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Report

SURVEY OF WASTEWATER TREATMENT FACILITIES
AND RECEIVING WATERS AND PROPOSED
PERFORMANCE SPECIFICATIONS
MCGUIRE AFB AND FT DIX NEW JERSEY

July 1973

EHL(K) 73-12

VOLUME I OF TWO VOLUMES

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USAF ENVIRONMENTAL HEALTH LABORATORY (AFLC)

UNITED STATES AIR FORCE

KELLY AFB, TEXAS 78241

SURVEY OF WASTEWATER TREATMENT FACILITIES AND RECEIVING WATERS AND PROPOSED PERFORMANCE SPECIFICATIONS MCGUIRE AFB AND FT DIX NEW JERSEY

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VOLUME I OF TWO VOLUMES

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PREFACE

This technical report has been written in two volumes due to its length. Volume I contains the basic discussion, conclusions, and recommendations. Volume II contains additional material, discussions, and detailed survey data that have been summarized in the discussion contained in Volume I. Volume II should only be required by those agencies/activities that require a more complete technical discussion and all collected raw data.

A preliminary version of this technical report, EHL(K) 72-23, "Preliminary Report of Wastewater Treatment and Disposal, McGuire AFB and Ft Dix NJ," November 1972, was previously distributed. The preliminary version was limited in discussion and presentation of the technical data which was not available at the time. This technical report supersedes the preliminary report and no further reference to the preliminary report is required.

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I. SUMMARY

This report contains data and discussion of the results of a field wastewater survey conducted by the USAF Environmental Health Laboratory, Kelly AFB, Texas at McGuire AFB and Ft Dix, New Jersey in September 1972. Extensive physical, chemical and biological sampling and analyses of these facility's sewage treatment plants and the surface waters to which the plants discharge were accomplished. The quality of the receiving waters was found to be degraded as a result of the sewage plant discharges. This report recommends that these two federal facilities join in efforts to create a regional wastewater management system, and during the interim period until such a system materializes, maintain the existing secondary sewage treatment facilities with minimum expenditure of capital investment funds. Performance specifications as required by current Executive Order are proposed for the interim period, and recommendations for interim upgrading of the existing facilities are made. Alternative courses of action are evaluated in the event the regional management system does not materialize.

II. INTRODUCTION

A. PURPOSE AND OBJECTIVES

1. Purpose - The purpose of this survey was to:

a. Conduct an extensive sampling program of the two wastewater treatment plants, of untreated industrial waste discharges, and of the natural receiving waters.

b. Accomplish sewage treatment plant effluent dynamic bioassays.

c. Accomplish limited bench-scale studies of modified treatment procedures.

d. Evaluate potential land disposal sites for the wastewater treatment plant final effluents.

2. Objectives - The objectives of this survey were to:

a. Define the existing quality of South Run and other area streams and to relate the present quality of South Run to background areas and to the desired water quality criteria.

b. Determine the rates of natural stream purification; to estimate the waste assimilative capacity of the receiving stream; to project the pollutional effects on the streams to other conditions than those occurring during the field study; and to estimate the reduction in waste loadings required to meet desired water quality criteria.

c. Establish proposed interim and long-range "performance specifications" for the two wastewater treatment plants in accordance with Executive Order 11507 and implementing USAF/USA directives.

d. Provide the Ft Dix and MAFB with data and analyses to prepare an environmental assessment for alternative courses of action.

e. Propose modifications to existing treatment facilities to meet interim and long-range proposed performance specifications.

f. Identify for correction sources of untreated or inadequately treated industrial wastes.

g. Provide a baseline for evaluation of the effects of future water pollution abatement efforts by the two military facilities.

B. HISTORICAL BACKGROUND

1. On 22 November 1971, the State of New Jersey's Department of Environmental Protection (NJDEP) issued administrative cease and desist orders to nine federal facilities located in New Jersey, including Ft Dix and McGuire AFB. These orders alleged that under critical low flow conditions in the receiving stream the discharges from Ft Dix and MAFB secondary sewage treatment plants overwhelmed the stream's assimilative capacity. A number of meetings and legal exchanges between the U.S. Attorney (Newark) and the NJDEP ensued. Prohibition of technical dialogue with the NJDEP was imposed during the initial legal exchanges. (See NJDEP Ltr to McGuire AFB, dated 22 Nov 1971, Appendix A).

2. On 9 December 1971 the MAFB Surgeon requested consultation services of the USAF Environmental Health Laboratory/Kelly, (EHL/K) through HQ Military Airlift Command (MAC) and HQ Air Force Logistics Command (see USAF Dispensary Ltr, "Water Pollution Abatement Survey," dated 9 Dec 1971 and HQ AFLC Ltr, "Water Pollution Survey, McGuire AFB, NJ," dated 23 Dec 1971, Appendix A).

3. In late February 1972, personnel of the EHL(K) conducted a preliminary survey of MAFB and Ft Dix to determine the scope of future local water pollution abatement efforts. As a result of this preliminary survey, a comprehensive field study at the Ft Dix/MAFB complex was recommended and tentatively planned for the summer of 1972. (See EHL(K), "Trip Report - McGuire AFB NJ," dated 7 April 1972, Appendix A).

4. Following a preliminary survey at MAFB and Ft Dix in late February by EHL(K) representatives, the embargo on technical discussions with the NJDEP was lifted. In late May, discussions among all interested agencies (MAFB, Ft Dix, HQ USAF, HQ MAC, Region II EPA, Delaware River Basin Commission (DRBC), N. Atlantic Army Corps of Engineers, EHL(K) and NJDEP) were held at MAFB. (See EHL(K), "Trip Report - McGuire AFB NJ - Special Project 72-1," dated 5 June 1972). These discussions concluded that:

a. The Ft Dix/MAFB engineers would investigate the feasibility of entering into one of the three known regional wastewater treatment plans.

b. Concurrently, the Army/Air Force would initiate a study of a total water quality management scheme for the Ft Dix/MAFB complex from an economic, technical and environmental viewpoint. The EHL(K) was requested by the Ft Dix/MAFB authorities to coordinate the required field studies.

c. Active participants in these field studies would meet again to coordinate necessary details.

5. In mid-July EHL(K) representatives visited MAFB and Ft Dix to coordinate the technical aspects of the proposed field study with the MAFB/Ft Dix authorities, the EPA, the Army Environmental Hygiene Agency (AEHA), the 1st Army Medical Laboratory, and the NJDEP. (See EHL(K), "Trip Report - McGuire AFB NJ - Special Project 72-1," dated 20 July 1972, Appendix A).

a. The Ft Dix and MAFB engineers were to continue investigations of the feasibility of entering into the North Burlington County regional waste treatment plan. Timely realization of this regional plan had been enhanced with the 12 July 1972 formal action by the Burlington County NJ Board of Freeholders, legally creating the North Burlington County Sewerage Authority (NBCSA). The NJDEP, Region II EPA, and DRBC view this plan favorably as conforming with the overall water quality management goals for this area. The representative of the NBCSA had agreed to invite the Ft Dix and MAFB authorities to the Authority's initial meetings.

b. The Ft Dix and MAFB authorities had requested that the EHL(K) and the 1st Army Med Lab conduct a comprehensive field study at the Ft Dix/MAFB complex in September 1972.

6. During the month of September 1972, a comprehensive field survey at the Ft Dix/MAFB complex was accomplished by the Special Projects Division, EHL(K), in cooperation with the U.S. Army Environmental Hygiene Agency, the 1st Army Medical Laboratory, the Federal Environmental Protection Agency (Region II), and the State of New Jersey DEP and Division of Fish and Game. (See EHL(K), "Trip Report- Special Project 72-1, McGuire AFB NJ," dated 18 October 1972, Appendix A). In early November 1972, the EHL(K), issued a preliminary report of the findings of the field study. (See EHL(K) Technical Report - "Preliminary Report - Survey of Wastewater Treatment and Receiving Stream, McGuire AFB and Ft Dix, New Jersey," EHL(K) 72-23, November 1972).

III. DISCUSSION

A. General Description of Ft Dix and McGuire AFB Complex.

1. Geography

MAFB is contiguous to Ft Dix and the community of Wrightstown, NJ which is geographically located approximately 25 miles east of Philadelphia PA and 12 miles southeast of Trenton NJ. The major portion of Ft Dix and MAFB (approximately 37,000 acres) lies within North Burlington County NJ. MAFB in most part is surrounded by Ft Dix Military Reservation. The main cantonement area of Ft Dix is located in the northwest section of

the reservation. MAFB is situated east of and adjacent to the main cantonement area of Ft Dix.

2. Climate

The Ft Dix Military Reservation is situated on the coastal plain of New Jersey and the climate is affected by moist maritime air and frontal movements of polar air masses from the northwest. The climate is relatively temperate; average temperatures range from 35 degrees F in January to 76 degrees F in July. Freezing weather may be expected during October to April. The annual average precipitation is 42 inches, with the highest monthly average between 4 and 5 inches. The prevailing winds are from the west and southwest. The average wind velocity is generally less than 12 knots.

3. Geology

Soils vary from medium and fine grained sands to silty sands with most undisturbed areas covered with a mantle of humus top soil of 3 to 12 inches. The average frost penetration is approximately 4 to 6 inches.

4. Topography

The terrain on Ft Dix Military Reservation is slightly rolling with elevations ranging from 100 feet to 200 feet above sea level. The slope of the land in the developed areas of the reservation falls in both a northerly and southerly direction. The terrain varies from open fields to deciduous and evergreen wooded areas containing dense brush and bog sections in the low-lying areas.

5. Hydrology

The major portion of storm runoff from the main cantonement areas of Ft Dix and MAFB discharge to the north into the Crosswicks Creek river basin and to the south into the Rancocas Creek river basin, thence to the Delaware River. The ground water table during the dry season varies from 6 to 10 feet below the surface and during the spring rains the water table rises to the ground surface. Figure 1 is an area surface drainage map.

6. Water Supply

Potable water for Ft Dix is obtained from a combination of deep wells and surface water sources, while MAFB obtains its potable water exclusively from on-base deep wells.

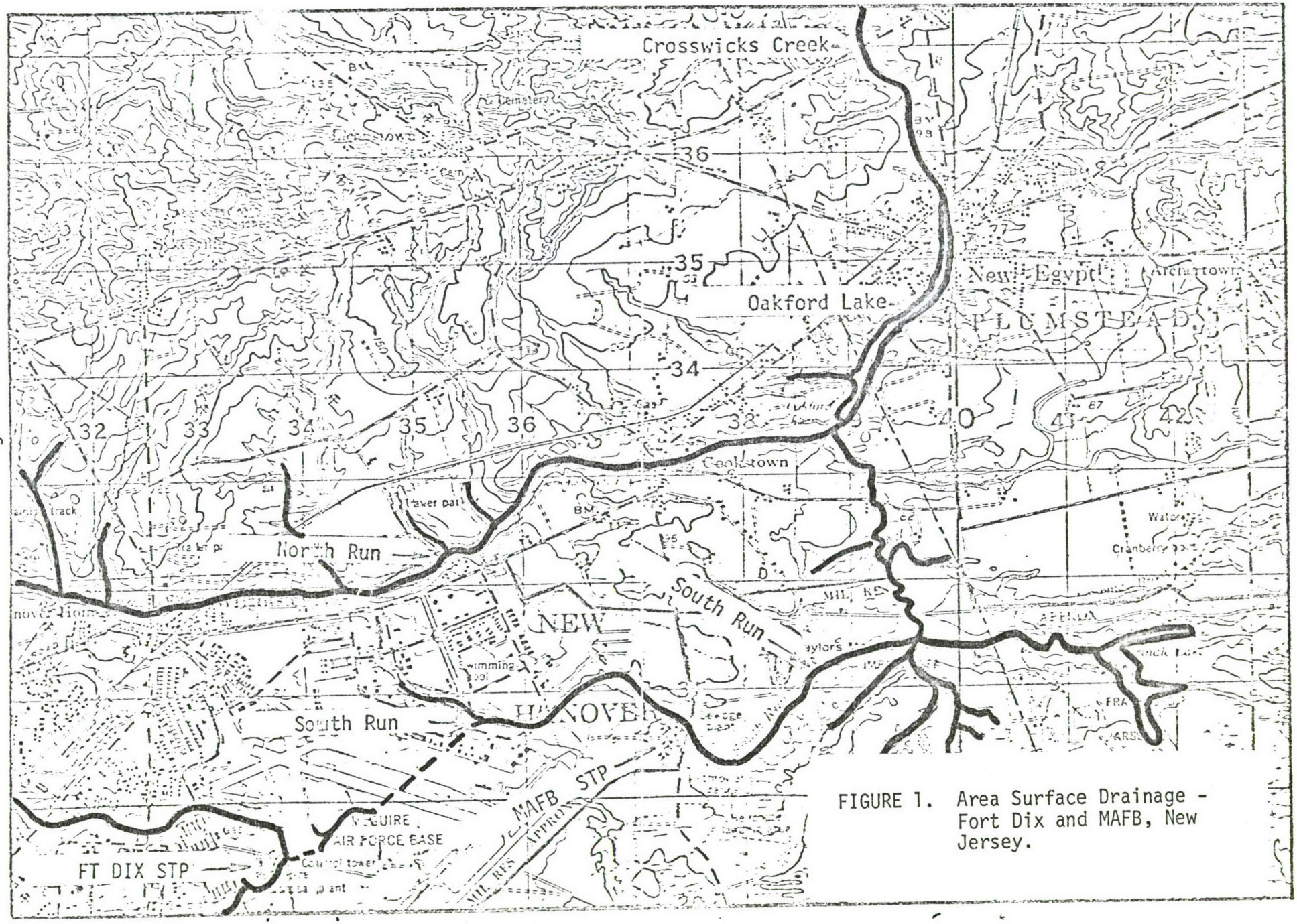

FIGURE 1. Area Surface Drainage - Fort Dix and MAFB, New Jersey.

7. Basic Missions

Ft Dix serves as a basic military training center. MAFB serves as a port of aerial embarkation for Military Airlift Command.

8. Resident Populations

The work force on Ft Dix is made up of approximately 30,000 civilian and military personnel. The work force on MAFB is made up of approximately 15,000 civilian and military personnel.

9. Sanitary Sewage Treatment

Sewage treatment on Ft Dix is provided in a secondary treatment plant having a design capacity of 3.0 MGD. Treated effluent from this plant is discharged into the headwaters of South Run, a tributary of Crosswicks Creek. Sewage treatment on MAFB is provided in a secondary plant having a design capacity of 1.25 MGD. Treated effluent from this plant is also discharged into South Run approximately 1.5 river-miles downstream from the Ft Dix outfall.

B. Applicable Water Quality Criteria and Interim Performance Specifications.

1. Applicable Directives

Current Federal Laws, Executive Orders, Department of Defense Directives, and Air Force/Army Regulations require Ft Dix and MAFB to comply with all applicable federal, state and local water pollution abatement and control criteria. Current directives also require the waste discharger to propose performance specifications for his waste water treatment facilities that will, as a minimum, provide for conformance with all known water quality requirements.

2. Proposed Interim Performance Specifications.

Appendix F contains the proposed interim performance specifications for the Ft Dix and MAFB sewage treatment facilities and the pertinent criteria on which these performance specifications have been based. The proposed performance specifications were verbally coordinated with the NJDEP and EPA, and should apply for the interim period until a final decision is reached concerning a basin-wide regional wastewater management program involving both Ft Dix and MAFB (discussed in Part III. E.). Long-range performance specifications for the Ft Dix and MAFB sewage treatment facilities may be developed and negotiated at a future date if regionalization of wastewater treatment in this drainage basin does not materialize. Table 1 contains the proposed interim performance specifications.

TABLE 1. Proposed Interim Performance Specifications for Sewage Treatment Facilities at Ft. Dix and MAFB.

Parameter	Proposed Specifications
5-Day Biochemical Oxygen Demand	90 percent removal or 25 mg/l whichever is more stringent.
Suspended Solids	90 percent removal or 100 mg/l whichever is more stringent.
Chemical Oyxgen Demand	80. mg/l
Dissolved Solids	400. mg/l
Detergents (MBAS as LAS)	3.0 mg/l
Phenols	0.015 mg/l
Oil and Grease	10. mg/l
Mercury	0.01 mg/l
Total Chromium	0.10 mg/l
Hexavalent Chromium	0.10 mg/l
Lead	0.10 mg/l
Zinc	0.60 mg/l
Copper	0.20 mg/l
Silver	0.01 mg/l
Nickel	0.05 mg/l
Arsenic	0.10 mg/l
Cyanide	0.01 mg/l
Barium	2.00 mg/l
Aluminum	1.00 mg/l
Cadmium	0.02 mg/l
Fecal Coliforms (Geom. Mean)	300/100 ml
Debris, Scum, Float. Materials	None
Toxicity (1:1 Dilution)	<96-hr TL_{50}
Odor (Threshold Odor No)	250
Chlorine Residual	1 mg/l following 30 minutes contact time.

C. Wastewater and Its Treatment at Ft Dix and MAFB.

1. Fort Dix

a. General Description of Domestic Waste Treatment Plant.

The high rate trickling filter sewage treatment plant at Ft Dix has a rated capacity of 3.0 MGD. This plant was originally constructed in 1943. An older, standard-rate, fixed nozzle biofiltration plant (design capacity - 1.25 MGD) has been used intermittently in recent years to treat waste flows exceeding the 3.0 MGD capacity of the newer plant. The basic unit operations and processes included in the 3.0 MGD plant are: bar screen; grit chamber; primary sedimentation; trickling filters; secondary sedimentation; recirculation facilities; effluent chlorination; sludge handling facilities, including anaerobic digestion and digested sludge drying beds. Figure 2 is a simplified schematic flow diagram of the Ft Dix sewage treatment facility.

(1) Recirculation Scheme

Recirculation of waste in a high rate trickling filter is considered advantageous for several reasons. Among the advantages may be included: resistance to shock loads, increased removal of dissolved organics, enhanced suspended solids removal and equalization of variations in raw sewage strength. The rate of recirculation versus the rate of raw sewage flow, the recirculation ratio, will vary between 1 and 10, or even higher at some high rate trickling filter installations. A total of 6.6 MGD of sewage is continuously recirculated in the Ft Dix plant, 3.3 MGD are recirculated from the final clarifier effluent to the trickling filter influent, and 3.3 MGD from the final clarifier effluent, including sludge underflow from the final clarifier to the primary clarifier influent. Sludge removed in the primary clarifier is transported to the anaerobic digesters. At the plant's design capacity of 3.0 MGD, the recirculation ration is 2:1.

(2) Expected Efficiencies

Since a trickling filter sewage treatment plant involves biochemical and physical processes the BOD_5 and SS determinations are the principle yardsticks used to measure both the characteristics of the applied loading and the quality of the final effluent. A well designed and well operated high-rate trickling filter treatment plant such as the Ft Dix facility may be expected to consistently achieve 85 percent removal of BOD_5 and SS.

(3) Plant Monitoring/Control

Plant daily monitoring and control operations are excellent. Daily operating parameters and sample analyses are recorded

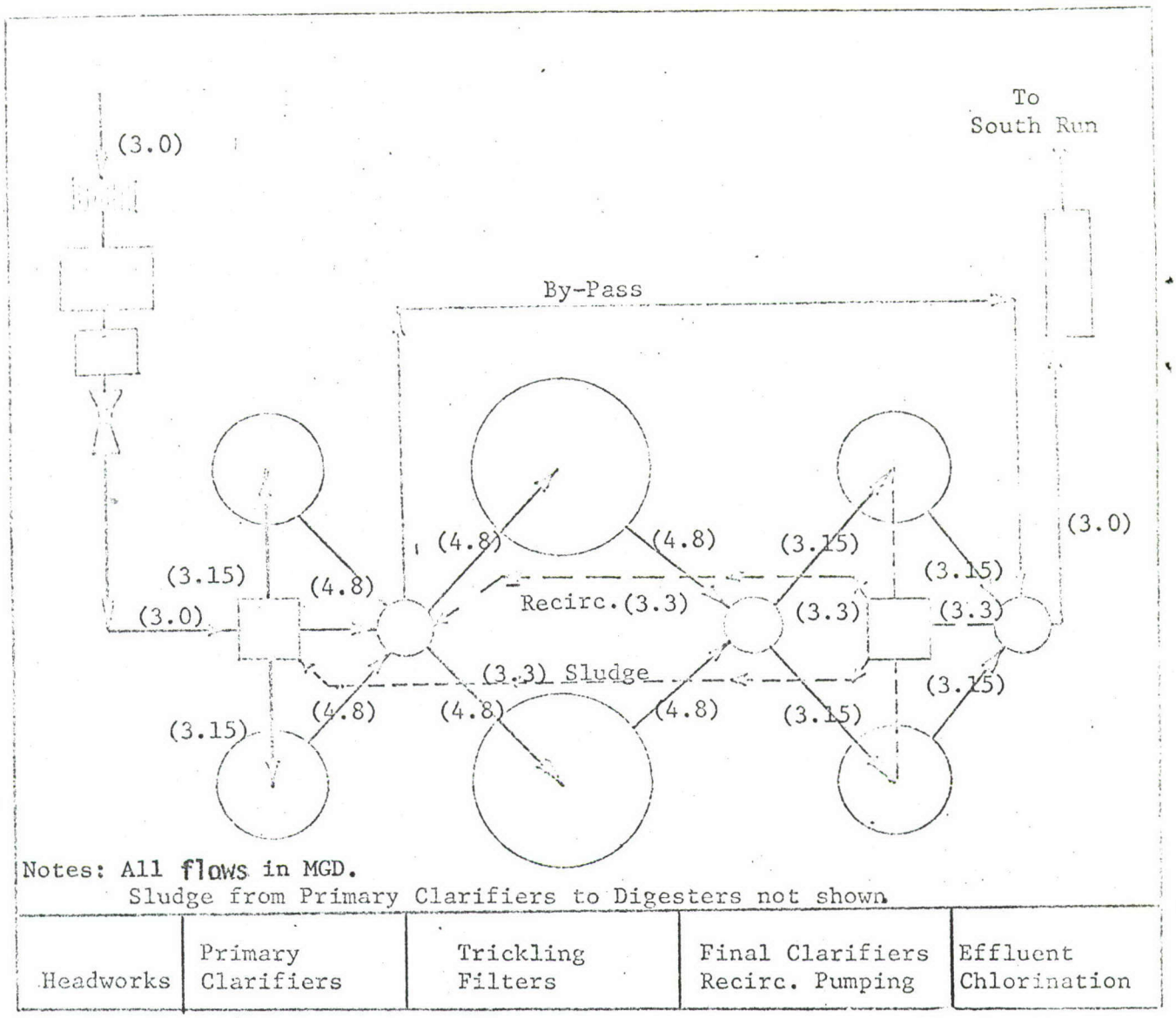

FIGURE 2. Simplified Schematic Flow Diagram - Ft. Dix Sewage Treatment Plant at Design Flow of 3.0 MGD.

TABLE 2. Routine Plant Monitoring, Ft. Dix Sewage Treatment Plant.

	Parameter	General	Raw Sewage	Primary Effluent	Filter Effluent	Final Effluent
Climate	Precipitation(in/day)	D	-	-	-	-
	Wind Direction	D	-	-	-	-
	Air Temperature(°F)	D	-	-	-	-
Volumes (MGD)	Flow (Avg)	-	D	-	-	-
	Flow (Max)	-	D	-	-	-
	Flow (Min)	-	D	-	-	-
	Recirculation	D	-	-	-	-
Character-istic (mg/l)	BOD_5	-	WD	WD	WD	WD
	Suspended Solids	-	WD	WD	WD	WD
	Settleable Solids	-	WD	WD	-	WD
	Dissolved Oxygen	-	-	-	WD	WD
	pH	-	WD	WD	-	-
Disin-fect-ion	Chlorine Application (lb/day)	D	-	-	-	-
	Chlorine Residual (mg/l)	-	-	-	-	D
Solids Hand-ling	Raw Sludge Pumped (gal)	D	-	-	-	-
	Grit Removed (ft^3)	M				
Receiv-ing Stream	BOD_5	W	-	-	-	-
	Dissolved Oxygen	W	-	-	-	-

*Code: D = Daily; WD = Weekdays; W = Weekly M = Monthly

on Utilities Operating Logs (DA Forms 5-60 and 5-61). Table 2 contains a summary of the routine plant monitoring program.

b. Historical Data Summary

Plant operating logs for two extended periods (Aug 70-July 71 and Mar 72 - Sep 72) were analyzed. Included in these analyses were evaluations of the operating data on a seasonal basis. The following discussion contains a summary of historical data for the Ft Dix treatment facility for waste volumes, effluent characteristics, and removal efficiencies. Appendix D contains detailed operating log data summaries.

(1) Waste Volumes

In general, the Ft Dix waste volumes have decreased considerably since January 1972 due to a gradual reduction in the resident population on the base. During the Aug 70 through July 71 period, the average daily waste volumes treated by the Ft Dix facility exceeded the plant's design capacity of 3.0 MGD 60 percent of the time. During the Mar-Sep 72 period, the plant's average design capacity was exceeded only 11 percent of the time. A comparison of a dry month (Sep 70) with a very wet month (Feb 71) revealed that a 90 percent confidence level, the mean daily flow during the wet month was significantly greater than for the dry month (see Table 3), and exceeded the plant's capacity more than 95 percent of the time. A direct cause-and-effect relationship was not developed between sewage flows and wet and dry weather conditions. However, the increase in waste flows during wet weather periods does suggest ground water infiltration into the sanitary sewer collection system.

Table 3. Ft Dix Sewage Plant Raw Sewage Flow Statistical Data Summary, Aug 70 - Sept 72.

Period	Raw Sewage Flow (MGD)				
	Range	Mean	Median	90% CI	N
Sept 70	2.35-3.73	3.04	3.10	2.97 - 3.11	30
Feb 71	2.92-4.89	3.69	3.60	3.59 - 3.79	28
Aug 70-July 71	2.96-4.89	3.10	3.10	3.07 - 3.13	366
Mar 72-Sept 72	2.14-3.97	2.74	2.75	2.72 - 2.76	177

(2) Effluent BOD_5 and Removal Efficiency.

Effluent BOD_5 data was available only for week days (Monday - Friday). An analysis of data contained in Tables 4 and 5 reveals that the weekday effluent BOD_5 and removal efficiencies have remained relatively constant. There was no significant difference in the mean weekday effluent BOD_5 while at a 90 percent confidence level the BOD_5 removal efficiency during the period of lower hydraulic loading (Sep 70) was significantly greater than for all other periods. Worthy of particular note is the weekday BOD_5 mass emission rate (MER) for the most recent period (Mar-Sep 72) was approximately 560 pounds per day while during the Aug 70-July 71 period the MER was 620 pounds per day.

Table 4. Ft Dix Sewage Plant Effluent BOD_5 Statistical Data Summary, Aug 70 - Sept 72.

Period	Effluent BOD_5 (mg/l)				
	Range	Mean	Median	90% CI	N
Sept 70	13 - 40	25.1	26.3	23.1 - 27.1	18
Feb 71	11 - 37	22.7	22.2	20.4 - 24.9	18
Aug 70-July 71	10 - 42	23.9	24.5	23.2 - 24.6	181
Mar 72-Sept 72	7 - 45	24.4	24.0	23.4 - 25.2	116

Table 5. Ft Dix Sewage Plant BOD_5 Removal Efficiency Statistical Data Summary, Aug 70 - Sept 72.

Period	BOD_5 Removal Efficiency (Percent)				
	Range	Mean	Median	90% CI	N
Sept 70	87.3 - 95.4	91.4	92.0	90.6 - 92.1	18
Feb 71	81.4 - 94.2	88.6	89.0	87.4 - 89.9	18
Aug 70-July 71	75.8 - 98.9	90.2	91.0	89.8 - 90.5	152
Mar 72-Sept 72	70.0 - 96.6	88.7	89.5	88.2 - 89.3	115

(3) Effluent Suspended Solids (SS) and Removal Efficiency

Only weekday SS data was available. The effluent weekday SS concentration was significantly lower during the period of lower hydraulic loading than for all other periods, while the mean weekday SS removal efficiencies for all periods were relatively constant. The weekday suspended solids MER for the periods Aug 70-July 71 and Mar-Sept 72 were 465 pounds per day and 480 pounds per day respectively (see Tables 6 and 7).

Table 6. Ft Dix Sewage Plant Effluent SS Data Summary, Aug 70 - Sept 72.

Period	Effluent SS (mg/l)				
	Range	Mean	Median	90% CI	N
Sept 70	7 - 22	13.7	14	12.6 - 14.7	19
Feb 71	11 - 65	21.6	16	16.7 - 26.5	15
Aug 70-July 71	7 - 65	18.0	15	17.2 - 18.8	174
Mar 72-Sept 72	4 - 74	21.1	18	19.6 - 22.6	120

Table 7. Ft Dix Sewage Plant SS Removal Efficiency Statistical Data Summary, Aug 70 - Sept 72.

Period	SS Removal Efficiency (Percent)				
	Range	Mean	Median	90% CI	N
Sept 70	86.6 - 92.7	90.2	91.0	89.6 - 90.8	17
Feb 71	50.0 - 94.5	85.7	90.7	81.5 - 89.9	17
Aug 70-July 71	55.0 - 97.9	87.6	89.5	86.7 - 88.5	167
Mar 72-Sept 72	56.7 - 96.3	89.2	90.5	88.7 - 89.7	119

c. Field Survey Results (11 to 23 Sep 1972)

Flow proportional samples at the Ft Dix waste treatment plant were obtained for two distinct periods: one period of seven consecutive days for 24-hour samples; and one period of 5 weekdays for 12-hour samples (0800-2000 hours). Appendix B, "Field Survey Procedures," contains locations of sampling stations, and analytical procedures used. Pertinent field survey data tabulations summaries are contained in Appendix C.

(1) Waste Volumes

The total daily flow at the Ft Dix plant during the 12-day field survey period ranged from 2.68 MGD to 3.21 MGD. The weekday average was 3.05 MGD while the weekend average was 2.48 MGD. The instantaneous peak flows were: weekdays - 5.16 MGD; weekend - 4.10 MGD. Figure 3 is a composite graph of hourly variations in average flow for a typical weekday (3-day average) and a typical weekend (2-day average). Waste volumes recorded during the 12-hour (0800-2000 hours) weekday composite sampling periods ranged from 55 to 62 percent of the total daily flow, averaging 59 percent.

(2) Raw Waste Characteristics

In addition to the normal characteristics for domestic wastes (BOD_5 and SS) other constituents were measured to characterize the industrial waste fraction of the wastewaters and to determine the nitrogen and phosphate forms present. Table 8 contains a summary of selected constituent concentrations noted for the 24-hour and 12-hour weekday and 24-hour weekend sampling periods. The raw waste is characterized as medium strength domestic sewage with only minor fractions of industrial wastes. As expected, the strength of the raw waste was higher for the 12-hour composite samples. In general, the concentrations of those constituents characteristic of industrial wastewaters were lower during the weekend 24-hour sampling period. Worthy of particular note are the concentrations of silver. During five weekdays of 24-hour sampling approximately 5.3 pounds of silver were contained in the Ft Dix raw wastewaters.

(3) Treatment Efficiencies

Tables 9 and 10 contain summaries of field survey influent and effluent concentrations of selected constituents in the Ft Dix sewage plant for the 7-day, 24-hour and 5-day, 12-hour composite sampling periods, respectively. Removal efficiencies for oxygen demands and suspended solids for each major unit process are included with overall efficiencies for the entire treatment process for all selected constituents based on raw sewage influent concentrations. Comparisons of these data with data obtained during the 12-hour, 5-day sampling period must be evaluated in light of the different sampling periods used (see Appendix C). In general, the overall removal efficiencies noted for the 5-day, 12-hour composite sampling period are higher than for the 7-day, 24-hour period, while the raw sewage and final effluent are somewhat stronger, suggesting slightly more efficient operations during periods of slightly heavier hydraulic and organic loadings.

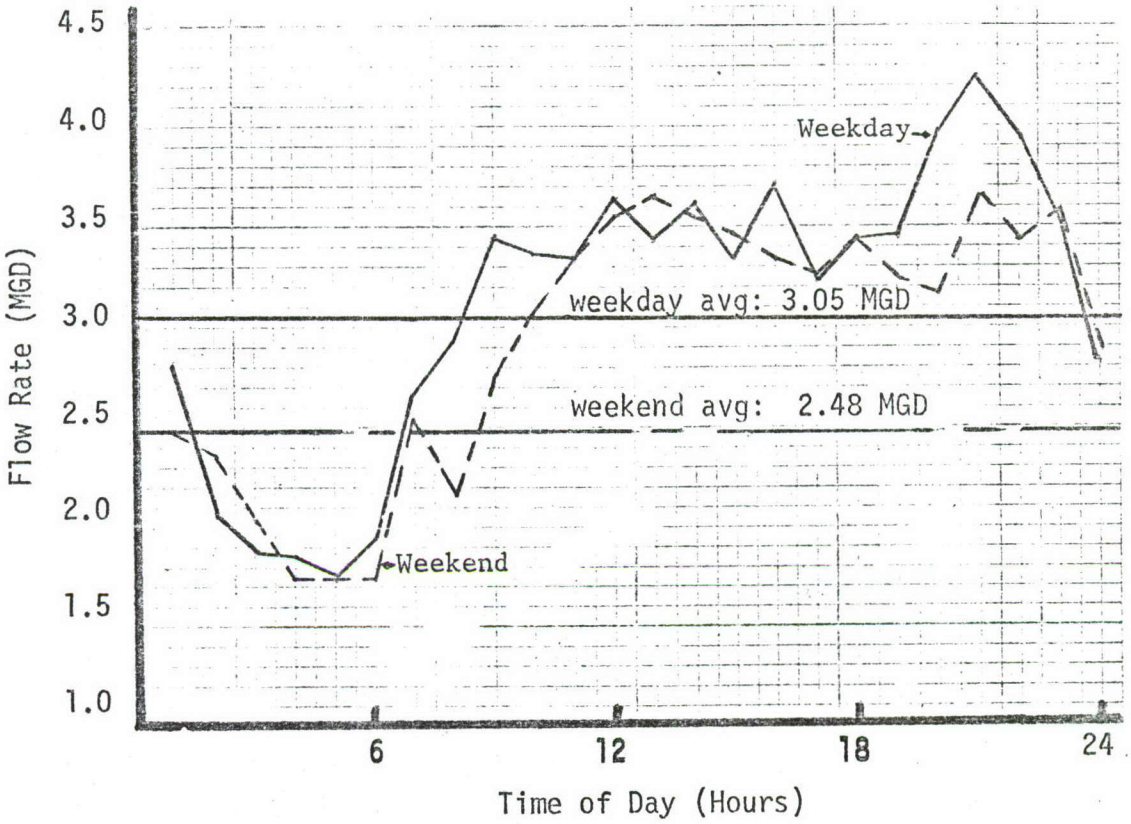

FIGURE 3. Composite Hourly Raw Waste Flow Variations - Ft. Dix Sewage Treatment Plant, September 1972.

TABLE 8. Field Survey Data Summary - Ft. Dix Raw Waste Characteristics, September 1972.

CONSTITUENT	INFLUENT CONCENTRATION (mg/ℓ)								
	5-Day 24-hour Composite			5-Day 12-hour Composite			2-Day Weekend 24-hour Composite		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
BOD_5	120	233	201.0	142	263	228	-	230	230
COD	364	422	393	393	561	474	357	382	369
TOD	425	620	549	-	-	-	370	450	410
TOC	63	123	91.8	86	123	105	59	81	70
SS	170	245	191	155	220	186	125	200	162
Oil & Grease	39	98	78.4	114	118	116	76	164	120
MBAS as LAS	4.6	7.6	6.8	6.4	12.0	8.0	8.0	9.2	8.6
Phenols	0.04	0.07	0.050	<0.08	0.14	<0.098	0.030	0.035	0.033
Phosphate-Total	9.8	11.6	10.7	6.7	11.6	8.8	13.5	14.2	13.85
-Ortho	7.7	8.5	8.05	8.2	8.6	8.37	7.7	7.8	7.75
CN	-	<0.010	<0.010	-	0.010	<0.010	-	<0.010	<0.010
As	-	<0.010	<0.010	-	-	-	-	<0.010	<0.010
Nitrogen-Kjeldahl	22.0	35.0	26.6	25.0	29.5	26.5	22.5	23.5	23.0
NH_3N	13.0	14.2	13.9	12.5	13.0	12.8	12.0	12.5	12.2
Cu	<0.02	0.07	<0.033	-	<0.02	<0.02	0.02	0.03	0.025
Zn	0.02	0.13	0.08	0.11	0.24	0.02	0.05	0.05	0.05
Ag	0.02	0.07	0.042	<0.01	0.03	<0.16	-	<0.010	<0.010

Table 9. Field Survey Data Summary - Ft. Dix Sewage Plant Unit and Overall Removal Efficiencies, 7-Day, 24-hour Composite Samples, September 1972.

Parameter or Constitutent	Raw Sewage	Primary Clarifiers				Trick. Filt.& Final Clarif				Final Chlorination			
		Infl	Effl	Percent Reduction Unit	Percent Reduction Over-all	Infl	Effl	Percent Reduction Unit	Percent Reduction Over-all	Infl	Effl	Percent Reduction Unit	Percent Reduction Over-all
Flow	(MGD) 3.01	(MGD) 6.31	(MGD) 6.31	-	-	(MGD) 9.61	(MGD) 6.31	-	-	(MGD) 3.01	(MGD) 3.01	-	-
	(mg/1)	(mg/1	(mg/1)			(mg/1)	(mg/1)			(mg/1)	(mg/1)		
BOD_5	206	131	79	39.4	61.4	74	21	71.6	89.8	21	21	0	89.8
COD	386	275	173	37.2	55.2	167	83	50.3	78.6	83	80	2.8	79.2
TOD	516	370	268	27.6	48.1	282	143	49.3	72.3	143	150	+4.7	70.9
TOC	86	-	-	-	-	-	-	-	-	-	25	-	70.4
SS	183	135	104	23.2	43.2	73	30	58.9	83.8	30	38	+29	79.1
Oil & Grease	90.3	-	-	-	-	-	-	-	-	-	116	-	+28.1
MBAS as LAS	7.3	-	-	-	-	-	-	-	-	-	2.4	-	~67.3
Phenols	0.045	-	-	-	-	-	-	-	-	-	0.012	-	73.0
Phosphate-Total	11.8	-	-	-	-	-	-	-	-	-	9.9	-	16.1
-Ortho	7.9	-	-	-	-	-	-	-	-	-	6.2	-	22.0
Nitrogen-Kjeldahl	25.6	-	-	-	-	-	-	-	-	-	19.7	-	23.0
NH_3-N	13.4	-	-	-	-	-	-	-	-	-	12.6	-	5.9
Cu	0.033	-	-	-	-	-	-	-	-	-	<0.024	-	~27.0
Zn	0.083	-	-	-	-	-	-	-	-	-	0.043	-	48.2
Ag	0.033	-	-	-	-	-	-	-	-	-	0.01	-	~70.0

TABLE 10. Field Survey Data Summary - Ft. Dix Sewage Plant Unit and Overall Removal Efficiencies, 5-Day, 12-hour Composite Samples, September 1972.

Parameter or Constituent	Sewage	Primary Clarifiers				Trick. Filt.& Final Clarif				Final Chlorination			
		Infl	Effl	Percent Reduction Unit	Percent Reduction Over-all	Infl	Effl	Percent Reduction Unit	Percent Reduction Over-all	Infl	Effl	Percent Reduction Unit	Percent Reduction Over-all
Flow	(MG) 1.73	(MG) 3.48	(MG) 3.48			(MG) 5.13	(MG 3.48			(MG) 1.73	(MG) 1.73		
	(mg/1)	(mg/1)	(mg/1)	-	-	(mg/1)	(mg/1)	-	-	(mg/1)	(mg/1)		
BOD_5	228	221	120	45.7	47.4	108	<27	>75.0	>88.2	<27	<20	~25.2	>91.1
COD	474	274	170	37.9	64.1	236	74	68.6	84.4	74	94	+28	94.3
TOD	-	-	-	-	-	-	-	-	-	-	-	-	-
TOC	105		-	-	-	-	-	-	-	-	27	-	74
SS	186	125	-	-	-	-	57.5	-	75.6	46	32	30.4	82.8
Oil & Grease	116	-	-	-	-	-	-	-	-	-	69.5	-	40.1
MBAS as LAS	8.0	-	-	-	-	-	-	-	-	-	1.94	-	75.8
Phenols	<0.098	-	-	-	-	-	-	-	-	-	0.019	-	<80.6
Phosphate-Total	8.83	-	-	-	-	-	-	-	-	-	7.5	-	15.1
-Ortho	8.37	-	-	-	-	-	-	-	-	-	6.4	-	23.5
Nitrogen-Kjeldahl	26.5	-	-	-	-	-	-	-	-	-	21.8	-	17.7
$-ND_3-N$	12.83	-	-	-	-	-	-	-	-	-	12.5	-	2.6
Cu	<0.02	-	-	-	-	-	-	-	-	-	<0.02	-	-
Zn	0.158	-	-	-	-	-	-	-	-	-	0.066	-	58.2
Ag	<0.16	-	-	-	-	-	-	-	-	-	<0.012	-	~92.0

(a) Unit Process Efficiencies

Following is a brief discussion of unit process efficiencies noted during the field survey.

1. Primary Clarification

The expected efficiencies for BOD_5 and SS reduction in primary clarification are 35 percent and 65 percent respectively. The BOD_5 removal efficiency noted during the field survey (approximately 60 percent) was somewhat above the expected level. The SS removal efficiency (approximately 43 percent), however, was found to be below the expected level. The surface loading rate was calculated as 720 gal/ft^2/day within the recommended range of 600-800 gal/ft^2/day. The calculated mean detention time of 1.97 hours was also within the recommended range of 1-2 hours. The weir loading rate was calculated as 13,800 gal/ft/day, within the recommended 15000 gal/ft/day. The apparent inefficient SS removal in these primary clarifiers may be a result of occasional excessive weir loading rate and inefficient sludge removal from the clarifiers. Operational problems with the primary clarifier sludge scraping mechanism were encountered during the field study but were corrected toward the end of the field sampling period.

2. Trickling Filtration and Final Clarification.

The theoretical BOD_5 unit reduction efficiency across this plant's trickling filter and final clarifiers, as calculated by the National Research Council (NRC) formula, is 81.4 percent. The actual BOD_5 removal efficiency (24-hour samples) was 71.6 percent. The hydraulic loading was calculated as 15.8 MGAD within the recommended range of 8.7 to 44 MGAD for high rate filters. The organic loading, including recirculation, was calculated as 1,740 lb/ac-ft/day within the recommended range of 1,100 to 13,000 lb/ac-ft/day. BOD removal by trickling filters is affected by climatic conditions. The removal efficiency noted during the field survey was probably depressed because of the colder sewage, and somewhat influenced by the depressed solids removal in both the primary and secondary clarifiers.

3. Final Chlorination

The expected reduction in BOD_5 through application of chlorine to such a secondary effluent should range from 10 to 35 percent, depending on the condition and stage of decomposition of the organic matter, the contact time, the pH, and temperature. No reduction in BOD_5 was noted during the field survey. An increase in

suspended solids was noted, and probably accounts for the lack of BOD_5 reduction by chlorination.

(b) Overall Plant Efficiencies

Overall, the BOD_5 removal efficiency was somewhat above the expected level, while the SS removal efficiency was somewhat lower than the expected level.

(4) Treated Effluent Disinfection

A single unit vacuum solution feed gas chlorination is being used for metering and injecting a chlorine solution into the sewage plant final effluent. During the field survey an existing final clarifier from the 1917 plant facilities was being used as a chlorine contact chamber. Periodically, settled sludge collected in this clarifier is pumped to the anaerobic digesters. The total estimated detention time achieved in this chlorine contact chamber exceeds 60 minutes at an average daily flow of 3.0 MGD. The existing chlorine contact chamber which was not being used during the field survey provides a chlorine contact time of 15 minutes at a flow of 3.0 MGD.

(a) Chlorine Dose Rate

The chlorine delivery rate is constant at approximately 100 lb/day. At the plant's average design flow of 3.0 MGD this chlorine dose rate results in an average daily application of 3.8 mg/l of chlorine. During the field survey (11 - 22 Sept), the daily chlorine delivery rate ranged from 64 to 122 lb/day, averaging 94 lb/day. The average daily dose rate ranged from 2.6 to 4.7 mg/l, averaging 3.8 mg/l. At sustained peak flow (4-hour duration, 3.9 MGD) the average chlorine dose rate was 2.5 mg/l. The recommended dose rate for this plant ranges from 3.0 to 15.0 mg/l. The State of NJ requires a 30-minute contact time at design flow with a free chlorine residual of 1.0 mg/l in the final effluent. The final effluent free chlorine residual noted during the field survey ranged from 0.0 to 0.6 mg/l, averaging 0.26 mg/l.

(b) Effluent Bacteriological Quality

Bacteriological analyses of this plant's chlorinated effluent were accomplished during the field survey. There is no NJ State standard for sewage plant effluent bacteriological quality. The receiving water standard; however, limits the concentration of fecal coliforms to a maximum geometric mean of 200/100 ml in the stream. The geometric mean of 6 day-time samples from the final chlorinated effluent of the Ft Dix plant was less than 233 fecal coliforms per 100 ml (see Appendix G).

(5) Effluent Toxicity

The DRBC effluent quality criteria require that the toxicity of the Ft Dix effluent be less than the 96-hour TL50 in a 1:1 dilution. Two species of test fish (fathead minnows from EHL(K) Laboratory culture and native sunfish from the Crosswicks Creek watershed) were exposed to 100 percent of prechlorinated effluent with aeration for a period of 96 hours. No mortality was experienced for either test species, documenting the absence of acutely toxic elements in the effluent (see Appendix G).

(6) Compliance with Proposed Performance Specifications

Appendix F contains a detailed summary of plant effluent characteristics compared with the proposed interim performance specifications. Table 11 contains a summary of data for parameters noted during the field survey that were not in compliance with the proposed specifications. The effluent characterisitcs for all other parameters complied with the proposed limits.

Table 11. Parameters Noted During Field Survey Not in Compliance with Proposed Performance Specifications - Ft Dix Sewage Plant.

Parameter	Performance Specification	Mean Effluent Concentration or Removal Efficiency	
		24-hr, 7 Day	12-hr, 5 Day
BOD_5	90% Removal	$\bar{>}$ 89.7%	-
SS	90% Removal	79.7%	82.5%
COD	80 mg/l	-	94.4 mg/l
Phenol	0.015 mg/l	-	0.019 mg/l
Oil & Grease*	10 mg/l	115.7 mg/l	69.5 mg/l
Aluminum	1.0 mg/l	1.4 mg/l	-
Silver	0.01 mg/l	-	0.012 mg/l

* Note: Validity of O & G data questionable.

2. McGuire AFB

a. General Description of Domestic Waste Treatment Plant

The high rate trickling filter sewage plant at MAFB has a rated capacity of 1.25 MGD. This plant was originally constructed in 1950. The basic unit operations and processes included in this plant are: bar screen/comminuter; grit chamber; primary sedimentation, trickling filters;

secondary sedimentation, recirculation facilities; effluent chlorination; sludge handling facilities, including anaerobic digestion and digested sludge drying beds. Figure 4 is a simplified schematic flow diagram of this facility.

(1) Recirculation Scheme

An average total of 1.28 MGD of sewage is intermittantly recirculated in the MAFB plant from the final clarifier effluent, including sludge underflow from the final clarifier to the primary clarifier influent. Sludge removed in the primary clarifier is transported to the anaerobic digesters. At the plant's design capacity of 1.25 MGD, this rate of recirculation results in a recirculation ratio of 1:1. The plant's capacity for recirculation is 2.50 MGD or a ratio of 2:1.

(2) Expected Efficiencies

Like the sewage plant at Ft Dix, the MAFB secondary sewage plant may be expected to consistently achieve 85 percent removal of BOD_5 and SS.

(3) Plant Monitoring and Control

(a) Daily plant monitoring and control operations are excellent. Daily operating parameters and sample analyses are recorded on Water Pollution Control Utility Operating Logs (AF Forms 1462 and 1463). Table 12 contains a summary of the routine plant monitoring program.

(b) Historical Data Summary

Plant operating logs for the MAFB plant were analyzed. The following discussion contains a summary of MAFB plant operating data for waste volumes, effluent BOD_5 and SS, and removal efficiencies. Appendix D contains detailed operating log data summaries.

1. Waste Volumes

The MAFB mean daily waste volumes have remained relatively constant during these periods (see Table 13). The mean daily waste flows exceeded this plant's design capacity of 1.25 MGD 60 percent of the time. A comparison of a dry-weather month (Sept 70) with a wet-weather month (Feb 71) revealed that at a 90 percent confidence level, the wet-weather flow was significantly greater. The plant's average daily design capacity was exceeded approximately 95 percent of the time during the wet-weather period, and exceeded only 20 percent of the time for the dry weather period. Ground water infiltration during wet

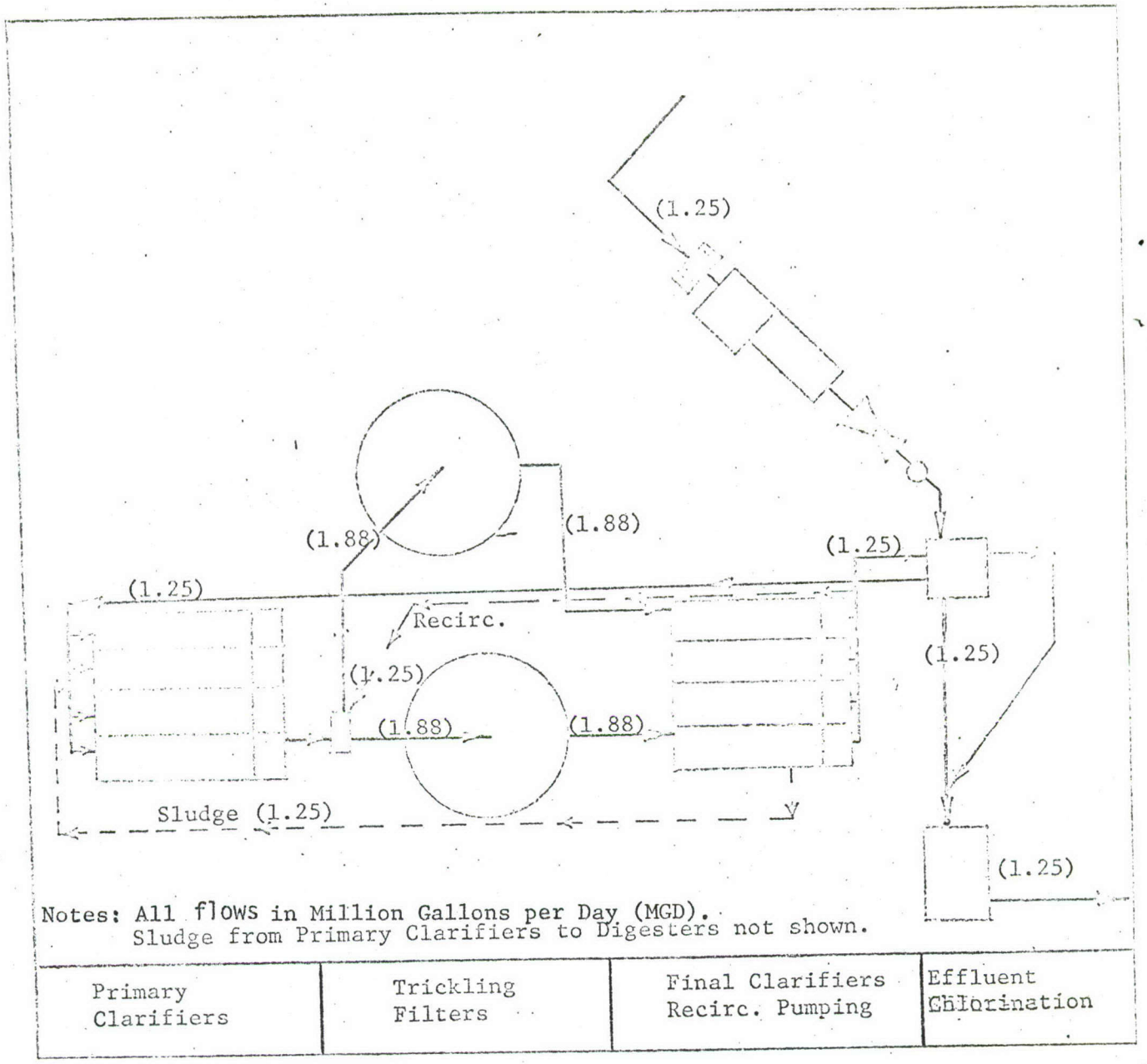

FIGURE 4. Simplified Schematic Flow Diagram - McGuire AFB Sewage Treatment Plant at Design Flow of 1.25 MGD.

Table 12. Routine Plant Monitoring - McGuire AFB Sewage Treatment Plant*

	Parameter	General	Raw Sewage	Primary Effluent	Final Effluent
Climate	Precipitation (in/day)	D	-	-	-
	Wind Direction	D	-	-	-
	Air Temperature (^{o}F)	D	-	-	-
Volumes	Flow (Avg)	-	D	-	-
	Flow (Max)	-	D	-	-
	Flow (Min	-	D	-	-
	Recirculation	D	-	-	-
Character-istics	BOD_5	-	D	D	D
	Suspended Solids	-	D	D	D
	Settleable Solids	-	D	D	D
	Dissolved Oxygen	-	-	-	D
	pH				
Disin-fection	Chlorine Applied (lb/day)	D	-	-	-
	Chlorine Residual (mg/l)	-	-	-	D
Solids Handling	Raw Sludge Pumped (gal)	D	-	-	-
	Grit Removed (ft^3)	M	-	-	-
	Raw Sludge % Solids	D	-	-	-
	Raw Sludge % Volatile	D	-	-	-
	Digested Sludge to Drying (gal)	W	-	-	-
	Dried Sludge Removed (yd^3)	M	-	-	-
Anaerobic Digesters	pH	M	-	-	-
	Solids (%)	M	-	-	-
	Volatile Solids (%)	M	-	-	-
	Temperature	D	-	-	-
Receiv-ing Stream	BOD_5	W	-	-	-
	Dissolved Oxygen	W	-	-	-

*CODE: D = Daily; W= Weekly; M= Monthly

weather periods is evident.

Table 13. MAFB Sewage Plant Raw Sewage Plant Flow Statistical Data Summary, August 1970 - September 1972.

Period	Raw Sewage Flow (MGD)				
	Range	Mean	Median	90% CI	N
Sep 70	0.82-2.20	1.17	1.12	1.11-1.23	30
Feb 71	1.19-2.40	1.66	1.60	1.34-1.98	28
Aug 70-Jul 71	0.82-3.06	1.39	1.33	1.37-1.42	301
Mar 72-Sep 72	0.79-2.53	1.36	1.32	1.33-1.38	178

2. Effluent BOD_5 and Removal Efficiencies

Daily effluent BOD_5 data was available for the periods reviewed. The mean daily effluent BOD_5 concentrations for the periods, Aug 70 - July 71 were significantly greater than for the more recent period, Mar - Sep 72 (see Tables 14 and 15). The mean daily effluent BOD_5 for the dry-weather month (Sept 70) was significantly lower than for the wet-weather month (Feb 71). BOD_5 removal efficiencies for this plant, according to plant operating logs, were within expected limits. Worthy of note is the daily BOD_5 mass emission rate (MER) for the most recent period (Mar-Sept 72) which was approximately 230 pounds per day BOD_5, while for the earlier period (Aug 70 - July 71) the MER was 260 pounds per day BOD_5. Although the most recent period's mean effluent BOD_5 concentration was significantly less than the earlier period's BOD_5 effluent concentration, the respective removal efficiency for the most recent period was unexpectedly lower. The depressed BOD_5 removal efficiency for the most recent period most probably results from inefficient sludge removal in the final clarifier, and the solids carry-over in the final effluent.

3. Effluent SS and Removal Efficiencies

The mean daily effluent SS concentration was lowest during the period of lower hydraulic loading (Sept 70) when the waste volume treated by this plant did not exceed the facility's design capacity. During the period of higher hydraulic loading (Feb 71) the

Table 14. MAFB Sewage Plant Effluent BOD_5 Statistical Data Summary, August 1970 - September 1972.

Period	Effluent BOD_5 (mg/l)				
	Range	Mean	Median	90% CI	N
Sep 70	15-29	20.3	21.0	19.6-21.0	30
Feb 71	17-48	24.1	23.0	22.7-25.6	28
Aug 70-Jul 71	10-48	22.1	22.0	21.4-22.9	70
Mar 72-Sep 72	12-26	20.3	23.0	19.5-21.1	34

Table 15. MAFB Sewage Plant BOD_5 Removal Efficiency Statistical Data Summary, August 1970 - September 1972.

Period	BOD_5 Removal Efficiency (Percent				
	Range	Mean	Median	90% CI	N
Sep 70	84.3-92.7	89.0	89.0	88.6-89.4	30
Feb 71	80.2-90.2	87.6	88.4	86.6-88.6	28
Aug 70-Jul 71	77.8-94.3	88.6	88.8	88.4-88.9	146
Mar 72-Sep 72	73.9-98.8	85.3	86.3	84.5-86.1	36

mean daily effluent SS was significantly elevated and the corresponding SS removal efficiency was depressed (see Tables 16 and 17). The mean daily MER for the periods Aug 70 - July 71 and Mar - Sept 72 were 465 pounds per day and 480 pounds per day respectively.

Table 16. MAFB Sewage Plant Effluent SS Data Summary, Aug 70 - Sept 72

Period	Effluent SS (mg/l)				
	Range	Mean	Median	90% CI	N
Sept 70	16 - 26	20.9	21.5	20.2 - 21.6	30
Feb 71	18 - 54	25.3	25.0	23.6 - 27.0	28
Aug 70 - Jul 71	14 - 54	22.2	23.5	21.4 - 22.9	70
Mar 72 - Sep 72	12 - 36	21.7	22.8	20.9 - 22.6	39

Table 17. MAFB Sewage Plant SS Removal Efficiency Statistical Data Summary, Aug 70 - Sept 72

Period	Range	Mean	Median	90% CI	N
Sept 70	84.5 - 90.8	88.2	88.6	87.7 - 88.7	30
Feb 71	78.0 - 90.5	86.5	87.2	85.6 - 87.4	28
Aug 70 - Jul 71	74.2 - 93.3	87.0	87.9	86.6 - 87.4	121
Mar 72 - Sep 72	77.2 - 89.2	84.7	85.3	84.1 - 85.3	41

(c) Field Survey Results

Flow proportional composite samples at the MAFB waste treatment plant were obtained for two periods: 7 consecutive days, 24-hour samples; and 5-weekdays, 12-hour samples (0800-2000 hours). Appendix B, "Field Survey Procedures," contains locations of sampling stations and analytical procedures used. Pertinent field survey data tabulations and statistical summaries are contained in Appendix C.

1. Waste Volumes

The total daily waste flow at the MAFB plant during the 12-day field survey period ranged from 0.98 MGD to 1.66

MGD. The weekday average was 1.40 MGD, while the weekend average was 1.00 MGD. The instantaneous peak flows were: weekdays - 3.1 MGD; weekend - 1.6 MGD. Figure 5 is a composite graph of hourly variations in average flow for a weekday (3-day average) and a typical weekend (2-day average). Waste volumes recorded during the 12-hour (0800-2000 hours) weekday composite sampling periods ranged from 49 to 67 percent of the total daily flow, averaging 63 percent.

2. Raw Waste Characteristics

Table 18 contains a summary of selected constituent concentrations noted in the raw waste for the 24-hour and 12-hour weekday and 24-hour weekend sampling periods. The raw waste is characterized as weak to medium strength domestic sewage with some industrial waste fractions. As expected, the strength of the raw waste was higher for the 12-hour composite samples. The strength of the raw waste during the 24-hour weekend sampling period is more characteristic of medium strength domestic sewage. In general, the industrial waste fraction of this raw waste occurs during the normal daylight duty shift on weekdays as reflected in the relative elevation in the concentrations of detergents and phenols for this period.

3. Treatment Efficiencies

Tables 19 and 20 contain respectively summaries of field survey influent and effluent concentrations of selected constituents in the MAFB sewage plant for the 7-day, 24-hour and 5-day, 12-hour composite sampling periods. Unit process efficiencies for other selected parameters (oxygen demands and suspended solids) are included with the overall plant efficiencies for all selected constituents based on raw sewage influent concentrations. As expected, the quality of the final effluent and the overall plant removal efficiencies for the 5-day, 12-hour weekday sampling period are somewhat depressed as compared to the 7-day, 24-hour period (see Appendix C).

a. Unit Process Efficiencies

Following is a brief discussion of unit process efficiencies noted during the field survey.

(1) Primary Clarification

The BOD_5 removal efficiencies noted during the two sampling periods were above the expected 35 percent removal. The SS removal efficiencies were significantly depressed for both sampling periods. The surface loading rate was calculated as 415 gal/ft^2/day within the recommended limit of 800 gal/ft^2/day. The calculated detention time of 3.85 hours is acceptable. The weir loading

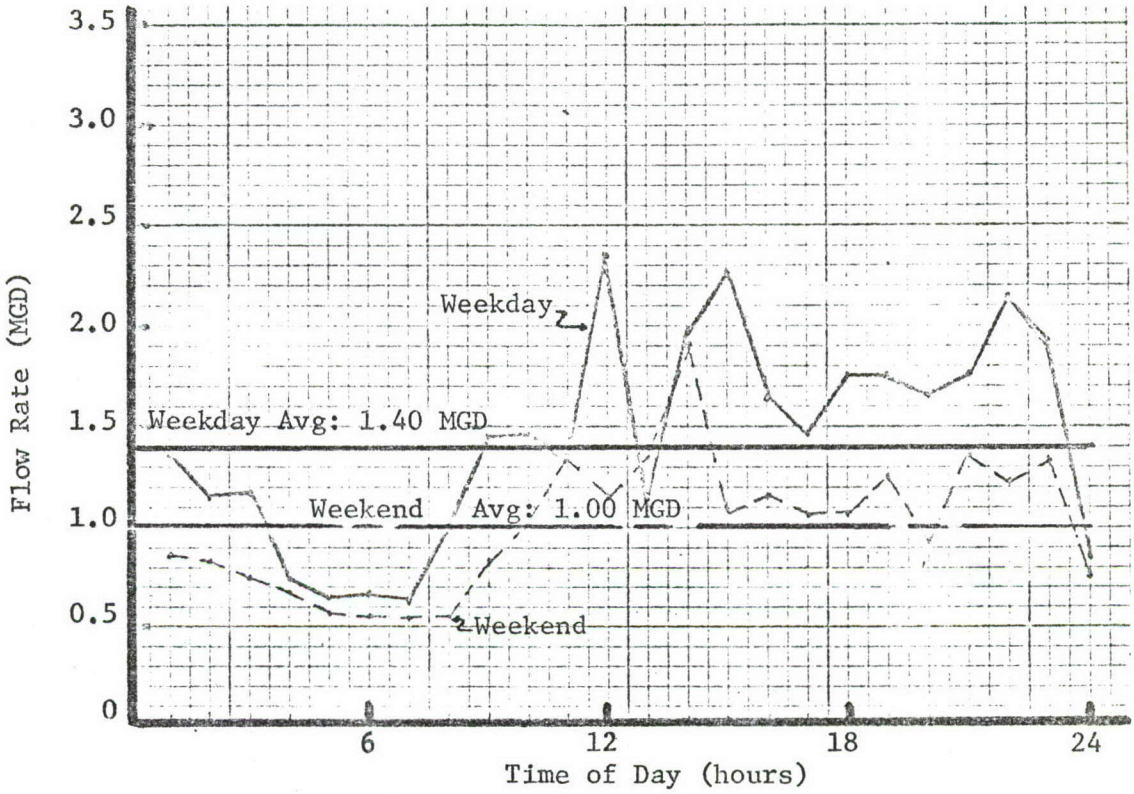

Figure 5. Composite Hourly Raw Waste Flow Variations-McGuire AFB Sewage Treatment Plant, September 1972.

Table 18. Field Survey Data Summary - MAFB Raw Waste Characteristics, September 1972.

	INFLUENT CONCENTRATION (mg/l)								
Oil & Grease	65	223	112	113	186	150	109	249	179
MBAS as LAS	7.6	10.6	9.1	9.0	19.0	12.6	9.6	11.2	10.4
Phenols	0.020	0.030	0.024	0.020	0.085	0.042	0.005	0.010	0.008
Phosphate-Total	8.8	11.1	10.2	6.9	10.3	8.0	9.6	13.9	11.8
-Ortho	6.2	6.8	6.6	6.6	6.9	6.8	6.4	6.6	6.5
CN	-	<0.010	<0.010	-	<0.010	<0.010	-	<0.010	<0.010
As	-	<0.010	<0.010	-	-	-	-	-	-
Nitrogen-Kjeldahl	14.2	27.5	18.2	16.0	17.5	17.0	14.0	15.0	14.5
NH_3-N	7.2	11.0	8.9	7.4	9.6	8.3	7.7	7.8	7.7
Cu	0.05	0.08	0.06	<0.02	0.03	< 0.028	0.07	0.08	0.07
Zn	0.01	0.07	0.03	0.06	0.09	0.08	0.02	0.04	0.03
Ag	-	<0.01	<0.01	<0.01	0.06	< 0.02	-	<0.01	<0.01

Table 19. Field Survey Data Summary - MAFB Sewage Plant Unit and Overall Removal Efficiencies, 7-Day, 24-hour Composite Samples, September 1972.

Parameter or Constituent	Sewage	Primary Clarifiers				Trick.Filt.& Final Clarif				Final Chlorination			
		Infl	Effl	Percent Reduction		Infl	Effl	Percent Reduction		Infl	Effl	Percent Reduction	
				Unit	Over-all			Unit	Over-all			Unit	Over-all
Flow	(MGD) 1.29	(MGD) 2.15	(MGD) 2.15	-	-	(MGD) 2.57	(MGD) 1.71	-	-	(MGD) 1.29	(MGD) 1.29	-	-
	(mg/1)	(mg/1)	(mg/1)			(mg/1)	(mg/1)				(mg/1)		
BOD_5	124	92	78	15.2	37.1	78	<30	>61.5	>75.8	<30	<24	~20.0	>80.6
COD	214	265	130	50.9	39.2	130	93	28.5	56.5	93	94	0	56.1
TOD	281	253	219	13.4	22.1	219	129	41.1	54.1	129	147	+14.0	47.7
TOC	51	-	-	-	-	-	-	-	-	-	27	-	47.0
SS	167	108	93	13.9	44.3	93	55	40.9	67.1	55	39	29.1	76.6
Oil & Grease	134	-	-	-	-	-	-	-	-	-	152	-	+13.4
MBAS as LAS	9.4	-	-	-	-	-	-	-	-	-	5.3	-	43.6
Phenols	0.019	-	-	-	-	-	-	-	-	-	0.010	-	47.4
Phosphate-Total	10.7	-	-	-	-	-	-	-	-	-	10.2	-	4.7
-Ortho	6.5	-	-	-	-	-	-	-	-	-	5.9	-	9.2
Nitrogen-Kjeldahl	12.2	-	-	-	-	-	-	-	-	-	14.4	-	+18.0
NH_3-N	8.5	-	-	-	-	-	-	-	-	-	7.6	-	10.6
Cu	0.063	-	-	-	-	-	-	-	-	-	0.056	-	11.1
Zn	0.033	-	-	-	-	-	-	-	-	-	0.020	-	39.4
Ag	<0.01	-	-	-	-	-	-	-	-	-	<0.010	-	-

Table 20. Field Survey Data Summary - MAFB Sewage Plant Unit and Overall Removal Efficiencies, 5-Day, 12-hour Composite Samples, September 1972.

Parameter or Constituent	Raw Sewage	Primary Clarifiers				Trick.Filt. & Final Clarif							
		Infl	Effl	Unit	Over-all	Infl	Effl	Unit	Over-all	Infl	Effl	Unit	Over-all
Flow	(MG) 0.73	(MG) 1.16	(MG) 1.16	-	-	(MG) 1.16	(MG) 0.73	-	-	(MG) 0.73	(MG) 0.73	-	-
	(mg/1)	(mg/1)	(mg/1)			(mg/1)	(mg/1)			(mg/1)	(mg/1)		
BOD_5	100	-	55	-	45	55	<29	>47.3	>71	<29	<24	~17.0	76.0
COD	273	326	164	49.7	39.9	164	85	48.2	68.9	85	108	+27.0	+60.4
TOD	-	-	-	-	-	-	-	-	-	-	-	-	-
TOC	75	-	-	-	-	-	-	-	-	-	34	-	54.7
SS	128	139	115	17.3	10.2	115	42	63.5	67.2	42	35	16.7	72.7
Oil & Grease	150	-	-	-	-	-	-	-	-	-	93	-	38.0
MBAS as LAS	12.6	-	-	-	-	-	-	-	-	-	6.9	-	45.2
Phenols	0.042	-	-	-	-	-	-	-	-	-	0.019	-	54.8
Phosphate-Total	8.0	-	-	-	-	-	-	-	-	-	10.1	-	+26.2
-Ortho	6.8	-	-	-	-	-	-	-	-	-	6.0	-	11.8
Nitrogen-Kjeldahl	17.0	-	-	-	-	-	-	-	-	-	13.8	-	18.8
NH_3-N	8.3	-	-	-	-	-	-	-	-	-	7.5	-	9.6
Cu	0.028	-	-	-	-	-	-	-	-	-	0.020	-	~28.6
Zn	0.080	-	-	-	-	-	-	-	-	-	0.044	-	45.0
Ag	<0.02	-	-	-	-	-	-	-	-	-	<0.01	-	~50.0
Al	0.48	-	-	-	-	-	-	-	-	-	0.21	-	56.2

rate was calculated as 32,000 gal/ft/day which is more than twice the recommended maximum of 15,000 gal/ft/day. The inefficiencies in SS removal in the MAFB primary clarifiers are a result of excessive weir loading rates which result in scouring of settled solids and suspended solids carryover in the primary clarifier effluent launder.

(2) Trickling Filtration and Final Clarification.

The theoretical unit process BOD_5 removal efficiency across the MAFB trickling filter and final clarifier is 76.5 percent. The actual efficiency (24-hour samples) was equal to or greater than 61.5 percent. The hydraulic loading of the trickling filter was calculated as 11.2 MGAD within the recommended range of 8.7 to 44 MGAD. The organic loading, including recirculation, was calculated as 2,400 lb/ac-ft/day within the recommended range of 1,100 to 13,000 lb/ac-ft/day. The final clarifier surface loading rate was 1,000 gal/ft^2/day in excess of the recommended 800 gal/ft^2/day while the weir loading rate was 7,100 gal/ft/day, within the recommeded range. Since the trickling filter organic and hydraulic loadings were within recommended limits, the depressed BOD_5 removals across the trickling filters and final clarifiers is probably due to hydraulic overloading of the final clarifiers. The settled sludge scraper mechanism in the secondary clarifier needs replacement/repair. During the field survey excessive suspended solids carryover was noted in the downstream end of the clarifier, and on several occasions "rising sludge" was noted. Rising sludge results when incomplete sludge removal causes anaerobic conditions to develop and denitrification raises sludge to the surface.

(3) Final Chlorination

The reduction in BOD_5 through application of chlorine was approximately 20 percent, within the expected range of 10-35 percent. Significant accumulation of solid materials was noted in the chlorine contact basin, and rising sludge blooms were apparent.

b. Overall Plant Efficiencies

Both the BOD_5 and SS overall removal efficiencies were below expected levels.

4. Treated Effluent Disinfection

A single unit chlorine gas solution feed chlorinator is used at this plant. The total detention time achieved in this chamber equals 26.5 minutes at an average daily flow of 1.25 MGD.

During the field survey the mean detention time was approximately 26 minutes.

a. Chlorine Dose Rate

The chlorine delivery rate is constant at approximately 100 lb/day. At this plant's average design flow of 1.25 MGD, this chlorine application rate results in an average daily dose of 9.5 mg/l. During the field survey (11-22 Sept) the daily chlorine application rate ranged from 91 to 112 lb/day, averaging 98 lb/day. The average daily dose rate ranged from 6.9 to 12.5 mg/l, averaging 9.4 mg/l. At sustained peak flow (4-hour duration, 1.9 MGD) the average chlorine dose rate was 6.4 mg/l. The recommended dose rate for this plant ranges from 3.0 to 15.0 mg/l. The State of NJ requires a 30 minute chlorine contact time at design flow with a free chlorine residual of 1.0 mg/l in the final effluent. The final effluent free chlorine residual noted during the field survey from 0.2 to 1.6 mg/l, averaging 1.2 mg/l.

b. Effluent Bacteriological Quality

Bacteriological analyses of this plant's chlorinated effluent were accomplished during the field survey. The geometric mean of 6 day-time grab-samples for fecal coliforms was less than 160 colonies per 100 ml of final chlorinated effluent which is within the State's maximum limit of 200 per 100 ml in the stream.

5. Effluent Toxicity

The DRBC effluent quality criteria require that the toxicity of the MAFB effluent be less than the 96-hour TL_{50} in a 1:1 dilution. Two species of test fish (fathead minnow from EHL(K) Laboratory culture and native sunfish from the Crosswicks Creek watershed) were exposed to 100 percent of prechlorinated effluent with aeration for a period of up to 175 hours. No mortality was experienced for either test species, documenting the absence of acutely toxic elements in the effluent (see Appendix G).

6. Compliance With Proposed Performance Specifications.

Appendix F contains a detailed summary of plant effluent characteristics compared with the proposed interim performance specifications. Table 21 contains a summary of data for parameters noted during the field survey that were not in compliance with the proposed specifications. The effluent characteristics for all other parameters complied with the proposed limits.

Table 21. Parameters Noted During Field Survey Not in Compliance with Proposed Performance Specifications - McGuire AFB Sewage Plant.

Parameter	Performance Specifications	Mean Effluent Concentration or Removal Efficiency	
		24-hr, 7-Day	12-hr, 5-Day
BOD_5	90% Removal	$\gtrsim$ 80.8%	79.9%
SS	90% Removal	76.5%	77.0%
MBAS as (LAS)	3.0 mg/l	5.3 mg/l	6.86 mg/l
COD	80 mg/l	94.1 mg/l	108 mg/l
Phenol	0.015 mg/l	-	0.019 mg/l

D. Physical, Chemical and Biological Effects of Ft. Dix and McGuire AFB Discharges on the Receiving Waters

1. Receiving Waters

South Run is the receiving stream for the effluents of Ft Dix and McGuire sewage treatment plants. South Run originates on the Ft Dix reservation and flows about 5.5 miles to a confluence with Crosswicks Creek. A short term study of the receiving waters was conducted during the period of 10-26 September 1972. The stream survey was limited to that portion of Crosswicks Creek from the headwaters to a point ten miles downstream, just below New Egypt. Eight primary stream sampling stations were selected (Figure 6); these were located on South Run, North Run, Jumping Brook and Crosswicks Creek to provide sampling of major tributaries and of the receiving waters prior to and following discharges to the stream. Appendix G contains detailed data summaries and a more thorough discussion of this study. The purpose of this ecological portion of the survey was to gather basic physical, chemical and biological data on the effects of Fort Dix and McGuire AFB wastewater discharges on the stream.

2. Physical Data

a. Flow data

Flows were estimated for South Run from U. S. Geological Survey gauged flow measurements at Extonville on Crosswicks Creek. Actual stream flow measurements were made using a velocity-area method during the field survey. Geological Survey data yielded a ten-year, seven-day low flow estimate for South Run to be 0.915 million gallons per day (MGD). The 43 years of data also showed that 90 percent of the time flows were greater than 1.6 MGD and 50 percent of the time flows were greater than 3.5 MGD in South Run. Actual mean daily flow measurements for the survey period revealed a flow of 7.8 MGD in South Run and 8.4 MGD in Crosswicks Creek at the reservation boundry.

b. Temperature, pH and Dissolved Oxygen Data

These data are summarized in Table 22. Temperatures in the shallow waters of the watershed are greatly influenced by atmospheric temperatures. Very little change in stream water temperatures due to STP effluents was measured during the survey, however some temperature differences may result in winter months when STP effluents may be warmer than the receiving waters. The temperatures in Jumping Brook were generally a few degrees warmer than other waters. This phenomena probably resulted from warmer waters in Brindle Lake being the source of flow for Jumping Brook. The mean pH of Jumping Brook (S-1) was 4.1 while all other stream waters had a pH range of 6.6 to 7.1. The acid bog waters of Jumping Brook are unique, high quality waters. The dissolved oxygen was monitored with continuous recording equipment

Table 22. Summary of Selected Physical Parameters in Receiving Waters, Ft. Dix and McGuire AFB Field Survey, Sept 1972.

	Stream Station*							
Parameter	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8
Flow (MGD)	1.1	0.3	4.9	7.8	8.4	10.9	2.9	13.0
Temperature (°C)	21.1	19.3	19.1	19.7	19.6	18.4	17.5	18.5
pH	4.1	6.6	7.0	6.8	7.1	-	7.0	6.9
Dissolved Oxygen (mg/l)	6.9	6.1	6.1	6.1	5.6	2.9	7.3	4.6

*Stream Station Locations

Location

S-1 Jumping Br Above Confluence with Crosswicks
S-2 South Run Above Ft Dix STP
S-3 South Run Below Ft Dix STP on McGuire
S-4 South Run Below McGuire STP
S-5 Crosswicks Cr at Brindle Lake Road
S-6 Crosswicks Cr at Bunting Bridge Rd
S-7 North Run Above Confluence with Crosswicks
S-8 Crosswicks Cr Below New Egypt

and with portable meters in the receiving waters. Figure 7 is a summary isopleth of these oxygen measurements. Mean hourly DO data was utilized for this isopleth. Dissolved oxygen in South Run stayed above a mean daily concentration of 5.0 mg/l except for two days when hourly measurements revealed DO concentrations at less than 4.0 mg/l. Stations 6 and 8 in Crosswicks Creek registered low DO readings much of the time while station 6 had a DO concentration below 4.0 mg/l all of the time. Diurnal DO fluctuations were observed in South Run (stations 2, 3, 4 and 5) and were the result of photosynthesis by algal cells in the stream. Reaeration by atmospheric exchange in the shallow, fast-flowing stream was more important than the impact of photosynthesis.

c. Oxygen Demand

A sharp increase in biochemical oxygen demand, chemical oxygen demand and ultimate oxygen demand was observed in South Run as a result of the Ft Dix and McGuire STP effluent discharges. Interferences with the analyses were caused by the humic acids and chemical qualities of the acid bog waters in Jumping Brook and Crosswicks Creek. BOD_5 concentrations increased from 4.4 mg/l upstream of the Ft Dix effluent to 14 mg/l in South Run downstream of this discharge but decreased slightly further downstream. The BOD_5 concentration in Crosswicks Creek below New Egypt was still 10 mg/l. The COD concentrations fluctuated from 51 mg/l in South Run (S-3) to 42 mg/l in Crosswicks Creek (S-5), but subsequent increases to 49 mg/l COD were observed in Crosswicks Creek (S-6). Analysis of the UOD grab samples revealed a peak demand of 120 mg/l in South Run (S-3) and a steady decline in this demand as the stream flowed to a concentration of 28 mg/l in Crosswicks Creek below New Egypt (S-8).

d. Theoretical Modeling of Dissolved Oxygen Sag Curve

The Streeter-Phelps equation was used to predict the dissolved oxygen profile of the receiving waters. Estimated coefficients of deoxygenation and reaeration of the stream were extrapolated from BOD data and stream characteristics and flow data. The initial plot for the predicted sag curve did not correlate well with actual stream data. Better correlation was obtained by changing the values for coefficient of reoxygenation. The DO sag curve equation did not adequately describe the DO profile in Crosswicks Creek probably because of interactions from nitrification, benthic oxygen demand, and photosynthesis which are not integrated into the equation.

e. Theoretical Permissible BOD_5 Daily Stream Loading

Discussions with representatives of the NJDEP revealed that their estimate of the receiving stream's critical low-flow BOD_5 assimilative capacity ranges from 50 to 100 pounds per day. The permissible daily BOD_5 stream loading for varying temperature, stream flow and initial stream DO were calculated for the critical reach in Crosswicks Creek (see Appendix G). The

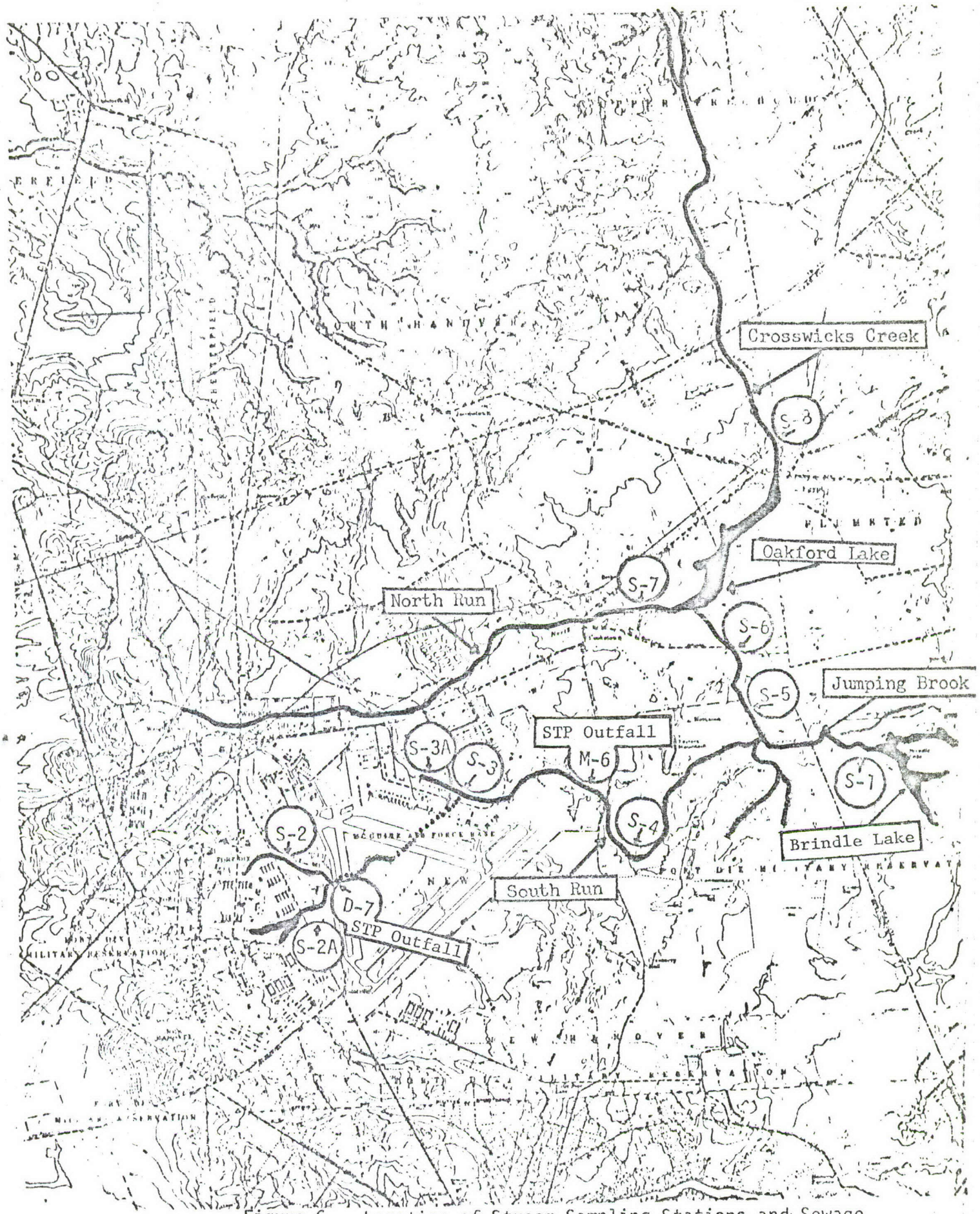

Figure 6. Location of Stream Sampling Stations and Sewage Plant Outfalls, Ft Dix and McGuire AFB NJ, Sep 1972

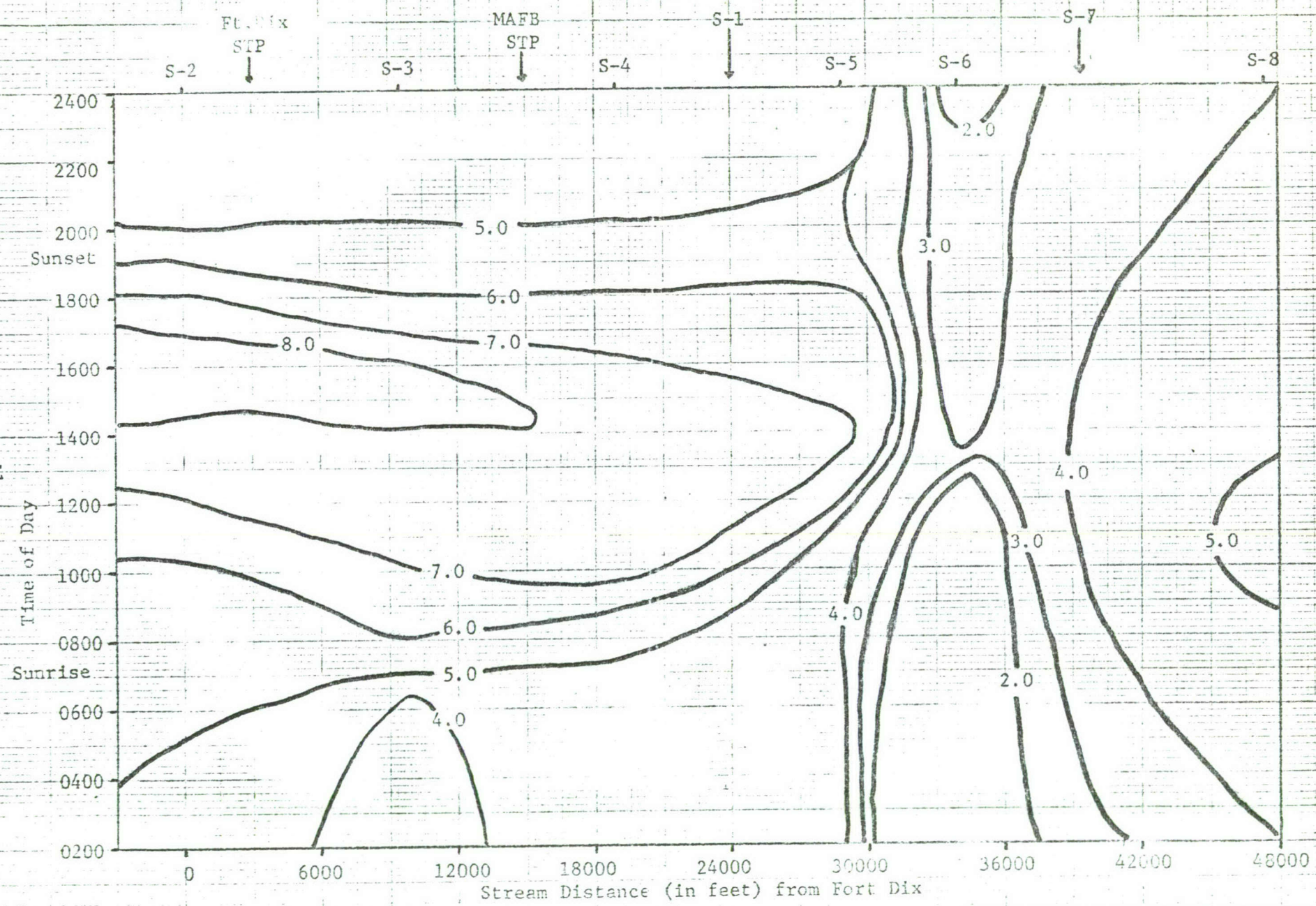

Figure 7. Isopleth of Dissolved Oxygen Concentrations (mg/l) in South Run and Crosswicks Creek, Ft. Dix and McGuire AFB, September 1972.

permissible stream loadings were calculated using the reoxygenation and deoxygenation rate constants determined in the field, and were based on maintaining the DO in the critical stream reach at or above 5.0 mg/l. The theoretical permissible BOD_5 daily stream loading at the critical flow (7-day, 10-year low flow) was estimated from analyses of field data to be approximately 300 pounds per day.

3. Chemical Data

Automatic composite daily samples were collected at each stream station for seven days and grab samples were collected for four days. Table 23 is a summary of stream chemical analyses data.

a. Nutrients and Organic Carbon

The two sewage plants add an average of 732 pounds of nitrogen and 312 pounds of phosphates per day to South Run. The resulting stream concentrations were 6.2 mg/l ammonia and 6.4 mg/l phosphates for these two basic nutrients. Normally less than 0.1 mg/l ammonia and 2.7 mg/l phosphates are present in natural waters. The nitrate concentrations increased with time of water travel in Crosswicks Creek as total nitrogen and ammonia concentrations decreased. This change is typical of the natural purification process in streams. The total organic carbon concentrations increased from about 8 mg/l in South Run to 17 mg/l following the Ft Dix discharge. The TOC concentration continued to increase, as expected from algal growth, to a maximum of 20 mg/l in Crosswicks Creek at Station S-6.

b. Heavy metals

Analyses for 15 heavy metals in the stream waters revealed no heavy metal pollution.

c. Surfactants, Phenolics and Oils and Greases

No deleterious effects of surfactants, phenolics or oils were detected. Surfactant concentrations were high enough in South Run to be theoretically harmful to game fish. No effects of phenol discharges were observed although the McGuire discharge increased the phenolic concentration in South Run to 0.026 mg/l. Oil and grease concentrations were high throughout the receiving waters, but the results may have been influenced by an accidental oil spill during the survey.

d. Sediments - Heavy Metals and Pesticides

Stream sediments were collected and analyzed for heavy metals and pesticides during the preliminary survey and the actual field survey. No

Table 23. Mean Daily Chemical Analyses Data For the Stream Survey Stations, Ft Dix and McGuire AFB NJ, September 1972

Parameter	Stream Station							
	S-1	S-7	S-2	S-3	S-4	S-5	S-6	S-8
PH	4.325	6.737	6.225	6.850	6.937	6.775	6.762	6.762
ALKALINITY	.000	34.556	36.375	83.869	77.333	57.000	61.909	50.444
COLOR	700.000	36.250	40.000	47.500	43.750	145.000	155.000	111.429
TURBIDITY	8.625	7.250	10.375	12.500	11.875	11.750	14.500	18.250
TOTAL SOLIDS	124.571	156.250	203.500	232.000	216.571	176.571	168.250	241.571
SUSPENDED SOLIDS	74.000	17.000	25.667	32.000	28.444	26.556	48.667	41.556
DISSOLVED SOLIDS	49.143	140.250	175.625	201.500	189.429	148.857	118.500	200.143
TOTAL ORGANIC CARBON	43.625	8.000	7.875	17.125	16.125	17.625	20.000	16.125
TOTAL OXYGEN DEMAND	129.143	.000	6.571	94.714	81.143	75.429	83.714	56.429
TOTAL COD	90.000	19.000	37.111	51.300	42.600	42.400	49.200	40.600
BOD	17.000	3.244	4.437	14.244	12.267	11.267	11.256	10.344
BOD SOLUBLE	19.667	5.433	4.400	13.100	12.900	12.433	12.067	11.400
KJELDAHL NITROGEN	.625	.658	.563	12.437	10.562	6.875	8.438	4.937
AMMONIA NITROGEN	.100	.100	.175	6.900	6.175	5.267	5.100	3.012
NITRITE	.100	.100	.100	.267	.237	.300	.187	.162
NITRATES	.112	.737	.725	1.067	.662	.475	.437	.675
TOTAL PHOSPHATE	2.700	2.962	1.725	7.600	6.425	6.150	6.187	4.425
ORTHO PHOSPHATE	2.167	1.162	.575	5.237	5.062	4.862	5.125	2.687
OIL & GREASE	50.500	215.714	138.250	71.833	122.143	126.500	178.714	170.714
PHENOLS	.012	.063	.006	.008	.026	.006	.004	.004
MBAS	.164	.180	.917	1.542	1.978	1.546	1.270	.522
MERCURY	.005	.005	.005	.005	.005	.005	.005	.005
CHROMIUM	.050	.050	.050	.050	.050	.050	.050	.050
HEXAVALENT CHROMIUM	.001	.001	.001	.001	.001	.001	.001	.001
LEAD	.050	.050	.050	.050	.050	.050	.050	.050
ZINC	.016	.017	.016	.026	.014	.012	.014	.010
IRON	10.087	.613	.832	1.250	1.708	3.318	4.825	2.675
COPPER	.020	.020	.020	.021	.022	.020	.020	.020
SILVER	.010	.010	.010	.010	.010	.010	.010	.010
NICKEL	.040	.040	.040	.040	.040	.040	.040	.040
ARSENIC	.010	.010	.010	.010	.010	.010	.010	.010
CYANIDE	.010	.010	.010	.010	.010	.010	.010	.010
MANGANESE	.047	.045	.148	.157	.152	.050	.062	.023
BARIUM	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
ALUMINUM	.526	.269	.204	.507	.367	.353	.631	.960
CADMIUM	.010	.010	.010	.010	.010	.010	.010	.010

NOTES: UNITS ARE AS FOLLOWS; TEMPERATURE IN DEGREES C, COLOR IN COLOR UNITS, PH IN PH UNITS, TURBIDITY IN JACKSON TURBIDITY UNITS. ALL OTHER DATA IN MG/L.

heavy metals pollution was detected by these analyses. High chlordane insecticide concentrations were found in the sediments during the preliminary survey, but chlordane was not found in the sediments during the September survey. Other pesticides were within normal ranges.

4. Biological Data

The biological characteristics of the receiving waters were determined by surveying the diversity and numbers of macroinvertebrates, plankton and fish as well as the measurement of periphyton biomass and bacteriological evaluation of the waters. In-stream bioassays were accomplished using sunfish (*Lepomis gibbosus*). Each biological parameter is discussed below and Table 24 contains a summary of each of these parameters.

a. Macroinvertebrates

The macroinvertebrate populations of the receiving waters were sampled by two methods, quantitative dredge sampling and non-quantitative diverse sampling. Quantitative sampling of the benthos with a 9"x9" Ponar dredge at each station revealed pollution-sensitive organisms in Jumping Brook (S-1) and pollution-tolerant forms throughout the remaining stream reachs. Large numbers of sludgeworms were found in Crosswicks Creek (S-5 and S-6). These sludgeworms are highly indicative of waters polluted with domestic wastes. Overall, low numbers of organisms were collected in South Run below the McGuire outfall (S-4) as a result of the chlorine residual in the effluent. The diversity index as applied to the invertebrate sampling showed that Jumping Brook (S-1) was unique among the sampling stations while all others were quite alike. Non-quantitative sampling of macroinvertebrates was accomplished by collecting with nets and screens. Jumping Brook (S-1), North Run (S-7) and Crosswicks Creek (S-5) at the reservation boundry had greater diversity of organisms while South Run (Stations 2, 3 and 4) had few types of organisms.

b. Plankton

Plankton (minute plants and animals suspended in water) were collected and enumerated at each station. Dense algal and diatom populations at all stream stations indicate nutrient enriched waters throughout the watershed. Few differences were noted as a consequence of the wastewater discharge, although the analyses did not include species differentiation, consequently no indication of changes in species are available. Algal species may be very different in Jumping Brook as compared to South Run or Crosswicks Creek, but all waters supported high algal populations.

c. Periphyton

Periphyton (assemblage of organisms growing on submerged subtrates) was analyzed by measuring the chlorophyll and organic carbon of periphyton that grew on glass slides placed in the stream for ten days. The autotrophic index (AI) is a ratio of this biomass (organic carbon) to chlorophyll. The AI's of Jumping Brook (S-1) and North Run (S-7) were low indicating good

Table 24. Summary of Selected Biological Parameters in Receiving Waters, Ft. Dix and McGuire AFB Field Survey, Sep 1972.

Parameter	Sampling Station							
	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8
Macroinvertebrates								
Qualitative Sampling:								
Nr. of Kinds	13	6	5	9	13	9	13	9
Quantitative Sampling:								
Nr. of Kinds	7	5	4	4	3	4	1	2
Diversity Index	1.4	0.7	0.5	0.6	0.2	0.4	0	0.4
Plankton (cell/l x 10^7)	4.0	70.0	8.0	27.0	21.0	9.0	12.0	8.0
Periphyton-Autotrophic Index	196	510	561	317	3556	1143	414	1241
Fish (Nr. of Species)	5	1	2	0	4	4	8	3
Bioassay (% mortality-72-hrs)	56	62	31	100	37	81	56	50
Fecal Coliform (Geometric Mean)	21	203	137	168	301	628	2475	226
Fecal Coliform/Fecal Strep Ratio	0.6		9.8	24.0	1.0	2.0	1.4	0.2

quality of water. The AI in South Run downstream of McGuire (S-4) decreased, probably as a result of the toxic chlorine residual in the McGuire effluent. Otherwise, South Run and Crosswicks Creek have high autotrophic indices which are a result of organic enrichment.

d. Fish

Fish populations and species are indicative of general water quality and healthiness of the aquatic system. Fish have long life cycles and consequently reflect long term ramifications of water pollution. Fish were collected by electro-shocking at each designated stream station and then identified and counted. North Run (S-7) and Jumping Brook (S-1) produced a good variety of fish, including game fish. Only pollution-tolerant killfish and bullheads were collected in South Run. The stream was devoid of fish immediately downstream from McGuire's outfall because of excessive chlorine. The fish-life showed some improvement in Crosswick's Creek, but only pollution-tolerant trash fish were found.

e. In-stream bioassays

Sunfish were seined from an impoundment on the upper reaches of South Run and were placed in cages at each of the stream stations. Mortality of the fish was sporadic and at least partially unexplainable. The sunfish did survive well in South Run (S-3) between the Ft Dix outfall and the McGuire outfall. This contradicts the absence of native fish in this reach but several possible explanations include: 1) occasional accidental spills may kill fish in this reach and these spills did not occur during the survey, 2) fish may not repopulate the area from upstream lakes and the sterile zone below McGuire may prevent the upstream migration of fish. The bioassay fish died within two hours immediately downstream of the Ft Dix outfall and the fish died within three hours immediately downstream of the McGuire outfall. This mortality was attributed to the chlorine residual in both effluents. The chlorine in McGuire's effluent persisted one-half mile downstream.

f. Pesticide Residues in Fish

Pesticide residue analysis was accomplished on several of the fish collected in the streams. Low concentrations of DDT and metabolites, chlordane and PCBs were detected. All residues were within normal ranges as found in the National Pesticide Monitoring Program.

g. Bacteriological Analysis

Samples were collected at each stream station and the STP effluents for ten consecutive days and analyzed for total coliforms, fecal coliforms and fecal streptococci. The control stations (S-1 and S-2) had low fecal coliforms counts. Ft Dix and McGuire STP effluents added fecal coliforms to South Run, but these concentrations were generally low.

Much higher fecal coliform levels were found in North Run and Crosswicks Creek. The source of these bacteria was not discovered. The presence of fecal streptococci indicates warm-blooded animal pollution. The fecal streptococci do not multiply in water, therefore, increases of fecal bacteria in the stream is a result of additional pollution. Fecal strep concentrations were low in South Run, but high in Crosswicks Creek. This indicates contamination of Crosswicks Creek from some source other than the sewage treatment plants. The fecal coliform/fecal streptococci ratios indicate that Jumping Brook (S-1), South Run (S-2) and Crosswicks Creek (S-5) are not polluted by human wastes. North Run (S-7) and Crosswicks Creek (S-5 and S-6) are possibly polluted by some human wastes; South Run (S-3 and S-4) showed definite pollution by human fecal bacteria.

E. REGIONAL WATER POLLUTION ABATEMENT EFFORTS

1. Background

Federal and DOD directives require that all federal facility pollution abatement projects be coordinated with other nearby federal installations as well as state, county or municipal authorities. These requirements specify that federal facilities should cooperate with other interested agencies in the evaluation of their pollution control needs and, as appropriate, in the development of joint or regional pollution control measures. These directives further identify that the discharge of wastes into municipal wastewater/regional authority treatment and disposal systems is the preferred method of disposal for all federal facilities. Two regional sewerage authorities were considered by the Ft Dix and MAFB authorities.

a. Ocean County Sewerage Authority (OCSA)

This authority has been in existence for approximately two years. Preliminary discussions with the OCSA representatives in September 1972 revealed that the Authority would be willing to accept the raw wastes from both Ft Dix and MAFB. The NJDEP, and the DRBC have voiced numerous objections to the proposed connection of the Ft Dix and MAFB wastewater systems to the planned OCSA system. The EPA concurred with the NJDEP and DRBC in their concern over the number of environmental issues involved, and recommended that this alternative be eliminated from further consideration. (See Appendix A, "Related Correspondence.")

b. North Burlington County Sewerage Authority (NBCSA)

This authority has been plagued by numerous political/organizational problems. There has been a long history of difficulty concerning the establishment of a regional agency to construct a comprehensive regional sewerage authority to serve Northern Burlington County. In December 1972 the Director of the NJDEP recommended to the Burlington County Board of Freeholders that the county undertake an environmental assessment basin study to examine all of the concepts and alternatives for providing environmentally sound water quality management for Northern Burlington County. Such a basin-wide study is required by the EPA before federal funding may be granted.

2. Basin Study Initiated

In late March 1973 the Burlington County Board of Freeholders contracted with a private consulting engineering firm to perform a wastewater management planning and engineering study of Northern Burlington County. The study area includes Ft Dix and MAFB, eight municipalities, and parts of three municipalities in neighboring counties which are located in the Crosswicks Creek watershed. The purposes for this study are:

a. To provide a preliminary general plan and cost estimates for regional wastewater management systems in accordance with State and Federal standards.

b. To effect a management plan which would contribute substantially to development of a State Basin Plan, making projects eligible for federal grant funds.

c. To incorporate and plan for public sewerage in as many area as feasible.

3. NJDEP Views

In September 1972 the NJDEP verbally agreed that if Ft Dix and MAFB intended to enter into a regional wastewater management authority, and no significant increases in waste flows would be expected, then the State would accept the "status quo" for the existing sewage treatment facilities. The NJDEP has agreed that major capital expenditures for upgrading of existing facilities would not be warranted if the two federal facilities were to enter into a regional waste treatment plan.

F. ADVANCED WASTE TREATMENT (AWT)

1. A consulting engineer's study of AWT for the MAFB/Ft Dix complex was released in January 1972. This study recommended a tertiary treatment plant located at Ft Dix to treat the combined secondary effluents from the two bases. A minimum 95 percent removal of BOD_5, phosphates and trace heavy metals was the basic design criterion. Estimated capital cost for this facility was $8.3 -million.

a. Following the EHL/K preliminary visit to MAFB in February 1972, the need for phosphate removal was challenged, and the question of whether the NJDEP would approve this particular design was voiced. The applicable State criteria did not specify phosphate removal and the State's tacit estimate of the receiving stream's BOD_5 assimilative capacity ranged from 50 to 100 lb/day. The proposed AWT plant would theoretically result in a discharge of approximately 380 lb/day BOD_5. (See Apr 7 EHL/K Trip Report)

b. In a letter to U. S. Army Corps of Engineers (NYDCE) dated 24 March 1972, the NJDEP expressed its opinion following review of the proposed AWT system. The State's letter stated that because of the limited assimilative capacity of the receiving waters "...some alternative method of treatment and disposal including possible land disposal should be investigated..."

c. In a 1 May 1972 letter to the NYDCE, the Federal Facilities Section, Region II, EPA stated "... we feel that even with the proposed treatment, water quality criteria would be violated during low flow conditions." The EPA also expressed concern over the siting of the proposed AWT plant at Ft Dix because of the hydraulic limitations of the storm drains beneath the MAFB runway to handle the combined wastewater flows during high storm runoff conditions.

2. The proposed AWT plant design was based on combined total average daily flow from Ft Dix and MAFB of 6.5 MGD. Possible mission changes at Ft Dix may reduce the volume of wastes from 5.0 MGD to some much lower value. No completely reliable information is presently available to determine the future reduction in waste volumes.

3. Enhanced Treatment Evaluations

Jar tests were conducted to evaluate chemical addition for enhanced treatment at both treatment plants in the primary clarifiers, secondary clarifiers and for final effluent polishing. Activated carbon adsorption isotherm tests were accomplished to evaluate the technical feasibility of activated carbon treatment of the final effluents from both plants (see Appendix E).

a. Chemical Additions: Addition of alum to the samples of influent to both the primary and secondary clarifiers at optimum pH was found to be very effective in improving the efficiencies of these units at both sewage treatment plants. The effluent polishing jar test results indicated that a greatly improved final effluent could be obtained by the addition at optimum pH of alum as a coagulant aid and additional sedimentation.

b. Activated Carbon Adsorption: The activated carbon adsorption isotherm tests revealed that the removal of dissolved organics from the final effluents of both plants is technically feasible. Ultimate carbon adsorption capacities were determined and found to be lower than had been estimated in the preliminary design of the advanced waste treatment plant. The results of these isotherm tests indicate that pilot scale adsorption testing would be required to determine final design criteria for activated carbon adsorption treatment facilities of any proposed advanced waste treatment plant.

G. LAND DISPOSAL

Three interrelated factors bear on the use of land disposal of treated wastewaters. These factors are: water quality goals, treated wastewater characteristics, and site conditions. The EHL/K has accomplished a preliminary evaluation of wastewater land disposal application for the MAFB/Ft Dix complex. Two possible sites in the area of Ft Dix/MAFB complex were considered. One site, within the confines of the Ft Dix Military Reservation, is a 350 acre area on the southeast boundary. The second site is "excess" U. S. Navy property along the Ft Dix Military Reservation/Lakehurst NAS common boundary, approximately 650 acres. Both sites are some distance from the main cantonment areas of Ft Dix and MAFB, and both areas lie within Ocean County. The Lakehurst NAS site drains eastward to the Atlantic, while the Ft Dix site falls within the Delaware River Basin drainage area.

a. Water Quality Goals: A review of recent literature has revealed that, under optimum operating conditions, the final product water quality from properly designed land disposal systems could be maintained at a level consistent with drinking water quality criteria. Attaining this final effluent quality by land disposal would meet all known NJDEP criteria. Nutrient uptake rates from the wastes and the possibility of increased nitrates in ground waters are concerns of the NJDEP.

b. Treated Wastewater Characteristics: The combined secondary effluents from the Ft Dix and MAFB treatment plants would in general be similar in character to the wastes being successfully applied at a number of operational land disposal projects in this country. (Reference land disposal sites at Penn State University; Santee CA and Sunapee State Park NH.)

c. Site Conditions: Four major factors determine the site conditions: climatic constraints; ground water levels; soil characteristics; and vegetation. A preliminary review of the climatological factors has revealed that during any year a period of nearly 260 days could be available for land disposal operations. Sufficient land area would be needed for storage of daily wastes during the remaining 100 days of the year. Preliminary discussions with the U. S. Geological Survey and review of available geological data indicate that the ground water table in the two areas of interest is located far enough (5-20 feet) below the ground surface to provide sufficient drained soil/wastewater contact to achieve the desired degree of renovation. Discussion with U. S. Soil Conservation Service (SCS) personnel has revealed that, in general, the soil types in the two areas are made up of fine to very coarse-grained quartz sands with little or no silt or clay. These types of soils are conducive to high rates of wastewater application. However, the renovative capacity of such soils using high application rates is significantly lower than for heavier textured soils using lower applications. The type of vegetation found on the two sites is essentially a pine-oak forest. When such forested areas are used for wastewater disposal, appreciable growth stimulation occurs. However, nutrient (particuarly nitrogen) uptake in forested areas is minimal and the toxicity of some of the constituents in the secondary effluents to the existing tree stand is unknown.

IV. CONCLUSIONS

A. Ft Dix and MAFB are adjacent federal facilities. Each currently provides conventional secondary treatment for their wastewaters. The use, however, of municipal or regional waste collection and disposal systems is the preferred method of disposal of liquid wastes for DOD activities. Two such regional sewerage authorities are proposed in the general area of the two bases, the Ocean County Sewerage Authority (OCSA), and the Northern Burlington County Sewerage Authority (NBCSA). In December 1972 the NJDEP recommended that the Burlington County Board of Chosen Freeholders initiate a basin-wide study to include Ft Dix and MAFB to examine all alternative water quality management schemes for Northern Burlington County. In late March 1973 such a study was initiated.

B. Ft Dix and MAFB are required to comply with all applicable federal, state and local water pollution abatement and control criteria. Performance specifications as required by Executive Order (EO) 11507 for both installations are included in this report. These specifications which were verbally coordinated with the Region II, EPA and the NJDEP representatives, should apply for the interim period until a final decision is reached concerning a basin-wide regional wastewater management program. If the proposed regional system does not materialize, long-range performance specifications for each plant would have to be coordinated with the NJDEP and DRBC through the EPA before definitive design specifications for modified or additional waste treatment facilities for the two bases could be proposed. Such long-range specifications for continued discharge to the present receiving waters would, no doubt, be very stringent and probably require advanced waste treatment technology. Long-range performance specifications are not proposed at this time because of the current emphasis on regionalization, the probable future development of more stringent water quality criteria, and the possibility of mission changes during the interim period.

C. The volume of wastes treated at the Ft Dix sewage plant has decreased in recent months with the gradual decline of the resident base population. During wet weather conditions significant ground water infiltration occurs and reduced BOD_5 and SS treatment efficiencies result. In general the Ft Dix raw waste is characterized as medium strength domestic waste. An occasional high concentration of silver does suggest a photo or x-ray processing waste is discharged without sufficient silver recovery. Disinfection of the final effluent is inadequate because chlorine is not metered in proportion to flow and insufficient chlorine is applied at peak flows. The Ft Dix final effluent met all 24-hour requirements of the proposed interim performance specifications with the exception of BOD_5 and SS removal efficiencies and oil and grease and aluminum concentrations. Plant monitoring and control is excellent and only minor modifications would be required to adequately monitor the solids handling and final effluent quality for conformance with the proposed performance specifications.

D. The MAFB sewage plant is presently hydraulically overloaded. During wet weather conditions the hydraulic overloading problem is compounded by infiltrating ground waters. This hydraulic overloading results in reduced BOD_5 and SS removal efficiencies. Most all industrial wastes from MAFB receive pretreatment before discharge to the sanitary sewer, and the MAFB raw wastes are characterized as weak to medium strength - with some industrial waste fractions. Chlorine is not metered to the treated effluent in proportion to flow. At low flows excessive chlorine is applied, resulting in significant detriment to South Run immediately below the MAFB sewage plant outfall. The MAFB final effluent met all 24-hour requirements of the proposed interim performance specifications with the exception of BOD_5 and SS removal efficiencies and the concentrations of chemical oxygen demand, detergents and oils and greases. Plant monitoring and control is excellent and only minor modifications would be required to adequately monitor the final effluent quality for conformance with the proposed performance specifications.

E. A comprehensive biological survey of the receiving waters was accomplished in this project. Results revealed violations of the specific dissolved oxygen criteria and the general toxicity criteria for aquatic biota. Chlorine residuals in the effluent of the McGuire STP caused the most significant detriment to South Run immediately below the MAFB STP outfall. Nutrient enrichment, dissolved oxygen depression, and sludge deposits in Crosswicks Creek occurred as a direct consequence of the sewage plant discharges. Clean water fish and other biota were displaced by pollution-tolerant organisms in the stream. If the nutrient loading and oxygen demanding materials were reduced in the effluents and better control of the effluent chlorination at McGuire were effected, definite improvement in the stream quality would result. Dicussions with representatives of NJDEP indicate that the State's estimate of the critical assimilative capacity of the receiving streams is 50 to 100 pounds per day of BOD_5. With certain limitations as described in Appendix G, the assimilative capacity of the receiving stream in the critical reach of Crosswicks Creek is estimated to be 300 pounds per day of BOD_5. If the effluent discharges were eliminated completely, Crosswicks Creek waters would be expected to approach the quality of Jumping Brook waters. However, other water discharges to the watershed besides the military do exist and would impact on Crosswicks Creek. Stormwater runoff from agricultural lands and residential areas would continue to add enough nutrients and bacteria to the stream that the water quality and associated biota would never fully achieve the conditions found in waters from the uninhabited areas of the Ft Dix reservation.

F. A preliminary design for an advanced waste treatment (AWT) plant at Ft Dix to treat the combined secondary effluents from Ft Dix and MAFB was completed in early 1972. (Alexander Potter Associates.) The uniform annual cost based on 25-year life at 10 percent would be $1,164,000. The design was based on a total flow of 6.5 MGD and a final tertiary effluent

containing 380 pounds per day (7.0 mg/l) BOD_5 and 27 pounds per day (0.5 mg/l) SS. According to available plant operating records and field survey analyses the two sewage plants combined are currently discharging to South Run an average of 4.4 MGD and approximately 800 pounds per day (22 mg/l) BOD_5 and 1,400 pounds per day (39 mg/l) SS. The NJDEP and EPA have indicated that the proposed AWT plant's discharge of 380 pounds per day BOD_5 would still exceed the critical assimilative capacity of the receiving stream. However, based on extensive analyses of the receiving waters, the critical assimilative capacity is estimated to be 300 pounds per day BOD_5, vice the 50 to 100 pounds per day BOD_5 estimated by the NJDEP. Possible future mission changes at Ft Dix may substantially reduce the waste volumes and if the NJDEP should allocate a total of 300 pounds per day BOD_5 to a combined AWT plant for Ft Dix and MAFB, the proposed AWT plant design could achieve the required level of treatment (i.e., the discharge of 300 pounds per day BOD_5) at a combined average daily flow of 5.1 MGD. The need for phosphate removal by the proposed AWT plant is not explicitly required by current NJDEP criteria, and some of the design criteria for activated carbon adsorption facilities require critical review. In addition, the siting of the proposed AWT plant at Ft Dix must be reevaluated in light of hydraulic limitations of storm drains beneath the MAFB flight line. Removal of dissolved organics from the secondary effluents using activated carbon is technically feasible. Results of activated carbon adsorption isotherm tests revealed that additional field pilot scale tests would be required before selecting the final design criteria for an AWT plant.

G. Land disposal of the disinfected secondary sewage effluents from Ft Dix and MAFB by spray irrigation is technically feasible. A review of climatological data revealed that approximately 35 weeks per year would be available for land disposal operations. The total area required for land disposal is estimated to be 1030 acres. Two proposed federally-owned forested areas in the general area of Ft Dix and MAFB combined would provide the minimum estimated area requird. In general, the geology, and topography of these two proposed areas are acceptable for land disposal operations. However, possible high water table conditions and depressed assimilation of nitrogen forms by the sandy soils and forest vegetation would have to be thoroughly investigated to discount the possibility of future contamination of potable ground water resources.

V. RECOMMENDATIONS

A. The Ft Dix and MAFB authorities should continue to negotiate with the North Burlington County Sewerage Authority for full participation in the proposed regional wastewater management system. Until a final decision is reached on the proposed basin-wide, regional waste treatment plan, no major MCP funds should be expended forplant upgrading.

Existing sewage treatment facilities should be maintained during the interim period through available O&M funds to achieve the degree of secondary treatment required to meet the proposed interim performance specifications contained in this technical report. The use of chemical coagulants to both plants may be required to maintain the status quo during this interim period.

B. If a regional wastewater management system to include Ft Dix and MAFB does not materialize, the Ft Dix and MAFB authorities should then negotiate with the NJDEP and the DRBC through the EPA for long-range sewage plant performance specifications for discharge to the present receiving waters. Of particular concern during such negotations would be the allocated daily permissible BOD_5 emission rate and the need for removal of phosphates. Once long-term performance specifications are established, they may be used as design criteria for required additional or modified sewage treatment facilities. A comprehensive review of the advanced waste treatment plant design should be accomplished, including field pilot scale tests to select final design criteria.

C. Flow proportional chlorination facilities should be installed at both sewage treatment facilities, and weekly bacteriological analyses of the chlorinated effluents should be initiated. Once each month two consecutive weekday, flow-proportional, 24-hour samples of the chlorinated effluents should be collected and analyzed for compliance with the proposed interim performance specifications. The EHL/K can support such efforts with routine wastewater chemical analyses of these samples.

D. All sources of untreated industrial wastes (vehicle washracks, etc., on Ft Dix and MAFB) identified in the industrial waste source inventory (Appendix H) should be programmed for connection to the sanitary sewer following gravity pre-treatment to remove oils/greases/solvents and grit.

E. Those portions of the Ft Dix sewerage system that are permitting excessive ground water infiltration should be located and repaired. Additional sewage plant monitoring of solids handling and anaerobic sludge digestion should include analyses of raw sludge, and digested sludge volumes and total and volatile solids content.

F. To relieve the hydraulic overloading of the MAFB sewage plant, a base-wide water conservation program should be initiated. All industrial operations that generate wastewater should be reviewed, and chemical use and wastewater volumes should be reduced wherever possible. In addition, those portions of the sewerage system that are permitting excessive ground water infiltration should be located and repaired. The sludge scraper mechanism in the secondary clarifiers should be repaired and secondary sludge should be pumped frequently to avoid excessive sludge accumulation in the clarifier sump.

G. A routine surveillance program should be initiated for the receiving waters to include as a minimum twice monthly 24-hour composite samples of the receiving waters above Ft Dix outfall on South Run above and below MAFB outfall on South Run and on Crosswicks Creek at the Ft Dix Reservation boundry. Such routine samples may be submitted to the EHL/K for chemical analyses.

H. A comprehensive study of proposed land disposal sites should be initiated if spray irrigation of the secondary effluents is selected as a viable alternative waste management scheme. Elements of such a study are included in Appendix I.

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13. ABSTRACT
This report contains data and discussion of the results of a field wastewater survey conducted by the USAF Environmental Health Laboratory, Kelly AFB, Texas at McGuire AFB and Ft Dix, New Jersey in September 1972. Extensive physical, chemical and biological sampling and analyses of these facility's sewage treatment plants and the surface waters to which the plants discharge were accomplished. The quality of the receiving waters was found to be degraded as a result of the sewage plant discharges. This report recommends that these two federal facilities join in efforts to create a regional wastewater management system, and during the interim period until such a system materializes, maintain the existing secondary sewage treatment facilities with minimum expenditure of capital investment funds. Performance specifications as required by current Executive Order are proposed for the interim period, and recommendations for interim upgrading of the existing facilities are made. Alternative courses of action are evaluated in the event the regional management system does not materialize.

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