Analysis section of the Federal EPA Guidelines. Phases II and III refer to the work involved under the Sewer System Evaluation Survey section.

PHASE I - INFILTRATION/INFLOW ANALYSIS

Figure 2 shows the essential considerations under this phase of the program. The first problem is to find the problem. Without identifying how much extraneous water one has to conquer, any program of search and correct would be a shotgun approach without direction. Without a definite objective, no one would know what

portion of the total problem is being solved at any one time nor would one know how much money would have to be spent for correction.

a. Patterned Interviews

The Patterned Interview involves the first look at the extraneous water problem in the community. An experienced professional in the area of infiltration/inflow should interview everyone who is, or has been, connected with the sewer system. Subsequent analysis of the data will answer questions and give the analyst a feel of the overall problem.

The general objective of the patterned interview is to focus the problem. The questions should cover a broad spectrum of subjects ranging from technological and geological matters to municipal performance capabilities to the socio-economic profile of the city. A well planned interview also helps the municipality to think about its problems in an orderly fashion and to recognize alternate methods for solution. The interviews reveal what the municipality knows and, more important, what it does not know about its sewer system. It tells both the engineer and municipality what yet remains to be answered before the evaluation

program can continue. This is the key to the evaluation process. If you cannot identify the problem you must solve, the system evaluation program should stop.

The next step is the collection of all available data such as the treatment plant records, maps, etc. pertaining to the infiltration/inflow problem. Many communities have no maps of their sewer system. It is often necessary to gather whatever data is available, however sketchy. Once all this information is gathered, it must be assimilated, and here is where analytical as well as practical experience in sanitary engineering and sewer system maintenance is necessary.

Questions and Comments:

b. Sanitary and Storm Sewer Map Study

The next step is to study the plot maps of the sanitary and storm sewer systems. If the maps are not available in reasonably accurate form, system evaluation is difficult if not impossible and efforts must be made to garner whatever piece-meal information is available. A map should be developed for those areas which need

evaluation since the patterned interviews may dictate that the entire sewer system need not be evaluated.

The study of the plot maps generally reveals relationship of storm sewers to sanitary sewers, location of pumping stations, key manhole juncture points, and a host of other valuable data. Without accurate plot maps and flow charts, further study is impossible.

Questions and Comments:

c. System Flow Diagrams

When the appropriate sewer plot maps are developed, it is then possible to divide the system into mini-systems which can be studied independently. The Vector Flow diagrams can be prepared which will relate the theoretical sewer capacities to the actual flow conditions.

Information from the vector flow diagrams coupled with the study of the sewer plot maps and analysis of the data collected during the patterned interviews gives

the experienced analyst the sense of direction he needs to solve the infiltration/inflow problems in the sewer system.

Questions and Comments:

d. Dry vs Wet Weather Flow Determinations

Analysis begins with a very careful comparison of the flow records obtained from the municipality. Correlations are drawn between times of high sewage flow and periods of heavy rainfall and/or runoff.

The difference between the peak industrial and domestic flow rates and peak wet weather flow rate determines what we call "Delta Q" flow rate, or the magnitude of the extraneous water problem.

The nature of the infiltration/inflow problem, the sewage treatment requirements, the industrial sewage contribution, the climatological and seasonal variations, must be considered in determining the scope of the study and the time of performance. The Delta

Q should be reduced to its contributing components by district to facilitate the investigation in the major problem areas.

Questions and Comments:

e. Preliminary Field Survey and Selective Flow Tests

Flow surveys and other tests can be conducted at selective locations to more accurately determine the scope of the infiltration/inflow problem. The engineer should familiarize himself with the subject of instrumentation relating to appropriate sewer flow measurement techniques. It is safe to say that there has been much time wasted gathering flow data by "V" notch or other types of weirs on a 24 hour surveillance basis. The results have either been useless or inconclusive.

Flow tests conducted at the wrong time and under the wrong conditions will lead to fallacious conclusions, and random weiring at key locations in the system may not yield meaningful results. Ineffectual tests can

result in costly corrective measures and provide no solution for the flooded basement conditions, raw sewage by-passing, or other infiltration/inflow connected problems.

The author has found that one of the most practical methods of flow measurement is simply to measure the depth of flow in pre-determined key manholes with a ruler. Knowing the hydraulic characteristics of the sewers in these manholes (slope, pipe size, etc.) a computation will determine the flow rate. It is important that these depth measurements are taken at the proper times, such as dry weather, high groundwater and rainfall situations, so that the relationships between the flows at these times can be compared. These measurements, coupled with allowances for peak domestic and industrial flow rates, will be the determinant as to whether flows are possibly excessive or non-excessive at these key points.

Questions and Comments:

f. Determination of Excessive or Non-Excessive Infiltration/Inflow

Information to be obtained and evaluated in making a determination as to whether flows are excessive or non-excessive includes:

1. Flow data for all flows in the sewer system including overflows and bypassed flows
2. Location, frequency and cause of overflow conditions in the collection/treatment system caused by infiltration/inflow
3. Relationships of existing population and industrial contribution to flows in the sewer system
4. Geographical and geological conditions which may affect the present and future quantities or correction costs of the infiltration/inflow
5. A general discussion of age, length, type, materials of construction and known physical condition of the sewer systems

From this information preliminary estimates can be developed for the relative costs (for the design life of the treatment works) both for correcting the infiltration/inflow conditions, and increasing the treatment works capacity to provide the required degree of wastewater treatment for the quantities of infiltration/inflow.

Excessive infiltration/inflow would be present in the sewer system if the cost estimate for its treatment would be greater than the cost estimates for its correction.

Questions and Comments:

g. Establish a Plan of Action, Budget and Timetable for Execution

Having determined in the earlier phases of the infiltration/inflow analysis that the infiltration/inflow problem is excessive, the engineer must now recommend a program that will culminate in the solution of the problem. A proposed detailed plan for a systematic sewer system evaluation survey would normally be divided into five phases:

1. Physical Survey
2. Rainfall Simulation
3. Preparatory Cleaning
4. Television Inspection
5. Analysis

An explanation of the plan would include the tasks to be performed, the method of task accomplishment, data to be obtained and recorded, information and data to be reported and a cost estimate for each phase of the survey which is recommended. An approximate estimate of starting dates and duration of execution of each phase is necessary taking into account the climatological restrictions for performance.

Questions and Comments:

PHASE II - FIELD INVESTIGATION AND SURVEY

The infiltration/inflow problem has now been identified, areas of study established, budget estimates set and expected results determined. Phase II can now be considered. Figure 3 generally outlines the work entailed in this phase of the system investigation. It should be pointed out that the physical survey, ground water analysis and rainfall simulation work must be completed before it is possible to prepare an engineering report, analysis and timetable for the performance of the preparatory sewer cleaning and selected television inspection studies.

a. Physical Survey and Groundwater Analysis

The physical survey of the sewer system involves the descent into every manhole that is within the study area of the sewer system. It should be emphasized that the mere observation of sewer flows from on the top of the ground does not constitute a physical survey. Accurate assessments of actual manhole and sewer conditions can only be made from inside the manhole. The physical survey is conducted by descending every manhole in the area of study and actually observing the degree and nature of the deposition in all lines into and out of the manhole.

Unless each manhole is descended and each pipe lamped, it is unlikely that the engineer can accurately judge the impact of infiltration on the system as a whole. By actual observation the engineer may be able to eliminate large portions of the system from further study.

Inspection by a trained observer during the physical survey generally reveals sources of inflow that might otherwise go undetected, such as manhole covers

with large holes, obvious deficiencies in the manhole structures, manholes located in natural ponding areas and other such deficiencies. These sources of inflow are usually the least costly to eliminate. The physical survey provides valuable information for refining the cost effective rehabilitation estimates.

Questions and Comments:

b. Rainfall Simulation

If the infiltration/inflow analysis demonstrates that major inflow problems occur during periods of intense rainfall, a controlled systematic check of all storm sewers that parallel or cross the sanitary sewer system and/or house services should be initiated. In performing this phase, the percolative capacity of the soil should be taken into account. A Rainfall Simulation study is not simply the flooding of storm sewers with dyed water, but is a geologic and hydrologic study of the assimilative capacity of soil surrounding the storm sewer, coupled with the susceptability of the sanitary sewers to accept

the exfiltration/infiltration phenomenon. In addition, before and after flow rate comparisons are essential to the success of this phase of the work. Unless these flow rates are compared, it is impossible to determine the impact of rainfall on the system as related to the exfiltration/infiltration phenomenon.

Without the appropriate engineering considerations, i.e. flow rate comparisons, time of flooding, time lapse for dye transfer, etc., the results of an improperly conducted storm sewer flooding program will yield fallacious results upon which equally fallacious conclusions and recommendations will be made.

Again the reader is cautioned that great care and professional judgement should be exercised in conducting these simulation tests. They should not be conducted by the inexperienced or lay person.

Diverse field conditions dictate the extent of this phase. The number of open ditches and closed storm sewer conduits to be tested and the availability of water supplies are a few of the major considerations that must be taken into account during this phase of the program.

It should be pointed out that rainfall simulation is not always required in every system evaluation study. Here again whether or not storm sewers are to be tested is dependent upon the pre-determination by the engineer. He must decide whether or not the impact of rainfall on the sanitary sewer system creates excessive inflow conditions. Furthermore, it should be brought to the engineer's attention that this work does not include the cleaning and/or televising of the storm sewers being tested. Only in very rare and unusual cases, will storm sewers need to be cleaned and televised as part of a sewer system evaluation study. Hydraulic testing of storm sewers to determine whether exfiltration and cross connections affect the adjacent sanitary sewers should not be confused with the procedure of televising sewers.

Questions and Comments:

c. Prepare Engineering Report and Analysis

The engineering report which summarizes and evaluates all of the findings of the physical survey, groundwater analysis and rainfall simulation studies, provides the basis for the culmination of this phase of the program. The engineer must be able to economically justify his recommendations for future work. His conclusions must assure the municipality that, if the work is carried out as recommended, the infiltration/inflow problem will be brought under control. The report should further itemize the infiltration/inflow findings by sewer district which then is correlated to the total Delta Q. Television inspection and cleaning schedules are established and the next phases of the study are determined.

Based on the recommendations and analyses from the physical survey and rainfall simulation, meaningful engineering reports can be prepared and budget adjustments made. At this juncture in the program, precise locations for televising can be determined and the exact cost of these TV inspections established. Completion dates and end results can be predicted. The engineer can plan the necessary preparatory sewer cleaning and television inspection. Sewer cleaning

costs can also be accurately predicted.

Because time is usually a critical factor, it should be pointed out that the television inspection generally can be accomplished much more rapidly than the preparatory sewer cleaning. Many municipalities are not sufficiently staffed to perform the preparatory sewer cleaning prior to the deadline stipulated by federal and state governments. Generally they do not possess the cleaning equipment which will minimize the time required for proper preparatory cleaning.

It is the engineer's responsibility to advise the municipality on the latest sewer cleaning techniques, the time required to perform the work and the anticipated costs. After a thorough discussion of all of the findings and recommendations as a result of the field investigations, the municipality is now ready to proceed with selective preparatory cleaning and television inspection.

Questions and Comments:

d. Preparatory Sewer Cleaning

At this point a reiteration and further clarification of the preparatory sewer cleaning program is necessary. The importance of identifying the physical condition of the sewer system was previously discussed. The findings of the physical survey indicate not only the apparent deficiencies in the system, but also the nature and degree of the deposition within the sewers.

In many smaller communities, routine maintenance may mean rodding of sewers on an as needed basis with occasional flushing of the rest of the system once or twice a year. In other communities, routine maintenance may mean actual cleaning of each section of sewer once every two to three years. The important point to stress is that full gauge instruments must be used in any sewer cleaning preparatory to TV inspection. Full gauge instruments may mean rubber squeegees with the use of the conventional bucket machines or they may mean an extra pass or two with the high velocity hydraulic jet machine.

Particular attention should be paid to root removal. Up to now, the successful removal of roots with the use

of a jet machine and hydraulic root cutter has not proven successful enough to be considered as sufficient preparation for TV viewing. It is recommended that conventional bucket machines be used with root scarifiers, brushes and squeegees where ever heavy root infestations are in evidence. These areas are located during the physical survey.

The preparation of a routine sewer maintenance program is included as part of the physical survey report since future costs for sewer maintenance are projected in the report. Intelligent budgeting is now possible rather than basing the sewer maintenance budget on last year's figures plus 10 per cent which were based on the previous year's figures plus 10 per cent, etc., all of which were really not based on cleanliness, or lack thereof.

In analyzing this data, the scope of the sewer cleaning program can be established in terms of crew hours and dollars. Sewer cleaning is a necessary prerequisite for any subsequent television inspection that may be required. Many engineers are not aware of the tremendous time involved in properly preparing sewers for television

inspection. They assume that this is a routine function that any municipality is capable of performing. Thorough cleaning of sewers which will permit optimum viewing with television cameras is not routine work in most municipalities. In addition, municipal governments generally do not provide adequate funds to do the "first time around cleaning" needed to restore full capacity to sewers. Therefore, it is the duty of the engineer to not only describe the general condition of the sewer system, including all of the physical deficiencies that can be visually observed, but also to point out the scope of the cleaning program required. Special emphasis should be placed on those locations where infiltration/inflow is known to exist. The data from the physical survey will dictate the most practical scheduling of municipal sewer cleaning crews, and for the first time will permit municipal officials to set realistic budgets for these activities.

There are various ways to clean a sewer. With the advent of the new hydraulic cleaning machines, more efficient sewer cleaning can be accomplished in a fraction of the time required by older methods. Facing up to the cleaning problems has forced many municipalities to reconsider not

only their budgets, but the methods they employ for sewer maintenance.

Cleaning costs, however, are a function of the nature of the deposition, volume of debris to be removed and the distance between manholes. It is the engineer's responsibility to accurately justify these cleaning costs as part of his estimated budget for system evaluation and restoration.

Normally more sewers will have to be cleaned than are televised. Depending on the findings of the physical survey, there are times when extra cleaning is necessary to avoid the reclogging of sewers prior to televising. This will assure that the sewers to be internally studied will remain clean long enough for television inspection work. The cleaning process is generally far more time consuming than the actual television inspection work. It is not reasonable to have a television camera available on site at all times while the cleaning crews are working in attempts to televise right behind the cleaning crews. This method will result in much higher costs for TV inspection.

The preparatory sewer cleaning will be an allowable Federal cost only where it is necessary prior to any

television inspection. WHOLESALE, INDISCRIMINATE AND ECONOMICALLY UNJUSTIFIABLE SEWER CLEANING AND TELEVISING WILL NOT BE ELIGIBLE FOR FUNDING ASSISTANCE.

Questions and Comments:

e. Television Inspection of Preselected Sewers

Under the previous phases of the work, the infiltration/inflow problem was localized. It was identified in terms of approximate quantities and the general areas where the sources originate. The municipality now knows that the sewers in these areas are leaking, but it does not know whether or not such leaks emanate from house services, joints, broken pipe, cross connections, etc. It also does not know the general condition of the pipe, the number of contributing sources, nor their quantitative contribution of extraneous water. The ONLY way to pinpoint the problem is by use of the television camera. The sophisticated use of this inspection tool will produce valuable data which can be constructively used for analytical purposes. Since viewing

the monitors also requires field interpretations, the same tool in the hands of the inexperienced, with little or no analytical capabilities can prove to be a great waste of time and money.

Television provides the only means by which moving water can be instantly observed. This, of course, is the object of a system evaluation.

If the infiltration/inflow analysis indicates that ground water is the major factor contributing to the infiltration/inflow problem, televising sewers in the middle of the driest months will not yield the expected results. TV inspection must be conducted during those periods when the ground water is at its highest level.

Groundwater studies are usually encompassed as part of the physical survey of the sewer system. Groundwater gages should be installed in key selected manholes as a means of correlating the impact of static heads on sewage flows. This procedure will be necessary in order to determine the relative significance of infiltration to the total infiltration/inflow problem. Figure 5 shows a typical static groundwater gage installation.

If it has been pre-determined that inflow is a significant part of the problem, selected storm sewers should be reflooded so that television inspection can be accomplished under simulated rainfall conditions. Those sections of storm sewers that must be reflooded during the TV inspection are determined during the Rainfall Simulation Study.

Experience to date has shown that the use of still photography is neither practical nor advisable for a sewer system evaluation survey. The objective in any study is to identify all of the sources of infiltration/inflow ... therefore, one must include the extraneous water contributions from service connections.

If, for example, a house service is flowing during a TV inspection, the camera travel must be stopped and the possibility of domestic contribution to the observed flow determined. If no flows are being generated within the house, then it can be assumed that the observed flow is infiltration or inflow. Basement footing drain tile, yard drains and other extraneous water sources entering the house service are further indications that the flows observed on the TV screen are not domestic contributions.

Still photography may indicate (after the film is developed) that a house service was flowing, raising the question, "Were those people using their facilities at three o'clock yesterday afternoon?" No one will ever know. To date, the author's attempts to conduct infiltration studies using still photography or movie cameras have met with little success.

Still photography or the use of movie cameras may have merit if the intent of the sewer inspection is merely for structural purposes. Experience, however, has shown that TV cameras are preferable for infiltration/inflow studies since deficiencies are more discernable and can be evaluated instantly as compared to waiting for film development. It is important that any TV inspection for infiltration/inflow identification include the location and rate of contribution of each leak. Without such quantitative evaluations, extensive repairs based on sealing big leaks, little leaks, drippers, etc. are strictly arbitrary. Without predetermining the relative contribution of sewer main leaks, house service leaks and manhole leaks, one cannot be assured of an accurate and meaningful analysis upon which decisions for correction can be made.

Polaroid or 35MM pictures taken from the TV monitor as permanent records will not always reveal the necessary information required for an infiltration analysis. The use of video tape recordings during the TV viewing process enables the engineering analyst to review the important findings. Based on his own independent observations along with those of the trained TV technician, he will be able to make an unbiased and a more accurate evaluation of the extraneous water findings.

Television inspection performed as part of any infiltration/inflow study usually cannot be successfully accomplished on a bid basis. If such a practice is followed, the successful bidder is interested only in how fast he can go through the sewer at a fixed price. Each time the TV camera travel must be stopped in order to determine whether the visible source of water flow into the sewer is extraneous water or domestic waste water (i.e. house service flow, etc.), the TV operator becomes nervous because he is wasting time. He cannot afford to spend the time to study the flow. The experienced professional can accurately determine a fair and reasonable fee for such infiltration/inflow study work. The engineer is

cautioned not to confuse volume bid type sewer televising with utilizing the same tool as an aid to engineering evaluation work. Costs of televising sewers for infiltration/inflow studies are generally higher than those for volume viewing for such purposes as TV inspection of new sewer construction, before paving, etc.

As was pointed out previously,during infiltration/inflow study viewing, camera travel must often be stopped so that extraneous water from house services, roof drains, footing tile, yard drains and other possible infiltration/ inflow sources can be accurately identified and quantified. It is essential that these types of extraneous water entry be differentiated from those emanating from sewer joints in the main sewers.

Viewing sewers above 24" and below 8" diameter may be higher in cost. Televising pipe smaller than 8" presents a higher degree of risk since protruding service connections, horizontal or vertical misalignment, offset joints, etc. could easily prohibit passage of the TV camera. Conversely, attempting to televise large diameter sewers which handle heavy flows often requires special setups and rigging to float the camera through the line.

Depending upon the distance between manhole stations, the setup and rigging costs could substantially increase the costs.

Questions and Comments:

f. Preparation of the Evaluation Survey Report and Analysis

All TV engineering reports should include the engineering analysis and recommendations, final map preparation and cost estimates for rehabilitation. The sewer system evaluation report is the basis for formulating the rehabilitation program. It represents the culmination of all the investigative procedures. At this stage of the program definite decisions can be made based on positive recommendations for replacement and/or repair. It is now possible to compare the extraneous water findings of the TV investigation to the original estimated Delta Q determinations that were made during the infiltration/inflow analysis. It is also possible

to accurately predict the end results that the municipality can expect in the way of extraneous water reduction if the recommended rehabilitation program is carried out.

It is important to stress the difference between a TV report and an analytical evaluation. A TV report contains log sheets showing field data along with polaroid pictures of obvious physical deficiencies and apparent leaks. A conventional TV report generally describes leaks as big leaks, little leaks, drippers, house service flowing or apparent break, etc. These reports often include comments at the bottom of the page indicating leaks should be sealed without any quantitative explanation.

In other words, a TV report still leaves the evaluation of the data to the municipality or its engineer who may or may not be experienced in the interpretation of the data. Without an accompanying video tape showing movement of water such evaluation would be valueless especially if the engineer did not have the opportunity to be in the field during the viewing operations. Attempts to evaluate a video tape in a remote office by an engineer

with no first hand knowledge of field operations could lead to interpretations of data that result in erroneous evaluations and marginal rehabilitation results. It is not possible to achieve meaningful interpretive results by having a TV inspection firm video tape every foot of sewer. This does not constitute a sewer system evaluation survey. It is also a waste of time to have to view video tapes which depict foot after foot of good sound sewer pipe. Recording all of the good pipe on video tape is very expensive and is not worth the cost.

A useful engineering report (analytical evaluations) will not only include standard log sheet data, Polaroid pictures, house service locations,etc., but also a quantitative analysis of each leak in terms of gallons per minute. These quantitative judgements are based on laboratory simulations, the combined judgements of a competent TV technician and an experienced reviewing engineering specialist. With this flow data, the engineer is able to make a sound judgement as to whether the infiltration/inflow sources should be rehabilitated.

Summary tables should be prepared which indicate the rehabilitation needed, differentiating between those repairs which will reduce the infiltration/inflow and those that should be made from a structural point

of view. The engineer should be able to point out the difference between excessive and non-excessive infiltration/inflow conditions. Therefore, based on the recommendations, interpretations and evaluations of the engineering report, an intelligent rehabilitation program can be prepared which will serve as a basis for funding requirements.

Questions and Comments:

g. Preparation of the Proposed Rehabilitation Program

TV reports can be voluminous. A municipality is not usually interested in all of the details. It is the job of the evaluating engineer to summarize the findings of the TV inspection, and to present the findings, recommendations and a rehabilitation program.

Questions and Comments:

THE NEED FOR PUBLIC RELATIONS

The municipality now knows its entire problem. It is able to witness the problem on video tape. It now has a budget, it feels comfortable in what it has to do ... but not so comfortable in raising the necessary money or seeking the support of the taxpayers. Here again, the engineer must take an active part in presenting the repair and rehabilitation program to the public. No matter how justified the project may be, the public must feel the urgent need for the work and must feel that the projects, as recommended, are worthwhile. It has been found that most municipal councils are more than willing to hold a public meeting on this matter. Announcing these meetings in the news media and inviting any and all interested parties to hear and see the results of the TV inspection are excellent civic public relations gestures.

It is becoming more and more apparent that the consulting engineer must become cognizant of the importance of public relations in his work. A well conducted presentation of an infiltration/inflow study using video tape equipment, large color-coded overlay maps and layman oriented engineering reports can serve as valuable tools at any public meeting. Showing selected portions of the video tapes which depict significant infiltration/inflow, structural deficiencies and as well as sound sections of pipe gives the interested citizen an opportunity to witness first hand the need for a rehabilitation program. Such meetings can be held in a

council chamber, school auditorium or some other appropriate place where a large group of people can gather. The engineer can explain to the public the findings of his report and the recommendations for rehabilitation.

In the case of new treatment works, the design consultant can explain his phase of the work and how it correlates to the collection system evaluations. The mayor or some other municipal official can explain the position of the council and the course of action they plan to take. An appropriate question and answer period stimulates further interest. In this way, the general public can recognize the need for money to be expended in correcting the infiltration/inflow problem. The pictorial, graphic and documented evidence is available for all to see.

Questions and Comments:

PHASE III - REHABILITATION

Figure 4 refers to Phase III of the program. A decision has now been made, based on the findings of the engineers' reports, as to which sewers will not need any work, which sewers can be successfully grouted, relined or replaced to eliminate the sources of infiltration/inflow, the amount of street repair that will be required, and a total program whereby the engineer will be able to prepare plans and specifications for each class of work. It should be the responsibility of the engineer to give serious consideration to all methods of rehabilitation. These considerations are a part of the analytical work encompassed in the engineering report for television inspection.

a. Sewer Repair

Sewer repair is defined as the partial physical replacement, internal or external grouting, or relining of the sewer pipe. The cost of rehabilitation varies over a wide range. Engineers should take into account local construction costs, availability of local contractors, etc. to determine meaningful costs for rehabilitation of the sewer pipe.

Grouting

In those cases where sewer grouting is recommended, a word of caution is in order. Not all soils will accept grout. The engineer should familiarize himself with the limitation of all available

grouting technology. If he is not acquainted with the latest techniques available, he should make it his professional duty to learn. There are limitations as to the types of soil that will readily accept grout and remain permanent. There are some grouting materials that are definitely not recommended for sewer rehabilitation.

A recent innovation in sewer sealing technology, involving the use of elastomeric polymer grouts has been developed. This technique involves internal in-place application of a new gasket to the pipe structure itself as compared to the common accepted procedure of grouting the soil surrounding the sewer pipe. However, at this date the methods involving elastomeric polymer compounds are new and untested in the field as to permanence, wearing quality, permeability factors, adhering quality, resistant to root penetration, etc. The new method does show promise in time but should not be confused with the proven soil grouting techniques in common use today.

The engineer should be forwarned that basic unit grouting costs quoted generally do not reflect the cost of the chemical grout needed which could inflate

unit costs by 100% to 150% or more, depending upon the geological characteristics of the soil such as percolation rates, void ratios, etc. The engineer must include the cost of the chemical grout in his rehabilitation estimates. Grouting should be accomplished by only experienced and qualified personnel. Attempts to restrict the bidders as to the maximum amount of grout to be pumped per joint can result in future joint failure. On the other hand, excessive use of grout can be a gross waste of money. It is possible to predetermine the reasonable amount of grout expected to be pumped per joint that will still assure a permanent repair job. Proven technology and time-tested materials are the standards by which the engineer must judge this work. CAUTION: SEWERS TO BE GROUTED SHOULD NOT BE DONE ON A"TEST AND/OR SEAL" EVERY JOINT BASIS WITHOUT THE BENEFIT OF SYSTEM EVALUATION. SEALING EVERY JOINT IN ANY ONE MANHOLE REACH CAN RESULT IN COSTS THAT COME CLOSE TO, OR EXCEED, COMPLETE SEWER REPLACEMENT.

The engineer must also include in his estimate the cost for correcting the sources of excessive inflow. These types of corrections would include, but not

be limited to, such items as disconnecting roof drains that are directly connected to sanitary sewers, replacement of manhole covers that contain holes, raising manhole covers above the flood plain, plugging off yard and driveway drains that are connected to sanitary sewers, changing grades to eliminate ponding situations, etc.

IN CONSIDERING ANY REHABILITATION WORK, THE ENGINEER SHOULD ALWAYS KEEP IN MIND THE QUESTION, "HOW MUCH INFILTRATION/INFLOW, IN TERMS OF G.P.M., WILL BE ELIMINATED FOR THE DOLLARS OF REHABILITATION MONEY SPENT AND ... WHAT PER CENT OF THE TOTAL INFILTRATION/ INFLOW PROBLEM IS BEING SOLVED BY SUCH WORK?"

It would require a separate presentation and lengthy discussion to adequately cover the technology and methodology of sewer grouting. At this point it is safe to emphasize that there are many responsible sewer grouting firms throughout the country with expertise from whom the consulting engineers can obtain reliable information. The consultant must obtain this information and seek the advice of such firms in preparing the rehabilitation costs for the proposed rehabilitation program. It is the responsibility of the engineer to accurately determine the costs of the

rehabilitation work he proposes.

Questions and Comments:

b. Pipe Relining

Another alternative for the rehabilitation of existing sewer systems is the recently developed technology of pipe relining. The location, type and condition of sewer to be rehabilitated will determine the feasibility of this method.

To date, relining technology has not progressed to the point where unit costing procedures can be standardized. Complications arising from the reconnection of house services or the backfilling of the void between the lines and the existing pipe can result in added costs not anticipated in the rehabilitation estimate. Relining is a method for achieving the rehabilitation objective and should be compared with other alternatives on a cost effective basis.

Questions and Comments:

c. Sewer Replacement

The latest standards for new sewer construction need not be explained here. Modern methods of acceptance of new sewer work, such as low pressure air testing, have been well publicized.

In those cases where complete sewer replacement is recommended, consideration must be given to dealing with the reconnection of existing house services, the proximity of other utilities, the traffic disruption, and a host of other factors that normally become involved in this sort of rehabilitation. Again, the costs for this work will depend on local experiences.

Questions and Comments:

d. Finalization of Treatment Plant Design

Once the quantity of excessive infiltration/inflow has been identified, the consultant can begin to seriously consider finalizing the hydraulic design parameters for the wastewater treatment works. He can be comfortable that he has a handle on the infiltration/inflow problem and that it will be brought under control.

The engineer can now prepare plans and specifications for the sewer system rehabilitation work along with those for the construction or expansion of the treatment works. There is assurance that the new treatment works will accept all of the waste water. Intensive rainfalls will not cause basement flooding raw sewage by-passing, lift stations will not be overloaded and the groundwater infiltration will be controlled. The wastewater treatment works will function and serve the needs of the community.

Questions and Comments:

SUMMARY

Infiltration/inflow of extraneous waters in sewer systems cause many problems including raw sewage by-passing. The "Zero Discharge" federal goal for pollution control has created new considerations that the engineer must now face in dealing with the design of wastewater treatment works. The recent advent of television inspection cameras, sewer relining, plus external and internal grouting equipment, has provided the engineer with useful and valuable tools for implementation of sewer system rehabilitation. However, the use of such equipment to solve the infiltration/inflow problem without the benefit of a logical and systematic approach can prove to be costly and ineffective.

APPENDIX

FIGURE 1

A "PHASED" PROGRAM FOR SEWER SYSTEM EVALUATION AND REHABILITATION INFILTRATION/INFLOW STUDIES

PHASE I	INFILTRATION/INFLOW ANALYSIS
PHASE II	FIELD INVESTIGATION AND SURVEY
PHASE III	REHABILITATION

FIGURE 2

PHASE I

INFILTRATION/INFLOW ANALYSIS

a. Patterned Interviews

b. Sanitary and Storm Sewer Map Study

c. System Flow Diagrams

d. Dry vs Wet Weather Flow Determinations

e. Preliminary Field Survey and Selective Flow Tests

f. Determination of Excessive or Non-Excessive Infiltration/Inflow

g. Establish a Plan of Action, Budget and Timetable for Execution

FIGURE 3

PHASE II

FIELD INVESTIGATION AND SURVEY

a. Physical Survey and Groundwater Analysis

b. Rainfall Simulation

c. Prepare Engineering Report and Analysis

d. Preparatory Sewer Cleaning

e. Television Inspection of Preselected Sewers

f. Preparation of the Evaluation Survey Report and Analysis

g. Preparation of the Proposed Rehabilitation Program

FIGURE 4

PHASE III

REHABILITATION

a. Sewer Repair

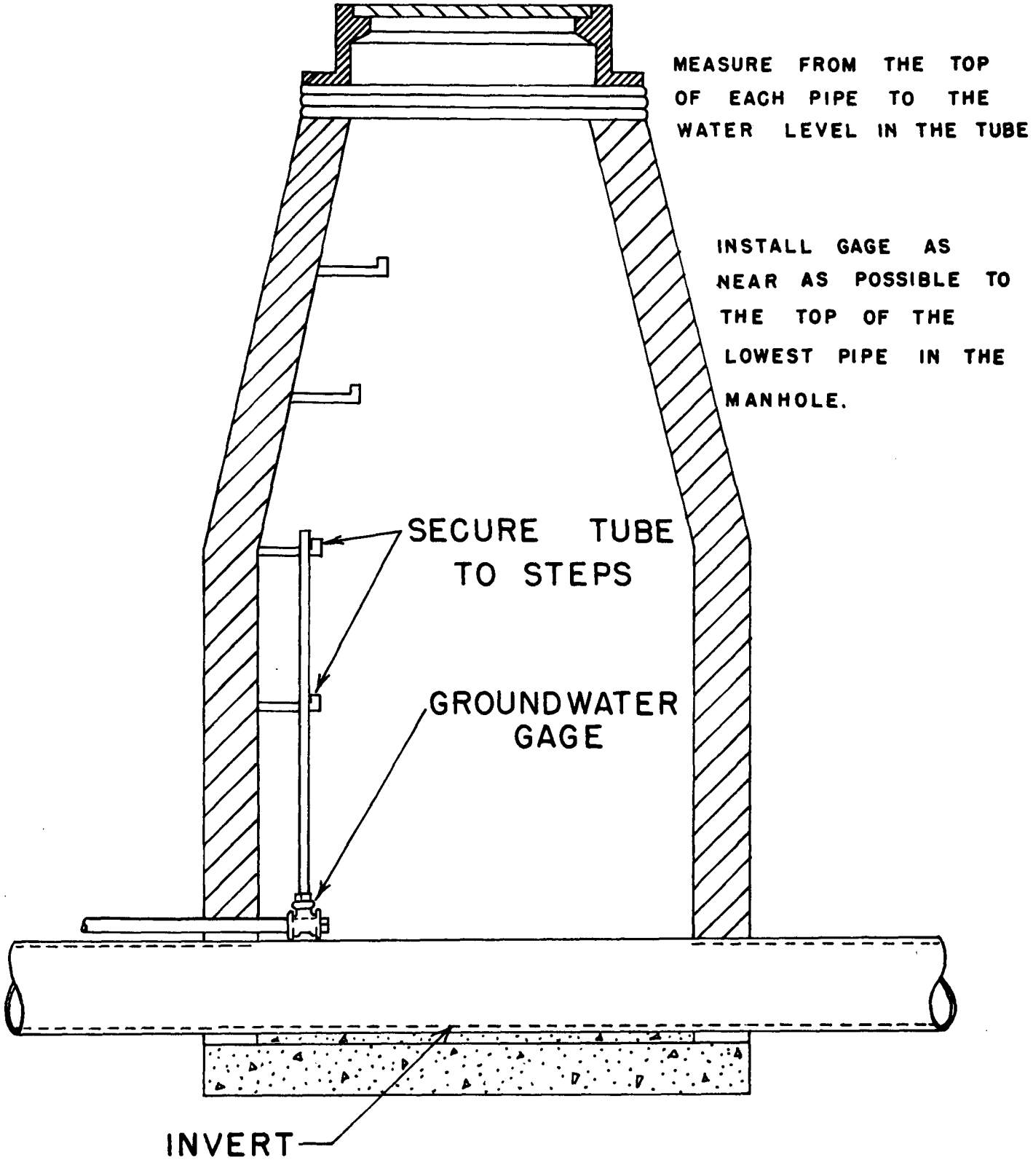
b. Pipe Relining

c. Sewer Replacement

d. Finalization of Treatment Plant Design

FIGURE 5

STATIC GROUNDWATER GAGE INSTALLATION



Public Law 92-500
92nd Congress, S. 2770
October 18, 1972

An Act

To amend the Federal Water Pollution Control Act.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Federal Water Pollution Control Act Amendments of 1972".

Federal Water Pollution Control Act Amendments of 1972. 70 Stat. 498; 84 Stat. 91. 33 USC 1151 note.

SEC. 2. The Federal Water Pollution Control Act is amended to read as follows:

"TITLE I—RESEARCH AND RELATED PROGRAMS

"DECLARATION OF GOALS AND POLICY

"SEC. 101. (a) The objective of this Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. In order to achieve this objective it is hereby declared that, consistent with the provisions of this Act—

"(1) it is the national goal that the discharge of pollutants into the navigable waters be eliminated by 1985;

"(2) it is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved by July 1, 1983;

"(3) it is the national policy that the discharge of toxic pollutants in toxic amounts be prohibited;

"(4) it is the national policy that Federal financial assistance be provided to construct publicly owned waste treatment works;

"(5) it is the national policy that areawide waste treatment management planning processes be developed and implemented to assure adequate control of sources of pollutants in each State; and

"(6) it is the national policy that a major research and demonstration effort be made to develop technology necessary to eliminate the discharge of pollutants into the navigable waters, waters of the contiguous zone, and the oceans.

"(b) It is the policy of the Congress to recognize, preserve, and protect the primary responsibilities and rights of States to prevent, reduce, and eliminate pollution, to plan the development and use (including restoration, preservation, and enhancement) of land and water resources, and to consult with the Administrator in the exercise of his authority under this Act. It is further the policy of the Congress to support and aid research relating to the prevention, reduction, and elimination of pollution, and to provide Federal technical services and financial aid to State and interstate agencies and municipalities in connection with the prevention, reduction, and elimination of pollution.

"(c) It is further the policy of Congress that the President, acting through the Secretary of State and such national and international organizations as he determines appropriate, shall take such action as may be necessary to insure that to the fullest extent possible all foreign countries shall take meaningful action for the prevention, reduction, and elimination of pollution in their waters and in international waters and for the achievement of goals regarding the elimination of discharge of pollutants and the improvement of water quality to at least the same extent as the United States does under its laws.

"(d) Except as otherwise expressly provided in this Act, the Administrator of the Environmental Protection Agency (hereinafter in this Act called 'Administrator') shall administer this Act. Administration.

"(1) the recycling of potential sewage pollutants through the production of agriculture, silviculture, or aquaculture products, or any combination thereof;

"(2) the confined and contained disposal of pollutants not recycled;

"(3) the reclamation of wastewater; and

"(4) the ultimate disposal of sludge in a manner that will not result in environmental hazards.

"(e) The Administrator shall encourage waste treatment management which results in integrating facilities for sewage treatment and recycling with facilities to treat, dispose of, or utilize other industrial and municipal wastes, including but not limited to solid waste and waste heat and thermal discharges. Such integrated facilities shall be designed and operated to produce revenues in excess of capital and operation and maintenance costs and such revenues shall be used by the designated regional management agency to aid in financing other environmental improvement programs.

"(f) The Administrator shall encourage waste treatment management which combines 'open space' and recreational considerations with such management.

"(g)(1) The Administrator is authorized to make grants to any State, municipality, or intermunicipal or interstate agency for the construction of publicly owned treatment works.

"(2) The Administrator shall not make grants from funds authorized for any fiscal year beginning after June 30, 1974, to any State, municipality, or intermunicipal or interstate agency for the erection, building, acquisition, alteration, remodeling, improvement, or extension of treatment works unless the grant applicant has satisfactorily demonstrated to the Administrator that— Conditions.

"(A) alternative waste management techniques have been studied and evaluated and the works proposed for grant assistance will provide for the application of the best practicable waste treatment technology over the life of the works consistent with the purposes of this title; and

"(B) as appropriate, the works proposed for grant assistance will take into account and allow to the extent practicable the application of technology at a later date which will provide for the reclaiming or recycling of water or otherwise eliminate the discharge of pollutants.

"(3) The Administrator shall not approve any grant after July 1, 1973, for treatment works under this section unless the applicant shows to the satisfaction of the Administrator that each sewer collection system discharging into such treatment works is not subject to excessive infiltration.

"(4) The Administrator is authorized to make grants to applicants for treatment works grants under this section for such sewer system evaluation studies as may be necessary to carry out the requirements of paragraph (3) of this subsection. Such grants shall be made in accordance with rules and regulations promulgated by the Administrator. Initial rules and regulations shall be promulgated under this paragraph not later than 120 days after the date of enactment of the Federal Water Pollution Control Act Amendments of 1972. Rules and regulations.

"FEDERAL SHARE

"SEC. 202. (a) The amount of any grant for treatment works made under this Act from funds authorized for any fiscal year beginning after June 30, 1971, shall be 75 per centum of the cost of construction

thereof (as approved by the Administrator). Any grant (other than for reimbursement) made prior to the date of enactment of the Federal Water Pollution Control Act Amendments of 1972 from any funds authorized for any fiscal year beginning after June 30, 1971, shall, upon the request of the applicant, be increased to the applicable percentage under this section.

"(b) The amount of the grant for any project approved by the Administrator after January 1, 1971, and before July 1, 1971, for the construction of treatment works, the actual erection, building or acquisition of which was not commenced prior to July 1, 1971, shall, upon the request of the applicant, be increased to the applicable percentage under subsection (a) of this section for grants for treatment works from funds for fiscal years beginning after June 30, 1971, with respect to the cost of such actual erection, building, or acquisition. Such increased amount shall be paid from any funds allocated to the State in which the treatment works is located without regard to the fiscal year for which such funds were authorized. Such increased amount shall be paid for such project only if—

"(1) a sewage collection system that is a part of the same total waste treatment system as the treatment works for which such grant was approved is under construction or is to be constructed for use in conjunction with such treatment works, and if the cost of such sewage collection system exceeds the cost of such treatment works, and

"(2) the State water pollution control agency or other appropriate State authority certifies that the quantity of available ground water will be insufficient, inadequate, or unsuitable for public use, including the ecological preservation and recreational use of surface water bodies, unless effluents from publicly-owned treatment works after adequate treatment are returned to the ground water consistent with acceptable technological standards.

"PLANS, SPECIFICATIONS, ESTIMATES, AND PAYMENTS

"SEC. 203. (a) Each applicant for a grant shall submit to the Administrator for his approval, plans, specifications, and estimates for each proposed project for the construction of treatment works for which a grant is applied for under section 201(g)(1) from funds allotted to the State under section 205 and which otherwise meets the requirements of this Act. The Administrator shall act upon such plans, specifications, and estimates as soon as practicable after the same have been submitted, and his approval of any such plans, specifications, and estimates shall be deemed a contractual obligation of the United States for the payment of its proportional contribution to such project.

"(b) The Administrator shall, from time to time as the work progresses, make payments to the recipient of a grant for costs of construction incurred on a project. These payments shall at no time exceed the Federal share of the cost of construction incurred to the date of the voucher covering such payment plus the Federal share of the value of the materials which have been stockpiled in the vicinity of such construction in conformity to plans and specifications for the project.

Limitation.

"(c) After completion of a project and approval of the final voucher by the Administrator, he shall pay out of the appropriate sums the unpaid balance of the Federal share payable on account of such project.

"LIMITATIONS AND CONDITIONS

"SEC. 204. (a) Before approving grants for any project for any treatment works under section 201(g)(1) the Administrator shall determine—

"(3) Each applicant for a grant under this subsection shall submit to the Administrator for his approval each proposal for which a grant is applied for under this subsection. The Administrator shall act upon such proposal as soon as practicable after it has been submitted, and his approval of that proposal shall be deemed a contractual obligation of the United States for the payment of its contribution to such proposal. There is authorizd to be appropriated to carry out this subsection not to exceed $50,000,000 for the fiscal year ending June 30, 1973, not to exceed $100,000,000 for the fiscal year ending June 30, 1974, and not to exceed $150,000,000 for the fiscal year ending June 30, 1975.

Appropriation.

Technical assistance.

"(g) The Administrator is authorized, upon request of the Governor or the designated planning agency, and without reimbursement, to consult with, and provide technical assistance to, any agency designated under subsection (a) of this section in the development of areawide waste treatment management plans under subsection (b) of this section.

"(h)(1) The Secretary of the Army, acting through the Chief of Engineers, in cooperation with the Administrator is authorized and directed, upon request of the Governor or the designated planning organization, to consult with, and provide technical assistance to, any agency designed under subsection (a) of this section in developing and operating a continuing areawide waste treatment management planning process under subsection (b) of this section.

Appropriation.

"(2) There is authorized to be appropriated to the Secretary of the Army, to carry out this subsection, not to exceed $50,000,000 per fiscal year for the fiscal years ending June 30, 1973, and June 30, 1974.

"BASIN PLANNING

"SEC. 209 (a) The President, acting through the Water Resources Council, shall, as soon as practicable, prepare a Level B plan under the Water Resources Planning Act for all basins in the United States. All such plans shall be completed not later than January 1, 1980, except that priority in the preparation of such plans shall be given to those basins and portions thereof which are within those areas designated under paragraphs (2), (3), and (4) of subsection (a) of section 208 of this Act.

79 Stat. 244. 42 USC 1962 note.

Annual report to Congress.

"(b) The President, acting through the Water Resources Council, shall report annually to Congress on progress being made in carrying out this section. The first such report shall be submitted not later than January 31, 1973.

Appropriation.

"(c) There is authorized to be appropriated to carry out this section not to exceed $200,000,000.

"ANNUAL SURVEY

"SEC. 210. The Administrator shall annually make a survey to determine the efficiency of the operation and maintenance of treatment works constructed with grants made under this Act, as compared to the efficiency planned at the time the grant was made. The results of such annual survey shall be included in the report required under section 516(a) of this Act.

"SEWAGE COLLECTION SYSTEMS

"SEC. 211. No grant shall be made for a sewage collection system under this title unless such grant (1) is for replacement or major rehabilitation of an existing collection system and is necessary to the total integrity and performance of the waste treatment works servicing such

community, or (2) is for a new collection system in an existing community with sufficient existing or planned capacity adequately to treat such collected sewage and is consistent with section 201 of this Act.

"DEFINITIONS

"SEC. 212. As used in this title—

"(1) The term 'construction' means any one or more of the following: preliminary planning to determine the feasibility of treatment works, engineering, architectural, legal, fiscal, or economic investigations or studies, surveys, designs, plans, working drawings, specifications, procedures, or other necessary actions, erection, building, acquisition, alteration, remodeling, improvement, or extension of treatment works, or the inspection or supervision of any of the foregoing items.

"(2) (A) The term 'treatment works' means any devices and systems used in the storage, treatment, recycling, and reclamation of municipal sewage or industrial wastes of a liquid nature to implement section 201 of this Act, or necessary to recycle or reuse water at the most economical cost over the estimated life of the works, including intercepting sewers, outfall sewers, sewage collection systems, pumping, power, and other equipment, and their appurtenances; extensions, improvements, remodeling, additions, and alterations thereof; elements essential to provide a reliable recycled supply such as standby treatment units and clear well facilities; and any works, including site acquisition of the land that will be an integral part of the treatment process or is used for ultimate disposal of residues resulting from such treatment.

"(B) In addition to the definition contained in subparagraph (A) of this paragraph, 'treatment works' means any other method or system for preventing, abating, reducing, storing, treating, separating, or disposing of municipal waste, including storm water runoff, or industrial waste, including waste in combined storm water and sanitary sewer systems. Any application for construction grants which includes wholly or in part such methods or systems shall, in accordance with guidelines published by the Administrator pursuant to subparagraph (C) of this paragraph, contain adequate data and analysis demonstrating such proposal to be, over the life of such works, the most cost efficient alternative to comply with sections 301 or 302 of this Act, or the requirements of section 201 of this Act.

"(C) For the purposes of subparagraph (B) of this paragraph, the Administrator shall, within one hundred and eighty days after the date of enactment of this title, publish and thereafter revise no less often than annually, guidelines for the evaluation of methods, including cost-effective analysis, described in subparagraph (B) of this paragraph. Methods, evaluation guidelines, publication.

"(3) The term 'replacement' as used in this title means those expenditures for obtaining and installing equipment, accessories, or appurtenances during the useful life of the treatment works necessary to maintain the capacity and performance for which such works are designed and constructed.

"TITLE III—STANDARDS AND ENFORCEMENT

"EFFLUENT LIMITATIONS

"SEC. 301. (a) Except as in compliance with this section and sections 302, 306, 307, 318, 402, and 404 of this Act, the discharge of any pollutant by any person shall be unlawful.

"(b) In order to carry out the objective of this Act there shall be achieved—