BR #66 2.2 4.0

II-I Rec'd 9-16-84

Steve

Table 20 on pgs 71 and 72 contains considerable information on hexavalent chrome content of the ash from four sewage sludge incinerators. I have talked to Steve Lipman and he said he would send me some additional information. He also stated that the sludge from these plants were atypical in that the pH was about 11 due to the use of lime and since lime is discharged in to the plant. Also he said there was some concern over the test method used by the industrial hygiene types. I am trying to contact the person that did the analysis

Ron

SOUTH ESSEX SEWERAGE DISTRICT: A CASE HISTORY

HEALTH EFFECTS DUE TO CHROMIUM CONVERSION WITHIN SLUDGE INCINERATORS: A CASE STUDY

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NOVEMBER, 1982

This report is comprised of two sections; Section 1 being a 5-year case history of the South Essex Sewerage District (SESD) and Section 2 being a case study of sludge incineration within Massachusetts with particular emphasis directed at documenting whether safety and/or health hazards exist at POTW's which incinerate high metal content sludges. The need for and scope of work detailed in Section 2 was a direct result of the Department's experiences at the SESD.

During the 5 year period from August 1977 to the present (September 1982), the Department expended over 3 1/2 man-years of its personnel resources working on the various problems and projects at the District. These resources included administrators, engineers, scientists, technicians, inspectors, accountants and secretaries. Of the 550 employees within the Department over 50 have been significantly involved at one time or another in District business.

Table 1 indicates, in chronological order, all significant grant actions regarding the District and an estimate of grant actions expected to be made prior to January 1986.

In addition to the $55,000,000 already awarded to the District since 1972, an additional $22,000,000 has been awarded to its member communities.

Section 1

The South Essex Sewerage District was formed by an Act of the Massachusetts Legislature in 1925 and is currently composed of the Cities of Salem, Beverly, and Peabody and the Towns of Danvers and Marblehead. In addition, the District treats wastewater from the Ferncroft Complex and various State and County facilities located within the Town of Middleton and Gordon College located in the Town of Wenham (see Figure 1). The District maintains a system of trunk sewers, major pumping stations, and a primary wastewater treatment plant (see Figure 2) and services approximately 120,000 people and numerous commercial and industrial facilities. The treatment plant is located in a combined residential/industrial neighborhood in an area of Salem known as Salem Willows. The plant is abutted on the northwest by Fort Avenue and a dense residential neighborhood, on the southwest by the New England Power Company's (NEPCO) Electrical Generating Facility, on the northeast by the Commonwealth of Massachusetts Cat Cove Marine Laboratory, and on the Southeast by the Atlantic Ocean (Figures 3 & 4). The wastewater treatment plant was designed in the early 1970's and construction was funded through a 90% joint Federal/State grant with a total project cost of approximately $26 million (Project No. C 250 241 01).

Table 1

South Essex Sewerage District

Project #	Description	Type of Grant	Combined Federal and State Grant	Date of Grant
222 R - 01	Peabody-Salem Interceptor	Step 3	$10,500,000	1972
241 - 01	Treatment Plant, Pump Station & Outfall	Step 3	23,000,000	1973
228 - 01	Marblehead System	Step 3	6,300,000	1976
445 - 01	Facilities Plan Secondary Treatment	Step 1	236,700	4/77
456 - 01	Danvers - Beverly Interceptor (Section 1)	Step 3	6,289,000	8/79
241 - 01	Odor Control/ Sludge Conditioning	Increase	730,000	7/78
EIS	Environmental Impact Statement - Danvers/ Beverly Int, Section 2, 3 & 4	--	152,000	1979-1981
456 - 01	Pretreatment Program	Increase	282,000	8/80
241 - 01	Incinerator Modi- fications	Increase	520,000	9/80
445 - 01	Ash Detoxification (Pilot Study)	Increase	57,000	10/80
445 - 01	Ash Detoxification (Pilot Study)	Increase	26,000	2/81
737 - 01	Ash Detoxification	Step 2	380,000	6/81
456 - 02	Danvers/Beverly Int. (Sections 2, 3 & 4)	Step 2	814,000	9/81
737 - 02	Ash Detoxification	Step 3	5, 264,000	11/81

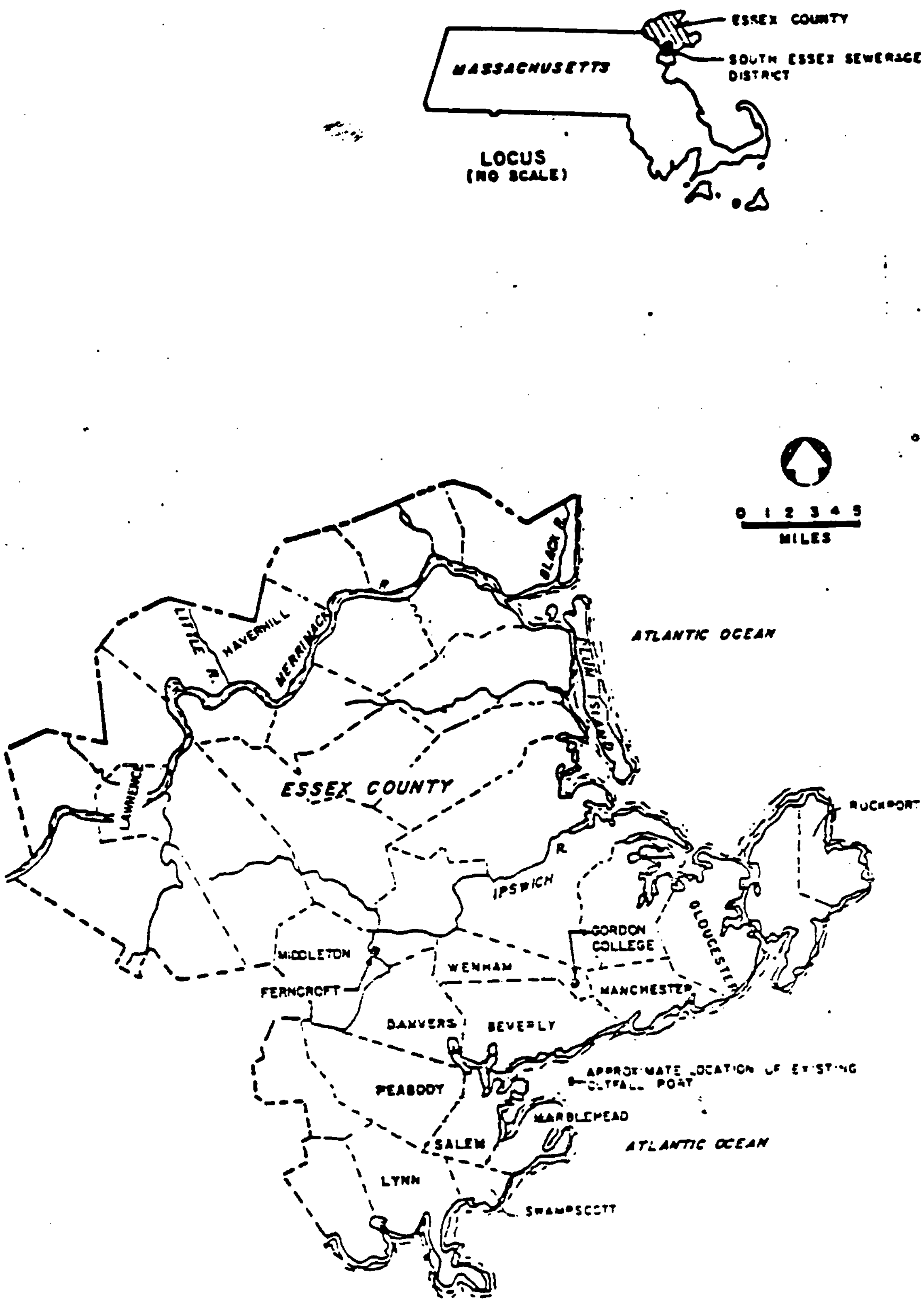
Table 1 (cont.)

South Essex Sewerage District (cont.)

Project #	Description	Type of Grant	Combined Federal and State Grant	Date of Grant
241 - 01	Odor Control, Start-up & Construction Services	Increase	$ 360,000	3/82
456 - 02	Danvers/Beverly Int. Special Study - Section 2	Increase	69,000	3/82
737 - 02	RCRA Part B Permit	Increase	39,000	3/82
		Approximate	54,979,900 (55,000,000)	

Anticipated Future Grants to SESD

737 - 02	Industrial Hygiene (Study Phase)	Increase	?	?
737 - 02	Industrial Hygiene (Construction Phase)	Increase	?	?
456 - 01	Danvers/Beverly Int. (Section 3E)	Increase	900,000	6/82
456 - 01	Danvers/Beverly Int. (Sections 2, 3 & 4)	Increase	12,600,000	4/83
241 - 02	Extended Outfall or Secondary Treatment	Step 3	18,000,000	1985



SOUTH ESSEX SEWERAGE DISTRICT

FIG. 1 LOCATION MAP

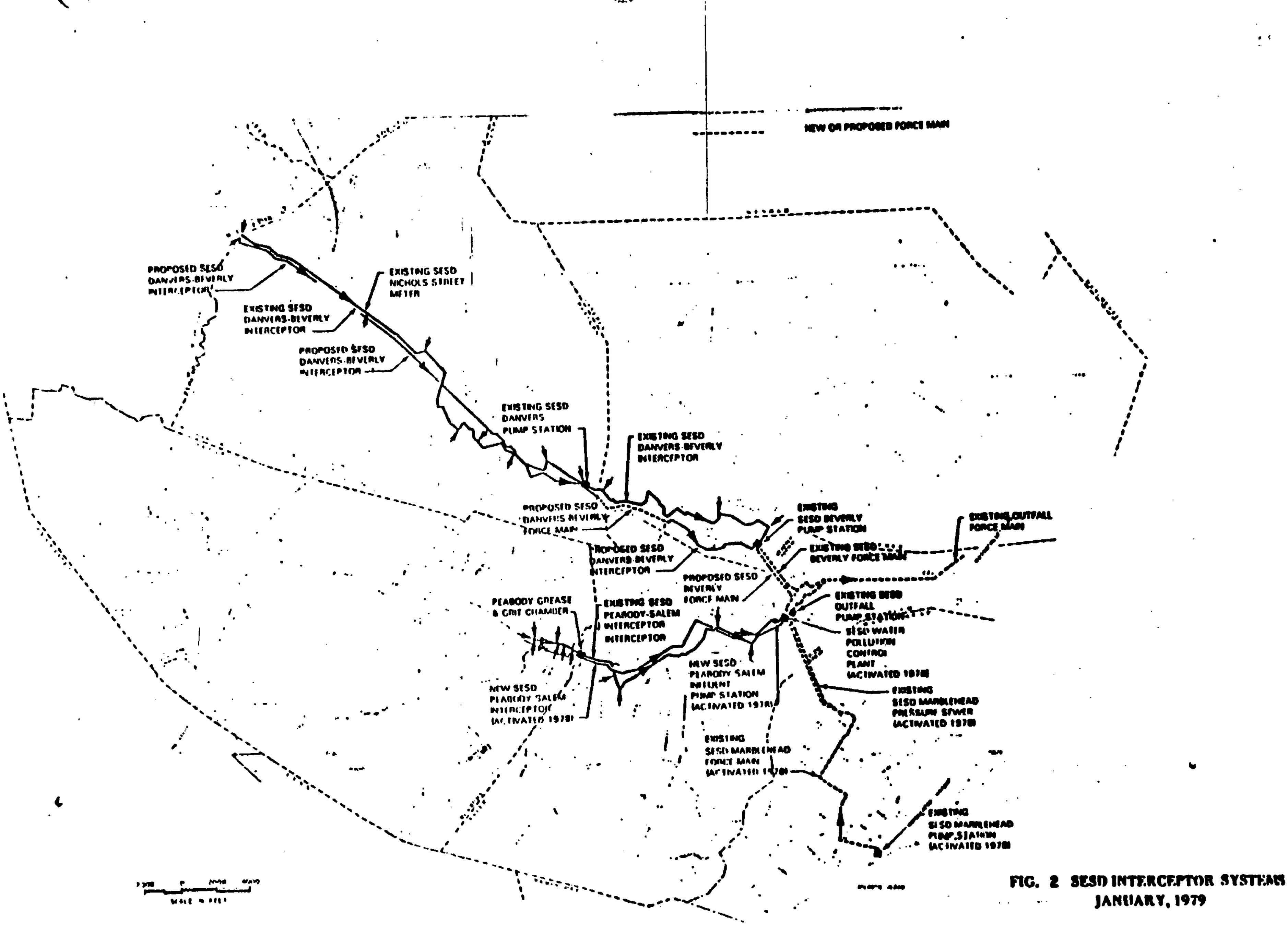
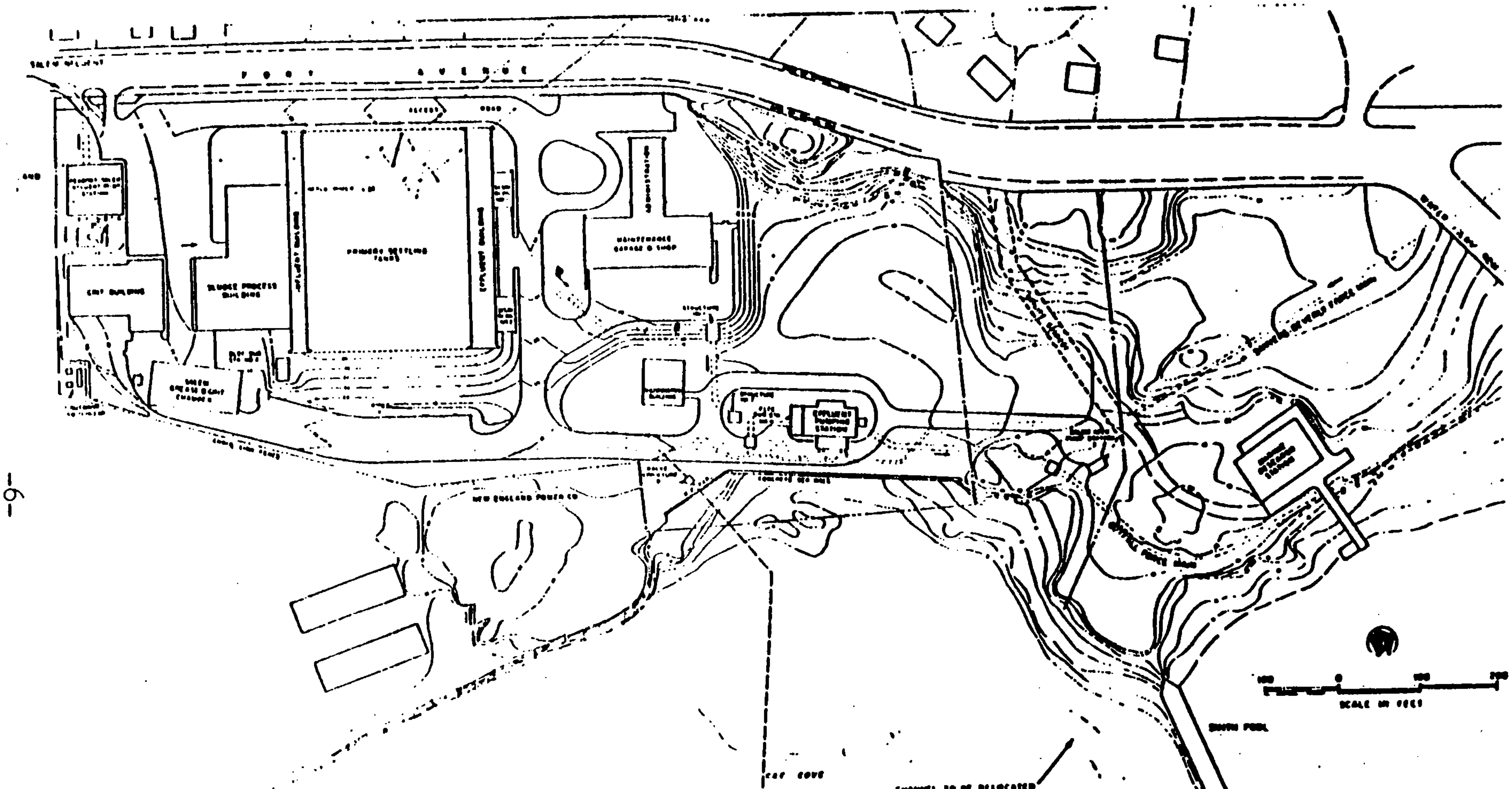


FIG. 2 SESD INTERCEPTOR SYSTEMS
JANUARY, 1979



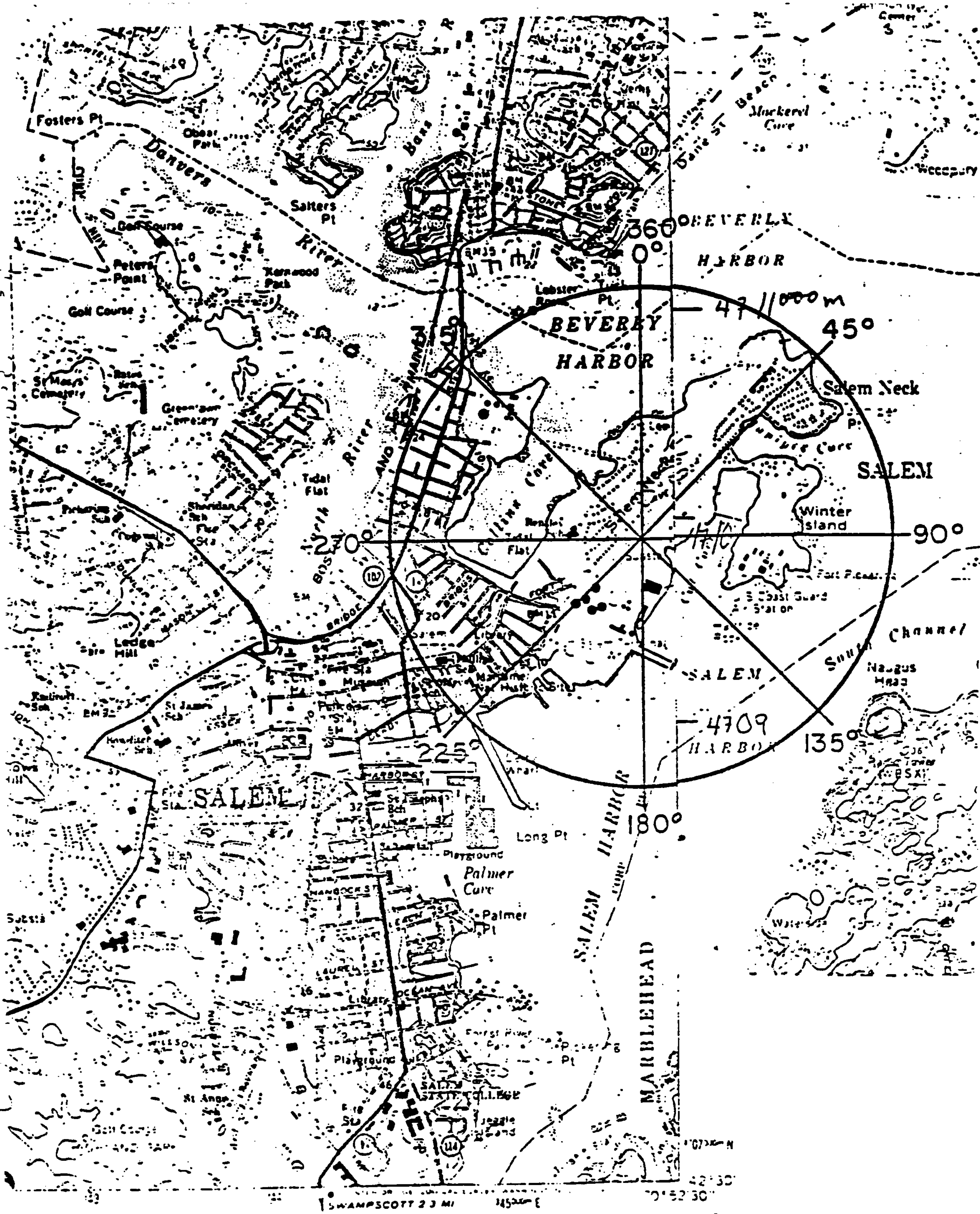
GENERAL NOTES

1. ELEVATIONS ARE BASED ON SOUTH ESSEX SEWERAGE DISTRICT DATUM WHICH IS 4.46 FEET BELOW USGS MEAN SEA LEVEL DATUM.
2. MEAN HIGH WATER ELEVATION + 9.0 FEET
3. MEAN LOW WATER ELEVATION + 0.0 FEET

—·—·— SHORELINE

- - - - - - PIPING

FIG. 3 PLAN OF EXISTING SESD



ROAD CLASSIFICATION

Primary highway ... Light duty road, hard or improved surface

Secondary highway

FIGURE 4

The plant is shown schematically on Figure 5 and was designed to treat an average wastewater flow of 41 million gallons per day (MGD) by providing primary treatment consisting of screening, grit removal, scum collection, prechlorination, primary clarification, disinfection, and effluent pumping via a 1½ mile outfall to Salem Sound (see figure 6). Sludge was to be collected in the clarifiers, drawn-off and stored in two 150,000 gallon blending tanks, and dewatered by eight (8) centrifuges to approximately 20 percent solids and processed in two (2) 12-hearth sludge incinerators with final ash collection and disposal at a local sanitary landfill. The entire facility is either constructed below ground or contained within structures with air collected from the facility and treated in two ozone units for odor control before being vented to the atmosphere.

This facility has been plagued by one major calamity after another since the initiation of operations in August 1977. This Section will detail the nature and extent of each problem and indicate the actions taken by the Department, District and EPA over the subsequent 5-years to correct these problems.

On August 29, 1977 operations were initiated at the SESD primary WWTF but were terminated 20 days later on September 17 due to severe hydrogen sulfide odors both within the facility and throughout the adjacent residential neighborhood. The hydrogen sulfide levels reached 200 ppm within the sludge processing area forcing employees working within those areas to utilize self-contained breathing apparatus (Scott air-packs). The treatment plant did not reactivate operations until August of 1978. During this intervening year substantial modifications were made to the facility, the most prominent being the installation of hydrogen peroxide and sodium hydroxide feed systems, a hydrogen sulfide monitoring system and a packed column hypochlorite air scrubber. This equipment was deemed necessary after an examination of the abortive startup which indicated that the hydrogen sulfide was formed by large concentrations of sulfides in the influent wastewater in combination with pH reduction within the sludge blending tanks. On May 26, 1978 the Department's Metropolitan Boston-Northeast Regional Office approved plans for the odor control and chemical feed systems and complete 90% federal/state funding was provided to the District through the Construction Grants Program for construction of the following $730,135 worth of equipment:

(a) Sodium hydroxide feed systems for pH adjustment in the sludge blending tanks.

(b) Hydrogen peroxide feed systems for application to blended sludge prior to centrifugation. (Dosages are normally small and are intended to oxidize any residual sulfides prior to dewatering).

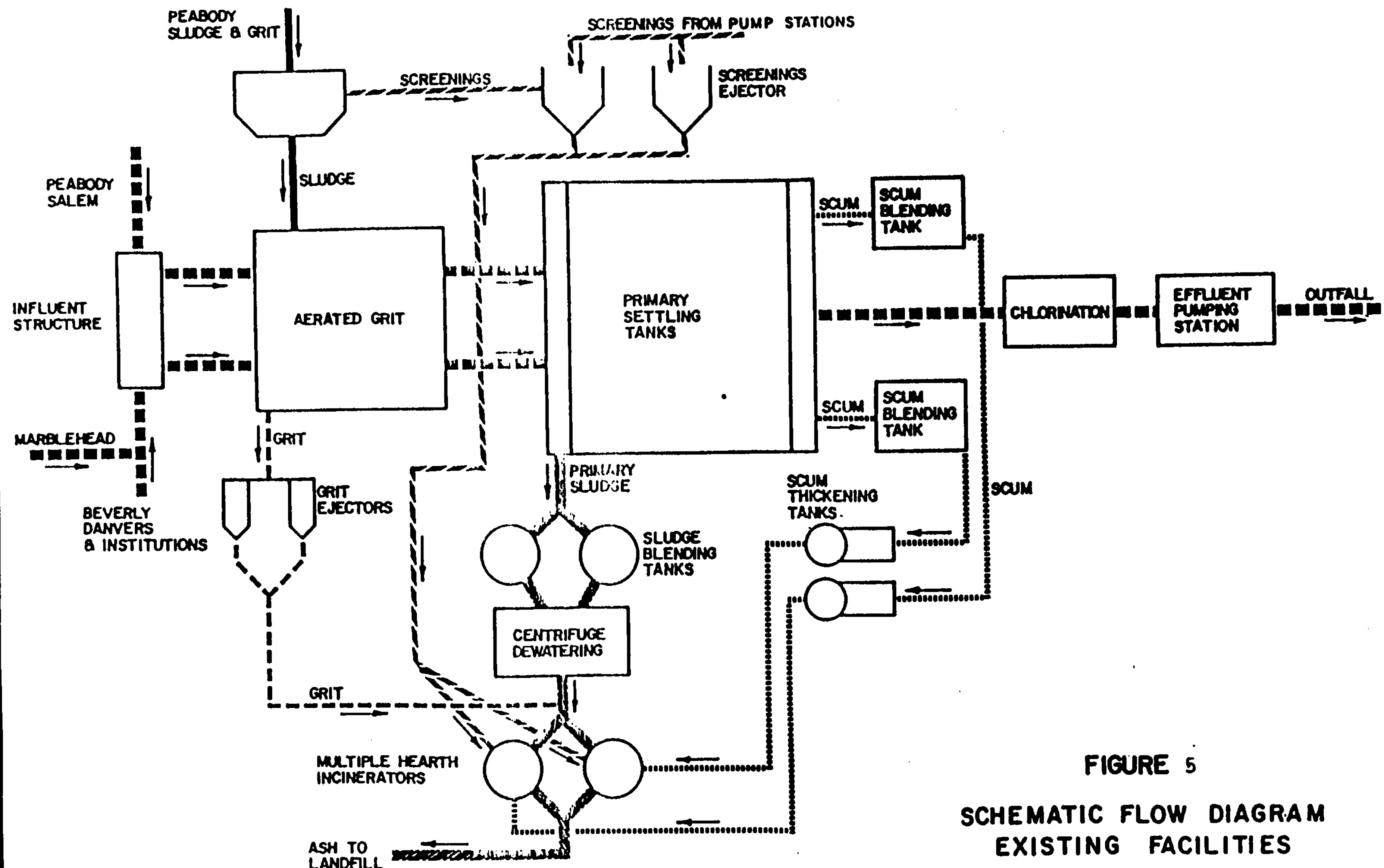


FIGURE 5

SCHEMATIC FLOW DIAGRAM
EXISTING FACILITIES

SOUTH ESSEX SEWERAGE DISTRICT

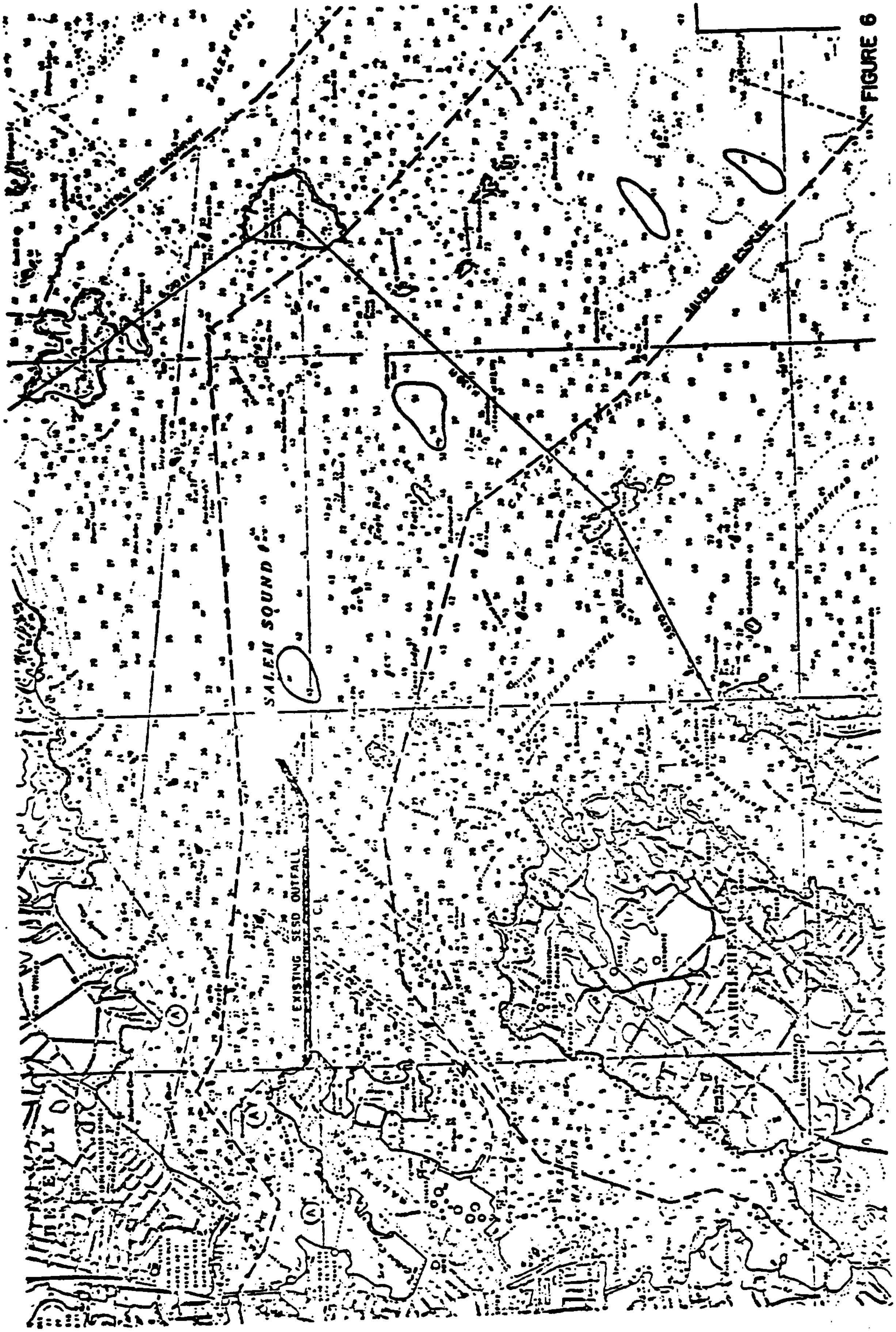

SALEM SOUND
EXISTING SESD OUTFALL
SALEM CHANNEL
MARBLEHEAD CHANNEL

FIGURE 6

(c) Gas scrubbing tower utilizing sodium hydroxide and sodium hypochlorite to treat vent gases from centrate lines and blended sludge tanks. One Heil Model 732 Scrubber was installed, rated at a maximum of 1600 scfm with a pressure drop of three (3) inches water gauge, which reduces the Hydrogen Sulfide emissions by 99%. The effluent from the scrubber is pumped to the head of the plant where it is introduced to the influent.

(d) Hydrogen sulfide monitoring is employed to detect unsafe levels throughout the plant and is connected to an alarm system. These alarms indicate Hydrogen Sulfide levels which must be maintained below the levels prescribed by the Occupational Safety and Health Administration (OSHA) for maintaining a safe working environment.

On August 9, 1978, the District re-established operations through a phasing in of flows and treatment systems:

<u>August 9, 1978</u> —	Flows from the Town of Danvers and the City ofBeverly entered the plant; (those flows being mainly residential);
<u>December 26, 1978</u> —	Flows from the Cities of Peabody and Salem entered the plant; (those flows containing a high industrial contribution);
<u>December 27, 1978</u> —	Flow from the Town of Marblehead entered the plant through the recently completed harbor force main;
<u>August 22, 1978</u> —	Sludge processing was activated with dewatered sludge disposed of at a commercial landfill in New Milford, Connecticut;
<u>February 21, 1979</u> —	Incineration was initiated. Between March and June 1979, the incinerators operated sporadically with numerous odor complaints received at DEQE. The incinerators were stack tested in April and met particulate emission limitations. Representatives from the Department's Division of Air Quality Control (DAQC) visited the facility and two Notice of Violations were issued by the Department to the District on May 30 and June 6, 1979 due to odors within the adjacent residential neighborhood.

In June 1979, incineration was discontinued due to the large number of complaints from residents. During June numerous meetings were held between the District, its engineering consultant (Metcalf & Eddy) and the Department to review the March to June operating records and to develop modifications to both the operating procedures and the physical facilities to cope with these difficulties. These meetings culminated in the following revisions being made to the system:

1. Installation of drag chains to the rabble arms in hearth #1 to insure uniform spreading of sludge and its timely removal onto hearth #2.

2. Installation of a potassium permangenate feed system to remove odorous compounds in the effluent flushing water.

3. Construction of a drop hole between hearths #1 and #2 on incinerator #1 to allow sludge to pass directly onto hearth #2 thereby allowing hearth #1 to act as an afterburner for the exhaust gases.

On July 9, 1979, incineration was again reinstituted (with modifications) but on July 13 operations were again curtailed due to severe odor conditions experienced on July 12. The Salem Board of Health issued an Order to SESD to cease incineration and on July 13 the Board voted to cease operations and pump sludge into Salem Sound. On the afternoon of the 13th the Department and the Massachusetts Attorney General's Office prepared the necessary legal documents and later that evening obtained a Temporary Restraining Order (TRO) against the District for discharging sludge into Salem Sound.

At this point all communications with the District came to a virtual standstill and all parties involved maintained an adversary position. The Department continued legal actions through the Mass. Attorney General's Office to enforce the TRO. On July 20, 1979, a hearing was held before Judge Young in Suffolk Supreme Court (Civil Action No. 36399) and at this hearing the Salem Board of Health intervened on the side of the District. Judge Young ruled that the District had three weeks to find an alternative environmentally exceptable alternative method of sludge disposal or reinstitute incineration. After this 3-week period, it was determined that the District was unable to find any alternative method of sludge disposal with the exception of hauling its 200 tons per day of dewatered sludge to a landfill in upper New York at an approximate yearly cost of $4.5 million. It was therefore agreed that the District, City of Salem, and DEQE should attempt to negotiate a consent judgment with a specific timetable for reinstituting incineration.

Technical review sessions were held during August which led to the following agreement:

1. Incineration will be reinstituted.

2. DEQE will monitor the residential area prior to warm up of the incinerator.

3. DEQE will provide surveillance and monitoring in the neighborhood during a finite initial operating phase.

4. DEQE will provide engineers from the DAQC to observe incineration operations and provide assistance to the operators if requested.

5. Operational modes as determined by Metcalf and Eddy will be adhered to by all parties involved unless revisions are approved by the coordinator representatives from DEQE, M&E, and SESD.

6. The District will engage a private consultant to perform independent odor surveillance and to sample and analyze exhaust gases from the incinerators and ozone vents.

7. All burners in hearth #1 will remain on high fire for the first week, even when no sludge is entering the incinerator; after which time optional operating conditions will be determined.

8. The District will determine which industries are discharging into the sewer system and maintain a daily log of such discharges.

9. Scum and screenings are not to be burned at this time.

10. Rabble arms on hearth #1 will be removed.

11. Drag chains will be added to rabble arms on hearth #3 to improve sludge distribution and drag out.

12. The facility shall be operated in a manner to minimize odors and control particulate emissions.

On September 14, 1979, the Department approved the interim disposal of incinerator ash in the District's abandoned concrete grease/grit chambers; one chamber located at the treatment plant site and the other located at the Peabody/Salem City line.

On September 25 incineration was reinstituted with DEQE personnel providing surveillance and monitoring. This technical assistance consisted of the following:

1. DAQC provided a minimum of one engineer within the incinerator control room at times of incineration (18 to 24 hours per day).

2. DAQC provided a minimum of one inspector within the adjacent neighborhood to monitor odors and respond to citizen complaints.

3. DEQE analyzed the two week test period and provided SESD with conclusions and recommendations.

4. DWPC provided an engineer to be on call 24 hours per day through the use of a personnel beeper.

The District procured the services of Arthur D. Little (ADL) and the City of Salem hired Bub Testing Laboratories to also monitor the operations.

During the observation period, sludge was burned in Incinerator #1 from September 25 through September 29, 1979 and no major odor problems were encountered. Some downwash did occur, but the odors were slight to moderate. Most complaints received were attributed to the process odors emanating from the ozone vents and were described as "sewage".

Mechanical problems with the Induced Draft (I.D.) fan and the by-pass damper forced operations to be transfered to incinerator number 2, which had not been modified to provide the afterburner mode. Temperatures in hearth number 1 of unit number 2 were 400-500°F lower than those observed in hearth 1 of unit number 1. Sludge was burned at the same rate of 10 tons per hour in unit number 2 as was burned in unit number 1. More odor complaints were received, and the surveillance personnel detected stronger levels of odors in the neighborhood. A severe rainstorm occured on October 1, 1979 which flushed the sewer lines and created a very "poor" sludge. Sulfides in the sludge could not be controlled and climatic conditions on October 5, 1979 were heavy fog with very light on-shore winds. Downwash was severe, and the neighborhood was "fumigated". Lack of the afterburn mode and high sulfides created a very odorous plume. Sludge burning was stopped, and the sludge was dumped (pumped to the main effluent line). Sludge was again collected on the 6th, and burning began on the 7th and on October 8th, 1979, the Department of Environmental Quality Engineering personnel stopped the continuous coverage at the plant.

Representatives from Arthur D. Little performed sampling of various emission points on September 28 which were evaluated for odor by a panel of four ADL trained odor analysts and the samples were also analyzed by Gas Chromatography/Mass. Spectroscopy (GC-MS) to identify the major organic chemicals present and determine the presence of EPA priority pollutants. Samples taken on September 28 included the following:

Sample No.

1. Primary Tank Ozonator Exhaust

2. Sludge Ozonator Exhaust

3. Incinerator No. 1 Scrubber Exhaust

4. Incinerator No. 1 Prescrub

Incinerator No. 1 at the time of sampling had been modified to have hearth 1 operate as an afterburner.

Additional sampling was carried out on October 23 on Incinerator No. 2 (without modifications to hearth No. 1) with and without the addition of potassium pemanganate ($KMnO_4$) in the scrubber effluent flushing water (EFW).

Sample No.	
5.	Incinerator No. 2 Scrubber Exhaust - No $KMnO_4$
6.	Incinerator No. 2 Prescrub
7.	Incinerator No. 2 Scrubber Exhaust - With $KMnO_4$

During the $KMnO_4$ test, 160 lbs of $KMnO_4$ was used over a 2.5 hour period with an EFW flow rate of approximately 1300 gpm. The Incinerator No. 2 samples were evaluated for odor only.

In addition to the sampling and evaluation program, off-site odor surveys were carried out by Arthur D. Little staff members on the following days:

Monday - September 17, 1979
Tuesday - September 25, 1979
Wednesday - September 26, 1979
*Friday - September 28, 1979
Wednesday - October 3, 1979
*Tuesday - October 23, 1979

In conjunction with the Arthur D. Little work, the Department performed modeling analysis on the stacks from the incineator and from the process vents. This modeling analysis confirmed Arthur D. Little's findings and showed downwash to be a major problem (downwash is a term applied to a plume that becomes entrained in air that is trapped in the wake of a building).

Stack heights were projected to determine what minimum elevation would be necessary to get out of the downwash conditions. A sixty five (65) foot incinerator stack (above roof level) was shown by calculations to be acceptable. Another downwash problem was also analyzed. The NEPCO facility which is located adjacent to the SESD Treatment Plant is much larger with stack heights of Units #1, #2, and #3 being 250 feet, and Unit #4 has a 500 foot stack. Wind from the southeast will cause turbulance and downwash of the sludge incinerator plume and stack heights necessary to overcome this specific downwash problem were not calculated, but are probably on the order of 300-400 feet. Downwash caused by NEPCO was not considered a major problem because of the wind direction involved; the majority of the odor complaints being from Fort Avenue, (below #70) Memorial Drive and Larkin Lane. Wind direction to this impacted area would not be caused by downwash from NEPCO.

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*Sampling was carried out on days indicated.

The source sampling laboratory odor evaluation program indicated that the Incinerator No. 2 (no afterburn) scrubber exhaust was the major odor source at the SESD plant at the existing level of operation. Odors from this source were described as burnt meaty, burnt fatty pungent and were observed at the moderate (2) intensity level on Fort Avenue and in the slight (1) intensity range on both Memorial Drive and on Essex Street, all of which are considered to be at or above the complaint level.

Odors from Incinerator No. 1 (with afterburn) were of a different quality (soapy phenolic, pungent) and have been observed in the community up to the slight (1) intensity as a maximum. This odor was observed less frequently than that of the other sources. A.D.L. considered this source to be at a borderline complaint level and suspects the community would tolerate the odor. Improvements such as increasing the release point, improving the retention time in the afterburner and/or the use of "clean water" rather than effluent water in the scrubber were also recommended for consideration. Odor from the Incinerator No.1 prescrub was less than the scrubber exhaust indicating that odors are being stripped from the effluent water in the scrubber. The addition of potassium permanganate ($KMnO_4$) to the effluent water in the Incinerator No.2 (no afterburn) scrubber was of virtually no benefit due to the high odor load in the incinerator exhaust.

Odors from the primary tank ozonator outlet (chlorinated sewage, solventy and occasionally fecal, animal sour type odors) and the sludge process ozonator outlet (fecal, slufide pungent) were observed in the community, at complaint levels.

Table 2 presents the data obtained by A.D.L. in the sampling program and ranks the various sources based on the maximum observed odor intensity that were found in the neighborhood. The predicted intensities are for the laboratory samples at given meterological conditions.

During the course of the surveys, fuel oil related odors described as asphalt tarry, oil, and mercaptan were observed in the neighborhood at up to moderate (2) intensity levels. These odors which appear to be from the tank farm off Fort Avenue are also at complaint levels.

GC-MS analysis of the organic components present in the primary tank ozonator outlet, the sludge process ozonator outlet, and before and after the scrubber of Incinerator No. 1 (afterburner mode) were carried out to identify the major chemical species that were present and to search for the presence of EPA priority pollutants.

SUMMARY TABLE 2

	Source Odor Strength (SOS)	Odor Emission Rate (Q)	Predicted Odor Intensity (TIA)	Maximum Odor Intensity Observed TIA
Incinerator No. 2 Prescrub (No Afterburner)	57,816	564,862	2.7 (Strong)	N.R.*
Incinerator No. 2 Scrubber Exh. (No $KMnO_4$)	18,044	176,290	2.3	2
Incinerator No. 2 Scrubber Exh. ($KMnO_4$)	19,680	192,270	2.2 (Moderate)	2
Sludge Proc. Ozon. Exh.	3,766	27,730	1.1 (Slight)	1.5-2
Primary Tank Ozon. Exh.	816	6,000	0.6 (Very Slight)	1-1.5
Incinerator No. 1 Scrubber Exh. (Afterburn)	3,891	38,016	.1.7	1
Incinerator No. 1 Prescrub (Afterburn)	1,686	16,472	0.3	N.R.*

*N.R. - Not released to atmosphere without further treatment

The incinerator No. 1 prescrub sample which had the lowest odor of the samples evaluated also showed a low organic content. Alkyl phenol, naphthalene and methyl naphthalene were found but in very small quantities.

The two ozonator outlet samples and the Incinerator No. 1 scrubber exhaust were heavily loaded with hydrocarbon material. The hydrocarbon material was primarily aliphatic, with a large secondary component of alkylated benzenes. These and other components identified are consistent with fuel oil and/or petrochemical solvents. A total of eleven primary pollutants were identified in the Incinerator No. 1 scrubber exhaust:

Dichlorobenzenes
Naphthalene
Fluorene
Diethylphthalate
Anthracene/Phenanthrene
Trichloroethylene
Toluene
Chlorobenzene
Ethylbenzene

These compounds were estimated to be present in the exhaust at the 6-600 microgram per cubic meter concentration range. Ambient concentrations of these materials after dilution in the atmosphere would be several orders of magnitude less than the concentration in the stack.

Table 3 summarizes the estimated concentration of the eleven priority pollutants found in Incinerator No. 1 Scrubber Exhaust (as mg per M3 exhaust). Also reported are available odor threshold data, as well as the Maximum Allowable Concentration (MAC) as promulgated by OSHA-DOL in the 1975 Federal Register. Column 4 in the table indicates the concentration of the priority pollutants found in the SESD raw wastewater on June 21-22, 1978.

Observations of Incinerator Operations

DEQE personnel were observers in the control room for the entire observation period and periodic records were kept of readings taken from the control panel. These recordings were reviewed, and the following conclusions were drawn:

1. Instruments were not always accurate.

   (a) percent open was really percent closed.

   (b) draft across one scrubber plate was really draft across three scrubber plates (then calibrated and defined as being across one plate).

   (c) draft gauges and air flow could not be correlated.

TABLE 3

PRIORITY POLLUTANTS FOUND IN SCRUBBER EXHAUST

	Estimated Conc. in Solution (ng/μℓ C_5)	Estimated Conc. in Exhaust (mg/M^3)	Odor Threshold mg/M^3 Air	Conc. in Plant Influent (μg/ℓ H_2O) a/	MAC (mg/M^3 Air) b/
Dichlorobenzenes	50	0.317		N.D.	300-450
Naphthalene	50	0.317		87	50
Acenaphthene	5	0.032		N.D.	
Fluorene	1	0.006		N.D.	
Diethylphthalate	1	0.006		10	
Anthracene/phenanthrene	1	0.006		N.D.	0.2
Trichloroethylene	10	0.063	107	24	300 ppm
Tetrachloroethylene	20	0.126	80	N.D.	300 ppm
Toluene	50	0.317	8-21	25	200 ppm
Chlorobenzene	1	0.006	0.92	N.D.	350
Ethyl Benzene	>>100	>> 0.633	0.12 (E)	18	435

a/ As determined by Camp Dresser McKee on raw wastewater samples on June 21-22, 1978.

b/ Maximum allowable concentration - Department of Labor, Federal Register, Vol. 29, 1975

2. Operators treat similar situations differently.

Observations of the equipment revealed the following:

1. refractory flacking off in Unit #1 By-pass stack.

2. sludge combustion vanes may be functioning improperly.

3. venturi shaft bent on both units.

4. Unit #2 differs from Unit #1 in feed location.

These observations were reviewed by staff engineers of the Metropolitan Boston/Northeast Regional Office, and resulted in the following recommendations:

1. Operations:

   (a) operators be trained to properly evaluate the incinerator operations.

   (b) a Standard Operating Procedure be established so that each operator will react in the same way to rectify similar situations.

2. Capital Improvement Area:

   (a) Stack height should be increased to prevent downwash (preliminary calculations indicate 65 feet above roof level).

   (b) establish wind direction and velocity indicator at plant, out of plant turbulance.

   (c) modify incinerator number 2 to mirror incinerator number 1.

   (d) modify hearth number 1 of both units to get better retention time and temperature to reduce gas consumption.

   (e) evaluate better control methods, perhaps intermittant, for process vents.

Odor Modeling

The purpose of conducting air quality modeling at SESD for odor impact was two fold; (1) to determine if models used could reasonably approximate odor levels found in the field by DEQE inspectors and ADL and (2); to utilize models if possible to predict the effects of changes in plant operation as they relate to odorous emissions.

Odor emission factors were developed by Greg Leonardos and the staff of ADL from samples taken at four points; incinerator #1 scrubber effluent, incinerator #2 scrubber effluent, sludge ozonator outlet and the primary ozonator outlet.

For incinerators #1 and #2, it was predicted that the interaction between the present stack height and incinerator building configuration will downwash in the wake formed by the incinerator building at any wind speed slightly greater than 2 meters per second. Therefore, for all wind speed situations exceding 2 meters per second, odor impacts were analyzed in a downwash condition. At all wind speeds 2 meters per second or less PTMPT dispersion modeling was conducted for appropriate stability classes.

Downwash Condition

Downwash or the likelihood of the South Essex plume being trapped by the wake created by the incineator building was analyzed using Briggs downwash equations. Wind direction was assumed to be off of the harbor and perpendicular to the incinerator side of the building facing the harbor. Wind speeds analyzed were 1, 2.5, 4.5, 7 and 10m/sec.

Results show that downwash will occur given the present building configuration at approximately all wind speeds greater than 2m/sec., (4.5 mph). This analysis predicts that this plume will, in the downwash condition, affect an area 62 feet from the building and 220 feet directly downwind of the building.

Table 4 indicates predicted versus observed odor impacts (TIA) resultant from the worst case downwash wind speed (3 m/sec) from incinerators #1 and #2. The values reported may be considered to be a maximum due to an assumption in estimation of constant K required in the Briggs equation that generates concentration estimates.

As a result of this testing, contract documents were prepared by Tighe & Bond/SCI Engineers for the District which contained the following items of work:

1. Remove the two (2) existing 30-inch diameter stacks which extend 20 feet above the roof of the sludge processing building and install two (2) 45-inch diameter stacks which will extend 65 feet above the roof.

2. Relocate the burners and air ducts from Hearth #1 to Hearth #2 on both incinerators.

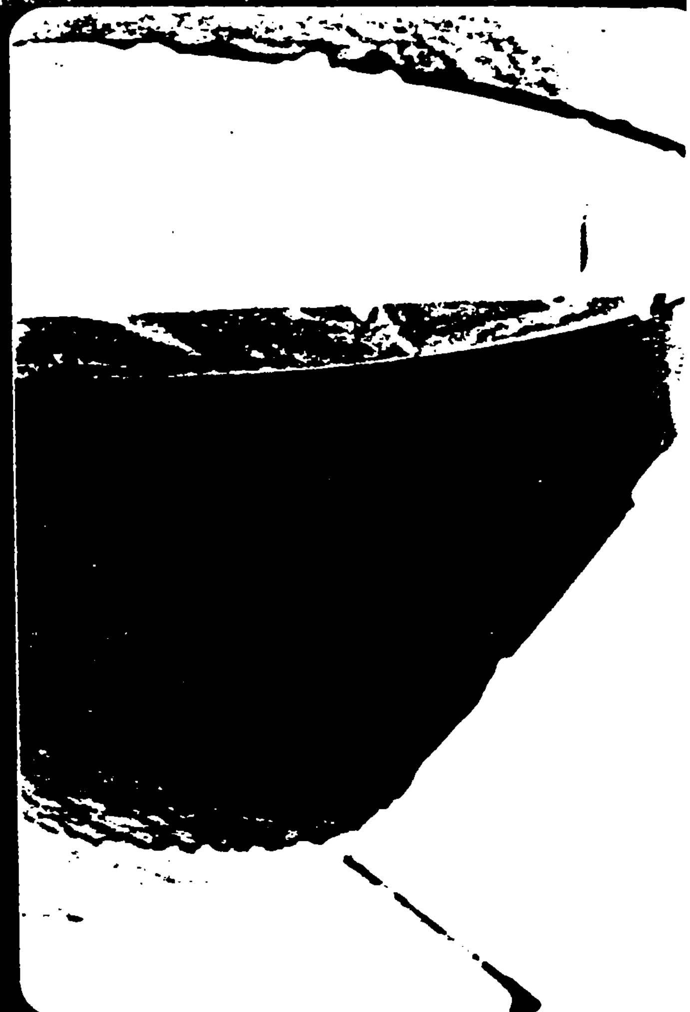
3. Modify the arangement of the existing rabble arms and teeth on Hearths No. 1 and 2 in both incinerators.

4. Construct a 22-inch diameter drop hole through Hearth #1 of incinerator No. 2 below the sludge feed flap gate duct.

5. Construct refractory damper seats for the existing damper in both of the by-pass stacks.

6. Construction of inspection doors with viewing ports in the duct work adjacent to operating dampers to allow observation of the dampers' operation.

7. Provide a Dwyer Model 400-23 Air Velocity Kit (portable draft gage).



View from access hatch looking down onto 6-foot diameter unseated damper installed in gunited by-pass stock.

Non-seated cross-over damper between incinerator stack and by-pass stack.

Table 4

Predicted vs Observed
Odor Impacts in Downwash Case
Wind Speed Set at 3 m/sec.

Incinerator	ADL Odor Emission Factor o.u./sec.	Briggs Predicted Odor Impact o.u./m^3	Predicted TIA	Observed TIA
1	38,015	34	1.8	1.5
2	176,209	158	2.4	2.0

TABLE 5
CHROME CONTENT

Company	Avg. Flow (MGD)	Current Cond. (lbs/day)	10 mg/l (lbs/day)	5 mg/l (lbs/day)	2 mg/l (lbs/day)
Bob-Kat (P)	.110209	7.21	7.21	4.60	1.8
Bond (P)	.086106	44.3	7.18	3.59	1.4
Fermon (P)	.097565	30.6	8.14	4.07	1.6
Gnecco & Grill (P)	.119812	78.5	9.99	4.995	2.0
JEC (P)	.220374	68.0	18.38	9.19	3.7
Masino (P)	.089921	18.63	7.50	3.75	1.5
Mass Split (P)	.093360	38.15	7.79	3.895	1.5
N.E. Sportswear (P)	.017306	1.2	1.20	.72	0.3
Stahl (P)	.027525	0.8	0.78	.39	0.2
Strauss (P)	.017000	3.0	1.42	.71	0.3
Tan-Rite (P)	.151636	54.1	12.65	6.325	2.5
Victory (P)	.113396	58.4	9.46	4.73	1.9
Creese & Cook(F)(D)	.101053	58.3	8.43	4.215	1.7
Creese & Cook(BH)(D)	.209037	63.0	17.43	8.715	3.5
John Flynn I (S)	.084807	53.8	7.07	3.535	1.4
John Flynn II (S)	.033320	10.0	2.78	1.39	0.6
Mason (S)	.019966	6.6	1.67	.835	0.3
Richard (S)	.062058	1.0	1.0	1.0	1.0
Salem Suede (S)	.314832	183.0	26.26	13.13	5.2
TOTALS	1.969283 (.103646 avg. per co.)	778.6	156.34	79.785	32.4

NOTES: D = Danvers
P = Peabody
S = Salem

8. Provide install and connect 1/2" copper tubing to allow the incinerator operator the option of reconnecting the incinerator draft gauge to any of the draft sensing points on each combustion hearth.

9. Install gas flow test ports in various ducts on both incinerators.

10. Install a wind speed-directional indicator and temperature indicator on a new mast located above the roof of the operations and maintenance building.

11. Install vibration monitors at each induced draft fan.

12. Install optical transmissometers in each stack capable of detecting and recording visible emissions in the stack gases.

13. Revisions to the scum feed system.

These plans were reviewed and approved by the DAQC on May 22, 1980 and June 2, 1980 respectively and September 8, 1980 the DWPC processed a grant adjustment to SESD which provided $530,000 in federal and state funds for the construction of these facilities.

All these modifications have been made with the exception of Item #2, relocation of burners. It was determined after additional discussions with sludge incineration manufacturers that the three large existing burners would not be able to attain the 1,400° required for deodorization. The addition of two more afterburners would be needed to attain the desired tempurature as long as primary effluent continues to be utilized as the scrubber medium. Therefore this additional work did not appear to be of great value and it was removed from the contract.

Both the A.D.L. and DEQE reports concerning odors at SESD indicate that the exhaust gases from the Two (2) ozone chambers contain odorous compounds at concentrations consistently at or above complaint levels. Since these discharges are continuous, the District and the residents considered the correction of this situation of equal importance to the odors emanating from the incinerators. The Department, EPA and the District met on numerous occasions to review the causes and possible correction measures.

The Department insisted that a thorough review of the entire ozone odor control system was necessary before we could consider providing funding for "partial" solutions which may not necessarily be cost effective. The District decided that they could not expend any additional time studying the situation and opted to construct, at their own cost — $370,000 — a 150 foot exhaust stack to which the ozone exhaust gases would be vented. The District retained the service of Malcolm-Pierne, Inc., to design and provide construction services for this project. In December 1980 plans for the system revisions were submitted to the Department for review and were approved on December 31, 1980 and construction was initiated and completed on February 9 and August 27, 1981 respectively. The Department's position with regard to this project was best summed up by Michael Maher of the Metropolitan Boston/Northeast Region - Division Air Quality Control as follows:

"It should be noted, first of all, that the proposed stack height reflects a good engineering practice (GEP) stack height for SESD process vents which is necessary to avoid building downwash. Secondly, that combining the process exhaust volumes would increase the stack exit velocity, thus enhancing the plume rise due to momentum. This momentum rise would also reduce the potential for stack-downwash. However, it should be noted that while the proposed stack modification is necessary to avoid the near-field nuisance conditions, this does not completely eliminate the likelihood of nuisance conditions developing in the far field.

Therefore while the Metropolitan Boston/Northeast Region is of the opinion that the proposed stack modification is consistent with good engineering proctice (GEP) and would consider approving the proposed stack modification as an interim solution to the existing odor conditions, such a modification could not be considered as effective as a method of positive emission reduction for a long-term solution to the existing problem."

As of this date there have not been any significant odor complaints received by the Department since the initiation of operations of the 150foot stack. This situation may or may not continue once sludge conditioning and dewatering is reinstituted since the nature of the exhaust gases may change considerably.

After the DEQE testing program, operations continued without major odor difficulties but the incinerators were shut down for 2 days due to severe vibration in the induced draft fan.

During this period ash continued to be disposed of in the two abandoned grease/grit chambers as approved by the Department on September 14, 1979. This method of disposal was interim in nature pending the development and implementation of a long term disposal plan. During January 1980 the District and the Department performed tests on the incinerator ash and on January 31, 1980 the Department informed the District that the ash had been deemed a hazardous waste due to excessive concentrations of chromium. Again the operation of the incinerators was thrown into a chaotic situation. Luckily the method of interim ash disposal consisted of dumping the ash into sealed concrete vaults. These vaults had enough capacity to last until mid-February which would then again have forced the shut-down of the incinerators. This situation never presented itself because another major disaster befell the facility on February 3, 1980 when the induced draft fan for incinerator No. 1 exploded causing considerable damage to the fan casing and pedestal forcing a complete shut-down of the incinerator.

Bolt Beranek and Newman Inc. (BBN) was retained by Tighe and Bond in June 1980 to provide investigative services relating to the failure of three I.D. fan wheels during plant operation. The failure of the fans is evidenced by cracking of the side ring of the wheel assembly which in one instance led to the separation of a portion of the ring and caused heavy secondary damage to the surrounding structure (see Pictures 1-4).

Induced draft fan wheel with section of side ring that separated during operations.

Induce draft fan wheel with missing section of side ring after separation.

Fan wheel housing badly misaligned due to side ring separation.

Portion of fan wheel which shows welds added to side rings.

Since examination of the cracked surface showed clear evidence of fatigue, a vibration study was conducted to aid in localizing the failure mechanism. A major objective of the BBN investigation was to identify, if possible, the cause of the failure and, in particular, to study the fans' operating environment to see if it could be the reason for the failure.

Experiments conducted with straingauges showed that, when the fan was operated at pressures greater than 27"H_2O, vibratory stresses occurred which were causal factors in the generation of cracks in the side ring. Since the fan is rated at 30" H_2O in this installation, failure will be expected in normal operation. An additional causual factor in the failure is considered to be the high "locked-in" stresses generated by the welding process.

SYNOSPSIS OF WHEEL HISTORY

The fan wheel installed in I.D. #1 casing commenced operation in 1977. A crack was found in its side ring during inspection after 11 hours of plant operation. The wheel was returned to Zurn Clarage, the manufacturer, for the replacement of both side rings. Following repair, this wheel was examined by Arnold Green Testing Labs, Natick, MA, and thence it came to BBN for testing purposes.

A second fan wheel installed in I.D. #1 on June 22, 1979 ran for a total of 2372 hours after which the side ring ruptured causing large unbalance and much secondary damage to the bearing pedestals and fan casing (February 3, 1980).

The fan wheel installed in I.D. #2 casing was found to be cracked on December 27, 1979 following 1220 hours of operation. The cracks were repair-welded at SESD but the process was deemed unsuitable by Zurn and thus the wheel has not been run subsequently.

The District has informed Zurn Clarage and Harvey Construction Corp. that it intends to initiate legal action against all parties concerned unless the I.D. fans are either replaced or rebuilt.

The District was now faced with a situation of having 200-250 tons per day of non-hazardous dewatered sludge but no landfill within New England capable or willing to accept it; an incinerator which cannot operate due to its induced draft fan having exploded; an incinerator needing over $500,000 worth of corrective work to control odor emissions; and an incinerator which even if it could physically operate produces 20 tons per day of hazardous waste which cannot be disposed of legally anywhere within New England; and a treatment plant which is violating its NPDES permit by bypassing sludge into Salem Sound.

Since February 1980 the District has been performing "modified operations" which consist of screening, grit removal, scum collection, and prechlorination on it 26 mgd current wastewater flows. These waste materials are then trucked to local municipal landfills for burial. Sludge collected in their primary clarifiers amounting to approximately 200 tons per day (TPD) based upon dewatering to 20% solids, is being bypassed on outgoing tides through their 1 1/2 mile outfall to Salem Sound, since they are not able to operate the incinerators or land dispose of the dewatered sludge.

Appoximately 1.5 to 2.0% of the District's sludge ash is chromium with 10-30% of the chromium in the more toxic hexavalent state (Cr+6).

Additional ash testing was performd by SESD and Tighe and Bond which determined that the ash after EP testing contained approximately 150-200 milligrams per liter (mg/l) of chromium whereas the maximum allowable concentration established in the May 19, 1980 Resource Conservation and Recovery Act (RCRA) regulations is 5.0 mg/l, total chromium. An EPA rule change (October 30, 1980 Federal Register) revised the toxicity parameter from total to hexavalent chromium. Regardless, essentially all of the chromium in the leachate extract from the EP test is hexavalent chromium.

The problem of ultimate disposal were compounded by the fact that levels of hexavalent chromium in the incineration building were determined to be above those judged safe by the Massachusetts Department of Labor and Industries, Division of Occupational Hygiene (DOH) without special occupational precautions such as full-body protective clothing, full-face resperators or goggles, and very specific housekeeping and sanitation procedures.

Two types of alternative methods of solving the existing problems at SESD were examined:

A. Continued operation of the sludge incinerators with reduction/elimination of the conversion of trivalent chromium to hexavalent during incineration or reconversion of the hexavalent chromium to its non-carcinogenic trivalent form.

B. Elimination of sludge incineration and treatment and disposal of liquid or dewatered sludge by other processes.

Alternate A was further subdivided as follows:

1. Source control such that chromium discharges to the sewer system are reduced or eliminated.
2. Chemical detoxification
3. Thermal Reduction (Procedyne)
4. Pyro-Magnetics
5. Stablex
6. Chemfix
7. Stabatrol
8. Disposal of the hazardous ash in a hazardous waste landfill.

1. Source Control - The major chromium dischargers within the District are the tanneries. There are currently eighteen (18) tanneries located in three communities, Peabody, Salem, and Danvers, which discharge chromium contaminated wastewater. The District has instituted a very thorough sampling and analysis program at all the tanneries and is expected to complete a pretreatment program by December 31, 1982.

   It has been calculated that the maximum 5 mg/l hexavalent chromium limit could be attained by allowing no more than four (4) pounds per day of hexavalent chromium in the 20 tons per day of sludge ash. Utilizing this maximum base figure of four pounds, an analysis was performed to determine the level of pretreatment needed by the tanneries in order to meet this theoretical figure. Table 5 shows a listing of all the tanneries within the District which produce chromium laden wastewater.

   Columns 1 and 2 list the current average wastewater flows and chromium content from each of the industries; Columns 3, 4, and 5 list the pounds per day of chromium that would be discharged to the sewer system based upon three (3) levels of pretreatment (10 mg/l, 5mg/l, and 2mg/l of total chromium). EPA is still developing their draft pretreatment guidelines for tanneries and final regulations are expected to be issued in late November 1982 but it appears at this time that the limit on chromium discharges to a municipal sewer system will be in the range of 5 to 7 mg/l and will allow special exemptions for small discharges, space limited facilities and those with financial difficulties.

   Taking the total pounds per day (ppd) of chromium from Table 5 based upon a 2 mg/l chromium pretreatment limit (substantially more stringent than the expected EPA requirements) and then assuming an 87* percent chromium capture of the 32.4 ppd of chromium in the sludge at the District's treatment plant we get 28.2 ppd (32.4 x .87). Current conversion rates during incineration from trivalent to hexavalent are typically between 10 and 30 per cent. Using a very conservative 15 percent conversion rate, 4.23 ppd (28.2 x .15) of hexavalent chromium is still contained in the sludge ash. In theory, this ash after EP toxicity testing would still be catagorized as a hazardous waste. It must be emphasized that a number of important assumptions entered into these calculations such as:

   1. The total tonnage of ash remains at 20 tpd. Any reduction in this figure would lower the 4 ppd limiting number. In fact, the District knows that the largest single contributor of solids to the District, Eastman Gelitan will soon be substantially reducing their load.

*current capture rate at SESD

This anticipated solids removal will lower the 4 ppd to at least 3 and more likely 2 ppd.

2. Most of the chromium leaving the pretreatment facilities is in the insoluble form. The more soluble the chromium the lower the capture rate at the District's primary treatment plant. It is certain that a percentage of the chromium will be soluble and will not be captured, although the exact percentages cannot be determined due to lack of knowledge of the type of pretreatment facilities to be constructed and their removal efficiencies.

3. Pretreatment systems would be fail-safe and not subject to periodic chromium discharges above the 2 mg/l limit. It has been shown that such systems are in fact not fail-safe and a plant upset of once per month is not unusual. Since the District would be potentially dealing with eighteen (18) separate pretreatment facilities, it could expect 18 discharges per month above the maximum 2 mg/l limit.

The tanneries have average flows approximating 100,000 gallons per day (gpd) with a high and low of 300,000 and 20,000 gpd respectively. In order to reduce the chromium level to 2 mg/l the following unit processes would probably be necessary; flow equalization, screening, maceration, flocculation, clarification, chemical feed systems, and sludge dewatering.

The captial cost to construct each of the 100,000 gallon pretreatment facilities has been estimated at $400,000, all costs being borne by the industry. This would relate to a total pretreatment cost (capital only) of $7,200,000 for the 18 tanneries. Operation and maintenance (O&M) costs have been estimated at $80,000 per year for each of the 18 facilities which equates to a present worth for O&M of $15,100,000. The total present worth cost for both capital and O&M is $22,300,000.

Therefore, it was determined that pretreatment would not solve the problems of hazardous waste production at SESD. The only type of source control which could solve the problem is the closure of any tannery which has a chromium tanning process or a conversion to non-chromium tanning.

After a review of the types of materials tanned in the affected industries, it has been determined that use of a non-chromium process such as zirconium, alum, or vegetable agents is not possible since those processes are only good for glove tanning, which is not a principal market for the tanning industry on the North Shore. The affected tanneries employ over 1,400 local people and provide work to other related local industries.

2-7 Treatment Alternatives - Table 6 is a comparison of alternatives 2 through 7 with regard to costs. These alternatives were subsequently reduced to Chemical Ash Detoxification and Thermal Reduction. Stabatrol was excluded due to the fact that the hazardous ash would have to be trucked to treatment and disposal sites in either New Milford, Connecticut or York, Pennsylvania which is not a feasible long-term solution. Regulations and prices change frequently and if shipments were prohibited or Stabatrol was forced to discontinue or reduce their services for any reason, the District would not have a back-up system. Chemfix was also exluded due to its extremely high cost as indicated on Table 6. The Stablex system has similar disadvantages as the Stabatrol system and currently has no operational facilities within North America although construction has started on facilities in Louisiana and Michigan. Pyro-Magnetics was exluded due to its high energy use and the fact that it must be run around the clock to maintain a molten bath.

8. Hazardous Waste Landfill - At the current time there are no approved hazardous waste landfills in New England and none are expected to be in operation within the next five (5) years capable of handling the large volumes of hazardous ash produced at SESD.

   The District also examined the possibility of transporting the hazardous ash to an existing hazardous waste facility outside the New England area. This alternative was quickly ruled out due to the fact that the 20 to 26 tons per day of hazardous ash would have to be trucked through high density residential areas to a facility as far away as Ohio.

Alternative B was further subdivided as follows:

1. Direct Land Application of stabilized sludge.
2. Composting with distribution of stabilized compost.
3. Landfilling of dewatered sludge
   a. separate sludge landfill
   b. co-disposal with municipal refuse
4. IGT anaerobic sludge digestion and residue disposal.
5. Ocean disposal of sludge.

1. Land Application - This alternative was determined to be non-viable due to the tremendous volumes of sludge to be land applied (200 TPD) and the excessively large land areas required which are not available within the District's boundary. Also, compliance with the mandatory RCRA regulations regarding stabilizing of the sludge prior to land application would necessitate major revisions to the existing sludge processing system.

TABLE 6 - COST ESTIMATES FOR ASH TREATMENT AND DISPOSAL

	Stabatrol $	Chemfix $	Stablex $	Pyro-Magnetics $	Thermal Reduction (Procedyne) $	Chemical Ash Detoxification $
Estimated Costs						
A. Capital Cost	79,300		79,300	2,774,000	5,150,000	3,700,000
B. Annual O&M	945,000		1,155,000	830,000	500,000	805,000
C. Salvage Value	12,200		12,200	427,000	792,000	570,000
Present Worth Comparison						
D. Cap. Cost Less Present Worth of Salvage Value	76,200		76,200	2,666,000	4,950,000	3,556,000
E. Present Worth of Annual O&M	9,915,000		12,118,000	8,708,000	5,246,000	8,446,000
F. Total Present Worth	9,991,200		12,194,200	11,374,000	10,196,000	12,002,000
Equivalent Annual Cost Comparison						
G. Equivalent Annual Capital Cost	7,300		7,300	254,000	470,000	340,000
H. Annual O&M	945,000		1,155,000	830,000	500,000	805,000
I. Total Equivalent Annual Cost	952,300		1,162,300	1,084,000	970,000	1,145,000
J. Cost per Ton	136	230*	166	155	139	164

*Chemical costs only

Composting - This method of sludge stabilization was examined twice, once by the Clean Communities Corporation and later by Tighe & Bond. Tighe & Bond estimated that a static pile composting facility would require a 29 acre parcel of land and would have a capital cost of between $10 and $11,000,000 and annual O&M costs of between $1,140,000 and $2,875,000. Due to these high costs, large land area requirements and questionable distribution of the final compost, this alternative has been deemed non-implementable.

3a. Separate Sludge Landfill - Metcalf & Eddy consulting engineers prepared a report for the District dated April 5, 1974, which examined possible disposal areas within the District's boundaries. Nineteen (19) possible sites were examined for the disposal of various waste materials from the treatment plant (grit, screenings, scum, and sludge ash). None of these sites were found to be feasible for use as landfill areas. These sites were again re-evaluated by the District in 1978 and 1979 and again were found not to be viable. The original 1974 report estimated the need for a 66 Acre-foot site for 10 years of disposal of sludge ash at 20 TPD. A sludge landfill approximating 700 Acre-feet would be required based upon the production of 200 TPD of 20% solids from the treatment plant. The enormity of the 200 TPD figure can be better comprehended when one compares that figure to the daily tonnage of all refuse (residential or commercial) collected within the City of Peabody (population of 47,000) which is only 180 TPD. Between 1974 and 1979 The Department attempted on various occasions to find an environmentally and politically acceptable site for landfilling the sludge but was also unable to find one.

In 1982 Tighe & Bond reexamined the possibility of a sludge only landfill. They estimated that a 155 acre site would be required for 20 years of landfilling at a capital cost of between $21 and $28,000,000 and an annual O&M cost of $1,130,000 to $1,145,000. This alternative also appears to be unacceptable due to the excessive land area and capital costs.

3b. Co-Disposal of Sludge and Refuse - In order to effectively and safely dispose of sludge at a refuse landfill, the Commonwealth of Massachusetts mandates that the sludge be dewatered to at least 18% solids and be mixed into the working face in a ratio not to exceed 1 part sludge to 3 parts refuse. At 200 TPD of sludge, this would require 600 TPD of refuse. There are no refuse landfills within the Distict's boundaries which are approved for disposal of more than 300 TPD of total disposable material. Therefore, co-disposal was dropped from further consideration.

4. Institute of Gas Technology (IGT) process - IGT has performed benchscale testing of sludge from the District and has detemined that it may be possible to anaerobicly digest their sludge using a patented two-stage process. They are attempting to obtain long-term funding to perform additional laboratory work and then consruct at SESD a full scale pilot plant. The estimated cost for this work is $900,000 and would span a three (3) year period. As of this date, funding has not been forthcoming. It is, therefore, uncertain whether the pilot facility will be constructed and the District would still be faced with the disposal of fairly large volumes of digested sludge. The viability of a full scale facility capable of treating all the sludge generated from SESD is dependent upon the outcome of this 3-year study, therefore, at this time it cannot be considered a viable alternative.

Chemical Detoxification - This process was developed by the Chief Chemist at SESD in the Spring of 1980 and utilizes conventional chemistry methods to reduce the hexavalent chromium to its stable trivalent form. This is accomplished by slurrying the incinerator ash and adding specific concentrations of ferrous sulfate and sulfuric acid to reduce the chromium. Lime is then added to raise the pH to produce relatively insoluble chromium hydroxide and iron hydroxide.

Extensive laboratory testing was then performed which verified that this method would consistently produce an ash which, when subjected to the EPA Extraction Procedure Test, showed concentrations of chromium less than 1 mg/l.

From November 17 to November 25, 1980 pilot testing was performed by Tighe & Bond at the District. The pilot plant was located in the existing ash truckway on the westerly side of the sludge process building and a schematic of the equipment layout for the pilot plant is shown in Figure 8. All work associated with this testing was eligible for 90% federal/state grants through the Construction Grants Program.

During the bench scale and pilot testing program three (3) separate reports dated January, March and October 1981 were prepared by Tighe & Bond and were distributed through DWPC to over ten (10) individuals representing five (5) sections within the Department and four (4) individuals representing three (3) branches at EPA.

One of the objectives of the initial testing was to identify the chemical composition of the incinerator ash. Only a limited quantity of dry ash was available for use in this study and all of it came from the incinerators when they were shut down on February 2, 1980.

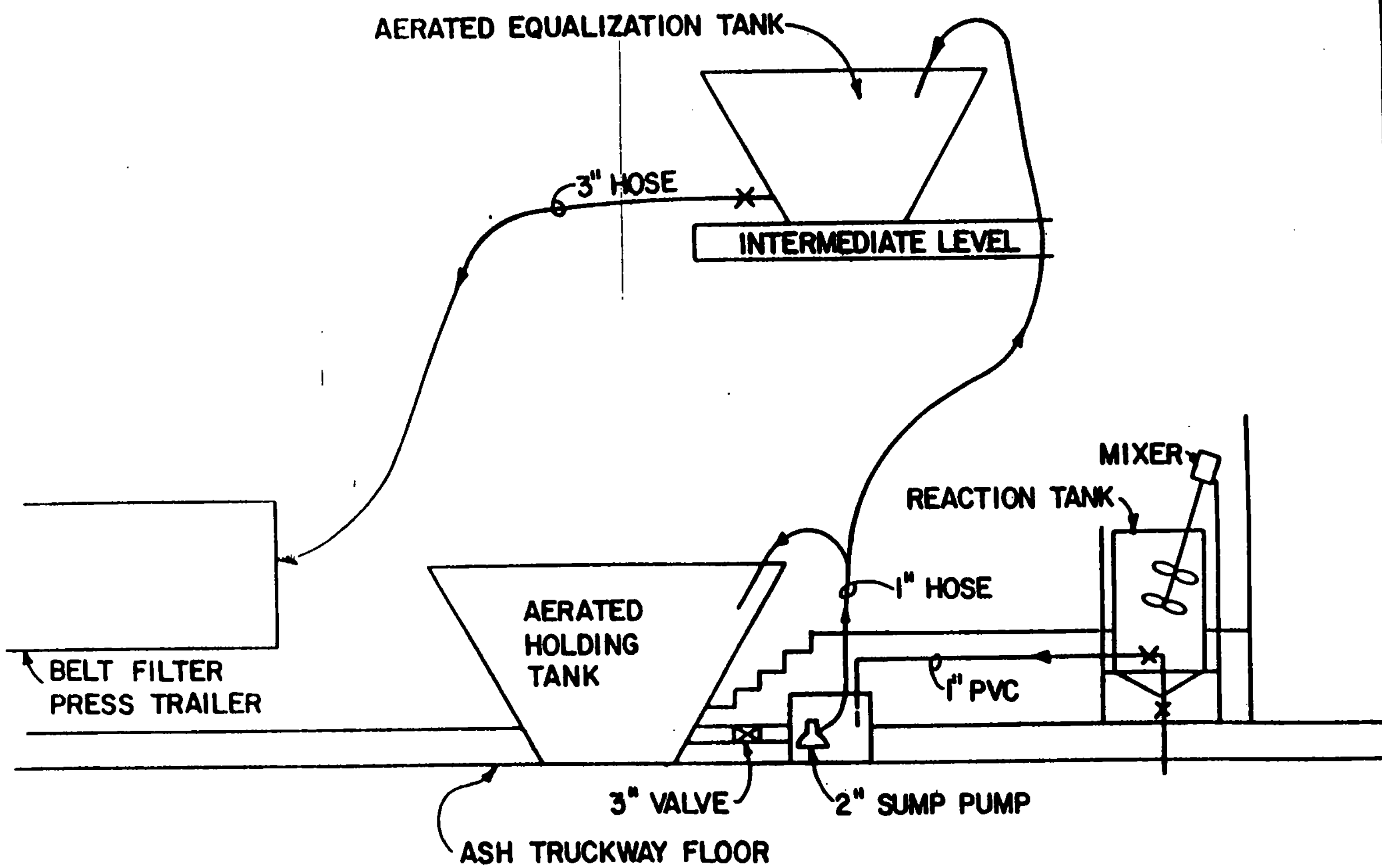
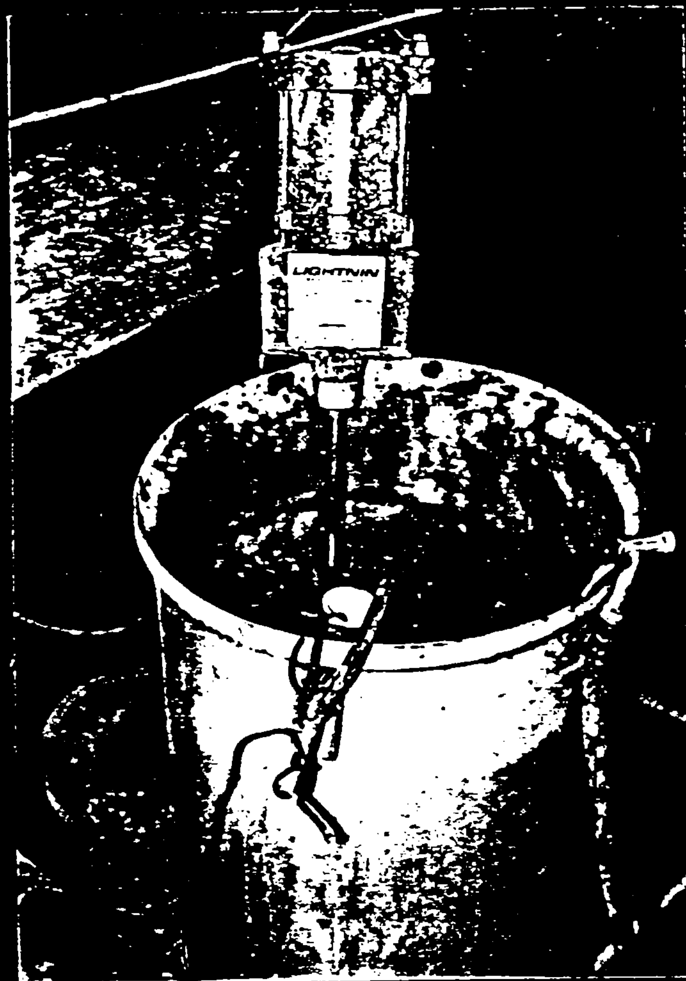


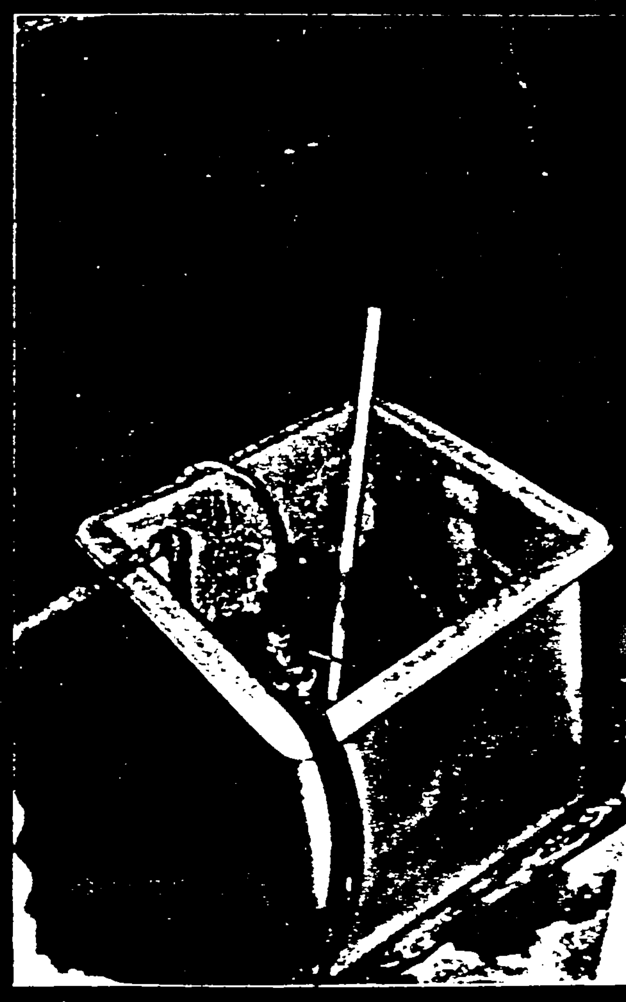
FIGURE 8

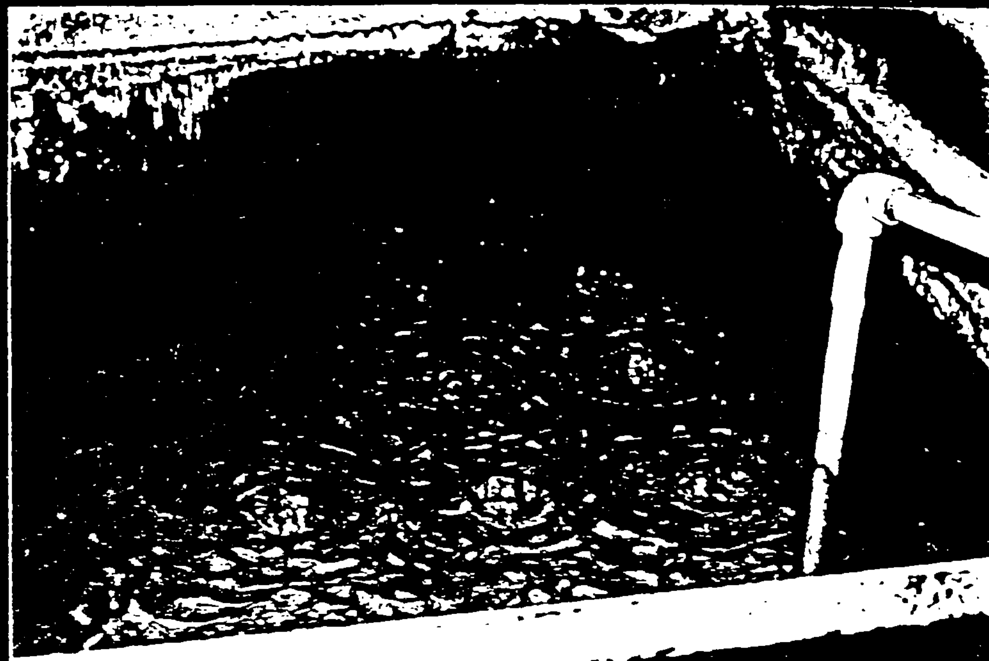
SCHEMATIC PILOT PLANT
ASH DETOXIFICATION

SOUTH ESSEX SEWERAGE DISTRICT



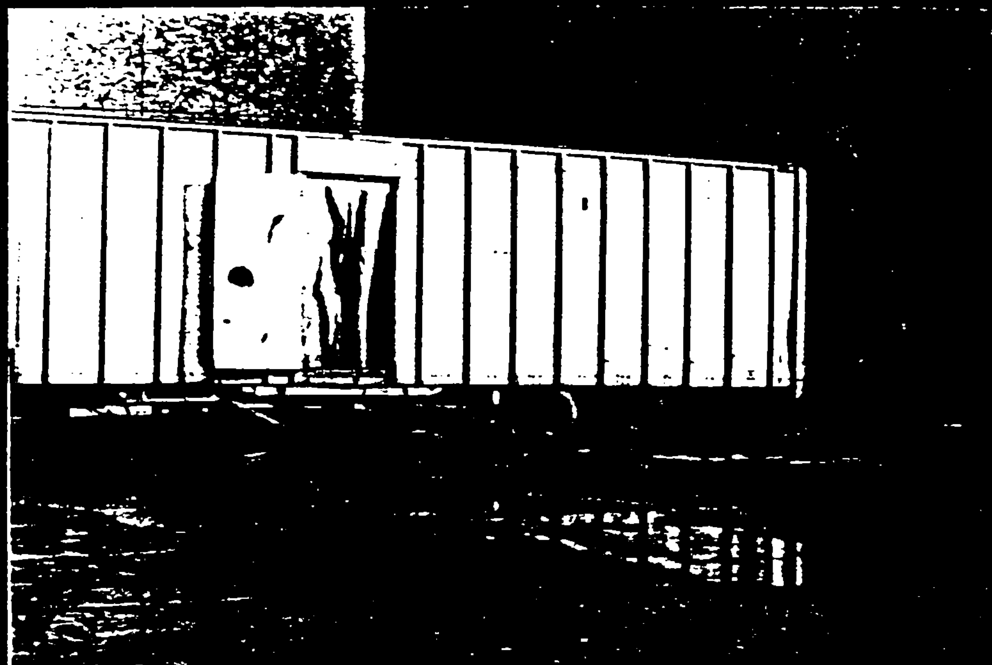
Mixing and holding tanks utilized during the chemical detoxification pilot plant operations.





Mixing and holding tanks utilized during the chemical detoxification pilot plant operations.

Trailer holding self-contained portable 1/2 meter belt filter press.



Dewatered chemical detoxified ash-exiting from belt filter press.

The available historical data regarding the composition of the ash is shown in Table 7. Most of the parameters analyzed are relatively consistent, with the exception of a few unusually high or low test results.

The ash was analyzed in the Tighe & Bond/SCI laboratory using both wet chemistry and atomic absorption methods and also by a Scanning Electron Microscope (SEM) at Worcester Polytechnic Institute in Worcester, Massachusetts. The data produced by the analysis on the Scanning Electron Microscope was limited in that it could not identify elements or concentrations of elements with an atomic number of 1 through 10. Although it is hypothesized that oxygen forms many of the compounds present in the ash, the total concentration of oxygen could not be identified by the SEM because the atomic number for oxygen if 8.

A listing of the concentrations of the elements identified by the ash analysis is presented in Table 8 . This data represents a combination of the results of the analysis performed by the wet chemistry, atomic absorption and Scanning Electron Microscope methods. In those cases where an element was identified by more than one procedure, the average concentration is shown in the table. The concentrations of all of the elements may vary significantly in the future depending on the industries in the service area and extent and type of pretreatment. Also, there may be elements that appear in the ash periodically that have not been identified by the analyses performed during this study.

The elements listed in Table 8 account for less than 50% of the total ash composition. It is assumed that the remainder of the ash composition by weight consists primarily of simple and complex compounds containing oxygen for the elements listed above. It is important to stress that the ash composition presented in Table 8 represents analysis of the ash present in the incinerators on one particular day. The concentrations of all the elements listed will undoubtedly vary with time.

Physically, the ash is a very fine particulate substance. A sieve analysis and unit weight of the ash are presented in Table 9 . This analysis does not indicate the clinkers and large particles which were observed in the ash during the operation of the pilot plant. The largest dimension of these particles was approximately 1 inch and they appeared to account for approximately 1-2 percent of the total weight of the ash.

Table 7

SESD LABORATORY ANALYSIS OF INCINERATOR ASH (dry weight basis)

DATE	Calcium Ca %	Chromium Cr_T %	Iron Fe %	Zinc Zn ppm	Lead Pb ppm	Copper Cu ppm	Nickel Ni ppm	Cadmium Cd ppm
3/6/79		1.35						
3/21/79		1.01		810			47	26
4/10/79		2.04		900	552		53	40
4/20/79		2.08	1.16	890			58	42
5/4/79		1.65		560			82	32
5/10/79		1.19		520	285	25	39	17
5/26/79	26							
5/30/79	27			590	460		60	48
6/5/79		0.93						
7/10/79	24	1.53			380	370	57	49
10/22/79	28	1.94		800	400	380	520	51
12/28/79	30	1.54	1.19	700	386	395	70	45
1/21/80		1.82		598		340	93	35
1/2/80	22	1.65	1.02	650	60	300		37

Table 8

COMPOSITION OF ASH[1]

ELEMENT		CONCENTRATION (%)
Calcium	Ca	21.00
Silicon	Si	7.16
Phosphorus	P	5.28
Chromium	Cr	1.71
Molybdenum	Mo	1.29
Iron	Fe	1.14
Aluminum	Al	1.08
Sulfur	S	0.58
Chlorides	Cl	0.51
Titanium	Ti	0.51
Magnesium	Mg	0.50
Potassium	K	0.27
Manganese	Mn	0.19
Zinc	Zn	0.06
Copper	Cu	0.03
Lead	Pb	0.006
Cadmium	Cd	0.004
Silver	Ag	0.0005
		Total = 41.33%[2]

Notes: (1) Ash obtained from incinerator on February 2, 1980

Table 9

SIEVE ANALYSIS & UNIT WEIGHT
INCINERATOR ASH

Unit Weights:	Poured	34 lbs/ft^3
	Fluidized	22 lbs/ft^3

Sieve Size No.	Opening (micrometers)	Opening (inches)	% Passing
30	600	0.0234	98.84
40	425	0.0165	98.39
50	300	0.0117	97.62
60	250	0.0098	97.02
70	212	0.0083	95.42
200	75	0.0029	22.14

During the first phase of the pilot plant operation, approximately 2,000 pounds of dry incinerator ash were processed on a batch basis in the pilot plant and stored in the large aerated holding tank. Once a sufficient amount of slurry had been treated, it was transferred to the equalization tank on the intermediate level and processed on the belt filter press. Two runs, each approximately 1 1/2 hours long, were made on the belt filter press with the treated slurry from the dry incinerator ash. Approximately 1,000 pounds (on a dry weight basis) of the ash from the Peabody pits was also processed in the pilot plant, stored in the holding tank and dewatered on the belt filter press.

Results - Samples of the dewatered ash cake from the belt filter press were tested in accordance with th E.P. Toxicity test requirements and were analyzed for chromium at both the Tighe & Bond/SCI laboratory and at the District's laboratory. The results of these tests are shown in Table 10.

The results of the pilot plant work clearly indicated that the ash could be effectively treated.

Full Scale Facility - Design Criteria and Proposed Facilities

The major design and process requirements for a full-scale continuous flow ash teatment system are shown schematically in Figure 9.

Thermal Reduction - The applicability of a thermal reduction treatment process for the detoxification of the South Essex Sewerage District incinerator ash was initially evaluated during the prepartation of the January 1981 Report on the chemical treatment process prepared by Tighe & Bond. Further study of the thermal reduction process was conducted because of its apparent low operation and maintenance costs when compared to the cost of the chemical treatment process.

The thermal reduction process achieves the reduction of hexavalent chromium by exposing the ash at high temperatures to a reducing gas. A temperature of 1400°F was selected for the initial tests. The reducing gas atmosphere during the preliminary tests was achieved by the use of carbon monoxide during one set of tests and the starved air combustion of charcoal during the second set of tests.

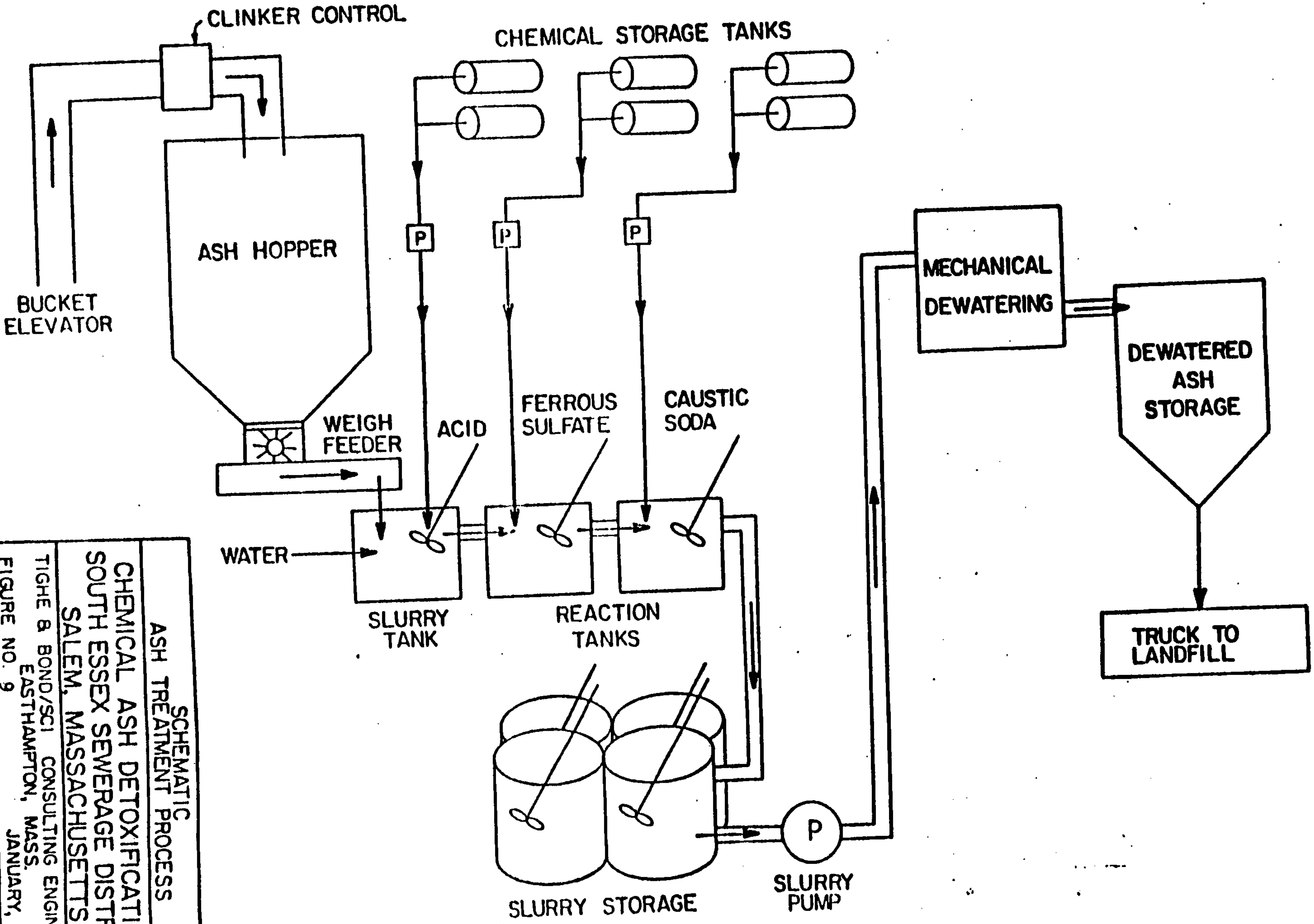
Bench-Scale Testing - Two sets of tests were conducted using the ash from the SESD incinerators. Both sets of tests were conducted at a temperature of 1400°F, with samples of the treated ash taken at the end of 1, 2 and 4 hours of treatment.

TABLE 10

Results of Pilot Plant Operation

Source of Ash	E.P. Toxicity Test Results: Total Chromium (Cr_T)	E.P. Toxicity Test Results: Hexavalent Chromium (Cr^{+6})
Incinerators - Feb. 2, 1980		
Tighe & Bond/SCI	less than 0.1 mg/l	less than 0.1 mg/l
SESD laboratory	less than 0.1 mg/l	(1)
Peabody Pits		
Tighe & Bond/SCI	less than 0.1 mg/l	less than 0.1 mg/l
SESD laboratory	less than 0.1 mg/l	(1)

Note: (1) Hexavalent Chromium not measured at SESD laboratory



SCHEMATIC
ASH TREATMENT PROCESS

CHEMICAL ASH DETOXIFICATION
SOUTH ESSEX SEWERAGE DISTRICT
SALEM, MASSACHUSETTS

TIGHE & BOND/SCI CONSULTING ENGINEERS
EASTHAMPTON, MASS.
FIGURE NO. 9 JANUARY, 1981

The two sets of tests consisted of the following:

1. Fluidizing an externally heated bed of ash using carbon monoxide.

2. Fluidizing an internally heated bed of ash and pulverized charcoal using ambient air.

During both sets of tests, an external source of heat was used to heat the bench-scale reactor. The chromium levels in the ash were measured and the treated ash samples were subjected to the E.P. Toxicity Test, the results of which are summarized in Table 11.

During August 1981, Procedyne conducted over 30 tests in their laboratory using a 6" diameter fluidized bed pilot plant unit. The tests were conducted to evaluate the feasibility and effectiveness of various sources of reducing gas to convert (reduce) the hexavalent chromium in the ash to its trivalent form. Treatment parameters evaluated were reaction time, temperature and the concentration and types of reducing gases. More than 120 samples of treated ash were generated by the first set of tests. The samples were shipped to the Tighe & Bond/SCI laboratory for analysis of the E. P. Toxicity Test filtrate for total and hexavalent chromium.

Procedyne refined their procedures so that they were able to produce repeatedly a treated ash that would pass the E. P. Toxicity Test with a total chromium concentration in the filtrate of less than 0.2 miligrams per liter (mg/l).

Procedyne proceeded to complete the laboratory testing work during September 1981. Forty additional tests were conducted to confirm the previous results and to refine the process parameters. This second set of tests produced another 150 samples of treated ash that were tested at the Tighe & Bond/SCI laboratory.

The work conducted by Procedyne indicates that the ash can be detoxified successfully using a wide range of reaction times and reducing gas mixtures. Recent testing also indicates that a reaction temperature of 1200°F is adequate, rather than the 1400°F temperature at which the initial work was conducted.

The results of a typical test conducted at 1400°F by Procedyne are shown in Table 12. The results of this test are typical of the successful tests. There were very few "marginal" tests, most of the successful tests produced chromium levels of less than 0.2 mg/l in the E. P. Toxicity test filtrate.

Procedyne also conducted extensive tests at an operating temperature of 1200°F. The data from some of the tests that are representative of the proposed process are included in Table 13. Since essentially all of the chromium extracted from the treated ash during the E. P. Toxicity Test was in the hexavalent form, only the concentration of total chromium in the filtrate is shown in the Table. In many cases, the concentration of total chromium was so low that the filtrate was not analyzed for hexavalent chromium.

TABLE 11
THERMAL REDUCTION TEST RESULTS

Type of Treatment	Treatment Time	Treated Ash[1] Cr_T	Treated Ash[1] Cr^{+6}	E.P. Toxicity[2] Test Filtrate Cr_T	E.P. Toxicity[2] Test Filtrate Cr^{+6}
A. Charcoal	1 hr.	3600	30	0.4	N.D.
"	2 hr.	2800	30	2.7	N.D.
"	4 hr.	3000[3]	160[3]	0.4[4]	N.D.[4]
B. Carbon Monoxide	1 hr.	---	---		
" "	2 hr.	9000	N.D.		
" "	4 hr.	8350[3]	N.D.[3]	0.5[4]	0.03[4]
C. Untreated Ash	---	12000[4]	1800[4]	165	165

Notes:
(1) Concentration in mg/kg; (2) Concentration in mg/l; (3) Average of 3 tests; (4) Average of 2 tests; N.D. = Not detectable

TABLE 12

Fluidized Bed Thermal Reduction Test Results
1400°F

E.P. Toxicity Test Filtrate(1)		Reaction Time (Minutes) 15	30	45	60
Total Chromium	Cr_T	0.063	0.052	0.052	0.043
Hexavalent Chromium	Cr^{+6}	0.025	0.022	0.027	0.022
Arsenic	As	0.009	0.005	0.005	0.005
Barium	Ba	0.68	0.75	0.80	0.71
Cadmium	Cd	0.02	0.02	0.02	0.02
Lead	Pb	0.3	0.1	0.1	0.1
Mercury	Hg	0.002	0.002	0.002	0.002
Selenium	Se	0.005	0.005	0.005	0.005
Silver	Ag	0.05	0.05	0.05	0.06
E.P. Toxicity Test Acidification Req't.					
Acetic Acid (2N) (ml)		125	135	125	100

Note: (1) All E.P. Toxicity Filtrate concentrations are mg/l.

Table 13

Fluidized Bed Thermal Reduction Test Results

1200°F

Procedyne Test No.	Total Chromium in E.P. Filtrate (mg/l) Reaction Time (Minutes) 10	20	30	45	60
39	3.72	0.07	0.22	0.05	0.14
64	0.07	0.13	0.84	0.06	0.05
70	0.41	0.33	0.71	0.11	0.08
72	0.60	0.57	0.76	0.05	0.06
74	0.34	0.07	0.50	0.06	0.04

Basically, the ash is detoxified by exposure to a gas stream, which consists primarily of nitrogen, with relatively low levels of carbon monoxide (CO), hydrogen (H_2) and carbon dioxide (CO_2) See Figure 10. The gas stream is recycled to conserve gas and to eliminate significant discharges of waste gases to the atmosphere. A small stream of carbon monoxide, hydrogen and nitrogen is added to the recycled gas stream to supplement the reducing gases consumed in the reactions in the fluidized bed reactor. Since carbon dioxide is one of the products of the reaction of the detoxification process, the level of carbon dioxide in the recycled gas stream is also monitored and purged as required to maintain the desired levels.

Procedyne developed the following preliminary design criteria for the proposed treatment process:

Ash Flow Rate:	1500 - 3000 pounds per hour
Reaction Temperature:	1200 - 1400°F
Average Residence Time:	1 hour*
Reducing Gas Requirement:	260 cubic feet/hr. of natural gas* (for conversion with air to form carbon monoxide, hydrogen and nitrogen)

The process developed by Procedyne provides for the separation of the following three primary operating parameters:

1. Reducing gas concentration & feed rate
2. Fluidizing gas rate
3. Reactor temperature

Although the fluidizing gas and the reducing gases enter the reactor in a single stream, the blower on the gas recycle system will be used to control the flow rate of the fluidizing gas in the reactor. Instrumentation will be used to control the addition of carbon monoxide and hydrogen make-up gases. The heat required by the reaction will be provided by an electrically heated jacket surrounding the fluidized bed reactor. An electrically heated jacket was selected because of the superior heat transfer efficiencies of an electrical system over combustion heating systems.

In order to provide standby equipment, two parallel trains of equipment will be installed. Each train will be capable of detoxifying all of the ash produced by the operation of one incinerator.

*Based on an average ash flow rate of 2000 lb/hr.

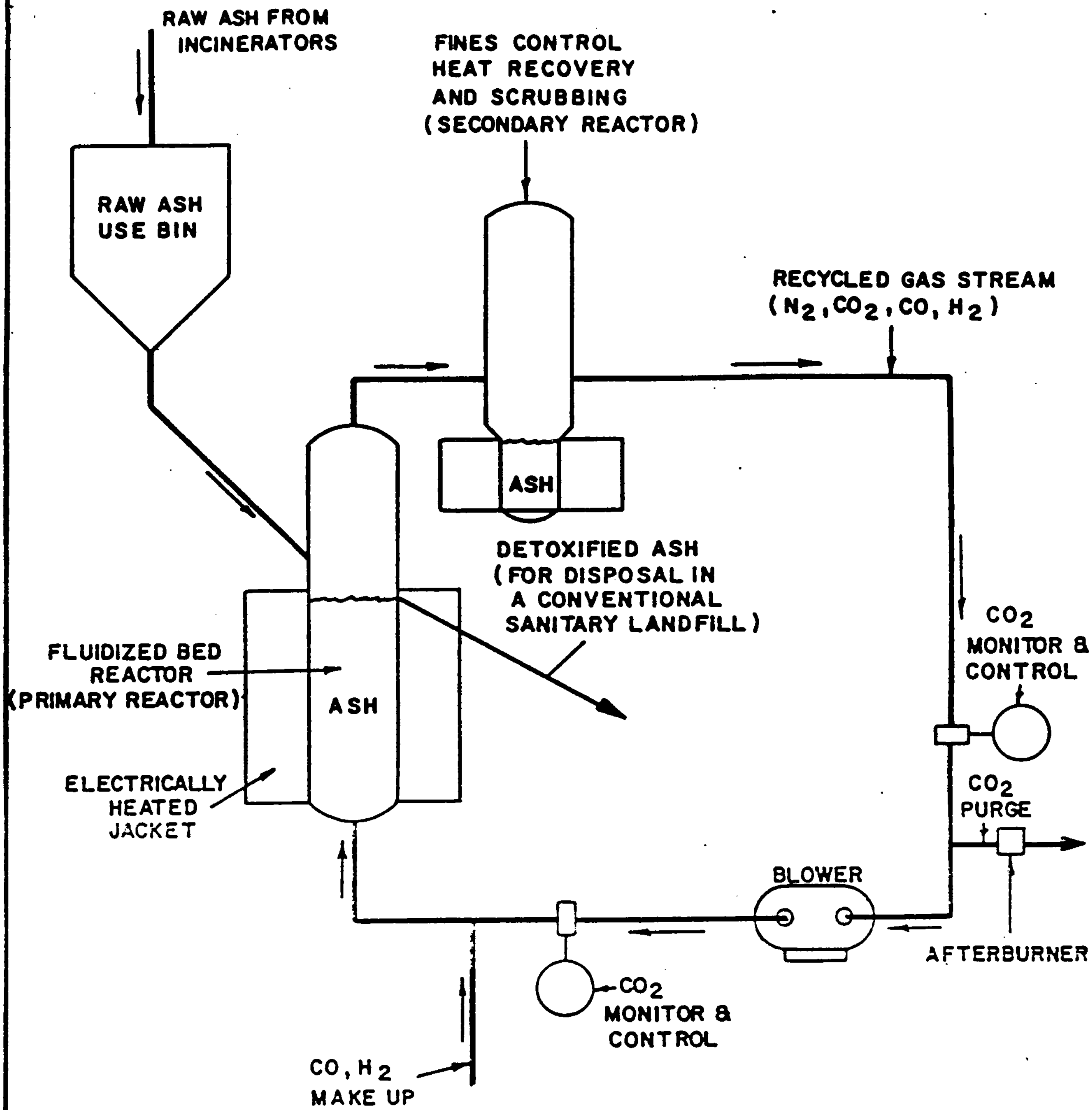


FIGURE 10

SCHEMATIC FLUIDIZED BED THERMAL REDUCTION PROCESS

SOUTH ESSEX SEWERAGE DISTRICT

The originally proposed Thermal Reduction Process was based on the partial combustion of an ash and coal mixture in a fluidixed bed reactor under a starved air mode. As a result of further testing and process development work conducted by Procedyne, a gas closed-loop on-site system is proposed in lieu of the combustion system.

Although treatment facilities for the detoxification of municipal sludge incinerator ash have never been designed or constructed before, the process and equipment currently proposed are not unique. All of the system components are commercially available and in use for a variety of manufacturing operations.

The full-scale fluidized bed thermal reduction facility will be housed in a building addition to the existing Sludge Process Building, as indicated in Figure No. 11. The addition will be approximately 70' by 36', with an overall height from basement to roof line of 52'. The addition will house the raw ash use bins, fluidized bed reactors and appurtenances and the pneumatic conveying system vacuum units.

Table 14 includes a comparison between the current project cost estimates and the projections included in March 1981 Tighe & Bond Report. Two sets of estimated costs are shown for the thermal reduction and wet chemical methods of treatment that were repeated from the March 1981 Report. The first set includes the costs as they appeared in the March 1981 Report while the costs included in the second set have been adjusted to reflect anticipated increases in landfill disposal costs. The landfill disposal rate utilized in the March 1981 Report was $6.50 per ton of material, whereas it is curently anticipated that the disposal rate may be $13.00 per ton.

The estimated costs in Table 14 indicate that the current estimate of the capital cost of the proposed thermal reduction ash detoxification facility is more than the cost estimated in March 1981. However, the projected operation and maintenance costs are less than the March 1981 estimates. As a result, the current equivalent annual cost estimate, based on th total capital cost and O&M cost, is essentially the same as the March 1981 estimate ($134/ton vs. $132/ton).

However, the equivalent <u>local</u> cost per ton is currently estimated at $60 per dry ton of ash, whereas the update March 1981 estimate is $71 per ton. In both cases, the annual cost for thermal treatment is substantially less than the cost for wet chemical treatment.

In October, 1981 construction plans and specifications for the ash detoxification facility were hand transmitted to the Department and the Army Corps of Engineers for reivew and approval. On November 4, 1981 The Army Corps deemed the project biddable/constructable, on November 6, 1981 the Division of Water Pollution Control approved the contract documents, and on November 13 the EPA issued a Step 3 grant award to SESD. The combined Federal/State Step 3 grant for the construction of this facility amounted to $5,264,000.

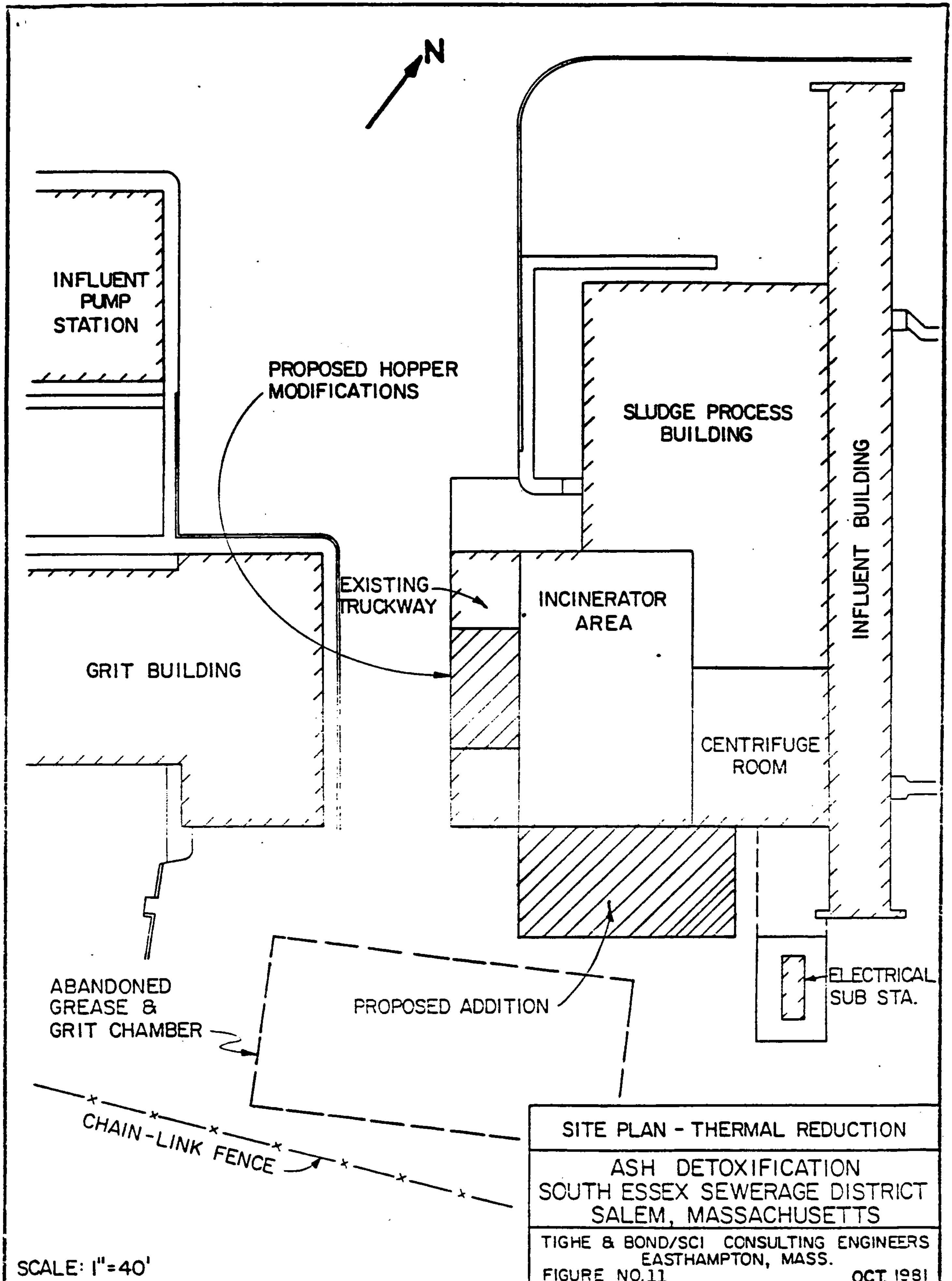

N
INFLUENT PUMP STATION
PROPOSED HOPPER MODIFICATIONS
SLUDGE PROCESS BUILDING
INFLUENT BUILDING
EXISTING TRUCKWAY
INCINERATOR AREA
GRIT BUILDING
CENTRIFUGE ROOM
ABANDONED GREASE & GRIT CHAMBER
PROPOSED ADDITION
ELECTRICAL SUB STA.
CHAIN-LINK FENCE
SITE PLAN - THERMAL REDUCTION
ASH DETOXIFICATION
SOUTH ESSEX SEWERAGE DISTRICT
SALEM, MASSACHUSETTS
TIGHE & BOND/SCI CONSULTING ENGINEERS
EASTHAMPTON, MASS.
FIGURE NO.11
OCT. 1981
SCALE: 1"=40'

Table 14
Cost Comparison
Thermal Reduction vs. Wet Chemical Treatment

Estimated Costs	Thermal Reduction (October 1981)	Thermal Reduction (March 1981)	Thermal Reduction Updated (3)	Wet Chemical (March 1981)	Wet Chemical Updated (3)
A. Capital Cost	$6,090,000	$5,000,000	$5,000,000	$ 3,200,000	$ 3,200,000
B. Annual O&M	380,000	400,000	465,000 (3)	770,000	870,000 (
C. Salvage Value	850,000	670,000	670,000	500,000	500,000
Present Worth Comparison					
D. Capital Cost less Present Worth of Salvage Value	5,880,000	4,830,000	4,830,000	3,070,000	3,070,000
E. Present Worth of Annual O&M	3,990,000	4,200,000	4,880,000 (3)	8,080,000	9,130,000 (
F. Total Present Worth	9,870,000	9,030,000	9,710,000 (3)	11,150,000	12,200,000 (
Equivalent Annual Cost Comparison					
G. Equivalent Annual Capital Cost	560,000	460,000	460,000	290,000	290,000
H. Annual O&M	380,000	400,000	465,000 (3)	770,000	870,000 (
I. Total Equivalent Annual Cost	940,000	860,000	925,000 (3)	1,060,000	1,160,000 (
J. Cost per Ton, Equivalent Costs	134	123	132 (3)	151	166 (
Equivalent Annual Local Cost					
K. Local Capital Cost (2)	365,000	300,000	300,000	192,000	192,000
L. Equivalent Annual Local Capital Cost	35,000	29,000	29,000	18,000	18,000
M. Annual O&M	380,000	400,000	465,000 (3)	770,000	870,000 (
N. Total Equivalent Annual Local Cost	415,000	429,000	494,000 (3)	788,000	888,000 (
O. Cost per Ton, Equivalent Local Cost	60	61	71 (3)	113	127 (

(1) Capital and O&M costs reflect only 2 treated ash slurry tanks, rather than the 4 tanks outlined in the January 1981 Report.
(2) Based on 94% EPA and State funding for Innovative/Alternative projects.
(3) Annual O&M Cost adjusted to include anticipated increase in landfill disposal costs from $6.50/ton to $13.00/ton.

This contract includes the following pieces of equipment and process revisions:

1. Thermal Reactor -

The principal components of the thermal reduction ash detoxification system include:

a. main fluidized bed reactor,

b. secondary fluidized bed reactor with combination dust filter system,

c. reactive gas generator,

d. blower, interchange, scrubber and heat exchanger for the recycle gas system and,

e. product cooler and associated heat exchanger.

Raw, untreated ash from the use bins will be fed to the electrically heated main fluidized bed reactor where it will be exposed to a reactive gas atmosphere at an elevated temperature of approximately 1200-1400°F. After an average 1 hour detention time, treated ash displaced by raw feed material will overflow a gravity spillway to the product cooler, which will discharge the ash to a pneumatic conveying system. The treated ash will be conveyed to the existing storage bin in the truckway of the existing Sludge Process Building. The system will have the design flexibility to operate without need for process adjustment over the range of 1000 to 3000 pounds per hour.

Upon exiting the main reactor, the spent reactive gas shall flow to an electrically heated secondary reactor where any entrained dust particles shall be separated from the gas stream, and dropped into the secondary reactor for treatment in a similar manner to the treatment provided in the main reactor. The cleansed exhaust gas from the secondary reactor shall pass through an interchanger for preheating the recycled reactive gas and subsequently pass through a scrubber for final cleansing and cooling before being mixed with the makeup reactive gas for recycling in the closed loop reactive gas system. A comparatively small split stream of reactive gas shall be continually purged from the system to prevent buildup of undesirable components in the reactive gas recycle system.

2. Ash Conveying Systems -

The raw ash reclaim system will be of the mechanical vacuum exhauster type. The operation of the system shall be to convey raw ash from the bottom of each of the two existing incinerators, through a separator where the ash and conveying air are separated. The ash shall drop into a use bin and the air shall pass through the vacuum pump and be exhausted to the treatment plant's aerated grit chamber. Two complete equipment trains shall comprise the system, such that ash from either of two incinerators can be conveyed to either of two use bins.

The treated ash reclaim system will also be of the mechanical vacuum exhauster type. The operation of the system shall be to conduct treated ash from the discharge of the product cooler through a separator where the ash and conveying air are separated. The ash shall drop into an existing ash bin and the air shall pass through the vacuum pump and be exhausted to a stack. Two complete equipment trains shall comprise the system, such that ash from either product cooler can be conveyed to the existing ash bin. Both separators will be mounted on the existing ash bin.

One pulverizer shall be furnished and installed directly below each of the two existing incinerators. Each pulverizer shall completely pulverize to 100% less than 40 mesh the incinerator ash, prior to discharge to a rotary valve.

Separation of dust, raw and treated ash from the transporting air shall be accomplished in sled mounted, three stage separators. One separator shall be furnished for each vacuum pump for a total of four (4) separators. The two separators in the raw ash reclaim system shall each be mounted on top of a use bin. The two separators in the treated ash reclaim system shall both be mounted on the existing ash storage bin.

Each separator shall utilize three receivers or stages. The primary and secondary receiver shall be of the cyclone type. The tertiary receiver shall be of the reverse jet type with cloth bag filters. All three receivers shall be mounted on a dump box assembly to protect the use bin from vacuum in the conveying system.

3. Central Vacuum System -

This system will allow maintenance personnel to keep the existing incinerator building and the proposed detoxification addition free of dust. The system will be equipped with a primary separator, secondary separator and absolute filter.

4. Center Shaft Cooling Air System Modifications -

The work will consist of disconnecting the 2 existing cooling fans, relocating and setting the fans on a new foundation and providing new ductwork between the 2 fans.

5. Induced Draft Fan System Modifications -

The work will consist of removing existing duct between each of 2 scrubber outlets and their induced draft fans, modifying and replacing the duct, and providing new duct between the existing scrubber units.

Permitting Procedures - Since the ash has been catagorized as a hazardous waste, applicable State and Federal regulations regarding the siting and operation of a hazardous waste treatment facility had to be complied with. This project has been coordinated with EPA's Hazardous Waste and RCRA Permits Branches and the Mass. DEQE, Division's of Hazardous Wastes, Air Quality Control and Water Pollution Control.

The federal permitting procedures are handled through RCRA Permits and consist of two filings, Part A and Part B Permits. In November 1980 the SESD filed a Part A permit application which has been reviewed and processed by EPA. Federal regulations published in the January 9, 1981 Federal Register regarding the Part B filing states that the Hazardous Waste Regulations have been amended to allow for the commencement of construction of a new Hazardous Waste Management Facility (HWMF) without a permit between November 19, 1980 and the effective date of the Phase II part 264 Standards applicable to such facility, except in the case of landfills, injection wells, land treatment facilities, or surface impoundments. To do so, the owner/operator, prior to initiating physical construction must:

a) have secured the Federal, State, and local approvals or permits necessary to begin physical construction;

b) have submitted Part A of the permit application; and

c) have made a commitment to complete construction within a reasonable time.

On September 15, 1982 Tighe & Bond submitted a Draft the Part B Permit to SESD and was subsequently filed with the Department and EPA on October 18, 1982. It is anticipated that the review period including any public comment period will take six (6) months.

The Commonwealth of Massachusetts regulates the construction and operation of hazardous waste facilities through M.G.L. Chapter 21C, known as the "Massachusets Hazardous Waste Management Act" and the siting of such facilities through M.G.L. Chapter 21D. known as the "Massachusetts Hazardous Waste Facility Siting Act." A "Facility" is defined in both c.21C and c.21D as "a site or works for the storage, treatment, dewatering, refining, incinerating, reclamation, stabili zation, solidification, disposal, or other processes where hazardous wastes can be stored, treated, or disposed of; however not including a municipal or industrial wastewater treatment facility if permitted under section forty-three of chapter twenty-one." (emphasis added). The permit issued by the Massachusetts Division of Water Pollution Control under the authority of Section 43 of Chapter 21 are the State equivalent of Federal NPDES Permits. Since the SESD wastewater treatment facility has been issued such a permit, the entire facility is exempt from the regulatory and siting requirements of Chapters 21C and 21D.

Ultimate Disposal of Detoxified/Stabilized Ash - The Department after careful review of the Tighe & Bond Reports, documents published by EPA, historical data obained during the observation of solid waste disposal facilities within the Commonwealth and consultation with chemists and scientific personnel from the Commonwealth's Lawrence Experimental Station has determined that the subject materials can be safely co-disposed of in an approved refuse landfill as long as testing procedures continue to verify the conversion of the hexavalent chromium to its stable trivalent form and the material is at least 20 percent solids.

On August 6, 1980 the Department approved the co-disposal of the grit, screening and dewatered scum from the District's plant at the Peabody Municipal Landfill and inspections to date have indicated that the materials are not causing any operational difficulties. At this time, it is anticipated that the detoxified ash will also be disposed of at the Peabody Municipal Landfill.

Air Quality Impacts

During April 1979 stack testing was performed at the treatment plant to collect particulate emissions from the sludge incinerators. Six samples were collected and analyzed for total and hexavalent chromium concentrations.

The results are indicated below.

Filter Sample No.	Total Chromium mg/filter	Hexavalent Chromium mg/filter	Total Chromium $\mu g/m^3$
3012	0.15	0.0	73
3013	0.47	0.0	178
3014	1.20	0.0	491
2881	0.32	0.0	136
2880	0.42	0.0	170
2987	0.39	0.0	163

Computer modeling performed by the Department indicated the concentrations of total chromium in the ambient air varied between 0.05 and 0.5 $\mu g/m^3$ with an average of 0.18. These figures are based upon discharge of exhaust gases through the existing 20 foot incinerator stacks under "downwash conditions" which existed during the April testing.

The District has replaced the existing 20 foot stacks with 65 foot units. Consequently, downwash conditions will not typically occur at this facility. This analysis was verified by TRC Environmental Consultants, Inc. and Tighe & Bond who performed their own computer modeling. The Department analyzed the incineration system with the 65 foot stacks to determine a worst case condition for chromium concentrations in the ambient air around the plant. This analysis determined that the maximum concentration of total chromium will be $0.0042 \mu g/m^3$ at a downwind distance of 200 meters (656 feet).

An interagency task force of representatives from the U.S. Environmental Protection Agency, Mass. Department of Public Health, Mass. Department of Labor and Industries-Division of Occupational Hygiene, Mass. Department of Environmental Quality Engineer-Division of Air Quality Control, Division of Hazardous Waste, Division of Water Pollution Control, and Office of Criteria & Standards, and the Harvard School of Public Health met on several occasions to develop an interim guideline for total and hexavalent chromium concentrations in ambient air.

A quantitative risk assessment was performed by the Cancer Assessment Group, EPA-Washington (CAG) at the request of the Massachusetts Department of Public Health. The risk assessment is as follows:

Total Chromium, $1 \mu g/m^3 = 1.27 \times 10^{-3}$ excess lifetime cancer risk. This means that a lifetime continuous exposure (24 hours/day, 7 days/week and 52 week/year) to $1 \mu g/m^3$ of total chromium containing carcinogenic hexavalent chromium compounds would lead to no more than 1.27 excess cancer cases in a populatin of 1000 people. These calculations were based on the epidemiological work of Dr. Thomas Mancuso on chromate workers in Ohio.

The task force summarized all of the available information regarding health effects and guidance regarding ambient air concentrations of chromium. This included federal and other state regulatory agencies. Based on the discussion of the available information, the following recommendatins are made:

1. The ambient air concentration for total chromium should not exceed $0.1 \mu g/m^3$ of air, annual average.

2. The ambient air concentration of hexavalent chromium should not exceed $0.03 \mu g/m^3$ of air, annual average.

This $0.1 \mu g/m^3$ concentration for total chromium (assuming it contained hexavalent chromium) would lead to no more than 1.27 excess cancer cases in a population of 10,000 people assuming a lifetime continuous exposure.

This interim guidance, heavily based on the CAG cancer risk assessment, is subject to revision if and when further information becomes available.

The stack test data previously discussed indicates an expected hexavalent chromium concentration of zero while the maximum concentration of total chromium would not exceed 0.0042$\mu g/m^3$ and would relate to no more than one excess cancer case in a population of 200,000 people.

Ambient air background concentrations for total chromium has been found to rank from 0.01 to 0.03$\mu g/m^3$ in a typical urban environment. Information received from the National Air Surveillance System lists the ambient air background concentrations for total chromium in the Metropolitan Boston area as less than 0.01$\mu g/m^3$. Since it is known that hexavalent chromium gets readily reduced in nature to the more stable trivalent form, it is quite certain that the background contains only trivalent chromium.

Assuming a worst case situation where at one particular time 40%* of the chromium emitted from the incinerators is in the hexavalent form, the total ambient air concentration of hexavalent chromium (0.0017$\mu g/m^3$) would also not exceed the recommended maximum level of 0.03$\mu g/m^3$.

When the facilities (both incinerators and detoxification reactor) become operational, a detailed surveillance and monitoring system will be activated to insure safe and proper operations.

Table 15 presents a community cost apportionment for the operation of the treatment plant for both current "modified operation" (column 3) and projected cost increased due to the ash detoxification facility (column 4).

The last column on Table 15 indicated that a typical household in Beverly, Danvers, and Marblehead will pay less than $10 per year for the detoxification system while a household in Salem and Peabody could be expected to pay $22 and $32 per year respectively. These cost represent a worst case situation. The District apportions costs among its member communities and the member communities apportion costs among their respective residents, industrial and commercial establishments. It is anticipated that the Salem and Peabody charges will be reduced at least 50% due to surcharges levied by the communities against the tanneries located with their borders. This will reduce the local residential share significantly.

*Chromium conversion in the incinerators normally range between 10 and 30% and has never exceeded 40%.

TABLE 15

Average cost ++/capita year
(dollars)

(1) Community	(2) Sewered Population	(3) FY 82* Assessment	(4) Annual Household Costs for Detoxification Facilities only+ (dollars)
Beverly	38,000	15	5.
Danvers	23,000	11	10.
Marblehead	22,000	13	4.
Peabody	45,000	24	32.
Salem	38,000	15	22.

Notes:

* based on current modified non-incineration operations

\+ assumes all incremental costs transferred to residents, whereas the affected communities are expected to transfer a portion of this increase to the tanneries via surcharge.

++ includes SESD costs only (excludes local O&M assessments)

6. <u>Summary of Agency and Public Consultation</u>

Two public meetings, one public consultation session,, and one public hearing were held at the South Essex Sewerage District. The first meeting took place on October 8, 1980 and consisted of a twenty (20) minute presentation by David Healey, Tighe & Bond, which covered the nature of the problem , the goals of the ash detoxification pilot study program and difficulties which can be anticipated during the testing program. The discussion included a review of the sludge ash composition, reaction formulas that relate to chromium chemistry and design factors that will be optimized during the program. Twenty-five individuals were present during the meeting, 10 being residents in the adjacent neighborhood. Major concerns expressed at the meeting were as follows:

1. Storage and/or disposal of hazardous sludge ash at the treatment plant.

2. Extent of additional facilities to be constructed on-site.

3. Status of the ash after detoxification per EPA hazardous regulations. Discussion of approval process relating to the Salem Board of Health.

4. Potential for an increase in odors at the plant.

The second public meeting was held on January 21, 1981. Again, Mr. Healey made a twenty (20) minute presentation explaining the results of the pilot project to date. Twenty-one individuals were present, six (6) being residents. The main concern expressed by the residents was whether the proposed detoxification system would increase odors in their neighborhood.

The public consultation session was held on March 16, 1981 to discuss the MEPA Environmental Notification Form (ENF) filing with eight (8) people in attendance. Mr. Healey, Tighe & Bond briefly compared the two types of detoxification systems being examined, thermal reduction, and wet chemical. He stated that the thermal reduction system appeared superior and that they would be recommending that system to the District.

The public hearing was held on March 18, 1981 and was attended by sixteen (16) individuals, two (2) being residents. The main concerns expressed were related to the coal feed system, potential for noise, location of construction work, and applicability of the thermal reduction system to chromium conversion.

The public participation meetings and hearing were advertised in the local newspaper and special mailings were sent to various local agencies, affected State and Federal agencies and to attendees of the previous meetings. The special mailing list was also used for distribution of the responsiveness summaries.

Section 2

The occupational hygiene situation was a slightly different problem. We were readily able to agree upon the maximum safe exposure levels but were again unable to perform any testing during actual operating conditions. Data was obtained in 2 ways:

(1) by testing for chromium while simulating operations by turning on various pieces of equipment in the incinerator building, and by testing by DOH during the detoxification pilot plant operations; and

(2) by testing at another operating sludge incinerator and attempting to relate the results to SESD.

The initial occupational hygiene testing was performed on March 1, 1980, by Stephen K. Piccolo, an industrial hygiene engineer, from the Massachusetts Institute of Technology. Since the incinerator was not operational, Mr. Piccolo attempted to simulate actual operations by turning on various fans and motors which caused considerable vibration and air movement in the incinerator area. The results of this testing are shown on Table 16 and Mr. Piccolo concluded that a potential hazard does exist. Mr. Piccolo noted that a build-up of very fine incinerator dust covered all surfaces of the facility, including floors and equipment with particularly heavy concentrations around the incinerators.

TABLE 16
SESD - OCCUPATIONAL HYGIENE TESTING

Sample #	Location	Sample Vol. (M^3)	Results: Total Chromium	mg/m^3 Soluble Chromates
1	Front of Control Room (Fans Off)	20.8	.005	.001
2	Front of Control Room (Fan on)	21.5	.098	.019
3	Personal Sample Floor Below Control Room (Fans on)	.11	.16	.03
4	Front of Control Room Fans Operational for 90 minutes	6.9	.025	.005

This extensive layering of the facility with incinerator dust was due mostly to the persistent operational problems encountered between March 1979 and February 1980. On numerous occasions, the I.D. fan "tripped-out;" an emergency situation which should have led to the automatic opening of the by-pass damper to allow venting of the incinerator. Due to problems with these dampers, they did not operate completely or at all, causing the incinerators to go positive, forcing large amounts of dust into the incinerator area. Therefore, the testing performed by Mr. Piccolo was relevant to the problem of cleaning the incinerator area but was not necessarily pertinent as an analysis for future operations of the incinerator with the I.D. fan and by-pass dampers reconstructed.

On October 16, 1980 Susan Woskie, industrial hygienist from DOH visited the treatment plant to discuss with the District and DEQE the in-plant exposure of chromium to employees at the facility. The major question discussed was the proposed operation of a pilot plant to test the chemical detoxification process developed by Bill Liss, Chief Chemist at SESD.

On November 17, 1980, Ms. Woskie performed detailed occupational hygiene testing on the first day of the pilot plant operations. The pilot plant was constructed in the existing truckway of the sludge processing building and a schematic of the system is shown on Figure 8. The occupational hygiene testing included the placement of personnel air monitors on all workers, and the supervisor from Tighe & Bond, and the operation of 2 area air samples. The results of this testing are shown on Tables 17 and 18.

Table 17 incidates that all but one sample exceeded the National Institute for Occupational Safety and Health (NIOSH) recommended level of 1 $\mu g/m^3$ and all but 2 exceeded the DOH standard of 5 $\mu g/m^3$.

The results of the atomic absorption total metal analysis shown on Table 18 indicate that air levels of the metals did not exceed the current occupational standards. Because the ash represents a mixture of various metals, the effects of the individual contaminants are considered additive.

TABLE 17
SESD - OCCUPATIONAL HYGIENE TESTING
PILOT PLANT OPERATIONS - HEXAVALENT CHROMIUM

Location	Time, Min.	Total Air Volume M^3	Air Level Chromium VI $\mu g/M^3$	NIOSH Occupational Standard $\mu g/M^3$
Area sample near acid bath	290	2812.3	6.8	1
Area sample near staircase	288	2907.0	0.9	1
Area sample on ash bin (morning)	151	1396.8	81.6	1
Area sample on ash bin (afternoon)	130	1300.0	130.8	1
G. Nelson Shovel and sift	206	404.6	35.8	1
D. Huston Shovel and dump	191	380.0	35.3	1
M. Parson Supervise	169	333.6	2.1	1

TABLE 18
SESD - OCCUPATIONAL HYGIENE TESTING
PILOT PLANT OPERATIONS - TOTAL METALS

Location	Time, Min.	Total Air Volume M^3	Air Level (mg/M^3)	Occupational Standard mg/M^3
Area sample on ash bin	283	548.1		
Lead			Less than 0.02	0.05
Zinc			0.006	10.00
Cadmium			Less than 0.001	0.05
Nickel			0.007	1.0
Chromium			0.129	0.5
Area sample near acid bath	292	572.6		
Lead			Less than 0.02	0.05
Zinc			0.003	10.00
Cadmium			Less than 0.001	0.05
Nickel			0.016	1.0
Chromium			0.063	0.5
Bulk sample of ash				
Lead			233 ppm	---
Zinc			445 ppm	---
Cadmium			24 ppm	---
Nickel			98 ppm	---
Chromium			13800 ppm	---

Thus, the fractions of the standard for each component can be added together. If the sum exceeds one, then the occupational standard for the mixture has been exceeded. The standard was not exceeded by the two air samples taken.

As with the testing performed by Mr. Piccolo, the results of this testing have limited use regarding the analysis of future operations at SESD. This is obvious when one remembers that the proposed method of detoxification will be a closed-loop system where this testing occurred under hand-operated conditions. The ash tested was shoveled and sifted by hand from storage bins into process tanks.

The Department decided to review all other sludge incinerators located within the Commonwealth and to institute a phased testing program to determine whether any of these facilities had problems similar to SESD. The intent was to determine the extent of such problems in Massachusetts and to choose the facility which had the highest concentrations of hexavalent chromium in its ash and perform detailed occupational testing.

The Department initially chose nine (9) treatment facilities for investigation: Upper Blackstone Water Pollution Abatement District (UBWPAD), Greater Lawrence Sanitary District (GLSD), New Bedford, Fitchburg East, Chicopee, Attleboro, Brockton, Fall River and Lynn. After reviewing existing sludge analysis data, it was decided to drop Chicopee due to its low chromium levels (40-60 mg/kg). Brockton, Lynn and Fall River were still under construction and therefore were not available for testing. Attleboro was just entering the initial start-up phase and it was decided to incorporate chromium testing into their mandatory stack testing program. This testing was performed during December 1981 but due to operation of problems encountered during the testing, and questions concerning the analytical data obtained, the results were discounted and additional testing will be conducted at a later date. Prior testing performed on the dewatered sludge and incinerator ash by the Department is shown on Table 19.

The GLSD is being required to perform additional stack testing on their No. 2 incineraor unit and chromium analyses will be included in that testing.

Also, Havens & Emerson, Inc. recently prepared a Wastewater Sludge Management Report for the Metropolitan District Commission which discusses various methods of sludge disposal including incineration. Discussions have been held with representatives from Havens & Emerson and DEQE emphasizing the need to carefully review the various impacts.

TABLE 19
ATTLEBORO WASTEWATER TREATMENT PLANT
METAL ANALYSES*

	INCINERATOR ASH		DEWATERED SLUDGE	
	TOTAL	E.P. TOXICITY	TOTAL	E.P. TOXICITY
Chromium + 6		1.1		0.00
Chromium	334		71	
Lead	215	0.15	110	0.12
Arsenic	11.9	0.00	5.2	0.00
Nickel	394	0.18	105	3.7
Cadmium	334	1.0	177	0.02
Zinc	1,314	0.18	366	0.04
Mercury	0.3822	0.0005	1.47	0.0006

Results expressed as ppm dry weight for total metals and Mg/L for E.P. Toxicity.

* Samples collected on October 12, 1981

During February 1981 grab samples of incinerator ash were collected from the Upper Blackstone Water Pollution Abatement District, the Greater Lawrence Sanitary District and the New Bedford Treatment Plant and analyzed for total and hexavalent chromium. After reviewing this data, it was decided to perform a 2-week testing program at these facilities along with testing at the Fitchburg Easterly Plant. The results of this testing are shown on Table 20.

Since the Upper Blackstone Facility had the highest levels of total and hexavalent chromium, it was decided to perform a detailed occupational hygiene testing program at this facility.

TABLE 20

TOTAL AND HEXAVALENT CHROMIUM
SLUDGE ASH FROM VARIOUS PUBLICLY OWNED TREATMENT PLANTS

Sample Location	Sample Date	Total Chromium (mg/kg)	Hexavalent Chromium (mg/kg)	EP Toxicity (Cr^{+6}) (mg/l)
Upper Blackstone Water Pollution Abatement District	5/20/81	1205	8.6	
	5/21/81	1157	35	
	5/22/81	690	18	
	5/23/81	925	12	
	5/24/81	789	35	
	5/25/81	1152	40	4.1
	5/26/81	1226	16	
	5/27/81	1130	19	
	5/28/81	1288	43	
	5/29/81	838	23	
	6/1/81	979	44	
	6/2/81	1073	43	
	6/3/81	1015	21	
	1/21/82	1500	41	
	2/13/81	700	0.00	0.0

TABLE 20

TOTAL AND HEXAVALENT CHROMIUM SLUDGE ASH FROM VARIOUS PUBLICLY OWNED TREATMENT PLANTS (Continued)

Sample Location	Sample Date	Total Chromium (mg/kg)	Hexavalent Chromium (mg/kg)	EP Toxicity (Cr^{+6}) (mg/l)
Fitchburg East	5/20/81	718	2.5	
	5/21/81	862	4.8	
	5/22/81	1519	1.4	
	5/27/81	448	2.8	
	5/28/81	1150	4.3	0.19
	5/29/81	806	3.4	
Greater Lawrence Sanitary District	5/20/81	504	0.00	
	5/21/81	820	0.00	
	5/22/81	931	0.00	
	5/23/81	446	0.00	
	5/24/81	445	0.00	
	5/25/81	616	0.63	
	5/26/81	449	0.68	
	5/27/81	1000	0.35	
	5/28/81	1163	0.46	
	5/29/81	861	4.9	
	5/30/81	624	11	0.03
	5/31/81	663	6.3	
	6/1/81	291	3.3	
	6/2/81	750	3.5	
New Bedford	6/5/81	446	0.34	
	6/6/81	348	0.23	
	6/7/81	407	0.57	
	6/8/81	299	0.45	
	6/9/81	788	1.30	
	6/10/81	236	0.80	

Even though the levels of total and hexavalent chromium were much lower than those found at SESD, they were significant enough to indicate that additional testing was necessary.

Concentration of hexavalent chromium in the UB ash after EP testing is approximately 1/50 of that determined at SESD (4 mg/l vs 150 to 200 mg/l) and 1/15 of gross total chromium concentration in the ash as compared to SESD (1200 vs 17,000 mg/kg).

The UBWPAD operates a conventional activated sludge treatment plant which services the City of Worcester and portions of several neighboring communities. The plant went on-line in August 1976 and currently treats 40 MGD of combined residential and industrial wastewater and produces 100 to 130 tons per day of 30% belt-filtered sludge which is processed in one of its three 10-hearth incinerators. Ash is landfilled behind the plant.

The occupational hygiene testing was performed between February and May 1982. This testing consisted of three (3) periods of sampling, February 23 and 24, March 16 and 17, and May 18 and 19.

The Division of Occupational Hygiene agreed to perform the actual testing with the bulk of the analytical work performed at DEQE's Lawrence Experiment Station (LES). Emil Holland, the Executive Director of the UPWPAD, provided total support to the project including personnel time, laboratory analysis and funding for a portion of the medical testing.

On February 23, Doctors Goldman and Zwerling of DOH drew blood samples, performed a brief medical examination and reviewed the occupational histories for six (6) employees on the 8 a.m. to 4 p.m. shift who work in areas of the treatment plant which may be subject to ash contamination. All blood analyses were performed free of charge by DOH with the exception of chromium which was performed by an outside medical laboratory at a cost of $45/test which Emil Holland agreed to fund.

Four of the employees who participated in the medical testing were each fitted with two personnel air samplers; one filter which was analyzed by DOH for hexavalent chromium and the other filter was analyzed by LES for total metals.

An area sampler was operated for approximately 1 hour periods at each of three (3) sampling points.

1. Adjacent to the control panel for incinerator #3;

2. Adjacent to incinerator #3 ash hopper located in the sub-basement area; and

3. Just outside the ash truckway.

The results of the total metals sampling is shown on Table 21. These analyses indicate that certain metals are consistently found in a fairly defined range of concentrations (iron, manganese, lead, zinc, chromium, and nickel) while others vary significantly (cadmium, silver, barium, arsenic and selenium).

TABLE 21

UPPER BLACKSTONE WATER POLLUTION ABATEMENT DISTRICT

INCINERATOR ASH-TOTAL METALS*

Sample Date	2/13/81 (1)	2/23/82 (1)	2/24/82 (1)	3/16/82 (1)	3/17/82 (1)	5/18/82 (1)	5/19/82 (1)	1/21/82 (2)
Iron	33,000	20,800	16,900	13,350	10,900	21,200	25,200	---
Manganese	1,020	1,100	850	1,300	2,000	810	740	---
Lead	940	---	---	620	760	770	790	530
Zinc	2,000	2,000	1,600	2,250	3,600	3,600	3,000	1,700
Chromium (Total)	700	1,700	1,000	1,300	2,200	1,100	1,000	1,500
Cadmium	6.0	11	30	25	15	16	12	6.4
Nickel	200	340	450	260	340	450	270	190
Silver	---	50	50	43	50	---	---	1.9
Barium	---	70	70	---	---	2,800	2,600	---
Arsenic	9.6	1.0	1.0	---	---	0.0	0.0	23
Selenium	---	1.0	0.8	---	---	---	---	10
Copper	---	---	---	---	---	---	---	1,500
Antimony	---	---	---	---	---	---	---	2.5

* All results expressed as mg/kg on a dry weight basis
(1) Analysis performed at DEQE-Lawrence Experiment Station
(2) Analysis performed at Camp, Dresser & McKee Laboratory

The results of the personnel and area sampling is shown on Tables 22, 23, and 24 and indicate that the concentrations of hexavalent chromium and lead were below the DOH standard of 5 $\mu g/m^3$ and the NIOSH recommended limit of 1 $\mu g/m^3$ for hexavalent chromium (with one exception) and the Occupational Safety and Health Administration (OSHA) standard of 50 $\mu g/m^3$ for lead.

This testing data was cross checked against a theoretical worst case exposure at the UBWPAD by utilizing the analysis performed for respirable dust and the concentrations of hexavalent chromium observed during the 2-week testing program previously described.

The concentrations of hexavalent chromium in the ash at UBWPAD during the two (2) week testing program (May 20, 1981 to June 3, 1981) varied from a low of 8.6 to a high of 44 mg/kg with an average of 27.5. Assuming a situation where the average concentration of Cr^{+6} is 40 mg/kg, the theoretical worst case exposure can be determined as follows:

1. Employee breathes 10 m^3 of air during an 8-hour shift (typical range is 4 - 10 m^3); and

2. Concentrations of respirable dust is no greater than 1.5 mg/m^3 (testing at the UBWPAD during May 1982 indicated respirable dust to be between 0.07 and 1.45 mg/m^3, see Table 24).

TABLE 22

UPPER BLACKSTONE WATER POLLUTION ABATEMENT DISTRICT
OCCUPATIONAL HYGIENE TESTING - SAMPLING RUN #1

Date of Sample	Sampling Location/Description	Total Chromium $\mu g/m^3$	Hexavalent Chromium $\mu g/m^3$ *	Lead $\mu g/m^3$
2/23/82	Ash Handler	0.0	< 2.0	3.35
	Incinerator Operator	0.0	< 0.3	0.0
	Vacuum Filter Operator	0.0	< 0.4	0.0
	Lab Manager	0.0	< 0.9	0.0
	Incinerator Control Panel	0.0	< 0.5	2.73
	Ash Hopper Area	0.0	< 0.4	0.00
	Truck Loading Control Panel (outside)	0.0	< 1.0	6.41
	Bulk Ash	1700 mg/kg	29 ppm	---
2/24/82	Ash Handler	0.0	< 0.5	0.0
	Incinerator Operator	0.0	< 0.5	0.0
	Vacuum Filter Operator	0.0	< 0.5	0.0
	Bulk Ash	1000 mg/kg	31 ppm	---

* Analyzed by NIOSH procedures utilizing acid wash

TABLE 23

UPPER BLACKSTONE WATER POLLUTION ABATEMENT DISTRICT
OCCUPATIONAL HYGIENE TESTING - SAMPLING RUN #2

Date of Sample	Sampling Location/Description	Total Chromium $\mu g/m^3$	Hexavalent Chromium $\mu g/m^3$*	Lead $\mu g/m^3$
3/16/82	Ash Handler	17.5	0.9	0.58
	Incinerator Operator	1.0	< 0.4	0.17
	Attendent	0.6	< 0.4	0.07
	Lunch Room	0.9	< 0.1	0.04
	Ash Hopper Area	---	< 0.1	---
	Truck Loading Control Panel (outside)	---	0.94	---
	Bulk Ash	1300 mg/kg	9.2 ppm	620 mg/kg
3/17/82	Ash Handler	23.8	< 0.4	0.43
	Incinerator Operator	1.1	< 0.3	0.38
	Attendent	1.0	< 0.2	0.20
	Ash Hopper			
	Bulk Ash	2200 mg/kg	---	760 mg/kg

* Analyzed by revised NIOSH procedures utilizing water wash

TABLE 24

UPPER BLACKSTONE WATER POLLUTION ABATEMENT DISTRICT
OCCUPATIONAL HYGIENE TESTING - SAMPLING RUN #3

Date of Sample	Sampling Location/Description	Total Chromium $\mu g/m^3$	Hexavalent Chromium $\mu g/m^3$ *	Lead $\mu g/m^3$	Respirable Dust mg/m^3
5/18/82	Incinerator Operator	0.47	< 0.1	0.68	0.18
	Attendent	1.5	< 0.1	0.96	0.07
	Ash Hopper Area	1.2	< 0.1	1.9	0.18
	Bulk Ash	1100 mg/kg	---	770 mg/kg	
5/19/82	Ash Handler	20.0	< 0.1	9.5	1.45
	Incinerator Operator	0.97	< 0.1	4.7	pump failure
	Attendent	0.28	< 0.1	0.55	1.13
	Ash Hopper Area	---	< 0.1	---	0.66 (total dust)**
	Truck Loading Control Panel (Outside)	---	< 0.1	---	4.75 (total dust)**
	Bulk Ash	1000 mg/kg	---	790 mg/kg	---

* Analyzed by revised NIOSH procedures utilizing water wash
** Total dust is all dust > 10 microns

Calculations

$(40\ mg/kg\ Cr^{+6})\ (1.5\ mg/m^3)\ (10m^3) =$

$(40\ mg/kg\ Cr^{+6})\ (1.5\ kg \times 10^{-5}) =$

$0.0006\ mg\ Cr^{+6}$ (total inhaled daily)

Again, assuming 10 m^3 of air breathed during an eight-hour shift, the theoretical worst case exposure would equal:

$$0.0006\ mg\ Cr^{+6}/10\ m^3\ air = 0.00006\ \frac{mg\ Cr^{+6}}{m^3}$$

or

$$0.06\ \mu g/m^3$$

This is one order of magnitude lower than DOH's sensitivity for analysis for personnel air samplers which is 0.5 $\mu g/m^3$ and is significantly below the maximum occupational exposure limits set by DOH and NIOSH.

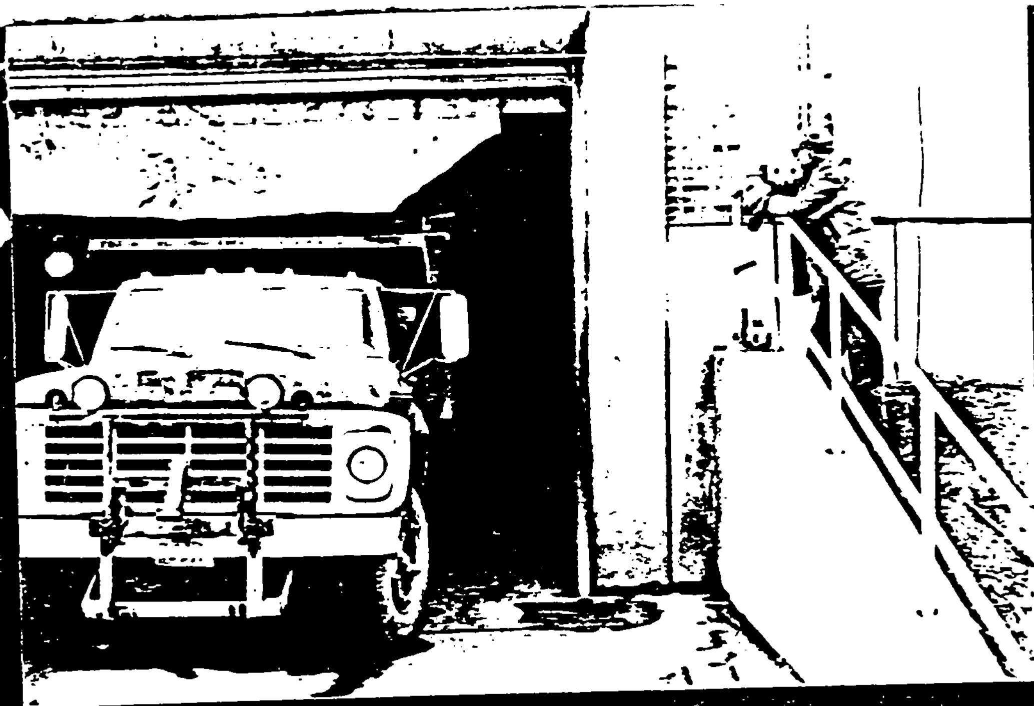
A similar analysis was performed for lead which indicated a theoretical worst case exposure of 1.35 $\mu g\ Pb/m^3$ based upon measured levels of lead in the UBWPAD ash which is also significantly below the OSHA standard.

Both of these analyses are supported by blood testing performed by DOH on six (6) employees at the plant on February 23, 1982. Results of the blood testing are shown on Table 25 and indicates that all chromium and lead levels are significantly within the normal range. The medical examinations performed by Doctors Goldman and Zwerling determined that none of the employees examined had chromium ulcers, either in the nose or on the hands, nor did anyone have a perforated nasal septum which is a typical sign of chromium overexposure. Three (3) of the operators had dry hands with mild scaling and callous, and one of the laborers had very dry hands with some fissuring and hyperatosis. None of them had any visible eye irritation or lead-exposure-related symptoms, such as crampy abdominal pain, changes in bowel habits, increase in irritability and memory difficulties.

Even though there is no indication that the employees at the UBWPAD are overexposed to metals during sludge processing, there is the potential for short-term overexposure to hexavalent chromium in the case of ash handlers during the operation of the then existing method of ash transfer from the ash conditioner to the dump truck and thence to the disposal area. The UBWPAD District, even before testing began at the plant, had been concerned with the current method of ash handling. In that regard plans were prepared and funds allocated for the construction of an extension of the truckway to provide for containment of the ash loading area so that fugitive dust emissions would be eliminated. The operation of this system would allow the ash handler to control and directly observe the truck filling operations without coming into contact with the ash. This facility was recently constructed and is in operation. The construction of such a facility would have been the major recommendation of this study. In addition to this recommendation, the Department strongly recommends the following:

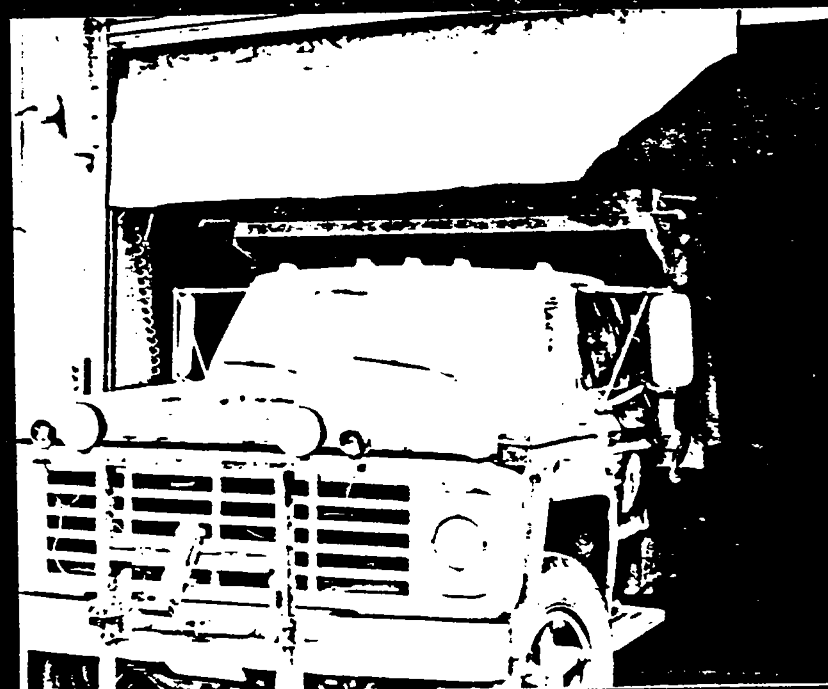
1. Yearly medical examinations by a physcian, familiar with occupational hygiene impacts, should be performed on all employees who work within the incinerator, ash handling, and ash disposal areas.

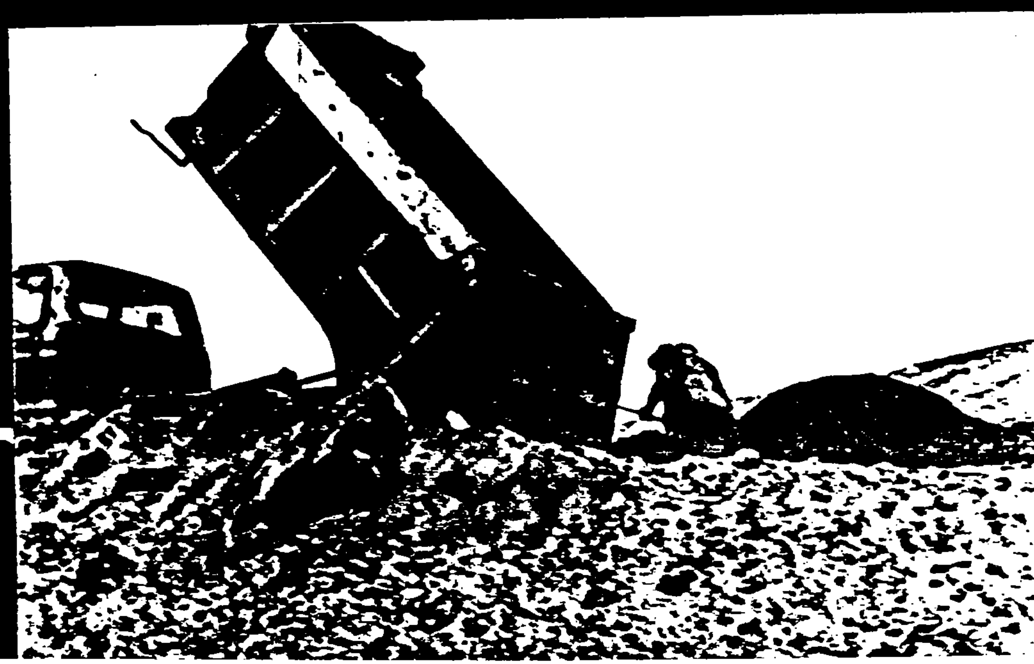
2. The District should review the types of breathing masks currently being utilized by its employees with the Division of Occupational Hygiene. It is our suggestion that higher efficiency respirators be utilized by those employees who enter the ash conditioning room, transport and dump the ash,



Original method of ash conveyance from ash conditions unit into dump truck.

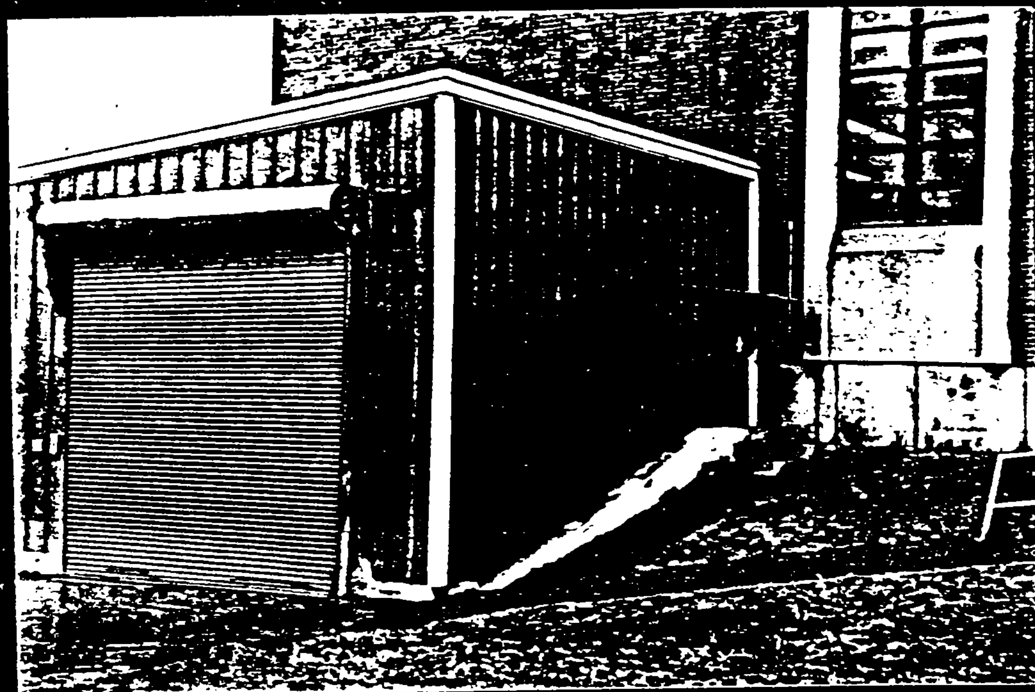
Close-up view of dump truck covered with incinerator ash.





Truck driver scrapin ash from bottom and sides of truck at as disposal area.

New truck enclosure which allows total containment of dump truck during ash filling operations.



Viewing panel at operators station.

operate the bulldozer during disposal operations, and perform normal maintenance operations which might include direct contact with the ash. In addition to the respirators, gloves should always be worn and soiled clothing should be changed and washed daily. The clothing which is worn by these employees should also be cleaned separately to avoid contamination of other clothing.

3. The dump truck transporting the ash from the truckway to the disposal area should always be covered prior to exiting the truckway, and the vehicle should be washed thoroughly once a day to remove any buildup of ash.

4. The method of dumping the truck should be reviewed to determine whether there is a way to get the ash from the vehicle without the truck driver being required to scrape the sides and bottom of the vehicle.

5. Uncovered ash shall be covered daily to ensure that fugitive dust does not escape from the disposal area behind the treatment plant to adjacent areas.

6. Any ash which ends up outside the treatment buildings, such as on the roadway leading to the disposal area, or the area adjacent to the truckway, should be promptly removed through a wet-cleaning method to avoid dust conditions.

7. Routine testing of the ash for heavy metal levels, including but not necessarily limited to hexavalent chromium, lead, arsenic, nickel and cadmium should be performed at the District's laboratory. If the

District does not have the capability to test for all of these metals, they should attempt to obtain the necessary additional cathode tubes for their atomic absorption spectrophotometer. This writer suggests that the District attempt to procure funding for these tubes through their currently ongoing pretreatment program.

8. The District should proceed with Phase 2 of its Industrial Pretreatment Program as soon as DEQE and EPA approve the Phase I Report and process the necessary grant adjustments to allow for funding of the additional studies.

Personnel of UBWPAD working the various shifts are rotated through a number of jobs over a six-week period. Since adverse impacts due to carcinogenic metals at the concentrations observed at most wastewater treatment plants are chronic in nature and therefore occur due to continuous exposure over long periods of time, the rotating of personnel is an excellent method of reducing possible adverse impacts.

An attempt was made to relate the results of the occupational hygiene testing at UBWPAD to the conditions at SESD. This information was then compared to the simulation testing performed by Mr. Piccolo and the DOH during the pilot plant operations. In order to determine the theoretical worst case exposure at SESD the following assumptions were used:

1. Similar levels of respirable dust to those measured at UBWPAD would be present at SESD;

2. The concentrations of Cr^{+6} would vary from a low of 1180 to a high of 5100 mg/kg. This range was determined by reviewing extensive testing data at

SESD. Since the range of values is so large, various concentrations within the range were utilized to determine a range of exposures:

Concentrations of Cr^{+6} in SESD Ash (mg/kg)	Theoretical Exposure Concentrations ($\mu g/m^3$)
1180	1.77
2000	3.0
3000	4.5
4000	6.0
5100	7.65

The simulation testing performed by Mr. Piccolo indicated an expected range of occupational exposure from 1.0 to 30.0 $\mu g/m^3$.

The pilot plant testing by DOH cannot directly be compared to incinerator operations since most of the personnel tested were shoveling or sifting large amounts of the ash. The chromium levels measured on the supervisor of the pilot plant operations would most closely compare to worst case incinerator operations. The 2.1 $\mu g/m^3$ for the supervisor compares very well with the range of theoretical exposure levels (1.77 to 7.65 $\mu g/m^3$) and the lower range of values (1 and 5 $\mu g/m^3$) determined during the simulation testing.

These results indicate that there is a potential for hexavalent chromium concentrations to exceed the DOH standard of 5 $\mu g/m^3$. If the detoxification facility enters the construction phase, a detailed study will be conducted at SESD to determine the necessary engineering controls in the incinerator area along with a complete respiratory program.

TABLE 25

UPPER BLACKSTONE WATER POLLUTION ABATEMENT DISTRICT BLOOD ANALYSIS FOR EMPLOYEES

FEBRUARY 23, 1982

Location/ Description of Sample	Serum Chromium μg	Blood Lead μg	Zinc Protorphorin
Ash Handler	3	21	5
Incinerator Operator	3	13	7
Incinerator Operator	3.1	13	2
Attendent	3	25	4
Attendent	--	16	6
Laboratory Manager	3.6	17	5
Normal Range	<11	< 40	---

Analyses performed by Environmental Sciences Association

In Massachusetts there are 117 publicly owned treatment works (POTW's) either in operation or under construction, 11 of which are equipped with sludge incincerators. Even though the number of sludge incinerators is comparatively small, those that utilize incinerators comprise 7 of the 10 largest, exclusive of the MDC.

These seven treatment plants process over 160 million gallons per day (mgd) of wastewater and produce over 350 tons per day of dewatered sludge.

Therefore, the impacts due to any curtailment of sludge incinerator operations would have far reaching implications for Massachusetts due to the lack of alternative methods of sludge disposal. Also, according to the EPA, 30% of all sludge produced within the U.S. is currently processed through incineration with most of these incinerators processing high metal-content sludges.

This writer believes that the potential exists for SESD types of problems at other sludge incinerators and anyone currently operating or proposing to construct such a facility should carefully examine the three areas of impact mentioned in this report with particular emphasis on occupational hygiene.

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