United States
Environmental Protection
Agency

Region V
230 South Dearborn
Chicago, Illinois 60604

SEPTEMBER 1979

Water Division

EPA

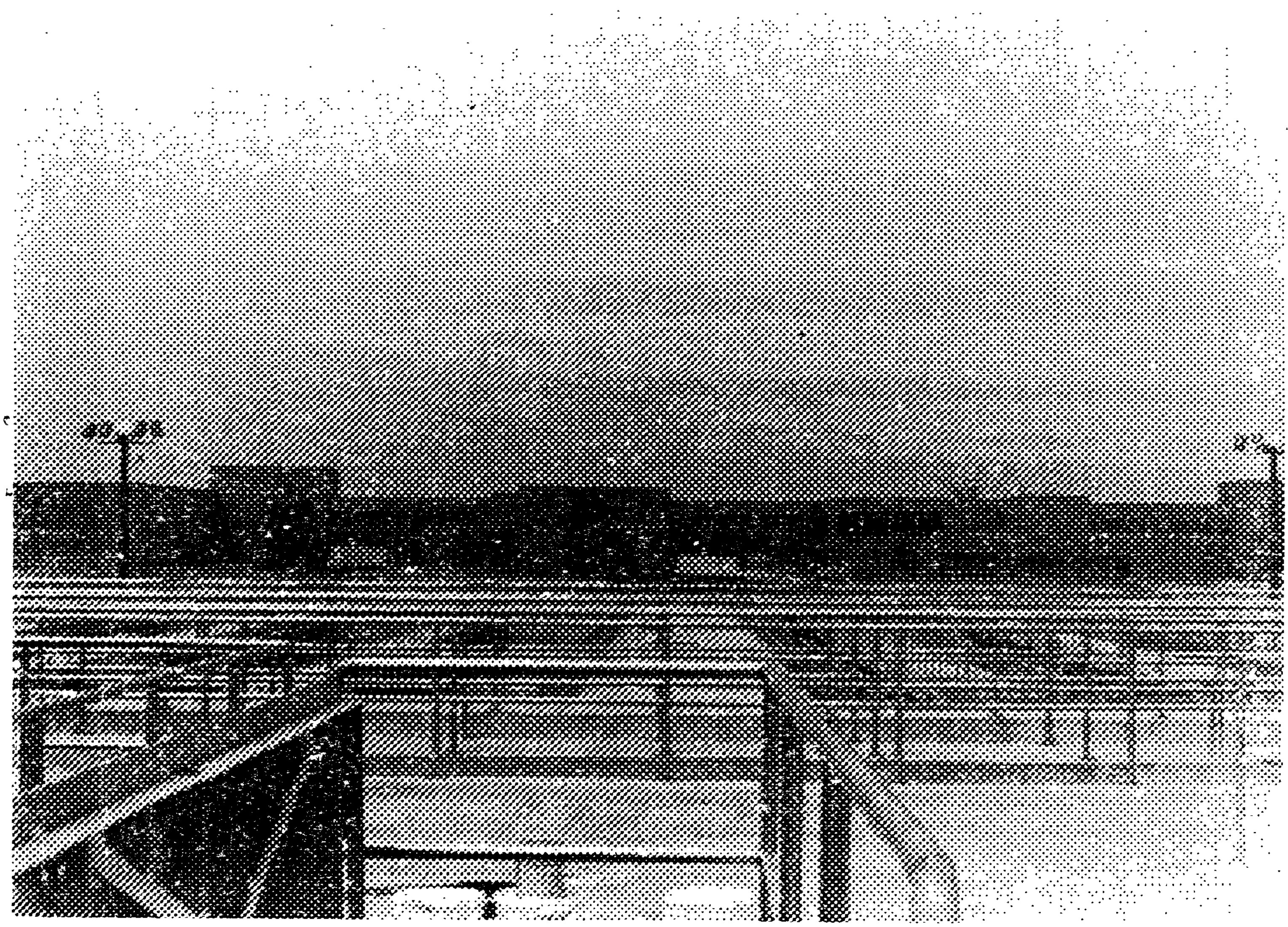
Environmental Impact Statement

Draft

Supplemental EIS

Metropolitan Sanitary District of Greater Chicago

O'Hare Water Reclamation Plant



DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

FOR THE

METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

DES PLAINES - O'HARE WATER RECLAMATION PLANT

Prepared by the

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION V

CHICAGO, ILLINOIS

Approved By:

Valdas V. Adamkus
Acting Regional Administrator
U.S. Environmental Protection Agency

September, 1979

DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

O'HARE WATER RECLAMATION PLANT

DES PLAINES, ILLINOIS

Prepared by

U.S. ENVIRONMENTAL PROTECTION AGENCY, REGION V

Comments concerning this document are invited and should be received by November 12, 1979.

For further information, contact
Mr. Gene Wojcik, Chief, EIS Section
USEPA Region V
230 South Dearborn Street
Chicago, Illinois 60604

Abstract

On January 13, 1975, a Notice of Intent to file an Environmental Impact Statement (EIS) was issued on the Metropolitan Sanitary District of Greater Chicago's (MSDGC) Des Plaines-O'Hare facilities plan. Two EIS's were prepared on this facilities plan, one on the proposed O'Hare Water Reclamation Plant (WRP) and Solids Pipeline, to be constructed in the City of Des Plaines, Cook County, Illinois, and the other on the proposed wastewater conveyance system for the Des Plaines-O'Hare service area. The final EIS's were published in May of 1975.

A primary issue addressed in the WRP EIS was the potential health effects resulting from respiration of aerosols generated from the WRP's aeration tanks.

The WRP EIS concluded that funding the project was acceptable to USEPA, provided the recommended measures were implemented. Since knowledge on the potential health hazard from aerosol generation at treatment plants was sparse and inconclusive at that time, the EIS recommended inclusion of a condition in the grant agreement which required aerosol suppression at the WRP. To ascertain the effectiveness of potential aerosol suppression facilities, the EIS recommended that MSDGC demonstrate the level of aerosol reduction achieved by the suppression facilities.

USEPA's original decision to require aerosol suppression facilities at the O'Hare WRP was based on the lack of scientific evidence regarding the relationship of wastewater aerosols and human health as well as our responsibility under NEPA to avoid health risks. Since that time, however, considerable research ahs been conducted to evaluate the potential discernible effect on human health from exposure to wastewater aerosols. The USEPA prepared this document to examine the quality of the recent research, and to decide whether the grant condition should be retained, rescinded, or modified.

TABLE OF CONTENTS

I. SUMMARY

A. BACKGROUND

On January 13, 1975, a Notice of Intent to file an Environmental Impact Statement (EIS) was issued on the Metropolitan Sanitary District of Greater Chicago's (MSDGC) Des Plaines-O'Hare facilites plan. Two EIS's were prepared on this facilities plan, one on the proposed O'Hare Water Reclamation Plant (WRP) and Solids Pipeline, to be constructed in the City of Des Plaines, Cook County, Illinois, and the other on the proposed wastewater conveyance system for the Des Plaines-O'Hare service area. The Final EIS's were published in May of 1975.

The O'Hare WRP is an activated sludge plant with a design capacity of 72 million gallons of sewage daily (MGD), and is to serve 277,000 residents located in a 52.8 square mile area of northwestern Cook County.

A primary issue addressed in the WRP EIS was the potential health effects resulting from respiration of aerosols generated from the WRP's aeration tanks.

The WRP EIS concluded that funding the project was acceptable to USEPA, provided the recommended measures were implemented. Since knowledge of the potential health hazard from aerosol generation at treatment plants was sparse and inconclusive at that time, the EIS recommended inclusion of a condition in the grant agreement which required appropriate aerosol suppression at the WRP. To ascertain the effectiveness of potential aerosol suppression facilities, the EIS recommended that MSDGC demonstrate the level of aerosol reduction achieved by the suppression facilities.

After the Final EIS was published, the City of Des Plaines filed a suit against the MSDGC and USEPA, alleging that the two Final EIS's issued by EPA failed to comply with the requirements of the National Environmental Policy Act (NEPA). The U.S. District Court entered judgment against the City. The City appealed this judgment, but the U.S. Court of Appeals upheld the District Court's judgment and ruled, in City of Des Plaines v. Metropolitan Sanitary District of Greater Chicago, 552 F.2d 736 (7th Cir. 1977), that:

1) "Our review of the adequacy of an EIS and of the merits of a decision reflected therein, while careful, has real limits. On the merits, the review should be limited to determining whether the agency's decision is arbitrary or capricious." (552 F.2d 737.)

2) "We believe the EIS unquestionably contains a fair statement of the problem and the solutions intended, insofar as was possible, and we do not believe more was required in this case." (552 F.2d 739.) "As to the procedure followed, we believe it is clear from the material of record that EPA took the requisite hard look at this problem and reacted sensitively to it." (552 F.2d 738.) Because no definitive answer could be made, ". . . EPA took a conservative approach and required MSD to design, construct, and install devices to suppress aerosol emissions." (552 F.2d 739.)

3) "The uncertainty regarding the very existence and scope of the potential health hazard is ignored by the City in its argument that the failure to specify standards and specific devices renders the pertinent EIS inadequate and in its insistence that the entire project be held in abeyance until definitive answers and solutions can be obtained." (552 F.2d 739.)

B. EVENTS SINCE MAY 1975

Since the court ruling, MSDGC has undertaken studies sponsored by the USEPA to evaluate the performance and costs of alternatives for suppression of aerosols.

In addition, other research listed below has been sponsored by the USEPA to evaluate aerosol emissions and the potential health effects from exposure to wastewater aerosols emanating from activated sludge treatment processes.

1) Report entitled "Health Effects of Aerosols Emitted from an Activated Sludge Plant" available as EPA-600/1-79-019.

2) Report entitled "Health Implications of Sewage Treatment Facilities" available as EPA-600/1-78-032.

3) Report entitled "Health Effects of a Wastewater Treatment System" available as EPA-600/1-78-062.

4) Report entitled "Assessment of Disease Rates among Sewer Workers in Copenhagen, Denmark" available as EPA-600/1-78-007.

5) Draft report entitled "Environmental Monitoring of a Wastewater Treatment Plant" in prepublication review by USEPA.

6) Final Report entitled "The Evaluation of Microbiological Aerosols Associated With the Application of Wastewater to Land: Pleasonton, CA." available from the Department of the Army.

7) Draft Report entitled "Health Risk of Human Exposure to Wastewater" in prepublication review by USEPA.

Also, other research on the potential health effects from aerosol exposure has been conducted.

Since May 1975, the construction of the interceptors leading to the O'Hare WRP, and construction of the plant itself, have been virtually completed. The plant will be available for operation as of October 1, 1979.

II. PURPOSE AND NEED FOR FURTHER EPA ACTION

USEPA's original decision to require aerosol suppression facilities at the O'Hare WRP was based on the lack of scientific evidence regarding the relationship of wastewater aerosols and human health, as well as our responsibility under NEPA to avoid health risks. Since that time, however, considerable research has been conducted to evaluate the potential discernible effect on human health from exposure to wastewater aerosols. The USEPA prepared this document to examine the results of the recent research, and to decide whether the grant condition should be retained, rescinded, or modified.

III. ALTERNATIVES CONSIDERED AND THEIR COMPARATIVE ENVIRONMENTAL IMPACTS

A. Alternatives Considered

1. Action.

   a) Remove the grant condition requiring MSDGC to construct aerosol suppression facilities at the O'Hare WRP.

   b) Modify the grant condition and allow operation of the O'Hare WRP without aerosol suppression facilities, and continue ongoing analysis to demonstrate whether or not the potential transmission of wastewater aerosols is a significant health concern.

2. No Action. Retain the grant condition requiring MSDGC to construct appropriate aerosol suppression facilities at the O'Hare WRP prior to operation of the plant.

B. Comparison of the Environmental Impacts

There is no indication that direct or indirect health effects will result from operation of the O'Hare WRP without aerosol suppression facilities.

If aerosol suppression facilities are constructed, there will be a significant expenditure of monetary, natural, and depletable resources in their construction and operation. Other adverse impacts include noise and dust associated with construction.

Based on our analysis of the studies, it is our conclusion that the grant condition can be rescinded with no significant impacts.

IV. AFFECTED ENVIRONMENT

The environment potentially affected by this action is that nearby the O'Hare WRP, including the areas's residents. For a thorough description of the areas land use, population, and environment, see Section III of this document.

V. ENVIRONMENTAL CONSEQUENCES

A. Basis of Evaluation

The research projects referenced in this document are used in the evaluation of the environmental consequences of alternatives.

B. Evaluation of Alternatives

1. Action

a) Rescind the grant condition requiring MSDGC to construct aerosol suppression facilities at the O'Hare WRP:

No significant direct or indirect effects result from this action, since testing of a thorough, critical, and sensitive nature, representing the feasible limit of scientific and economic capability, have shown that no significant adverse health effects result from exposure to aerosols.

b) Modify the grant condition and allow operation of the O'Hare WRP without aerosol suppression facilities, and continue ongoing analysis of potential health effects:

i) If further study shows need for aerosol suppression:

Monetary, natural and depletable resources would be expended on further study and in the construction and operation of aerosol suppression facilities. Other adverse impacts include noise and dust associated with construction.

ii) Further study shows no need for aerosol suppression:

Beyond the expenditure of monetary resources to further study the potential effects of aerosol exposure, no direct or indirect impacts will result from this action. Thorough research has shown that no significant adverse effects result from exposure to aerosols emanating from activated sludge wastewater treatment processes within the envelope of accepted U.S. design and operational practice.

2. No Action

Retain the grant condition requiring MSDGC to complete construction of aerosol suppression facilities prior to or concurrently with commencement of operation:

Monetary, natural, and depletable resources would be expended on the construction and operation of aerosol suppression facilities. Other adverse impacts include noise and dust associated with construction.

If operation of the O'Hare WRP would be delayed to construct aerosol suppression facilities, the overloaded system presently used would cause continued combined sewer overflows and flooding of basements with combined sanitary and stormwater, thereby threatening public health.

VI. PUBLIC PARTICIPATION

A Notice of Intent to prepare a Supplemental WRP EIS was issued on July 18, 1979. The distribution of this Draft Supplemental EIS will be followed by a 45-day comment period. A public hearing will be held as indicated on the Notice enclosed with this Draft Supplement. Comments on this Draft Supplemental EIS should be submitted to: Mr. Gene Wojcik, Chief, EIS Section (5WEE), U.S. Environmental Protection Agency, 230 South Dearborn Street, Chicago, Illinois 60604. A Final Supplemental EIS will then be published. After a mandatory 30-day waiting period, the USEPA will issue its final decision.

VII. PREPARER

Richard Beardslee, Environmental Engineer, U.S. EPA, Region V.

VIII. LIST OF AGENCIES, ORGANIZATIONS, AND PERSONS TO WHOM COPIES OF THIS STATEMENT WERE SENT

The following Federal, State, and local agencies have been requested to comment on the Draft Supplemental Environmental Impact Statement:

Council on Environmental Quality
Department of Agriculture
  Soil Conservation Service
U.S. Army Corps of Engineers
  Chicago District
  North Central Division
Department of Energy
  Argonne National Laboratory
Department of Health, Education and Welfare
Department of Housing and Urban Development
Department of the Interior
  Fish and Wildlife Service
  Geological Survey
  Heritage Conservation and Recreation Service
Department of Transportation
  Federal Aviation Administration

Governor of Illinois
Illinois Sanitary District Observer
Illinois Environmental Protection Agency
Illinois Institute for Environmental Quality
Illinois Division of Waterways
Illinois Department of Conservation
Illinois Department of Public Health

Northeastern Illinois Planning Commission
Cook County Department of Environmental Control
Metropolitan Sanitary District of Greater Chicago

City of Des Plaines
Village of Elk Grove
Village of Arlington Heights
Village of Mount Prospect
Village of Palatine
Village of Wheeling

DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

FOR THE

METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

DES PLAINES-O'HARE WATER RECLAMATION PLANT

I. PURPOSE AND NEED FOR FURTHER EPA ACTION

USEPA's original decision in May, 1975 to require aerosol suppression facilities at the O'Hare WRP was based on two considerations. The first involved the state of scientific knowledge at the time with respect to the health impacts associated with the respiration of wastewater aerosols. Our review of the literature at that time revealed that no conclusive evidence could substantiate either a health effect existed or that it did not exist. We did find that aerosols were generated and could be transmitted by winds to the areas in the vicinity of the O'Hare WRP. There was also some evidence relating to the viability of bacterial and viral organisms under differing atmospheric conditions. While this evidence indicated that organisms were adversely affected by transport on aerosol particles, we felt there was still a possibility that viable organisms could reach some residents near the O'Hare WRP.

The second consideration came directly from the National Environmental Policy Act of 1969 (NEPA), which declares that it be National policy that the Federal Government use all practicable means to assure a healthful environment and to attain the widest beneficial uses of the environment without undue risk to health or safety. Therefore, given the state of scientific knowledge, the possibility of exposure to residents, and our responsibility to avoid health risks, we chose to require the appropriate suppression of aerosols generated at the O'Hare WRP.

In the past four years, considerable research has been undertaken to explore the relationship between health and the respiration of wastewater aerosols. The purpose of this document is to examine this new information regarding the health risks of human exposure to aerosols and to decide whether the grant conditions should be retained, rescinded, or modified.

II. ALTERNATIVES CONSIDERED AND THEIR COMPARATIVE ENVIRONMENTAL IMPACTS

A. Alternatives Considered

1. Action

a) Rescind the grant condition requiring MSDGC to construct aerosol suppression facilities at the O'Hare WRP, since the conclusions of the studies to date indicate that no significant adverse health effects result from exposure to aerosols emanating from activated sludge wastewater treatment processes within the envelope of accepted U.S. design and operational practice, either to proximate residents or to plant workers, and by inference to the general public apart from these categories.

b) Modify the grant condition and allow commencement of functional operation of the O'Hare WRP without aerosol suppression facilities, and continue ongoing analysis to demonstrate whether the potential emission of wastewater aerosols at the O'Hare WRP is a significant health concern.

2) No Action

Retain the grant condition requiring MSDGC to complete construction of appropriate aerosol suppression facilities at the O'Hare WRP prior to or concurrently with the commencement of functional operation, since studies to date do not indicate significant adverse health effects result from exposure to aerosols emanating from activated sludge wastewater treatment processes.

B. Comparison of the Environmental Impacts of the Alternatives

There is no indication that direct or indirect health effects will result from operation of the O'Hare WRP without aerosol suppression facilities.

While it is always desirable to study an issue in more detail, it is our conclusion that further study would only have the direct impact of expending monetary resources, and would not alter the conclusions that the health risk associated with close proximity to wastewater aerosols, and hence the O'Hare WRP, is not any greater than that presented by routine environmental exposure to bacterial and viral organisms.

If aerosol suppression facilities are constructed, there will be a significant expenditure of monetary, natural, and depletable resources in their construction and operation. Other adverse impacts include noise and dust associated with construction.

If operation of the O'Hare WRP would be delayed to construct aerosol suppression facilities, the overloaded system presently used would cause continued combined sewer overflows and flooding of basements with combined sanitary and stormwater, thereby threatening public health.

Based on our analysis of the studies, it is our conclusion that the grant condition can be rescinded with no significant impacts.

III. AFFECTED ENVIRONMENT

The environment potentially affected by this action is that close to the O'Hare WRP, particularly the 1200 residents within 2000 feet of the plant boundaries, and is shown in Figure 2. Figure 1 delineates the O'Hare WRP and adjacent service areas. The northern and southern boundaries of the O'Hare Service Area follow the Cook County boundary lines. The eastern boundary extends from Lake County south along the Des Plaines River to the intersection of Rand and River Roads, thence in a southwesterly direction along the Chicago and Northwestern Railway to the DuPage County line. The western boundary separates the O'Hare and Salt Creek Service Areas, and generally follows the ridge line dividing the Salt Creek and Des Plaines River drainage areas.

The O'Hare Service Area lies in the northwest portion of Cook County. It encompasses an area of 37,250 acres of which 26,400 acres are residential, 5,000 acres are industrial and 5,850 acres are rural or otherwise unsewered. The 1970 census population for the O'Hare Area was 223,000 people.

The area includes the older (but growing) communities of Arlington Heights, Mount Prospect, Wheeling, and a part of the City of Des Plaines, as well as newer urban developments such as Elk Grove Village, Rolling Meadows and Buffalo Grove.

IV. ENVIRONMENTAL CONSEQUENCES

A. Basis of Evaluation

Since May, 1975, MSDGC has undertaken studies sponsored by the USEPA, to evaluate the performance and costs of alternatives for suppression of aerosols. Phase I of the study which is projected to be completed by March of 1980, is to measure the physical, chemical, and biological properties of aerosols emanating from the aeration tanks of the J. E. Egan WRP and relate these to measurements of the wastewater aeration process parameters of the plant and environmental parameters which may have an influence on aerosol properties. Using these data, MSDGC would prepare engineering estimates of the potential efficiency of alternative aerosol suppression methods identified for consideration, and select up to five (other than covering or vegetative barrier) alternates for detailed testing by pilot plant performance trials. The performance characteristics of the Egan WRP are presumed to be representative of the planned operation of the O'Hare WRP.

The proposed Phase II and III portions of the study were designed to construct a pilot plant, representing a segment of the O'Hare WRP aeration tanks, emitting aerosols comparable to a demonstrated degree, in physical, chemical, and biological properties, to those of the entire Egan WRP, and to construct full-scale short segment prototype equipment for up to five selected alternative aerosol suppression systems to be tested on the pilot plant. Aerosol suppression efficiency of each alternative would then be measured, and the most appropriate alternative would be recommended, and detailed design criteria presented.

Since virtually nothing was known about the possible health effects of wastewater aerosols on populations living near activated sludge wastewater treatment plants, the USEPA sponsored several research efforts to investigate potentially related health effects. The first study funded by USEPA was an investigative study conducted at MSDGC's Egan WRP to determine if a potential problem existed for residents which would warrant further investigation. Since this study revealed a possible association of certain symptoms with nearby operation of a wastewater treatment plant, further investigation was initiated.

The USEPA also sponsored a study at Pleasanton, California which obtained detailed information on the types and concentrations of microorganisms in aerosols, and the factors affecting their viability after aerosolization in order to estimate exposure of those nearby.

To further evaluate potential health effects from exposure to wastewater aerosols, the USEPA sponsored studies conducted by the University of Michigan and the University of Illinois to investigate potential health effects of those residents near a wastewater treatment plant.

Meanwhile, a study conducted by Hebrew University was investigating the incidence of disease on Kibbutzim utilizing wastewater irrigation and those not using wastewater. This study showed some evidence of increased incidence of disease associated with wastewater use. However, there was doubt indicating the possible pathway of infection, so USEPA is sponsoring further study to clarify this issue.

Another study sponsored by the USEPA to evaluate potential health effects from aerosol exposure involved the health experience of students attending schools adjacent to the wastewater treatment plant in Tigard, Oregon.

Health reports of sewer maintenance workers in Copenhagen, Denmark were also reviewed by the USEPA.

To evaluate potential health effects from close occupational exposure to wastewater and their aerosols, the USEPA then sponsored a study of sewage treatment plant workers and sewage maintenance workers, to be conducted by the University of Cincinnati.

The research studies are discussed in the following pages.

This study was conducted by the Southwest Research Institute to identify the health implications of operating a recently constructed activated sludge sewage treatment plant. The general study design was to make baseline (preoperational) period versus operational period comparisions at the Egan Water Reclamation Plant (WRP) in each of two seasons on the same participants and sampling areas.

The Egan WRP was chosen since the design of this epidemiological study required that the sewage treatment plant had to be a new plant being built on a new site and could neither be an expansion of an existing plant nor built on the site of an old plant. The design capacity of the plant had to be one millions gallons per day (MGD) or larger and use the activated sludge method of treatment. Other constraints also limited the choice of plant. The plant had to serve a residential area with no heavy industry contributing to the waste influent, and there could not be another sewage treatment plant within a six-mile (approximately 10 Km) radius.

The other major factor which influenced the selection or rejection of a plant was the population living around the plant site. Within a 5.0 kilometer (Km) (3-mile) radius of the plant, a minimum of 1,000 households had to be present. Ideally, a uniform population density was needed throughout the study area.

The Egan WRP was placed in service December 16, 1975, serving a design population of 160,000 people in an area of 49 square miles. A generalized flow diagram is presented in Figure 3. The wastewater treated at the STP is primarily normal to low strength domestic-commercial waste. The area served has limited light industry. The influent biochemical oxygen demand (BOD) concentration averages approximately 100 to 150 milligrams per liter (mg/l). The total suspended solids (TSS) concentration is in the same range (100 to 150 mg/l). The waste flow at plant start-up was in the range of 10-15 MGD.

The daily waste flow presently is in the range of 15 to 20 MGD. The monthly average daily flow is aproximately 17 MGD. The flow into the plant is somewhat equalized by a wet well and by allowing the collection system (sewer lines) to act as a holding device. This is done in an attempt to distribute the daily flow variations in a more uniform fashion. The design dry weather daily average flow capacity is 30 MGD.

The plant is presently operated in the conventional mode; that is, the raw sewage is discharged into the head end of a series of long tanks and aerated. The flow process of the plant is given in Figure 3.

A map of the study site is provided in Figure 4. The Egan Sewage Treatment Plant is located at the center of the map, on Salt Creek, a tributary of the Des Plaines River. The area is located in the northwest portion of the Chicago Metropolitan area, approximately 35 miles from the downtown business district. A number of suburban communities as village, surround the Egan Plant. These are the villages of Rolling Meadows, Arlington Heights, Elk Grove Village, Itasca, Schaumburg, and Hoffman Estates.

The area occupies a plain, which for the most part, is only some tens of feet above Lake Michigan (579 feet above mean sea level). Topography does not significantly alter air flow, except that lesser frictional drag over Lake Michigan causes winds to frequently be stronger along the lakeshore.

The quandrant from the east to about due north of the Egan treatment plant is a designated forest preserve. Two four-lane highways (Higgins and Arlington Heights Roads) pass through portions of this preserve. Estimated traffic patterns for each of these roads would be between 20,000 and 30,000 cars/day.

The remaining three quandrants of the study area can be described as a mixture of residential, agricultural, and small business tracts. Residential areas are estimated to comprise about 30-40 percent of these quandrants. However, rapid growth in the area is taking over the available farmland and would appear to substantially increase the residential percentage within the next few years. The agriculture usage is predominately for grain crops such as corn, wheat, and oats. An extimated 10 percent of the study area is presently commercial enterprise such as shopping malls and business zones along the major thoroughfares.

The study design provided for a self-paired comparison of individual health observations from the operational period against those from the corresponding baseline period is a very sensitive procedure for detecting changes because it eliminates the substantial inherent variability between human subjects and between locations. For an epidemiological investigation of microbiological hazards to have the power to identify any health hazards that are present, newly exposed human subjects were necessary, because sporadic inhalation of low concentrations of pathogens may confer a degree of immunity. With a new sewage treatment site, all the potential perticipants are newly exposed.

The original human subjects selected as participants were not to be replaced if they dropped out of the study. Each participant was to be his own control, so very sensitive self-paired comparisons of the corresponding operational and baseline results could be performed. In the health surveys and for the soil and water environmental samples, the same locations were to be used in each sampling period, again to improve the sensitivity of the comparisons.

Pathogens might come from various sources both within and adjacent to the study area. Local farmers use a combination of chemical and biological fertilizers for their grain crops. As manure is spread by machine over the fields some form of particulate matter would be emitted to the atmosphere. No feedlots were observed within the study area.

Environmental monitoring was conducted to characterize the ambient air, surface soil, and surface water in the vicinity of the WRP aeration basin, outward to residential distances of 0.3 to 5.0 Km in all four sampling periods. The researchers' concurrent extensive aerosol and wastewater monitoring study of spray irrigation at Pleasanton, California helped develop a superior microbiological aerosol sampling and analytical protocol. Six high volume air samplers operating simultaneously were used to perform ten aerosol sampling runs over a seven-day period, with one upwind and five downwind. The upwind station was intended to describe the background levels of airborne microorganisms and trace metals.

For sampling off the plant grounds, 24 sampling sites were preselected to describe the windrose pattern at 1.6 and 5.0 Km distances from the plant. Twelve additional sites were preselected in case the wind direction was different than that predicted by the windrose pattern charts for the area. The sampling sites were changed each day to follow the wind direction. If the wind direction changed drastically during any one sampling period attempts were made to move the samplers. Sampler location distances in meters (m) from the edge of the aeration basin fell into the following distance ranges: 15-30; 50-75; 100-150; 200-400; 600-1200. An upwind station was located directly upwind at a distance of 500-1600 m for each run. In the event wind direction and physical obstructions prevented placement of samplers at one of the distance ranges, the sampler in question was placed at the nearest unobstructed point.

Sampling occurred only if the mean wind direction remained fairly constant and if no marked changes in meteorological conditions were expected over the next 30 minutes. The run was continued as long as there was no marked change in mean wind direction prior to the completion of 15 minutes of sampling.

Each of the 60 aerosol samples was analyzed for total viable particles (TVP), total and fecal coliform, coliphage, pathogenic bacteria-salmonella, Shigella, Pseudomonas, streptococcus, proteus, and viruses: polio, adeno, coxsackie, and echo. Air samples were also analyzed for concentrations of lead, zinc, copper, cadmium, and mercury. In the operational periods, the mixed liquor being aerated in the aeration basins was also sampled for trace metals, viruses, parasitic worms, protozoa, and enteric and respiratory human pathogenic bacteria.

A health survey was conducted to obtain personal information on households and detailed background information on volunteer participants. The household health survey was also to obtain disease and symptom incidence on the household members through a door-to-door interview. Half of the households were within 3.5 Km in all directions from the plant site, with the other half residing between 3.5 and 5 Km in all directions from the plant. Clinical specimens were obtained from the participating subjects for microbiological and trace metal analyses. The clinical specimens selected were blood, feces, hair, throat swabs, sputum, and urine. One hundred of the participants' baseline and operational blood samples were analyzed using 23 additional viral serology tests.

The household health survey was conducted only in the baseline and operational sampling periods, with health information being collected on the members of 1000 households in each survey. From 200 to 240 participants were selected from the baseline household volunteers residing within the 3.5 kilometer radius, so at least 140 to 160 would remain to provide clinical specimens through all four sampling periods. The participants were equally distributed among four desired age groups: 3 months to 4 years; 6 to 12 years; 21 to 45 years; 60 years or older. The months during which the samples for each sampling period were actually obtained were: September-October 1974; February 1975; September 1975; February 1976; September-October 1976.

The data from the Household Health Survey was in the form of frequency counts for occurrence of a particular chronic illness, symptom, or disease.

The statistical methodology used was designed to determine if any significant changes in the frequency of occurrence were detectable between the baseline (pre-operational) period and the operational (post-operational) period. In addition, any increase in incidence should be related to the distance of the household to the Egan plant, if the sewage treatment plant was to be implicated as a potential health hazard.

In order to determine whether the occurence of pathogens in the clinical specimens had increased after the plant began operating, the analytical results of the samples taken from each participant were matched according to season (February or October) and compared for each of the bacteria, parasites, and viruses analyzed in the four sample media (feces, throat swabs, sputum, and blood).

The study concluded that the Egan plant appears to be a source of indicator bacteria, coliphage, pathogenic bacteria, enteroviruses, and mercury in the aerosols emanating from its aeration basins.

However, the levels of microbiological or chemical agents of the air, soil, and water samples in the neighboring residential areas were not distinguishable from the background levels monitored before plant operation.

From the patterns observed in the household health survey, the reported incidence of skin disease, and the symptoms of nausea, vomiting, general weakness, diarrhea, and pain in chest on deep breathing may be associated with the nearby operation of the wastewater treatment plant. However, it was considered that this correlation could be due to people biasing their responses to the questionnaire because they were aware of the purpose of the study and consciously or unconsciously recalled a higher incidence than they might have otherwise.

Results for alpha-and gamma-hemolytic streptococci isolations in the throat swabs for the subjects from the Lexington Green Apartments provide some evidence that the pattern may relate to exposure to the wastewater treatment plant aerosols. However, alpha-and gamma-hemolytic streptococcus species are part of man's normal flora in the intestinal tract, upper respiratory tract and skin, and of his environment (e.g., vegetation, insects, and animal feces) and do not normally produce disease. Therefore, their presence in the vicinity of the wastewater treatment plant or in the throat swabs is of little practical health concern. Thirty-one viral antibody tests and attempted isolations of many pathogenic bacteria, parasites, and viruses yielded no evidence of an adverse wastewater treatment plant effect.

The combined baseline-operational and distance experimental design used in this study is very sensitive for identifying potential health hazards and inferring whether or not the wastewater treatment plant may be their source. However, the findings obtained in this study, when considered overall, did not detect a public health hazard for persons living beyond 400 m from a well-operated wastewater treatment plant.

The Evaluation of Microbiological Aerosols Associated with the Application of Wastewater to Land: Pleasanton, California /2

This research project was conducted by the Southwest Research Institute to determine to what extent individuals living near sites practicing spray irrigation are exposed to microorganisms.

A water reclamation plant in the City of Pleasanton, California was selected as the study site: the City of Pleasanton Sunol Sewage Treatment Plant (STP). The plant was modified just prior to the study by the addition of an activated biofiliter process following the trickling filter to enhance the treatment system's biochemical oxygen demand (BOD) removal efficiency. The City of Pleasanton STP utilized physical and biological processes in the treatment of its sewage flow. This STP is unique in that it combines two biological waste treatment systems, fixed film and fluidized culture. The fixed film is conveniently termed "trickling filter" and the fluidized culture is termed "activated sludge". Additionally, the STP has aerated ponds which serve as polishing and equalization for the land application phase. Provisions have been made for odor control, such as lime addition, partial chlorination, and off-gas ozonation. Figure 5 presents the general plant layout flow scheme for liquid wastes.

A schematic of the study area is shown in Figure 6. A population with middle-class socioeconomic characteristics is located within one mile to the east/southeast of the plant. This population is located in a recently completed subdivision off Mission Drive. Mission Drive runs east-west, and the street begins on Sunol Blvd. opposite the treatment plant. The prevailing winds in this area are from the southwest to northwest quandrant; thus, this inhabited area would be downwind of the spray fields. There is a population in this subdivision to conduct an epidemiological study, and there are also suitable control populations in Pleasanton with middle-class socioeconomic characteristics located more than 2000 m from the spray fields.

The principal objectives of the first phase of the study were to establish the relationship in wastewater between pathogen levels and levels of the traditional indicator organisms (total and fecal coliform and standard bacterial plate count), to determine microorganism levels in air within 100 m of the spray source, and to begin the assessment of factors thought to affect the levels of pathogenic organisms collected in aerosol samples, including aerosolization efficiency, pathogen survival upon becoming airborne (impact), and microbiological die off with time (viability decay).

Routine monitoring of the wastewater was accomplished by taking a 20 liter composite sample from the aeration basin during the hours of spraying. Analyses included total and free chlorine, pH, total organic carbon, total solids, and total suspended solids. In addition, one-half of the composite samples were tested for biochemical oxygen demand, chemical oxygen demand, total phosphorus, hardness, and the nitrogen series (nitrite, nitrate, ammonia, and organic nitrogen). Microbiological analyses run on all wastewater samples included total and fecal coliform, total viable particles (TVP), coliphage, and assays for selected pathogens (*Klebsiella*, *Pseudomonas*, fecal streptococci, *Clostridium perfringens*, and enteroviruses).

The objectives of the second phase of the study were toward the development and validation of a predictive model of aerosol dispersion and pathogen survival. To accomplish this goal, 50 successful aerosol runs (each utilizing a minimum of 8 samplers) were made using large volume electrostatic precipitator samplers. These samplers were selected because the large volume of air sampled over a 30-minute period increases the sensitivity for the microbiological assay. Air sampling was conducted upwind and up to 600 m downwind in configurations to obtain the information necessary to perform the mathematical modeling. The samples were analyzed for the same microbiological parameters as the wastewater, with the exception of one run for which the collecting fluids from all samples were pooled for conduct of a pathogen screen.

Two special virus aerosol runs were conducted with all available samplers operating close to the spray line under meterological conditions expected to result in high virus aerosol concentrations. The sampler collection medium was changed every 30 minutes and the samplers ran for a total of about three hours, therefore the results were based upon a total of over 5000 cubic meters (m3) of air. Additionally, 17 aerosol runs were made after the injection of dye into the wastewater to allow estimation of the proportion of the sprayed effluent that became aerosolized. All glass impingers were used to collect the aerosols from the dye runs, to determine the aerosolization efficiency of the sprinklers.

An explicit model for predicting downwind concentrations of pathogens was developed by expanding more general mathematical dispersion models. The model adds factors for microorganism impact, viability decay, and aerosolization efficiency, to the standard diffusion model estimate of pathogen concentration based on source strength. The distributions of aerosolization efficiency and the impact and decay values for each organism were determined and these were used to allow evaluation of the model using monitoring data from the Egan WRP study and the Tigard, Oregon, study.

The dispersion model developed in this study was then validated. It was shown to produce satisfactory results when used to predict aerosol concentrations at three sites. Most of the predicted results fell within a factor of five of the measured concentrations when non-chlorinated effluent was being sprayed.

Through wastewater monitoring it was found the wastewater effluent applied was of relatively consistent day-to day quality (BOD-18.7 mg/l; Chemical Oxygen Demand (COD) 99.5 mg/l; Total Organic Carbon (TOC) 33.0 mg/l; pH 8.4; hardness 235.2 mg/l; TSS-33.0 mg/l; total phosporus-5.6 mg/l; and nitrite, nitrate, ammonia, and organic nitrogen-0.15 mg/l; .06 mg/l; 23.9 mg/l; and 5.6 mg/l, respectively).

Pathogenic bacteria and viruses were found consistently in the pre-application effluent samples, and coliphage was found in all pre-application effluent samples. A wide range of levels of these microbial components was found. Concentration levels routinely varied by one order of magnitude and variation often approached two orders of magnitude.

A special study of respiratory viruses in wastewater found confirmed viruses in five of forty cultures. Typing disclosed that four of the five tubes contained echovirus 6, while the other viral isolate could not be identified. Echovirus 6 may occur as either a respiratory-tract virus or as an enteric virus. The failure to isolate respiratory viruses in the Pleasanton wastewater confirmed the researchers' suspicion that the likelihood of finding respiratory viruses in wastewater is very small.

There was no significant difference in the coliform or coliphage concentration in corresponding effluent samples taken from a spray head during the aerosol runs and from the effluent composite samples at the pond pump. The standard bacterial plate count, however, was significantly higher in the spray-head wastewater samples. The correlations of the spray-head and pond composite microorganism concentrations were generally significant, but not adequate for prediction.

The median aerosolization efficiency obtained for the sprayers over 17 dye runs at Pleasanton was 0.33 percent. There was over an order of magnitude of variation in aerosolization efficiency estimates. Eighty percent of this variation in aerosolization efficiency at Pleasanton appears to have resulted from changes in meterological conditions (air temperature, wind velocity, and solar radiation) that affect the evaporate capability of the air.

The median impact factor estimates for the micro-organism groups studied were 0.13 for fecal coliform (13% survive aerosol impact), 0.16 for total coliform, 0.21 for standard bacterial plate count, 0.34 for coliphage, 0.89 for mycobacteria, 1.2 for Clostridium perfringens, 1.7 for fecal streptococci, 14 for Pseudomonas, about 10 for three-day enteroviruses (mostly polioviruses), and about 40 for all (3-day and 5-day) enteroviruses. Most individual impact factor estimates were quite imprecise, reflecting the imprecision of the microbiological aerosol concentration measurements. Since the middle range of impact factor values (fortieth to sixtieth percentiles) for each microorganism group were quite consistent, they were considered to be characteristic of the microorganism groups' typical survival through aerosol impact.

As indicated by impact factors exceeding 1.0, the enteroviruses and some hardy bacterial pathogens were frequently found in wastewater aerosols at higher concentrations than could be expected based on their wastewater concentrations. Mechanical splitting of colony forming units (CFM) may account for this phenomenon.

The range of impact factor estimates for each microorganism group was broad, generally covering two orders of magnitude from the tenth percentile to the ninetieth percentile. The detectable viability decay rates of each microorganism group also covered a wide range. Limited data suggest ambient conditions such as low relative humidity, high wind velocity, and a large temperature differential between wastewater and air all may reduce the initial survival. Viability decay may be more rapid with high solar radiation, high temperatures, and middle or low relative humidity.

The viability decay rates for total coliform and fecal coliform were more rapid, more reliable, and more frequently detectable than those of the other microorganism groups. Viability decay was less rapid for coliphage, Clostridium perfringens, and standard bacterial plate count and its effect could only be ascertained within 100 m on about half the runs. Viability decay could seldom be ascertained for fecal streptococci, mycobacteria, and Pseudomonas. No attempt was made to determine the viability decay of enteroviruses due to insufficient data.

The geometric mean aerosol concentrations obtained at 50 m downwind of the wetted spray area were:

1)	standard bacterial plate count	460.0 /m3
2)	total coliform	2.4 MFC/m3
3)	fecal coliform	0.37 MFC/m3

4)	coliphage	0.38 PFU/m3
5)	fecal streptococci	0.61 CFU/m3
6)	Pseudomonas	34.0 CFU/m3
7)	Klebsiella	5.0 CFU/m3
8)	Clostridium perfringens	0.9 CFU/m3
9)	mycobacteria	0.8 CFU/m3
10)	enteroviruses (3 and 5 day)	0.014 PFU/m3

PFU = Plaque Forming Units
CFU = Colony Forming Units
MFC = membrane filter count
m3 = cubic meters

Individual aerosol measurements frequently differed by more than an order of magnitude from these mean values.

Limited particle size data obtained with two-stage Andersen samplers showed a substantial portion in the respirable range. The median percent respirable particle values downwind of the spray line were 44 percent for total count and 74 percent for total coliform. In general, there was a higher percentage of respirable particles at close downwind distances (5 to 25 m), than at background and farther downwind distances. This meager data is in general agreement with more thorough particle size studies performed at the Egan WRP. Particle size was not considered in the mathematical modeling.

Wastewater quality as measured by chemical and physical parameters was unrelated to the generation or transport of microbiological aerosols from spray irrigation. In addition, little correlation was found in the wastewater between levels of the traditional indicator organisms; total coliform, fecal coliform, standard bacterial plate count, and coliphage, with the levels of the pathogens which they are intended to indicate.

Aerosol studies indicated that use of the traditional indicator organisms to predict human population exposure results in extreme underestimation of pathogen levels. The pathogens studied survived the wastewater aerosolization process much better than did the indicator organisms. Based upon the results of this study, fecal streptococci may be an appropriate indicator due to ease of assay, levels routinely seen in wastewater, and the similarity of their hardiness upon impact and viability decay rate to those of the pathogenic organisms of interest. However, an apparent problem was the occasional presence of fecal streptococci in aerosols due to non-wastewater sources.

Although Klebsiella was relatively prevalent in the wastewater, it was far less prevalent in the wastewater aerosol. It appears that Klebsiella die off repidly during the aerosolization process. This finding was in contrast to data seen in the literature which consistently report Klebsiella as the predominant pathogen found in the air near spray irrigation sites and near sewage plants. More analytical confirmation steps were used in this study than in earlier studies. If the confirmation steps had been stopped at the point used by other investigators more values would have been reported as Klebsiella when, in fact, they were primarily other organisms of the mucoid type.

The study was supported by an extensive quality assurance program. Chemical, physical, and microbiological methods used were subjected to accuracy and precision studies, and alternative laboratories were used, where feasible, to verify the results.

Studies conducted on the aerosol collection media, the temperature at which the samples are shipped, and the total time from collection to analysis were examined in detail in the laboratory. The results led to the design of adequate methods for sampling and analysis so that pathogenic organisms were found consistently.

Some difficulties were encountered in contamination of the high-volume aerosol samplers between aerosol runs. This problem appeared primarily in the standard bacterial plate count and Pseudomonas assays. Special care must be taken to adequately decontaminate high-volume aerosol samplers between aerosol runs.

The microbiological aerosol data varied substantially in quality and statistically usable information content. Accordingly, a suitable aerosol data weighting procedure was employed, according to consistent rules, in conducting the aerosol factor analyses. In the quality assurance aerosol runs for systematic sampler differences, it was concluded that after correcting for the air flow rates, there was no systematic bias in microbiological collection efficiency among the high-volume samplers evaluated.

There was substantial imprecision using the methods employed in this study for measuring microbiological concentrations in aerosol samples. The aerosol measurement coefficients of variation were 17 percent for dye, 50 percent for total coliform and standard bacterial plate count, 58 percent for fecal coliform and Pseudomonas, 60 percent for Clostridium perfringens, 73 percent for coliphage, 74 percent for Klebsiella, 77 percent for fecal streptococci, and 81 percent for mycobacteria. While the microbiological aerosol variation due to field sampling sources was considerable, even more variation was caused by analytical sources such as sample processing, shipping, and laboratory procedures. Relatively little of the analytical variability was reflected in replicated analyses, which is the usual manner of reporting analytical variation.

The accuracy and precision of microbiological dispersion model predictions have, in general, been validated to 100 m downwind of spray sources of unchlorinated wastewater aerosols. Most model predictions (e.g., 77 percent for standard bacterial plate count, 71 percent for total coliform, and 80 percent for coliphage) were within a factor of five of the net measured aerosol concentrations evaluated. Considering the imprecision and cost of measuring micro-organism aerosol concentrations from spray irrigation by field sampling, using predictions of the micorbiological dispersion model supplemented with minimal field sampling does appear to be a preferable alternative to extensive field sampling when the sprayed wastewater does not contain residual chlorine.

The University of Michigan and the IIT Research Institute utilized data obtained as part of a comprehensive community health study conducted during 1965-71 to examine the incidence of acute illness in a population surrounding an activated sludge wastewater treatment plant and a control location in Tecumseh, Michigan.

The Tecukmseh wastewater treatment plant (WWTP) is located in the southeast quandrant of the city (Figure 7). The plant is at a lower elevation than most of the populated study area and is surrounded by deciduous trees on the east, west, and south. This plant processes approximately 1 million gallons of wastewater per day (MGD) by activated sludge secondary treatment. Activated sludge has been in use since 1956, when the plant was redesigned from a trickling filtration facility. Data that might be used to estimate the fecal contribution to the wastewater, such as total or fecal coliform concentrations, are not available for the study period. Wastewater flow rates for the study period were not available from the Tecumseh WWTP, but available data were obtained from the Michigan Department of Natural Resources.

Average monthly flow rates at the Tecukmseh wastewater treatment plant ranged between 0.64 and 1.18 MGD from 1965 to 1971. Data, however, were not available for 1966 and some data for 1965, 1968, and 1969 are missing.

The study population was defined as those participants in the University of Michigan Tecumseh Community Health Study from 1965 to 1972 who resided in dwelling units at specific distance ranges from the Tecumseh wastewater treatment plant (Figure 7). Dwelling units located within each of five concentric rings and beyond, radiating from the plant in approximate multiples of 600m, were identified. Dwelling units were likewise identified with a second set of concentric rings constructed around a nonemitting location. This site was located in the northwest quandrant of the city in an undeveloped area approximately 180 m west of Seminole and 275 m south of Brown Roads. This control location was selected because it is upwind from the wastewater treatment plant and had a surrounding population density comparable to that of the study groups. The dwelling units within the study area were primarily single family houses, although multiple family units occured at various locations within the area. Confirmation of dwelling unit locations near concentric ring boundaries was made by site visitation. All dwelling units studied were assigned to concentric rings surrounding both the wastewater treatment plant and control location. Data with reference to each index point were analyzed separately.

The population used in nonseasonal-related analyses included those individuals who were contacted at least 50 weeks in a row with no absences during four or more weeks. The illinesses included are those whose onset occurred within this 50-week period. The entire population on report from 1965 to 1971 was used for determination of true illness incidence rates.

As used in this study, colder months included November through April whereas warmer months included May through October. In each case, the study population was defined as those persons on report for the entire

26-week period, with no long periods (two weeks or more) off report. The illnesses included are those whose onset occurred during the 26-week period.

Data were obtained from the participating families regarding health history, socioeconomic factors, employment locations, and schools attended by all children. After recruitment, each family was contacted weekly by telephone or personally, and a single respondent was questioned regarding the occurrence of short term illness within the family during the past week. When illness was reported, the details of the specific event were recorded using a questionaire. The respondent was contacted during the weeks following the initial report and asked whether the illness persisted and to describe the symptoms. The date of illness termination, was obtained and the respondent was questioned regarding other illness development within the family. An illness occurring at least two days after a termination date was regarded as a new event.

Acute illnesses were grouped into three general categories: total, respiratory, and gastrointestinal. Data are reported as incidence rates and as individual illness rates. Age-sex-distance-specific true incidence rates were determined by dividing the number of each kind of illness by the number of person-years observed within each group. Age-sex-distance-specific individual illness rates were calculated by number of illnesses during report period/number of weeks on report.

Study participants were classified into concentric rings of approximately 600m each by dwelling unit distance from both the study and control site. School children were classified by school attended in a similiar manner.

The objective of the statistical analyses was to determine whether the incidence of illness varied with distance of the dwelling unit from the wastewater treatment plant, and, in children, also whether incidence depended upon distance of the school attended from the wastewater treatment plant. Dwelling units and schools were also classified with respect to distance from a control location.

Differences in illness incidence occurred during the May through October season at varying distances from the wastewater treatment plant, but persons within 600m appeared to have a greater risk of respiratory and gastrointestinal illness than the control group. The data do not, however, demonstrate a causal effect and factors other than the wastewater treatment plant, such as higher rates of illness transmission in areas of higher densities of lower socioeconomic families, could have contributed to these findings. Persons dwelling within 600m of the plant had respiratory illnesses that exceeded those of the control group by 20% and 27%, and gastrointestinal illnesses that exceeded those of the control group by 78% and 50% when specified for income and education, respectively. When specifying socioeconomic factors, education and income exerted an unequal influence on the significance of illness incidence variation and, in general, such variations between geographiic locations were found to be greatest in groups having the lowest income and education. Therefore, the data suggest the higher illness rates are related to higher densities of lower socioeconomic families rather than the wastewater treatment plant.

The group within the 1800 to 2400m concentric rings from the wastewater treatment plant had a greater than expected incidence of respiratory illnesses during both warm and cold seasons. Significant differences were not found in the control location related groups at this distance. However, the higher than expected illness cannot be related to the wastewater treatment plant itself, since they appear to be related to socioeconomic status.

Differences in total illness were observed in the school children with regard to distance of school attended from both the wastewater treatment plant and control location. But these results are inconclusive since the schools were very unevenly distributed with reference to distance from these locations.

These observations should be tempered with the recognition that the Tecumseh wastewater treatment plant is located at a lower elevation than most of the populated study area and is surrounded by deciduous trees on the east, west, and south. Depending upon wind direction, velocity, and atmospheric stability, surrounding trees may act as a partial barrier for persons dwelling nearest the plant while lofting the airflow, resulting in further downwind dispersion.

This research project investigated the potential health effects of aerosols emitted from an activated sludge plant. The University of Illinois Medical Center conducted an 8-month environmental health study using a stratified sample of persons residing near the North Side sewage treatment plant (NSSTP) in Chicago.

The NSSTP was chosen for the study since the plant is nearly surrounded by a substantial number of residences. Census information (1970) indicated the population to be of homogeneous socio-economic status and to consist of appropriate numbers of individuals in the desired high-risk age groups. The sewage is not heavily industrial, and the prevailing wind patterns and topography appeared to be conducive to exposure of population groups.

Built in 1929, the NSSTP is one of the three main plants of the Metropolitan Sanitary District of Greater Chicago (MSDGC). The plant is located on Howard Street between Hamlin Avenue and McCormick Boulevard in Skokie, Illinois (Figure 8), which is a northwest suburb of Chicago.

The NSSTP is an activated sludge plant employing diffused aeration with tapered aeration. Chlorination occurs after the final settling process. No sludge processing occurs at the plant. A schematic of the plant is shown in Figure 9. The maximum capacity of the plant is 399 million gallons of raw sewage per day. During the study period (April-November, 1977) the plant had an average daily flow rate of 292 million gallons of sewage and a median air rate of 4.6 x 10 m3/day. The estimated surface area of sewage in the aeration tanks is about 55,000 m3 in settling tanks, concentration tanks, etc., exposed to the atmosphere. The total retention volume of one battery of aeration tanks is 7.45 x 10 m3. The tank levels are maintained at approximately 4.6 m. Residence time of sewage in the aeration tanks is generally 5-1/2 hours.

The area within a 1.6 Km radius of the treatment plant as shown in Figure 8 was designated as the study area. Previous studies at other locations have found that the dispersion of viable particles does not exceed 0.8 Km from the source. Therefore, the 1.6 Km radius study area permitted analysis of exposed and unexposed populations. The study area included portions of four communities: Skokie, Lincolnwood, Evanston, and Chicago. As can be seen in Figure 8, the plant is located in a small industrial area. Light industries are situated north, east, and south of the plant, occupying most of the land within the first 0.4 Km (1/4 mile) radius of the plant. Residences are located about 152 meters west of the aeration basins, and about 0.8 Km (1/2 mile) directly east of the tanks. Housing also exists within 0.8 Km north and south of the plant. The major residential section begins at the 0.4 Km radius line and extends uniformly through the 1.6 Km radius area.

The population of the study area was estimated to be 15,850 persons, or 5,600 households, based on the 1970 census. Considering property value, age, and race, the population appeared to be relatively homogeneous.

Although there were differences in several characteristics between some of the tracts, these 1970 figures were used for preliminary evaluation of the population and not for subsequent demographic analysis.

In order to characterize the nature and degree of exposure of the study population to pollutants emitted during treatment plant operation, environmental air quality, measurements of total viable particles (bacteria containing particles), total coliform bacteria, total suspended particulates (TSP), and 19 metals and gases were made at regular intervals at different distances from the plant in ambient air. Concentrations of total viable particles (TVP) were measured on a regular basis (approximately every other day) at the plant and in the community for eight months (April-November, 1977) using Anderson 2000 six-stage (A6S) viable samplers. Initial attempts to monitor for total and fecal coliform were made using an All-Glass-Impinger on six days during April and May. These samplers were found to be below the sensitivity required for detection of the concentrations present. Beginning in September, airborne total coliform samples were taken with Andersen samplers on days of total viable particle sampling and with a Litton Large Volume Air Sampler (LVAS) one day per week. Airborne coliphage measurements were originally scheduled to be taken once every other week. However, many equipment problems were encountered with the LVAS, and only eight coliphage in air measurements were obtained. Animal virus in air samples were obtained for two days using LVAS's (one upwind and one downwind each day). Monitoring of nonviable constituents was conducted every five days from April through November on the plant and in the community.

The Andersen 2000 six-stage (A6S) viable samplers used are a multi-orifice cascade impactor consisting of six aluminum stages accompanied by six glass petri dishes and a pump. Each stage collects particles of pre-determined size range with stage six collecting particles of 0.65 to 1.1μm diameter and stage one collecting particles of 7.7μm and above. These samplers were calibrated to sample air at 28.3 liters/minute.

The LVAS's use a liquid collection media to filter the air samplers which are initially collected at approximately 1.0 m3/minute. The fluid containing the air sample is then filtered through a membrane filter in a Millipore filtration apparatus.

Grab samples of sewage were collected from the aeration tanks concurrently with the air measurements and were analyzed for total viable particles, total coliform bacteria, trace metals, sulfates, and nitrates. A limited number of measurements were also made of viruses and coliphage in sewage.

The environmental measurements were used to develop study period exposure indices for each household for total viable particles, TSP, and eight metals and gases, a similiar 2.5-month exposure index was developed for total coliform bacteria. Virus and coliphage measurements in sewage and air were inadequate in number to determine their concentrations with any confidence.

In an attempt to determine whether or not the sewage treatment plant was hazardous to the health of the community exposed to the plant aerosols, several measurements of health were made.

An important requirement for this study was that the sample of households be equally distributed throughout the study area. Therefore, three concentric sampling zones were designated around the sewage treatment plant as follows: I) 0-.8 Km; 2) .8-1.2 Km, 3) 1.2-1.6 Km (from center of plant). A random sample was chosen from each zone in order to obtain a more uniform geographic distribution of households throughout the study area. The sample size for each zone was determined by the number of households in the smallest zone (nearest the plant, 394 households). Thus, nearly every family in this zone was included in the sample.

A history of the baseline health status of each participant was tabulated in a health questionnaire developed in collaboration with the Survey Research Laboratory (University of Illinois, Circle Campus). Specific questions were asked regarding any acute illnesses the participant had experienced in the past year. Additional questions concerned such factors as chronic disease, smoking habits, demographic characteristics (i.e., age, sex, race, income, occupation), length of residence in the study area, travel, and vaccination history.

In order to obtain ongoing, prospective information about health in the study population, a subsample of the persons interviewed in the Health Questionnaire Survey was solicited into the Health Watch. Participants, as family units, were asked first to maintain a health diary to self-report any and all illnesses they encountered for an 8-month period. Secondly, they were requested to provide blood samples at the beginning and again at the end of the 8-month period, and finally, families with young children were asked to provide clinical specimens, i.e., throat and/or stool specimens, for biweekly microbiological surveillance.

The cross-sectional demographic and health survey carried out in the area surrounding the activated sludge plant (which processes 292 million gallons of sewage daily) revealed a relatively homogeneous, predominately white, upper middle class group, with no remarkable prevalence of health problems. Seven hundred and twenty four people (246 families) volunteered to record self-reported illnesses at biweekly intervals. Throat and stool specimens were collected from a selected subsample of about 161 persons. In addition, 318 persons submitted paired blood samples at the beginning and at the end of the study period to determine prevalence and incidence of infections to five coxsackievirus and four Echovirus types potentially associated with aerosol exposure.

In relating illness rates to total viable particle exposure, it was necessary to limit the illnesses to those which potentially have a casual association with viable particle exposure—respiratory, gastrointestinal, eye and ear, skin, and total illness.

A dose-response approach was taken in the analysis of exposure and health effects. Conceptually, if the sewage treatment plant was the source of infections, trace metals and gases, or other hazardous materials, then the level of exposure may be directly related to the number of infections and/or diseases occurring in the exposed population. Standard techniques such as regression analyses were performed to determine if health effects increased with exposure, or if the two variables varied independently. Scatter diagrams were prepared to further examine the relationship between exposure and health effects.

Results of the health survey and the specimen and serological analyses of residents as close as 152 meters were compared with the household exposure indices. No significant correlations were found between the exposure indices and the rate of self-reported illnesses or of bacterial or viral infection rates (antibody levels) determined by laboratory analysis. This lack of correlation between 8-month total viable particle exposure and illness rates may be the result of an inadequate sample size (in terms of number of households), an unequal frequency distribution of household exposure indices in terms of not having enough households exposed at "low" or "high" levels of TVP concentrations, the inaccuracies in self-reported illness rates, the existence of more complex functional relationships between health and exposure variables, or no relationship at all.

The relationship between temporal illness and exposure was also evaluated on a 2-week averaging period basis. No linear relationships were found when analyzed separately or together for all types of illnesses evaluated or for respiratory illnesses alone.

In order to examine a possible lag effect between exposure and illness, a 2-week lag period analysis was carried out. Again, no linear relationship was detected. A 2-week period was the smallest lag period possible to analyze, since the health survey was conducted biweekly. In addition to the possible reasons for lack of correlation provided above, it was possible that the 2-week lag period was too long in terms of incubation period for most bacterial and viral agents possibly associated with these illnesses. It was also important to note that the 2-week exposure indices were much less reliable than those based on the total study period.

An attempt was made to examine the relationship between illness and exposure for various sub-populations potentially at high risk to the effects of TVP exposure. Age (0-12, 13-18, 19-59, greater than 59 years), chronic respiratory disease (chronic bronchitis, emphysema, or asthma), chronic gastrointestinal problems, smoking, family composition (families with one or two adult members, youngest children aged: 0-5; 5-14; and greater than 13 years), and length of residence (less than 1 yr., 1-5 yrs., 6-10 yrs., 11-20 yrs., and greater than 20 yrs.) in the study area were considered potential risk factors. The analysis did not reveal any linear relationships except for skin illnesses for families with the youngest child between 5 and 14 years, and for skin conditions in the over 20 years of residence sub-population. However it was reported by the researchers that these linear relationships are of questionable importance since the mean illness rates were so low.

No linear relationship was found for respiratory illnesses or for all illnesses combined when compared to total coliform bacteria exposure. Exposure to metals, gases, and TSP did not exhibit a linear relationship when compared with household illness rates for all illnesses combined, as well as for the separate illness categories.

Throat bacterial infection rates were compared to TVP exposure and no dose-response relationship was found. Analysis of virus infections was possible through serosurvey. The differences observed were not statistically significant.

This draft research report was compiled by the Southwest Research Institute to evaluate aerosol emissions from the Durham activated sludge treatment plant (DASTP, Tigard, Oregon) and their possible health effects.

The DASTP is situated next to Fanno Creek, a tributary of the Tualatin River, in an area which has recently (Fall 1978) been annexed by the City of Tigard. The DASTP services the entire Fanno Creek drainage basin and nearby areas. Figure 10 shows the location of the plant and the area served. The DASTP commenced operation on July 6, 1976, with an initial design capacity of 75,000 cubic meters per day (20 MGD) that can be expanded to 227,000 cubic meters per day (60 MGD) by the year 2000 to meet the needs of this rapidly growing area.

Designed as a modern activated sludge plant incorporating some advanced processes for wastewater treatment, the DASTP is comprised of two parallel plants which can be operated separately from primary clarification to the point of effluent discharge. Alternatively, flows can be combined from the separate plants after various stages of treatment. All plant influent first passes through barminutors to screen out and reduce the size of large objects. The flow is then divided to two primary clarifiers in parallel where settleable solids and grit are removed. Secondary treatment begins with the classical activated sludge process in four aeration tanks.

After secondary clarification, the wastewater is subjected to advanced wastewater treatment processes for reduction of phosphorus and solids. Plant effluent is then filtered and chlorinated prior to discharge in the Tualatin River. Organic sludge from the primary and secondary clarifiers is processed in a series of gravity sludge thickeners, cyclone-type grit separators, disc centrifuges and continuous bowl centrifuges. After heat treatment and incineration, the resulting ash is landfilled. A schematic flow diagram of plant processes is shown in Figure 11.

To accommodate plant flow during periods of extensive rainfall, two large surge basins were built adjacent to the plant. The largest surge basin has a capacity of 38,000 m3 (10 million gallons), while the others have capacities of 19,000 m3 (5 million gallons). A small basin of 7,600 m3 (2 million gallons) capacity is situated adjacent to the surge basins and has no surface aeration. Its purpose is to catch backwash from the filters. Flow from any of the plant processes can be diverted to the surge basins, but typically, primary clarifier effluent is diverted to these basins in sufficient quantity to maintain a relatively constant flow through the activated sludge process. Three surface aerators in the second largest surge basin (No. 1 surge basin) prevent the primary treated wastewater from becoming anaerobic. During periods of low influent flow, wastewater from the surge basin can be reintroduced into the secondary treatment process to equalize flow through the secondary and tertiary treatment sections of the plant.

It was determined that there were three potential sources of aerosol formation within the DASTP: the aeration basins, the surge basins, and the secondary recarbonation basin.

No chemical treatment (including recarbonation) was performed during either of the sample periods. This eliminated the secondary recarbonation basin as a source of aerosol.

Also, plant personnel determined that use of a single aeration basin resulted in optimal operation of the activated sludge process. In this mode of operation, all wastewater is mixed with activated sludge in a 3,800 cubic meter (1 million gallon) capacity aeration basin with a detention timne of 1.5 to 2 hours. Air at a pressure of 0.39 to 0.53 kg/cm (5.5-7.5 psi) is introduced through a 10-cm (four-inch) diameter nozzle located 1.5 m (5 feet) from the bottom of the basin.

Each nozzle is oriented vertically upward underneath a variable speed turbine aerator that agitates the aeration basin liquor and disperses the air stream from the nozzle. There are two nozzle mixer systems in each 21 x 30 x 6 m deep (69 x 100 x 20 feet) aeration basin. Based on the surface area of the aeration basins, perhaps one-fourth of the potential aerosol was being generated, since only one of the four aeration basins was being utilized for secondary treatment during the monitoring period.

The third source of aerosol generation, surface aerators on the No. 1 surge basin, was functional during both sampling periods. When the wastewater characterization samples were collected in November 1977, the No. 1 surge basin was being used to return surge to the aeration basin. A total of 12,200 m3 (3.22 million gallons) were returned to the aeration basins during 19 hours of the 24-hour operating day commencing at midnight November 9. During the aerosol study in Mary 1978, the depth of the only aerated surge basin (No. 1) remained constant at 4 m (13 feet) since no wastewater was diverted to or removed from it.

One objective of this study was to measure the types and quantities of viable microorganisms present in the ambient air 0-100 m downwind of the DASTP. A second objective was to determine whether the absentee rate at Durham Elementary school (next to the DASTP) was significantly different from the absentee rates at control schools located in the same area but not near a wastewater treatment facility. This would provide some preliminary indication of possible health effects which might be associated with the treatment facility.

To address the first objective, large wastewater samples were collected from each potential source of aerosols, to characterize the type and approximate concentration of viruses and enteric bacteria available for aerosolization. These results were used to select the types of organisms and methods to be used during routine monitoring of wastewater and aerosols.

Six aerosol runs were conducted to simultaneously measure levels of microorganisms in wastewater and air. This was achieved using a sampler array of eight high-volume air samplers (Litton Model M). Two samplers were paired upwind, while the six downwind samplers were deployed as three pairs, at planned distances of 30 m and 100 m downwind of the aeration basin and 50 m downwind of the surge basin. During the six high volume aerosol runs, temperature, relative humidity, wind direction, wind speed, and solar radiation intensity were monitored. The aerosol runs were taken over a wide range of solar radiation conditions, from darkness during run 3 to noon during run 6.

Based on experience in detecting microorganisms in the aerosols monitored at the Egan WRP and at Pleasanton, California, the following microorganisms groups were selected for routine monitoring: total coliform; fecal streptococci; Pseudomonas, mycobacteria, and coliphage. A special enterovirus aerosol run was also conducted to measure enterovirus levels at the aeration basin.

The level of microbial aerosols reaching the school were then estimated. Since previous experience had shown aerosol monitoring beyond 400 m downwind of the aerosol source was infeasible, the only means to obtain exposure dose information was by calculation involving a mathematical model, monitoring data, and wind direction data. Since the calculation required data extrapolations and assumptions whose validity is uncertain, the estimated peak exposure doses do contain considerable uncertainty. However, the researchers have verified the predictions of the model from extensive monitoring data at the Egan WRP and at Pleasanton, California.

The frequency with which children at Durham Elementary were exposed to aerosols from the DASTP was investigated. Two exposure locations at the school (classroom and playground area) were considered. Wind direction observations made at Portland International Airport (24 Km northeast of the DASTP) by the Portland Weather Service office at 7 a.m., 10 a.m., 1 p.m., and 4 p.m. on each of the school days were used in estimating the frequency of student exposure.

A daily exposure index was computed for each exposure location-aerosol sources combination, based on the four wind direction observations for the day. Wind direction observations within 30 degrees of the schools direction were considered to represent an occasional exposure, and the exposure index was adjusted using a weighting factor.

Quarterly attendance for Durham Elementary and eight control schools were obtained for the seven school years prior to DASTP operation and for the first two school years of DASTP operation. If the DASTP had an adverse health effect, one would expect higher absenteeism at Durham Elementary (relative to the control schools) in the two operational years. Such absenteeism might take the form of a uniformly higher absence rate throughout the two operational years, or because of acquired immunity, it might only be evident during the first several months of aerosol exposure.

Wastewater monitoring detected the concentration levels for mycobacteria and Klebsiella were fairly high relative to the microbiological indicators at the DASTP. Also Pseudomonas were found at relatively high concentration levels. However, Salmonella and Shigella, generally regarded as the most common bacterial pathogens, were not prevalent in the wastewater samples. Microorganism concentration levels tended to be higher in the aeration basins than in the surge basin, recarbonation basin or effluent pond. Consequently, the aeration basin was selected as the most suitable source for monitoring the aerosols.

The geometric mean aerosol concentration at 30-50 meters downwind of the aeration basin were 5.8 cfu/m3 of total coliforms, 2.0 cfu/m3 of fecal streptococci, 9.1 cfu/m3 of mycobacteria, 7 cfu/m3 of Pseudomonas, and 0.7 pfu/m3 of coliphage.

Enteroviruses were not detected in the air 30 meters downwind of the aeration basin. This resulted from their low concentration in the wastewater and from the association of 98 percent of the wastewater enteroviruses with solid matter which is not readily aerosolized. Mycobacteria were observed to be more prevalent at the DASTP than at the Egan WRP and Pleasonton, California wastewater aerosol monitoring sites.

The microorganism aerosol concentration levels tended to decrease with increasing downwind distance from the wastewater aerosol source, and also tended to vary from one aerosol run to another due to variations of microorganism levels in the wastewater. However, high and extremely variable aerosol concentration levels were probably due to contamination of the high-volume aerosol samplers.

Aerosol runs indicated that levels of fecal streptococi, Pseudomonas, and mycobacteria were generally as high or higher at 70-100 m downwind than the levels of such indicator organisms as total coliform and coliphage. Thus, the use of indicator microorganisms such as total coliform or coliphage in wastewater aerosol monitoring appeared to be inadequate to characterize the pathogenicity of the aerosols.

The calculated daily exposure index over the 355 school days the DASTP was operational showed that on the majority of school days the classroom area had no exposure to aerosols. On ten days the classroom area was steadily exposed to aeration basin aerosols and on five days to surge basins aerosols. The playground area had steady exposure to DASTP aerosols more frequently, but the number of days was still low. These calculations were based on four wind direction measurements per day, and since wind direction is variable, exposure was greater than indicated here.

The weather on the days of steady aerosol exposure in the classroom area was reviewed, and revealed conditions conducive to survival of aerosolized microorganisms. However periods of rainfall experienced on the days of steady aerosol exposure would reduce the duration of exposure. The weather on days of steady aerosol exposure in the playground area was similiar. Based on precipitation during and proceeding the school day, the playground was considered usable for student play on 13 of the 31 school days with steady aerosol exposure.

Assuming a breathing rate of 0.25/m3/hr, the estimated peak microorganism dose received by Durham Elementary students on a single school day was as high as 9 cfu of mycobacteria and 3.5 cfu of fecal streptococci during seven hours while in the classroom area. Substantially lower doses were calculated for one hour of playground exposure. However, since the bacteriological strength of the surge basin wastewater may vary substantially, the peak playground exposure may be considerably underestimated. In making this calculation it was assumed that the wastewater and aerosols sampled during the one-week monitoring period were representative of the levels and variability occurring throughout the two-year DASTP operational period.

From comparison with usual outdoor background exposure, measured upwind of the aerosol source, the peak exposure dose during a school day may exceed the usual seven-hour outdoor background dose by two orders of magnitude for fecal streptococci, and perhaps three or more orders of magnitude for mycobacteria.

In the two school years after the DASTP began operating, annual school attendance at neighboring Durham Elementary School improved. The improvement at Durham was evident in comparison both to prior school attendance at Durham and to school attendance in the surrounding control schools. Hence, there was no evidence that operation of the DASTP had any sustained adverse effect on school attendance at Durham Elementary. Analysis of the school attendance data on a quarterly basis also yielded no evidence of adverse effects having a shorter duration. However, very occasional transitory effects could not have been identified from the quarterly attendance data available for this study.

The analysis of class attendance data showed some extended periods of elevated absenteeism among first and second grade students at Durham Elementary (compared to the control school class attendance) after operations at the DASTP commenced. However, periods of even higher absenteeism among first and second grade students at Durham Elementary also characterized many of the baseline years. Thus, it was indeterminate whether the absenteeism among the younger students at Durham Elementary had any relationship to DASTP operation.

This study illustrates both the advantages and disadvantages of using elementary school attendance data for an epidemiologic investigation of a localized potential health hazard. The advantages are the uniformity, availability, and copious volumes of school attendance data, which permit the detection of many significant differences. The primary disadvantage is the existence of many potentially confounding factors affecting school attendance which are unrelated to student health and which can obscure the potential hazard being investigated. School attendance is affected by school factors under the principal's and teachers' control (e.g., policies regarding student progress, nature of curricular and extracurricular activities), as well as student factors (e.g., personal stress, sickness in family, work at home, poverty, inclement weather, parental difference, travel distance in rural schools) /6. While personal illness is one of the leading causes of absence, other factors may also have sizable effect. Hence, school attendance is quite an insensitive measure of adverse health effects. The lack of an effect on school absenteeism does not necessarily imply the absence of any health hazard.

There were three principals at Durham Elementary during the school attendance study period. The third principal served only during the two DASTP operational years, so the effects of his policies on school attendance are confounded with those of the DASTP. This change in principal may have been responsible for much of the improvement in attendance at Durham Elementary in the DASTP operational years.

This report attempts to provide an assessment and discussion of pertinent data as it applies to the health of sewer workers from a series of documents published over the period of 1975-1977. The report was based on four separate sources: 1) responses to a questionaire to sewer workers about health and working conditions; 2) a study of sick leave records from January 1957-December 1973 for sewer workers and a control group of all city office workers; 3) a study of death records compared with national mortality statistics; and 4) assessment of reports of analyses of sewer atmospheres for toxic substances.

The municipality of Copenhagen serves 600,000 permanent residents, approximately 200,000 transients and commuters and has an industrial load equivalent, on a BOD5 basis, to 1,600,000 additional persons for a total equivalent load of 2.4 milion. The sewage is strong with a BOD5 concentration of 750 mg/l. Over the entire period covered by the reports, sewer work involved primarily cleaning and maintenance of sewers, manholes, screens, and pump stations. About eighty permanently employed workers were classified as sewer workers in 1976.

Mortality statistics show that sewer workers die earlier than Copenhagen males of comparable age, many of them within the year that employment terminates. Attempts to correlate the statistics with sick leave records or chemicals in the environment were not successful. Sewer workers experience a high rate of gastrointestinal tract disorders which the workers associate with chemical odors and infectious agents. Workers have elevated levels of gamma globulins. Analytical work has not identified any agents that might be responsible for the observed death rates or gastrointestinal problems.

This draft research report was compiled by the Department of Environmental Health and Medicine at the University of Cincinnati (U of C) Medical Center to determine the health effects, if any, associated with occupational exposure to biological agents present in municipal wastewater. An additional objective was to determine the sensitivity of the methodology used for detecting potential health impacts of other wastewater exposures, such as recreational contact with surface water receiving wastewater effluents.

About one year after this research began, its goals were expanded to include a determination of the health effects, if any, associated with the dispersion of airborne bacteria and viruses generated by the activated sludge wastewater treatment process.

In order to evaluate potential health effects, a sero-epidemiologic study was conducted with municipal wastewater workers and controls in three metropolitan areas: Cincinnati, Ohio; Chicago, Illinois; and Memphis, Tennessee. The study consisted of four aspects: epidemiological, environmental monitoring, clinical aspects, and a serological survey. The epidemiological phase involved selection of study population, recruitment of volunteers, collection of biological specimens for the serological and clinical survey, collection of illness information, collection of demographic and medical history information, and worker activity observations.

The environmental monitoring portion of the study consisted of determination of airborne bacterial levels at worksite locations, and assay of wastewater for viruses and bacteria.

The clinical aspects consisted of yearly multiphasic and physical examination of study volunteers, and analyses of throat and fecal specimens for bacteria, viruses, and parasites. Parasitic examinations were performed only during the early period of the study in Cincinnati. The multiphasic and physical examinations served three purposes: (1) to evaluate whether wastewater exposure affected certain tests of liver function, (2) to assess the overall comparability of study populations, and (3) to provide motivation for volunteers to participate in the study.

The core of the study involved an extensive serological survey to determine levels of antibodies to a group of viruses and bacteria and to assess overall immunoglobulin levels. Of concern in the serologic survey was whether overall concentration of antibody concentration was different among the various study groups.

Possible correlations among results from the epidemiological, environmental, clinical, and serological phases of the study were investigated to evaluate potential health effects.

As initially conceived, the study was to include four groups of workers in Cincinnati, Ohio. Each group was to be a minimum of 30 in number. Two of the groups were to be routinely exposed to municipal wastewater: one group for a minimum of two years, and the other just beginning such exposure. The other two groups were to be engaged in an occupation not involving wastewater contact, and, again, one was to have been on the job for at least two years and the other just employed. In Cincinnati, the occupational group thought to be most exposed to wastewater was sewer maintenance workers, who were thus chosen as the exposed population. These workers maintained the combined sanitary and storm sewer system. Highway maintenance workers of the Cincinnati Public Works Department were selected as the control group, since they were similar in age and race to the sewer maintenance workers, and the types of jobs they had were similar.

Because of a moratorium on hiring new employees in the Cincinnati Public Works Department, prospects for establishing a newly employed highway maintenance study group could not be obtained, and the group of 30 inexperienced sewage-exposed workers was expanded to include newly-hired wastewater treatment plant workers as well as the newly-hired sewer maintenance workers. The study design was then expanded to include two additional exposed population groups: fifty (50) men at the Cincinnati Mill Creek Sewage Treatment Plant, which was in the process of being expanded from primary wastewater treatment to include the activated sludge process; and a total of one hundred (100) men employed at activated sludge treatment plants. The purpose of including this group was to differentiate between aerosol exposure and exposure to wastewater and sludge through those operations associated with primary wastewater treatment.

In all cities the wastewater-exposed workers recruited were generally outdoor workers engaged in various operational aspects of wastewater treatment. In Chicago the inexperienced wastewater treatment plant worker groups that were recruited were laborers and security guards. Laborers and selected operating personnel at the two Chicago water filtration plants were chosen for control groups because they were more similar in age and race than Chicago street maintenance workers. (The choice of a control group in Chicago was also based in part on an interest in using a different occupational group than in Cincinnati, where during the first year of the study the highway maintenance group repeatedly had higher immunoglogulin levels than the sewer maintenance group.) In Memphis neither highway maintenance nor water treatment plant workers were similar in age and race to the newly hired wastewater treatment plant workers. A suitable control group were located at the Gas Service Center of the Memphis Light Gas and Water Division (MLG&W).

In each city, meetings were held with appropriate management and employee representatives to explain the study and what was expected of participants. The study was identified as the Public Works Employees Health Study. It was stated that participation was voluntary and that all results would be treated in a confidential manner.

At the time of joining the study, a family history questionnaire was administered by a member of the research team. Questions included ones relating to chronic health conditions and previous major health problems of household members. In addition, at the time of the annual health evaluation, a more detailed medical history questionnaire was given. Permission to share study results with the participant's personal physician was obtained at the time of recruitment.

Demographic information collected on each worker included age, race, years of school, job classification, salary, total household income, number of persons dependent on family income, household size, and household composition broken down as to adults, school-age children, and other children. The breakdown of household composition was primarily for the purpose of examining the number of school-age children, as they are likely to be a source of infection.

Each worker was generally visited on his job several times during the study to determine type of job, frequency of wastewater contact and aerosol exposure contact, and other related work conditions. Results of these observations were used to categorize the worker on a relative exposure scale for direct wastewater contact and one for aerosol exposure.

The environmental monitoring program consisted of viral and bacterial analyses of wastewater samples and bacterial analyses of aerosols. The purpose of the aerosol sampling procedure was to provide data for the estimation of the worker exposure to airborne microorganisms. The viral analyses of wastewater were used in deciding what viruses to test for in the household member serologic survey.

Six stage Andersen samplers were used to collect the aerosols at about ten sites at each treatment plant studied. The Andersen samplers were fastened to tripods about 4 feet high. For all aerosol samples, calibrated pumps pulling 1 cfm were utilized. Each sampler was specially equipped with six molded Andersen glass petri dishes containing 27 ml of plate count agar.

In order to process the aerosol samples as soon as possible, preparation and analyses of the plates for bacterial aerosol sampling was performed in Chicago by the MSDGC, in Memphis by the Memphis State University, and by the bacteriologist on the study staff in Cincinnati. At least once during the study, duplicate samples were collected in Memphis and Chicago for analyses by University of Cincinnati personnel.

A portable weather station was used during periods of airborne bacterial sampling. This station consisted of instruments for wind directions and speed, temperature, relative humidity, and barometric pressure readings.

During the quarterly specimen collection periods, 45 ml of blood were collected from each worker, in three 15 ml portions. After clotting at room termperature, the tubes were centrifuged, and the serum placed in labeled vials.

Viral isolation specimens were obtained from a throat swab collected by a medical technician or nurse, and a rectal swab collected by the participant. Bacterial isolation specimens were obtained by a second rectal swab, collected by the participant at the same time as the first.

During the early portion of the study, before the aerosol-exposed worker expansion, stool samples rather than rectal swabs were collected and were analyzed for parasites in addition to viruses and bacteria. At the same time rectal swabs were substituted for stool specimens for virus isolation, stool specimen collection was continued for new sewage-exposed workers in Cincinnati. Urine specimens were also collected during the early portion of the study and were used for isolation of cytomegalovirus. These collections were discontinued because no such virus was isolated during the first study year, probably because this virus does not survive long in the environment.

Single blood specimens were obtained from the household members of study volunteers during late summer of 1978. These specimens were obtained at various locations in the study cities, including in homes of the volunteers. These specimens were collected for use in a limited serologic survey to look for differences among study groups in household-member antibody levels.

Illness information was obtained through monthly family health diaries, telephone contacts, and on-the-job contacts. The objective was to contact each worker at least once a month. At the time of worker absence, telephone contact was made by a study nurse to determine if an infectious disease existed. If appropriate, a home visit was attempted for specimen collection. In order to facilitate a worker in contacting a member of the research staff in the event of illness, or to ask a question about the study, telephone answering systems consisting of tapes with remote retrieval capabilities were installed in all three cities. Illness symptom information from all sources was categorized as "respiratory," "gastrointestinal," "other," and combinations of these.

During periods of illness, attempts were made to collect a throat or rectal swab from the study volunteer. These specimens were generally obtained in the worker's home, but on occasion were obtained at the office of his physician or at work.

Annual health evaluations of study participants and viral and bacterial isolations from biological specimens were the primary sources of clinical data. Stool samples from some Cincinnati workers were examined in the early portion of the study for the presence of ova and cysts of parasites.

Results of the serological survey of sera collected quarterly provides the basic core of data for the study. The sera were analyzed for antibodies to 33 viruses or groups of viruses, 10 bacteria, and 3 classes of immunoglobulins. Their purpose was to determine: (a) whether there were differences in antibody levels between groups, and (b) whether there were significant increases in antibody levels within a group of workers over a period of time, indicating infection. The researchers also investigated the relationships between an increased antibody level in a volunteer and the presence of illness symptoms.

In an effort to determine if there were any relationships among various types of data, several comparisons have been made among the many possible ones:

I. Worker Exposure - Virus Serology Comparisons

Every study participant was ranked into one of two categories for wastewater/sludge and airborne bacteria exposure: (1) above average, or (2) average or below average. These rankings are in all cases relative to fellow workers in the same worker group (i.e., experienced sewer maintenance). Job observations and environmental monitoring data even made it possible to separate the control group into "clean" and "less clean" working environmental groups. None of the comparisons had a significant correlation.

1) Control Group Comparisons—

Using data from January 1978 and October 1978 from the final virus serology survey, the control group in all three cities were compared by exposure. One exposure category referred to airborne exposure and the others to solids and dirty water.

2) Exposed Group Comparisons—

The inexperienced sewage-exposed group in each city were ranked according to their direct contact with wastewater and sludge regarding the airborne bacterial levels of their workplace air. Prevalence levels and seroconversion rates were compared between combined-city groups with above average exposure to these conditions with those having average or below average exposure.

Results indicate that for only one comparison is the correlation significant. For sera collected in January 1978, the workers with average or below average wastewater/sludge contact had more titre levels less than the detection limit for the test than above average exposure workers.

3. Comparison of Above-Average Sewage Exposed Group with Control Workers in Cleaner-Than-Average Working Environments

The inexperienced sewage-exposed workers ranked above average in wastewater/sludge or airborne bacteria exposure were compared with control workers ranked average or below average in either liquid/solids or contaminated air exposure. January 1978 and October 1978 virus serology data were used in making the comparisons. No statistically significant differences were detected.

II. Illness Rate - Antibody Level Change Comparison—

Four-fold or greater increases in titer level to a virus antibody is generally regarded as a medically significant increase. Such occurrences signify an infection which may be either clinical or subclinical. The study did not reveal statistically significant increases in viral infections that might be related to occupational exposure to wastewater, as indicated by virus isolations, distribution of antibody titers (comparative antibody levels), or increases in antibody titer levels, either in individuals or among work groups in Chicago, Illinois, or Memphis, Tennessee. In Cincinnati, Ohio experienced sewer maintenance workers had higher antibody levels to Poliovirus Type 2 in January 1977. This same group had statistically significant increases in Echovirus Type 6 antibody levels from January-September 1977.

Based on the testing to date, there is no indication that occupational exposure to sewage increased the risk of Hepatitis A or B infection in study participants.

Analyses of single blood specimens from family members of study participants for antibody to six viruses did not reveal higher infection rates among families of exposed workers than controls.

No evidence was found to suggest that occupational exposure to wastewater by the study participants produced any increase in bacterial infection by Salmonella, Leptospira, and Legionella pneumophila.

Examination of biological specimens from workers for bacteria and parasites did not reveal any increase in isolation rates among sewage-exposed workers.

Immunoglobulin (IgA, IgG, IgM) levels were not found to be consistently higher in the sewage-exposed workers in any of the cities studied.

Testing of liver function did not reveal any consistent abnormalities in either the sewage-exposed groups or control groups.

Airborne bacterial levels, TVP's, inside buildings where wastewater sludge was being processed, were higher than those at aeration basins. TVP levels at some highway maintenance work areas are on occasion as high as those at aeration basins of activated sludge sewage treatment plants.

From preliminary analyses of illness rates, inexperienced workers exposed to sewage had a higher rate of gastro-intestinal illnesses than experienced sewage treatment plant workers.

B. Evaluation of Alternatives

The aerosol monitoring procedure, used in 4 of the other 5 studies, represents the state of the art, since the LVAS's used offer increased sensitivity over other available methods. These instruments sample at 1000 l/min, and to increase sensitivity for the viral runs, the Tigard, Oregon, and Pleasanton, California, studies pooled samples from LVAS's running simultaneously, resulting in sample volumes of 1,980,000 l and 5,000,000 l, respectively. The less sensitive Andersen samplers used in the University of Cincinnati study were considered adequate, since the microorganism aerosol concentrations at the treatment plant site itself are of the magnitude where these samplers' sensitivity are adequate to characterize the exposure levels present.

Since experience in monitoring wastewater aerosols at Pleasanton, California, showed that statistically usable biological analysis results could be obtained only up to 200 m away from the aerosol source during the day, and 400 m during the night, models were used to predict concentration levels beyond these distances in Pleasanton, California; Tigard, Oregon; and at the Egan WRP. Although the model used required assumptions whose validity is uncertain, the predictions of the model have been verified to 100 m for all three sites and were considered satisfactory by the researchers. This model represents the feasible limit of scientific capability for estimation of microorganism aerosol concentration levels.

To detect possible health effects, all but the Tigard, Oregon study utilized health surveys to record infectious diseases, symptoms, and frequency. In addition to using clinical samples (collectively: blood, feces, urine, sputum, throat swabs) analyzed for bacteria, viruses, and parasites, the Egan WRP, the University of Illinois, and the University of Cincinnati studies utilized a sensitive measure of antibody titer to detect infection. Antibody titer can detect subclinical infection which might not be detected through a health survey or other clinical specimens.

The Egan WRP and University of Cincinnati studies were designed to make pre- and post-exposure measures of health on the same participants and sampling area. This self-paired comparison of the results is a very sensitive procedure for detecting changes because it eliminates the inherent variability between human subjects and between locations. This study design also eliminates the possibility of acquired immunity masking potential health effects, since some participants are newly exposed.

The Tigard, Oregon study utilized a variation of the very sensitive pre- and post-exposure study design to evaluate health effects of a potential high risk group with exposure as close as 40 m from the aerated surge basin. Even though not all of the same students were investigated in the pre/post-exposure phases of the study, the potential variability created by this should be minimized through comparisons with data from the control schools.

To evaluate possible relationships between wastewater aerosol exposure and health effects, rigid statistical procedures were used to analyze the data. The epidemeologic study design used in the Egan WRP, University of Illinois, and the University of Cincinnati studies was the most sensitive that could be devised at the time for determining if any relationship between wastewater aerosol exposure and health effects exists.

The Tigard, Oregon and the University of Michigan studies also utilized health related data; however, these studies' measure of health and exposure, respectively, were not as sensitive as those mentioned above. Nonetheless, these studies should have detected any statistically significant relationship between exposure to wastewater aerosols and significant adverse health effects, if present.

The researchers concluded that several pathogens (Klebsiella, Mycobacteria, and Staphylococcus) in wastewater are usually higher in concentration than, and appear to have no relationship to, the concentration of indicator organisms such as T.C. and F.C. Viable enterovirus were found in low concentration in the primary effluent because they are primarily associated with the solids fraction of the wastewater.

The University of Illinois study concluded that activated sludge wastewater treatment plants are a source of low concentrations of bacteria, coliphage, pathogenic bacteria, and enteroviruses, but are not a source of trace metals, particulates and gasses.

The study conducted in Tigard, Oregon concluded aerosol concentration levels tended to vary from one run to another due to variations of microorganisms levels in the wastewater. However, high and extremely variable aerosol concentration levels were probably due to contamination of the LVAS's. The University of Illinois study found no correlation between the concentration of TVP or T.C. in aerosols and sewage characteristics. However, the Tigard, Oregon and Pleasanton, California studies concluded that the use of such indicator organisms as T.C. and coliphage appear to be inadequate to characterize the pathogenicity of aerosols. Microorganism aerosol concentration levels 70-100 m downwind of the aeration basin at Tigard, Oregon were generally as high or higher than levels of such indicator organisms as T.C. or coliphage. The Pleasanton, California, study suggested some microorganisms (Coliphage, Clostridium perfringens, TVP) have a lower decay rate than T.C. and F.C.

The higher concentrations of substances detected close to the aeration basins have been found to rapidly decrease in concentration with distance away from the aeration basins. For example, the very sensitive enterovirus monitoring conducted at Tigard, Oregon (referenced above) detected no enterovirus at 30 m downwind of the aeration basins, indicating a concentration less than 0.0009 pfu/m3. The study conducted at the Egan WRP concluded that the levels of microbiological or chemical agents of the air, soil, and water samples in the neighboring residential areas were not distinguishable from background levels monitored.

It has been suggested that other factors also affect the microorganism concentration levels detected. The Pleasanton, California study suggested ambient conditions, such as low relative humidity, high wind velocity, and large temperature differentials between wastewater and air, may reduce initial microorganism survival, and die-off may be more rapid with high solar radiation and high termperature. In contrast, the University of Illinois study found no relationship between TVP or T.C. bacteria concentrations and ambient conditions. However, as stated above, the use of such indicator organisms as T.C. appears inadequate to characterize microorganism aerosol concentration, and since the Pleasanton, California study used more sensitive sampling techniques, it appears a relationship does exist between ambient conditions and microorganisms survival in aerosols.

Several studies investigated microbiological aerosol particle size distributions to determine if certain microorganisms contained in the aerosols could be inhaled. The Egan WRP study and University of Illinois study found the majority of the T.C. and TVP were in the respirable range, but no clear trend for change of particle size distribution with sampler distance could be detected. The Pleasanton, California, study of aerosols from spray irrigation equipment did detect a relationship between some microorganisms particle sizes and distance; however, this relationship would not be expected to apply to aerosols generated from aeration tanks.

The studies conclude that residential populations as close as 152 m from the aeration basins at activated sludge wastewater treatment plants have no significant adverse health effects from aerosols emitted during plant operation. In addition, elementary school children—a potential high risk group, appeared to have no adverse health effects from aerosol exposure as close as 40 m from the aerosol source at an activated sludge wastewater treatment plant.

Some preliminary analysis of illness rates indicates that inexperienced sewage plant workers had a higher rate of gastro-intestinal illness than experienced workers. Since these workers have exposure both from direct contact and aerosols, the appropriateness of extrapolating these findings to a population residing near a sewage treatment plant remains to be determined.

The isolated instances associating wastewater exposure to health effects could be due to chance, or a result of biased responses to health questionnaires, and are not considered significant when weighed against the preponderance of evidence indicating no adverse health effects from exposure to aerosols emanating from activated sludge wastewater treatment plants. This is especially true if considering nearby populations rather than intensely exposed workers.

Despite the fact it could be argued that weaknesses in individual studies may lower their sensitivity, if any significant adverse health effects result from exposure to activated sludge wastewater treatment plant aerosols some substantial indications of health effects should have been discovered.

Since the studies' conclusions result from the investigation of:

1) activated sludge plants receiving up to 292 million gallons of primarily residential sewage daily,

2) potential health effects of:

   a) residential populations exposed to wastewater aerosols as close as 152 m from the aerosol source,

   b) elementary school children, a potential high risk group, exposed to aerosols emanating from sources as close as 40 m, and

   c) workers who directly contact sewage and are exposed to much higher aerosol concentrations than those residing near an activated sludge treatment plant,

and since the O'Hare activated sludge WRP will initially receive up to 35 million gallons of residential wastewater daily, and will potentially transmit aerosols to residents not closer than 117 m to the aerosol source, the conclusions of these studies are considered applicable to those residing near the O'Hare WRP.

1. ACTION

   a) Rescind the grant condition requiring MSDGC to construct aerosol suppression facilities at the O'Hare WRP:

      No significant direct or indirect effects result from this action, since testing of a thorough, critical, and sensitive nature, representing the feasible limit of scientific and economic capability, have shown that no significant adverse health effects result from exposure to aerosols.

   b) Modify the grant condition and allow operation of the O'Hare WRP without aerosol suppression facilities, and continue ongoing analysis of potential health effects.

      i) If further study shows need for aerosol suppression:

         Monetary, natural and depletable resources would be expended on further study and in the construction and opeeration of aerosol suppression facilities. Other adverse impacts include noise and dust associated with construction.

      ii) Further study shows no need for aerosol suppression:

         Beyond the expenditure of monetary resources to further study the potential effects of aerosol exposure, no direct or indirect impacts will result from this action. Thorough research has shown that no significant adverse effects result from exposure to aerosols emanating from activated sludge wastewater treatment processes within the envelope of accepted U.S. design and operationsal practice.

2. NO ACTION

Retain the grant condition requiring MSDGC to complete construction of aerosol suppression facilities at the O'Hare WRP prior to or concurrently with the commencement of functional opoeration:

Monetary, natural, and depletable resources would be expended on the construction and operation of aerosol suppression facilities. Other adverse impacts include noise and dust associated with construction.

If operation of the O'Hare WRP would be delayed to construct aerosol suppression facilities, the overloaded system presently used would cause continued combined sewer overflows and flooding of basements with combined sanitary and stormwater, thereby threatening public health.

V. PUBLIC PARTICIPATION

A Notice of Intent to prepare a Supplemental WRP EIS was issued on July 18, 1979. Copies of this Draft Supplemental EIS are available to the public approximately 30 days prior to the scheduled Public Hearing. Depending upon the response to the Public Hearing, the record may remain open for 15 days to allow further comment on matters brought up at the Public Hearing. Comments should be submitted to: Mr. Gene Wojcik, Chief, EIS Section (5WEE), U.S. Environmental Protection Agency, 230 South Dearborn Street, Chicago, Illinois 60604. After all comments have been received, a Final Supplemental EIS will be published.

VI. PREPARER

Richard Beardslee, Environmental Engineer, USEPA, Region V.

VII. LIST OF AGENCIES, ORGANIZATIONS, AND PERSONS TO WHOM COPIES OF THIS STATEMENT WERE SENT

The following Federal, State, and local agencies have been requested to comment on the Draft Supplement Environmental Impact Statement:

Council on Environmental Quality
Department of Agriculture
  Soil Conservation Service
U.S. Army Corps of Engineers
  North Central Division
  Chicago District
Department of Energy
  Argonne National Laboratory
Department of Health, Education and Welfare
Department of Housing and Urban Development

Department of the Interior
  Heritage Conservation and Recreation Service
  Fish and Wildlife Service
  Geological Survey
Department of Transportation
  Federal Aviation Administration

Governor of Illinois
Illinois Sanitary District Observer
Illinois Institute for Environmental Quality
Illinois Environmental Protection Agency
Illinois Division of Waterways
Illinois Department of Conservation
Illinois Department of Public Health

Northeastern Illinois Planning Commission
Cook County Department of Environmental Control
Metropolitan Sanitary District of Greater Chicago

City of Des Plaines
Village of Elk Grove
Village of Arlington Heights
Village of Mount Prospect
Village of Palatine
Village of Wheeling

VIII. SELECTED REFERENCES

1. Camann, D. E., H. J. Harding, D. E. Johnson, C. A. Sorber, 1979. Environmental Monitoring of a Wastewater Treatment Plant. Southwest Research Institute.

2. Camann, D. E., M. N. Guentzel, H. J. Harding, D. E. Johnson, J. W. Register, C. A. Sorber, J. M. Taylor, R. E. Thomas, 1977. The Evaluation of Microbiological Aerosols Associated With the Application of Wastewater to Land: Pleasonton, California. Southwest Research Institute.

3. Camann, D. E., J. M. Hosenfeld, D. E. Johnson, R. J. Prevost, J. W. Register, J. M. Taylor, R. E. Thomas, J. B. Tillery, 1978. Health Implications of Sewage Treatment FAcilities. Southwest Research Institute.

4. Carnow, B., J. Holden, S. Meyer, A. Neal, R. Northrop, S. Rosenberg, P. Scheff, L. Sheaff, R. Wadden, 1979. Health Effects of Aerosols Emitted From an Activated Sludge Plant. University of Illinois School of Public Health.

5. Clark, C. S. Health Risks of Human Exposure to Wastewater. University of Cincinnati Medical Center.

6. Cochran, K. W., K. F. Fannin*, A. S. Monto, H. Ross, 1978. Health Effects of a Wastewater Treatment System. University of Michigan and *IIT Research Institute.

7. Lun Dean Environmental Company, 1978. Assessment of Disease Rates Among Sewer Workers in Copenhagen, Denmark. Health Effects Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency.

8. U.S. Environmental Protection Agency, 1975. Metropolitan Sanitary District of Greater Chicago O'Hare Water Reclamation Plant and Solids Pipeline Environmental Impact Statement.

IX. GLOSSARY OF TERMS

acquired immunity—specific immunity attributable to the presence of antibody and to a heightened reactivity of antibody-forming (and phagocyte) cells after exposure to an infective agent or its antigens.

activated sludge sewage treatment plant—a biological wastewater treatment system in which a mixture of wastewater and biological sludge (microorganisms) is agitated and aerated. The solids are separated from the treated wastewater and returned to the aeration process, as needed.

adenovirus—a group of thirty-one viral sero-types that cause diseases of upper respiratory tract.

aerosol—colloidal-size droplets dispersed in the atmosphere (air).

alpha and gamma hemolytic streptococci—aerobic, facultative/anaerobic Streptococcus genus of bacteria; gram positive spheric (or oval) cells occurring in pairs or chains. Beta hemolytic group include human and animal pathogenic; alpha hemolytic occur as normal flora in upper respiratory and intestinal tract.

antibody—an immunoglobulin molecule of specific amino acid sequence which interacts only with the antigen that initiates its synthesis in lymphoid tissues or with antigen closely related to it.

antigen—any substance which is capable, under appropriate conditions, of inducing formation of antibodies and of reacting specifically, in some detectable manner, with the antibodies so induced.

bacteria—typically one-celled microorganisms containing no chlorophyll—some cause diseases and others are necessary, e.g., for nitrogen transformations, fermentation and organic matter decomposition.

Biochemical Oxygen Demand (BOD)—a standard test, used in assessing wastewater composition, which measures the oxygen required to oxidize the organic matter in a sample under standard conditions.

cfu—colony forming units.

cfu/m3—colony forming units per cubic meter.

Chemical Oxygen Demand (COD)—the amount of molecular oxygen required to oxidize all compounds in water, organic and inorganic.

Clostridium perfrigens—a gas-producing species of bacteria that produce several toxins and are the principal cause of gas gangrene in humans. Also known as Clostridium welchii.

coefficient of variation—the statistical ratio of the standard deviation of a distribution to its arithmetic mean.

coliform—an organism found in the intestinal tract of humans and animals. Its presence in water indicates pollution and potentially dangerous bacterial comtamination.

coliphage—any bacteriophage able to infect Escherichia coli.

composite sample—a combination of individual samples taken at selected intervals that represents the total material (population) being sampled.

coxsackievirus—one of the enteroviruses producing a disease resembling poliomyelitis but with no paralysis.

echovirus—one of a subgroup of the picornoviruses infecting the gastrointestinal tract and discharged in the excreta; includes polioviruses, coxsackieviruses and echoviruses.

enterovirus—a subgroup of human viruses including the coxsackieviruses and the echoviruses.

epidemiology—a field of medicine concerned with the determination of specific causes of local outbreaks of infection, e.g., hepatitis and toxic disorders such as lead poisoning and other diseases of recognized etiology.

flora—plant life in a specific location.

free chlorine—the free elemental form of chlorine from a chemical used for the disinfection or ixidation of drinking water, sewage, or industrial waste.

gamma globulin—any of the serum proteins with antibody activity. Also known as immune globulin.

gastrointestinal—pertaining to that portion of the digestive system including the stomach, intestine, and all accessory organs.

intestinal flora—bacteria normally residing in the lumen of the intestine.

Klebsiella—a genus of nonmotile, rod-shaped bacteria in the family of Enterobacteriaceae; species are human pathogens.

liter—a unit of metric volume or capacity equal to 1000 cubic centimeters.

mfc—membrane filter count.

mixed liquor—a mixture of activated sludge and water containing organic matter undergoing activated sludge treatment in the aeration tank.

micrometer (μm)—a unit of metric length equal to one-millionth of a meter.

mucoid type—pertaining to large colonies of bacteria characterized by being moist and sticky.

parasitic worms—worm-like organisms that live in or on another organism of different species from which it derives nutrients and shelter.

particulates—fine solid particles which remain individually dispersed in gases and stack emissions.

pathogen—disease-producing organism.

pfu—plaque forming unit.

pH—a term used to describe the hydrogen ion activity of a system, or how acid or alkaline a material is presently.

Proteus—a genus of Enterobacteriaceae that occurs in the motile and non-motile forms.

Protozoa—a diverse phylum of microorganisms; the structure varies from a simple uninucleate protoplast to colonial forms.

Pseudomonas—a genus of the Pseudomonadaceae family; most species are aerobic and include cellulose decomposers and human, animal, and plant pathogens.

regression analysis—analysis which measures the mean expectation one variable to another, given two dependent random variables.

Salmonella—a genus of rod-shaped pathogenic bacteria of the family Enterobacteriaceae that are usually motile by flagella.

scatter diagrams—statistical diagrams involving the plotting of the pairs of values of two variates in rectangular coordinates.

Shigella—the dysentery bacilli, a genus of the family Enterobacteriaceae.

serological—pertaining to the branch of science dealing with the properties and reactions of blood sera.

sero survey—a survey involving the properties and reactions of blood sera.

sputum—matter discharged from the surface of the respiratory passages, mouth, or throat; may contain saliva, microorganisms, blood, or inhaled particulate matter in any combination.

Streptococcus—a genus of the tribe Streptococceae including many pathogenic strains; the cells are round and occurring characteristic chains.

titer—the concentration in a solution of a dissolved substance as shown by titration.

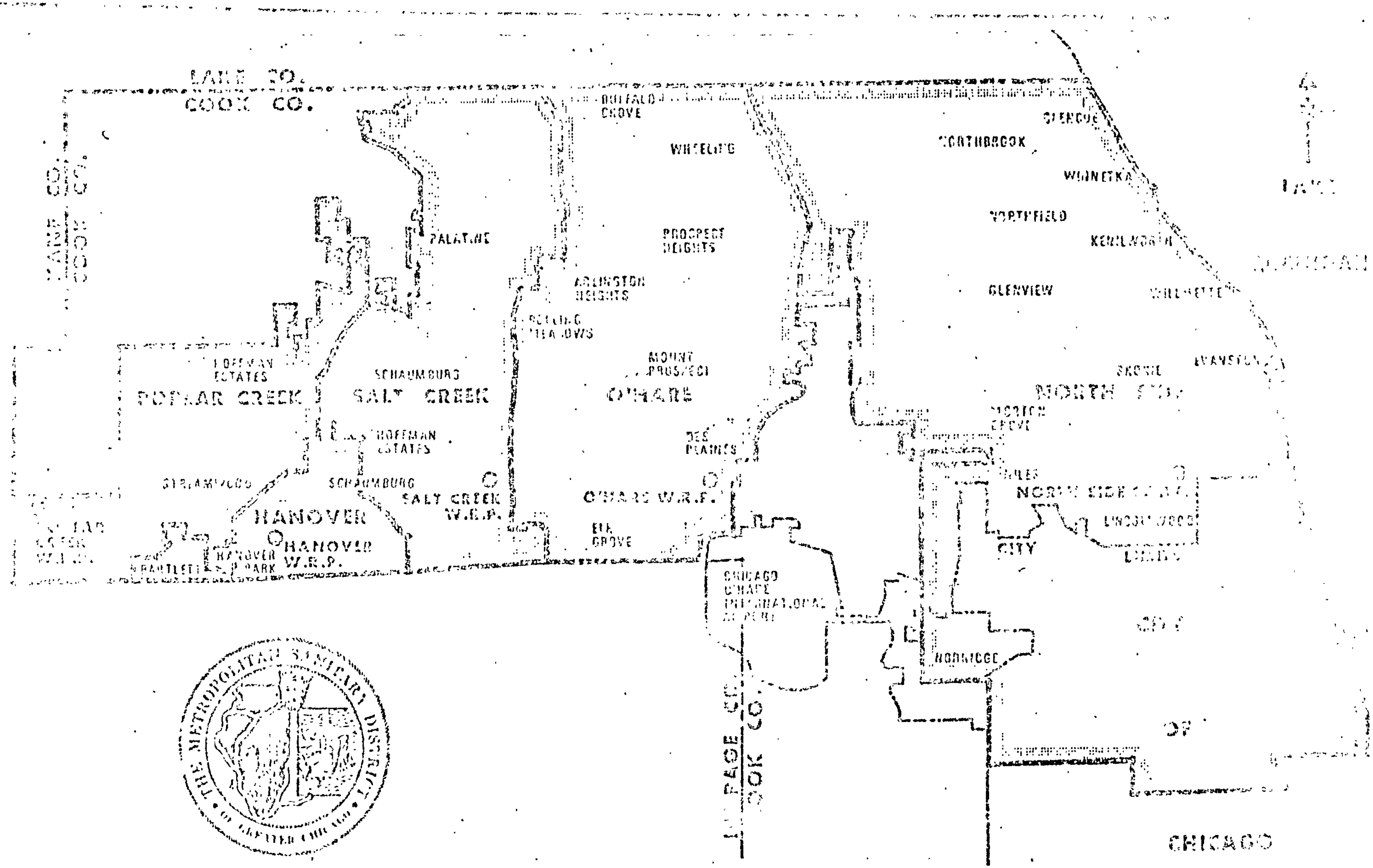
total organic carbon (TOC)—a measure of the amount of organic material in a water sample expressed in milligrams of carbon per liter of solution.

total suspended solids (TSS)—the total number of small particles of solid pollutants in sewage that contribute to turbidity and that resist separation by conventional means.

viable—capable of living, e.g., a pathogen capable of infecting.

virus—a large group of infectious agents capable of infecting animals, plants, and bacteria; characterized bo total dependence on living cells

windrose pattern—a diagram in which statistical information concerning direction and speed of the wind at a location may be summarized.

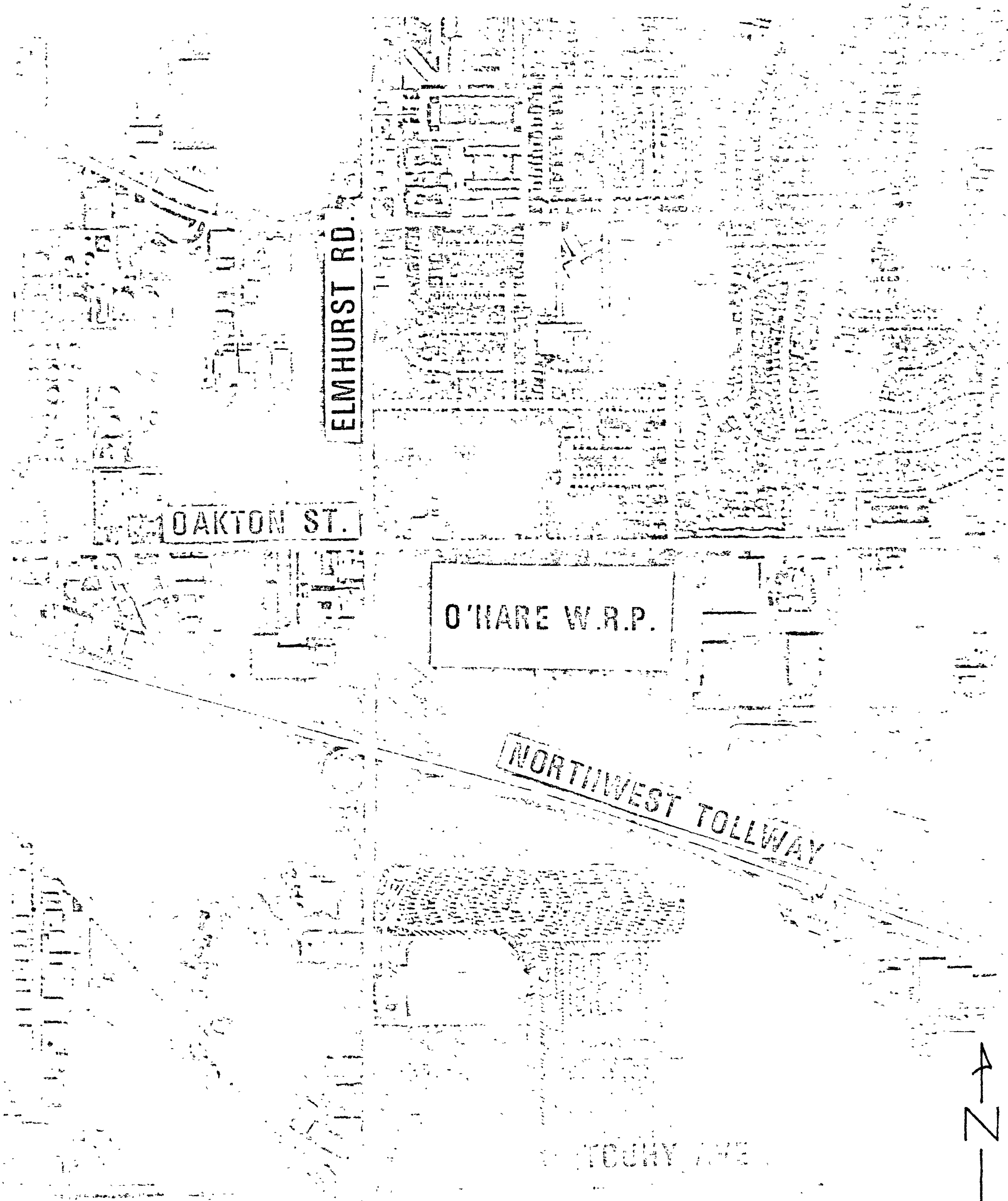


NORTHWEST REGION-FACILITY AREA

THE METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

FIGURE 1

FIGURE 2. ENVIRONMENT POTENTIALLY AFFECTED



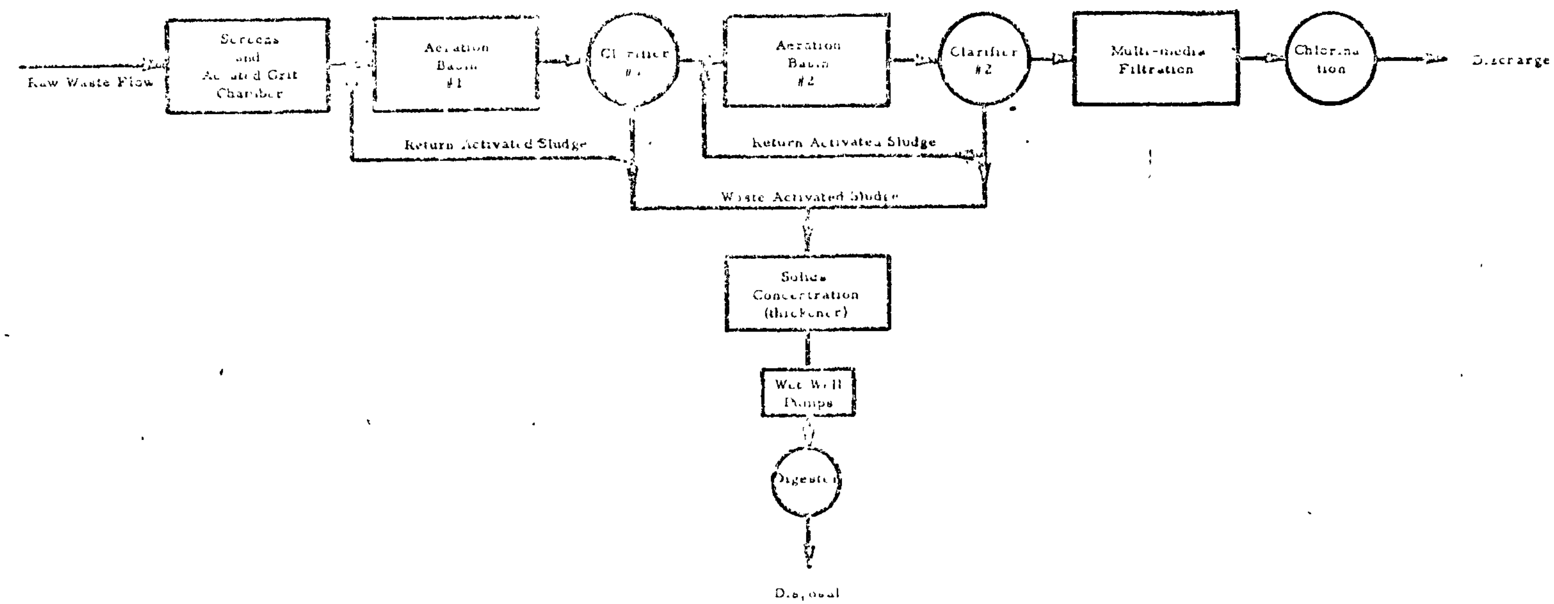


Figure 3. John E. Egan Water Reclamation Plant Flow Diagram.

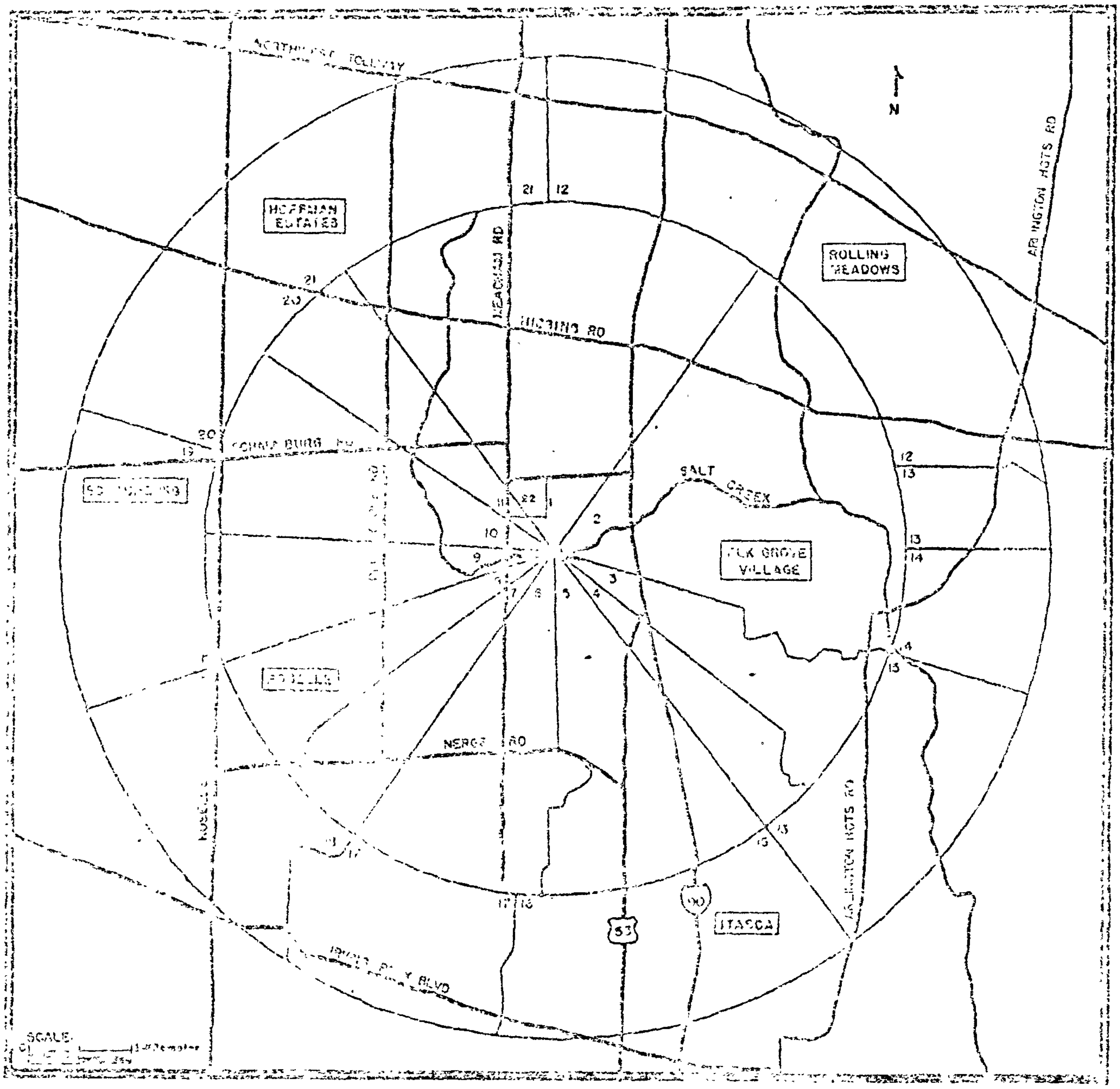


Figure 4. John E. Egan STP project study area map.

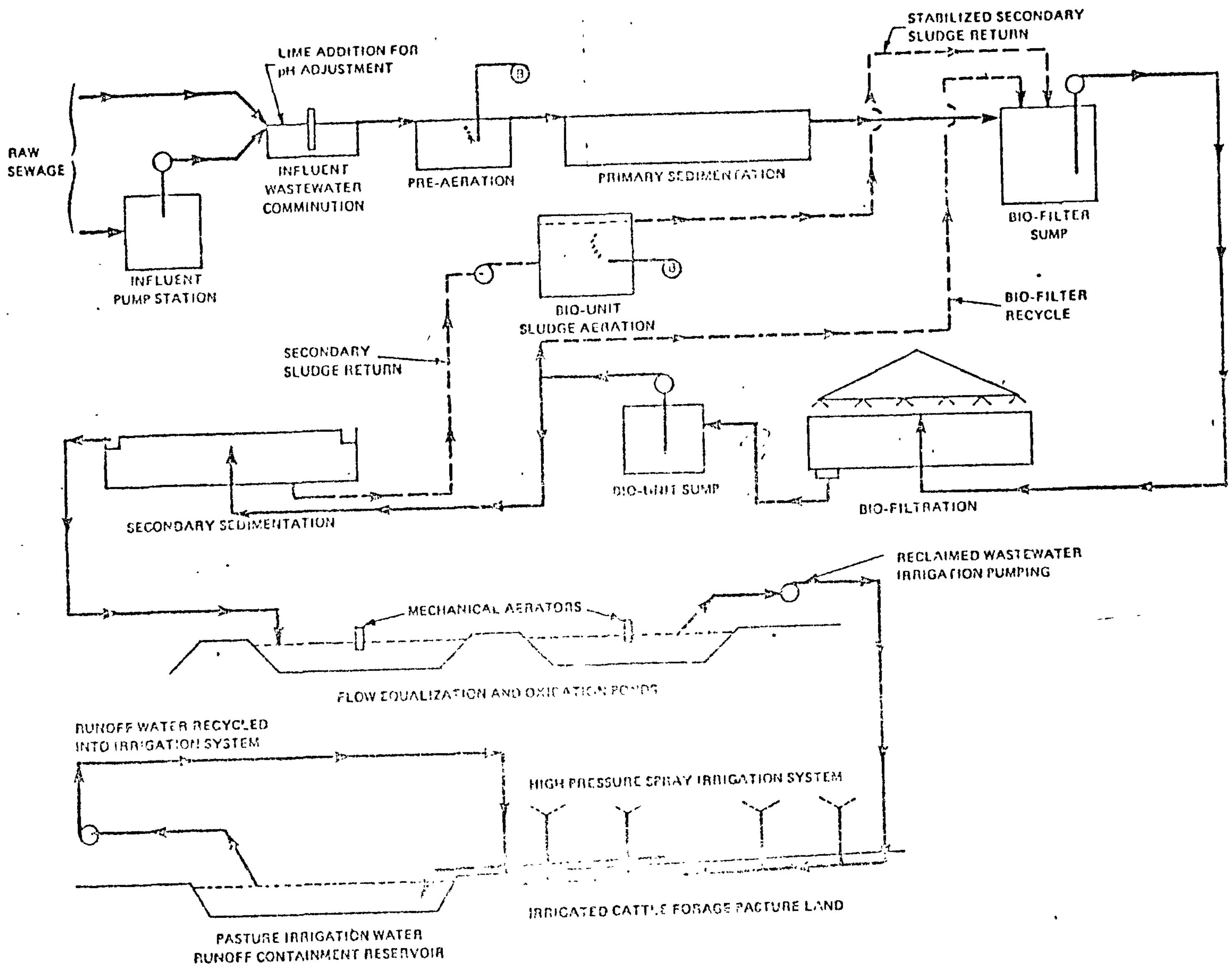
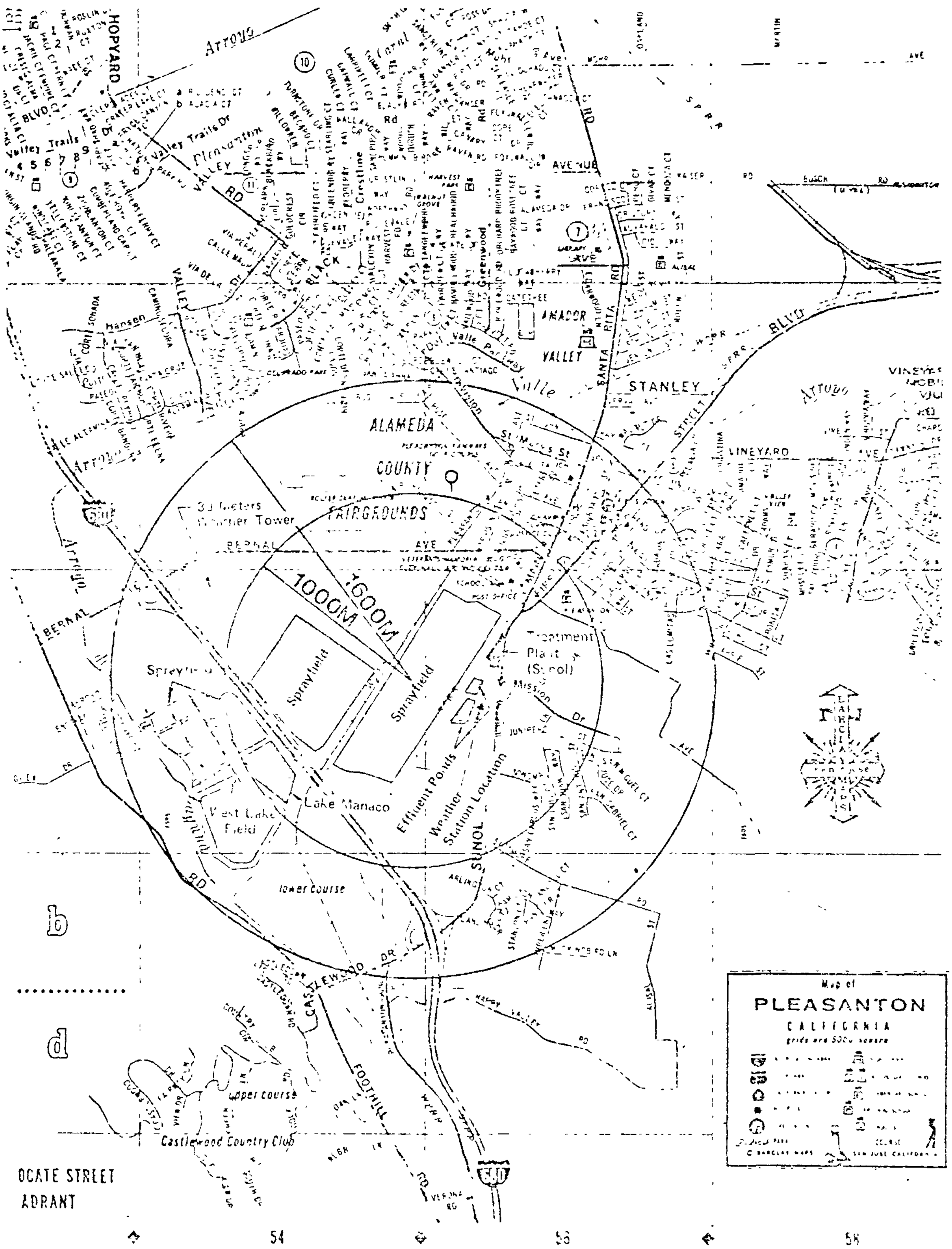


Figure 5
PLANT AND DISPOSAL FACILITY FLOW SCHEMATIC

Figure 6
SCHEMATIC OF STUDY SITE



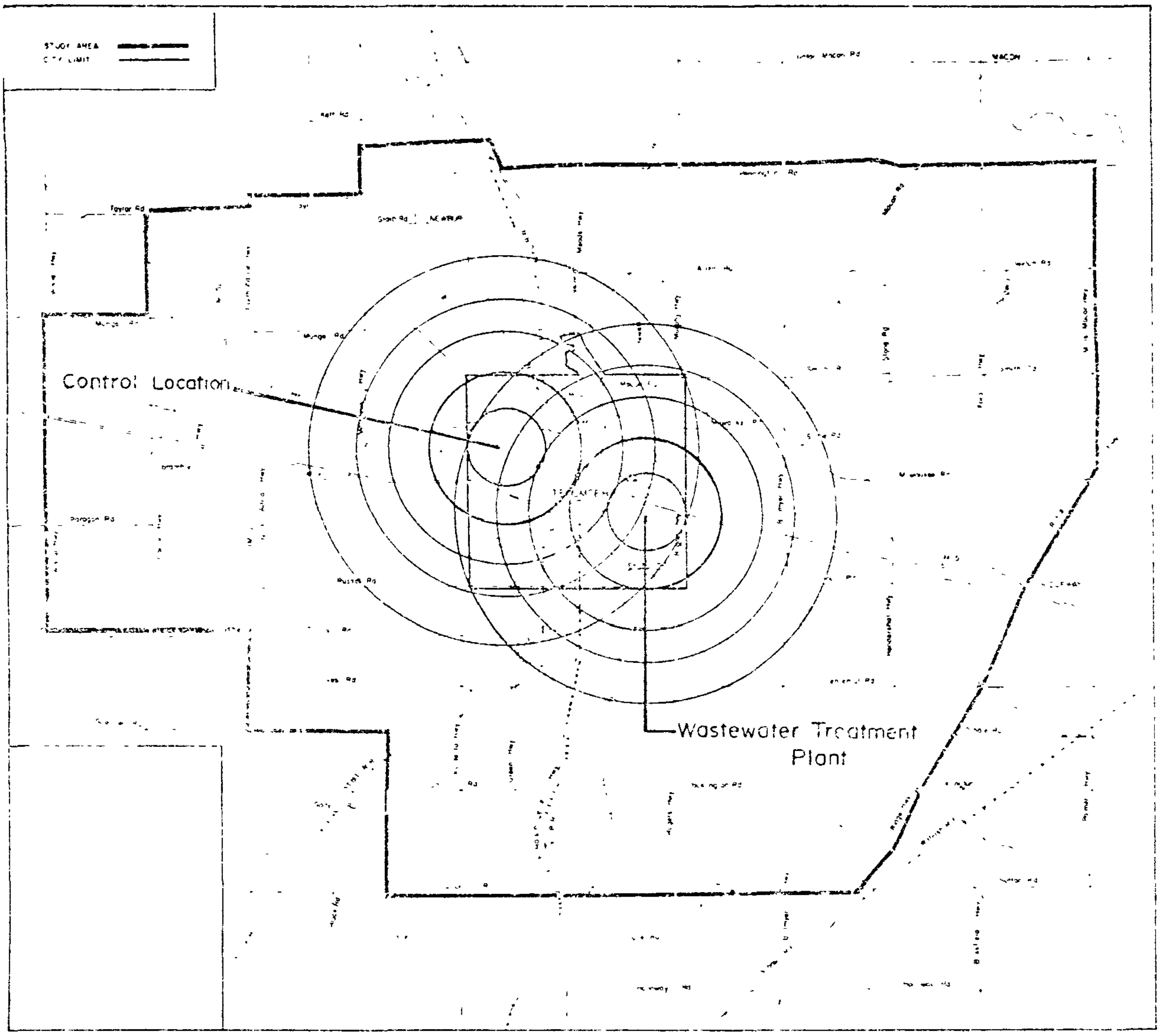


FIGURE 7 Wastewater treatment plant and control location concentric circles within Tecumseh study area.

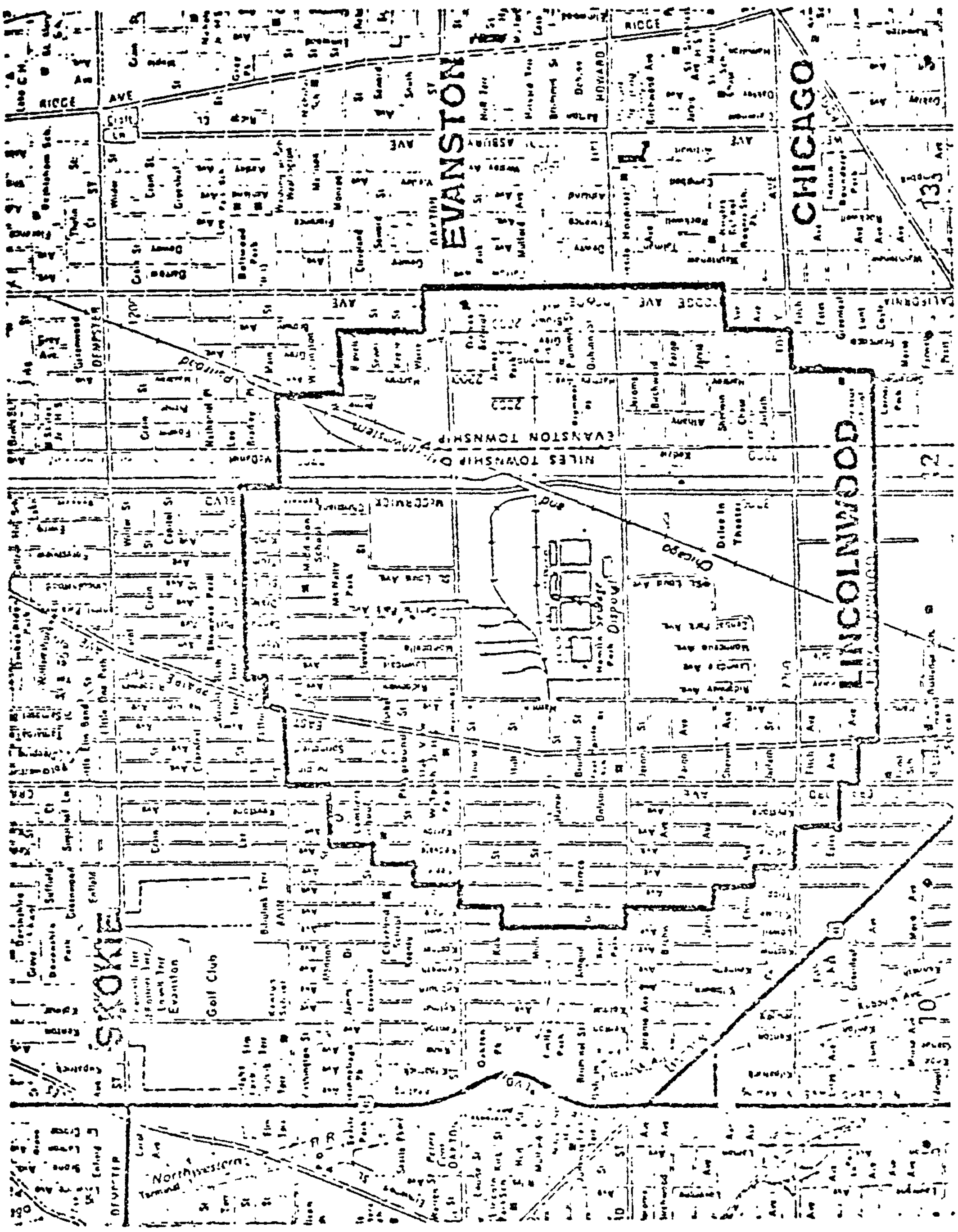
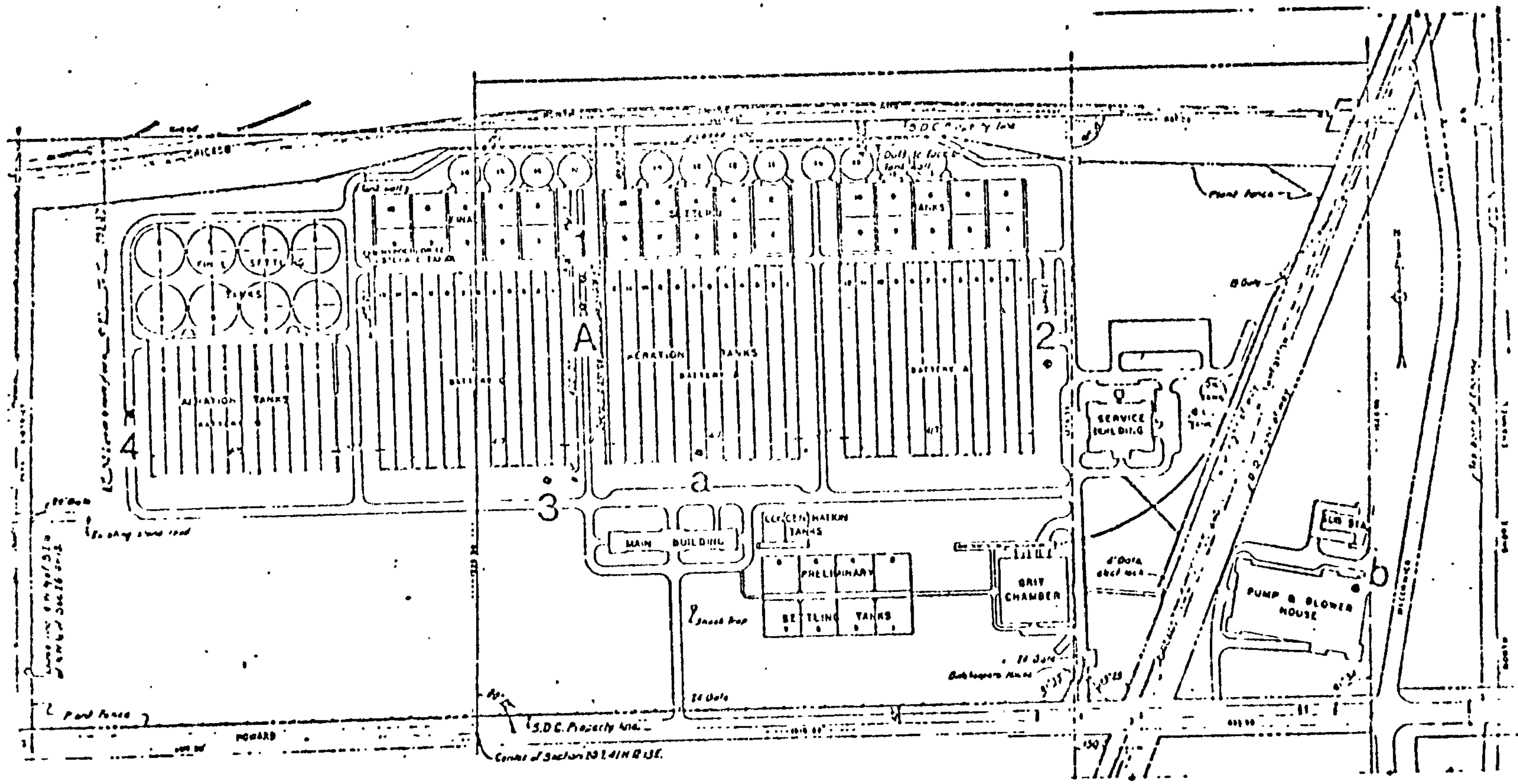
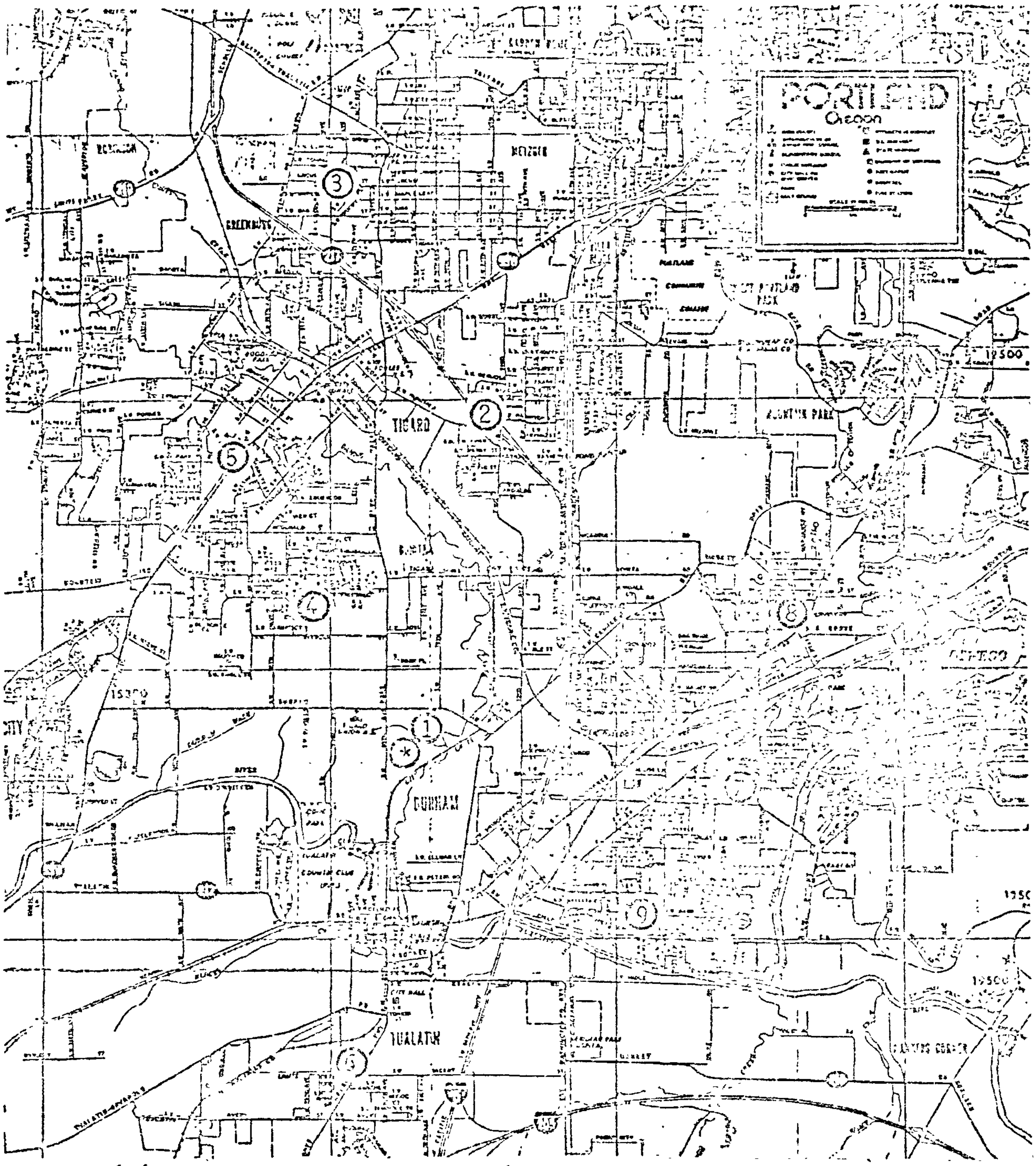


Figure 8. Map of study area.



Sites 1-4 are for sampling of airborne viable constituents.
Site A is for sampling of airborne non-viable constituents.
Sites a and b are points for grab samples of sewage for analysis of viable and non-viable constituents.

Figure 9. Schematic of North Side Sewage Treatment Works with on-plant sampling sites.

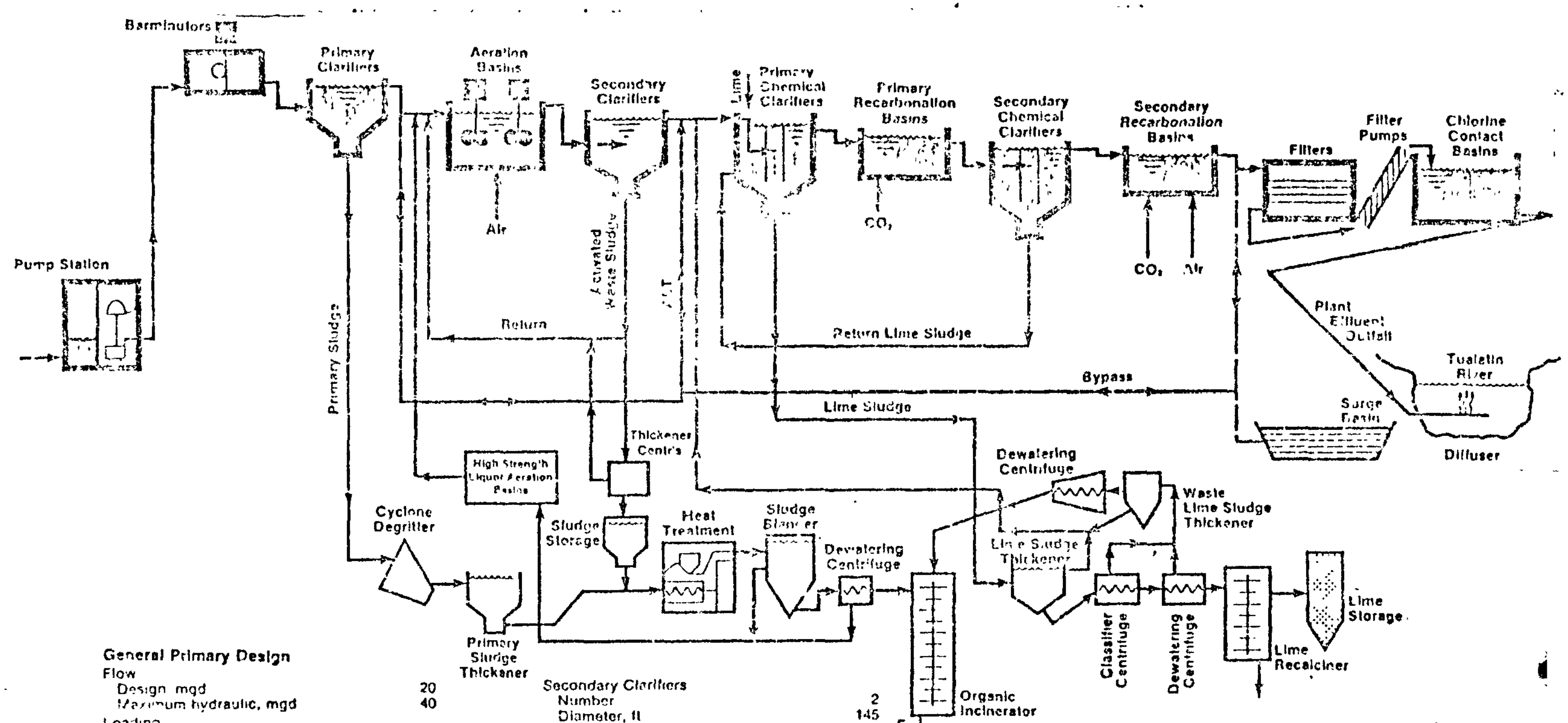


Legend

* Durham Advanced Wastewater Treatment Plant

1 Durham Elem. School
2 Lewis Elem. School
3 Metzger Elem. School
4 Templeton Elem. School
5 Tigard Elem. School
6 Tualatin Elem. School
7 Byrant Elem. School
8 Lake Grove Elem. School
9 River Grove Elem. School

Figure 10 Map of Study Area



General Primary Design	
Flow	
Design mgd	20
Maximum hydraulic, mgd	40
Loading	
Design BOD, mg/l	205
Design, suspended solids, mg/l	255
Design total phosphates, mg/l	25
Pump Station	
2 Variable speed pumps, gpm each	13,200
2 Fixed speed pumps, gpm each	8,300
Primary Clarifiers	
Number	2
Diameter, ft	120
Surface overflow rate gal/sq ft/day	880
Detention time, hrs	2.4
Primary Sludge Thickeners	
Number	1
Diameter, ft	50
Solids loading lbs/sq ft/day	14
General Secondary Design	
Aeration Tanks	
Number	4
Water depth, ft	20
Volume, cu ft each	142,000
Loading lbs BOD/day/lb MLSS	0.35
Detention time, hrs	5.1

Secondary Clarifiers	
Number	2
Diameter, ft	145
Surface overflow rate gal/sq ft/day	600
Detention time, hrs.	4.2
Return Activated Sludge Pumps	
Number	2
Rated capacity, gpm, each	10,500
mgd, each	15
Lime Sludge Thickeners	
Number	2
Diameter, ft	50
Sludge Heat Treatment (Secondary Only)	
Number of systems	2
Capacity, gpd 1 @	96,000
1 @	24,000
Sludge Dewatering	
Type	centrifuge
Number	4
Total rated capacity, lbs/hr	5000
Sludge Incinerator	
Number	1
Capacity, lbs/hr	2000
Lime Recalcining	
Centrifuges	1
Capacity, lbs/hr	5000
Recalciner	1
Capacity, lbs/hr	5500

Chlorination	
Number	4
Capacity, lbs/24 hrs.	32,000
Chlorine contact time	
Design, hr.	1
Peak, hr	0.5
General Advanced Treatment	
Primary & Secondary Chemical Clarifiers	
Number, primary	2
secondary	2
Size, each	100 ft. sq
Detention time, hrs.	2.8
Primary & Secondary Recarbonation Basins	
Number, primary	2
Detention time, hrs	0.33
Number, secondary	2
Detention time, hrs.	0.6
Filtration System	
Number	4
Type	mixed media
Area sq. ft each	900
Rate, gpm/sq ft	3.9

Figure 11. Durham Advanced Wastewater Treatment Plant Processes