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EVALUATION OF OPERATING AND MAINTENANCE PROCEDURES AT THE BLUE PLAINS WASTEWATER TREATMENT PLANT WASHINGTON, D.C.

NATIONAL ENFORCEMENT INVESTIGATIONS CENTER
DENVER, COLORADO

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National Enforcement Investigations Center
Denver, Colorado

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I. INTRODUCTION

During the first three months of 1978, the District of Columbia's Blue Plains Wastewater Treatment Plant effluent did not not comply with the District's NPDES* permit limitations for BOD and TSS.** The permit requires that the effluent concentrations for both BOD and TSS not exceed 30 mg/l based on a 30-day average. The permit also limits the total loadings of both BOD and TSS which can be discharged from the plant to 34,800 kg (77,400 lb)/day on a 30-day average. The plant's BOD and TSS concentrations for January, February and March 1978 were 31 and 31 mg/l, 32 and 32 mg/l, and 32 and 34 mg/l, respectively. In January and March, the loading limitations for BOD and TSS were also both exceeded by about 10%.

The District notified USEPA-Region III of these permit violations each month. District personnel stated that the main cause of these violations was that the existing sludge solids processing equipment at the plant was inadequate to handle the solids load generated by the treatment processes. The solids inventory in the wastewater treatment units had thus built up to the point that the plant effluent deteriorated and permit violations had occurred. The District stated that the permit violations would probably continue until late summer 1978 at which time additional sludge solids processing equipment was anticipated to be operational at the plant.

The District adds chemicals (ferric chloride and polymer) to the wastewater in the plant's secondary treatment units to remove phosphorous and to improve the suspended solids removal efficiency. In April 1978 the District informed Region III that the chemical addition rates

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* NPDES = National Pollutant Discharge Elimination System.

** BOD = Biochemical Oxygen Demand; TSS = Total Suspended Solids.

were being cut back in an attempt to reduce the solids inventory of the plant. The District reasoned that, by reducing the chemical addition rates, less chemical sludge volume would be generated, albeit at some reduced suspended solids capture efficiency.

In early 1978, the District requested additional construction grant monies from Region III for the design and construction of lime handling facilities to be used in conjunction with the new solids dewatering units at the plant. The District contended that the lime facilities were required to improve the dewatering characteristics of the sludge and had not been included in the original design for the new dewatering units.

In May 1978, the Director of the Enforcement Division, USEPA Region III requested that the National Enforcement Investigations Center (NEIC) conduct an inspection at the Blue Plains plant. The purposes of this inspection were threefold: (a) to determine if the District's failure to comply with its NPDES permit limitations was due to improper maintenance and operation of the plant treatment units, (b) to evaluate whether the District's decision to reduce chemical feed rates at the plant constituted a violation of the NPDES permit general condition that the plant be operated as efficiently as possible at all times, and (c) to determine if the new lime handling facilities requested by the District were required for efficient sludge dewatering.

On July 18 to 20, NEIC engineers, accompanied by Region III personnel, conducted an on-site inspection at the Blue Plains plant. The inspection team met with key District operating personnel, observed the various treatment processes, and collected pertinent data on the plant operations. This report summarizes the findings of that inspection.

It was not within the scope of this project to have NEIC develop an independent data base by sampling and analyzing the plant wastewater streams. The NEIC evaluation of the plant operating practices therefore used the monthly operating data summaries generated by the District, since these data were all that were available. However, the reader should be aware that the validity of the District's data is questionable and conclusions derived from these data may subsequently be biased accordingly. The Appendix summarizes analytical problems previously identified at the District's laboratory by Region III and District personnel. Potential sampling and flow monitoring discrepancies, identified by NEIC engineers during their inspection at the plant, are also discussed in the Appendix.

II. SUMMARY AND CONCLUSIONS

Findings of the July 18 to 20, 1978 NEIC inspection of the operating and maintenance procedures employed at the District of Columbia's Blue Plains Wastewater Treatment Plant and the conclusions drawn from these findings are discussed below.

1. The Blue Plains wastewater treatment systems were designed around the modified aeration mode of the activated sludge (A.S.) process. Inherent in this process mode are intermediate levels of BOD and TSS removal, ranging from 60 to 80%. Based on the plant's average BOD and TSS influent concentrations of about 145 mg/l and 160 mg/l, respectively, and the above removal efficiencies, the plant effluent concentrations should range between 29 and 58 mg/l BOD and 32 and 64 mg/l TSS. At these concentrations the permit 30-day average effluent limitations of 30 mg/l BOD and 30 mg/l TSS would be exceeded.

2. The District adds ferric chloride and polymer to the activated sludge mixed liquor just ahead of the secondary settling tanks to increase the activated sludge process BOD and TSS removal efficiencies above those inherent in the modified mode and, also for phosphorous removal. District data indicate that the quality of the plant effluent is quite dependent on the constant addition of these chemicals. During most of 1977 and early 1978 several mechanical problems were encountered with the chemical feed systems for both ferric chloride and polymer. Several of the permit effluent violations, or near violations, experienced at the plant were related to the loss of chemical feed. Apparently

these problems were related to the temporary nature of the chemical feed equipment and should be eliminated when construction of new permanent chemical facilities is completed.

3. The major operating problem at the Blue Plains plant during 1977 and 1978 has been the lack of adequate sludge solids handling equipment. At the time of this inspection, the sludge solids could not be removed from the wastewater treatment processes as fast as these processes generated them. The sludge solids in excess of the capacity of the removal/dewatering equipment were recycled to the plant influent. Consequently, this recycle load increased to the point where the treatment processes could no longer remove the solids efficiently enough to meet the permit limitations, and violations occurred.

   The bottlenecks in the sludge handling system were the gravity sludge thickening units and the sludge dewatering vacuum filters, the latter units playing the major role. Since the existing vacuum filters had insufficient dewatering capacity, they could not keep pace with the solids load being sent to the gravity thickening tanks. As a result, the thickener became overloaded and the thickener supernatant quality deteriorated, increasing the solids load in the recycle stream.

   District personnel reported that new solids handling/dewatering equipment, incorporating dissolved air flotation thickening units for waste-activated sludge and twenty-four new vacuum filters for dewatering sludge solids, was on-line by late August 1978. This new equipment should eliminate the solids handling problems which have plagued the plant, resulting in a marked improvement in the plant effluent quality.

4. General equipment maintenance at the plant is a potential problem which could ultimately affect performance. The general appearance of the plant grounds and structures is poor. NEIC engineers noted maintenance problems with the final clarifer scum collection systems and effluent weirs. District personnel acknowledged that the lack of full-time maintenance personnel at the plant has caused reduced plant performance when emergency repairs were needed during off-hours.

5. The data available to the NEIC are insufficient to substantiate or refute the District's claims that it requires extensive lime handling/feed equipment to condition the sludge solids to be dewatered at the new vacuum filter units. Parameters such as solids capture by the filters and optimum filter cake solids content do not appear to have been adequately addressed. Some lime handling/feed facilities are probably needed at the plant for those periods of time during the year when changes in sludge characteristics dictate lime conditioning.

6. Previous inspections of the District's laboratory facilities, conducted since May 1976 by personnel from Region III's Surveillance and Analysis Division, have documented numerous problems with the physical condition of the laboratory and the analytical procedures employed. Intra-Regional memoranda and correspondence between the Region and the District have highlighted these problems. The problems are serious and, though the District has made some progress toward correcting them, recent Region III inspections at this laboratory have revealed that many problems still remain.

The problems existing with the laboratory plus those noted by NEIC with the sampling procedures, flow monitoring equipment and techniques, and the methods used to calculate the final effluent loads could affect the accuracy of the data the District generates. However, this data base is the only one available for the plant and was therefore used by NEIC for evaluation of the treatment systems.

III. HISTORY AND CURRENT OPERATING STATUS OF THE BLUE PLAINS PLANT

HISTORICAL BACKGROUND

To appreciate some of the operating problems currently encountered at the Blue Plains plant, an understanding of the historical development of the treatment processes at the site is necessary. This development is briefly summarized below.

1938 The original treatment facility, consisting of a pumping station, plus process units for grit removal, grease separation, primary sedimentation and anaerobic digestion, elutriation, and vacuum dewatering of sludges, was placed in operation. These units, which today are incorporated in the West plant, were designed to treat an average flow of 5.7 m^3/sec (130 mgd).

1949 Four primary sedimentation tanks and four anaerobic digestion tanks were added to increase the plant capacity to 7.7 m^3/sec (175 mgd).

1953 to 1955 Pre- and post-chlorination were added and sludge incineration facilities were installed. The incinerator equipment proved unsatisfactory and was abandoned.

1959 Biological secondary treatment units were added and the primary capacity was increased to 10.6 m^3/sec (240 mgd).

1968 Design was initiated to increase the plant capacity to 13.6 m^3/sec (309 mgd) as well as to provide extensive new treatment units for nutrient removal and tertiary filtration of the total wastewater flow (this design is further discussed later in this section).

1971 to 1974 Six vacuum filters were added to increase the sludge dewatering capacity of the plant.

1974 Twenty new primary sedimentation tanks and a new pump station were added. These facilities plus the addition of increased secondary treatment units, discussed below, constitute the East plant which parallels the older West plant operation.

1976 Two new aeration tanks and attendent settling tanks for the East plant were added to provide a total secondary treatment capacity for 13.6 m^3/sec (309 mgd). Also, the plant began adding ferric chloride and polymer to the wastewater to remove phosphorous.

The District has been confronted with space problems at the Blue Plains site. Because of this and because effluent limitations for BOD and TSS were significantly less stringent during the 1950's and early 1960's when the first Blue Plains activated sludge batteries were designed and constructed, the District opted to install the modified aeration mode of activated sludge (A.S.) treatment. The modified A.S. mode employs a significantly shorter aeration period than does the conventional A.S. mode, about 2 hours versus 4 to 8 hours, respectively. The modified A.S. systems sacrifice treatment efficiency due to the reduced contact period, generally achieving 60 to 80% reduction of BOD and TSS. The more conventional A.S. modes can consistently achieve in excess of 90% reduction of these parameters.

During the late 1960's, as the flow rate to the plant increased and the hydraulic detention time in the aeration basins decreased, the Blue Plains effluent quality deteriorated. Simultaneously, the new pollution control awareness which developed throughout the nation resulted in stricter effluent limitations for wastewater treatment plants. In 1968, the District contracted with Metcalf and Eddy (M&E) consulting engineers, to evaluate the needs of the District to meet future effluent limitations. In their summary report[1], M&E concluded that the modified A.S. mode alone could not attain the greater than 90% BOD and TSS reductions anticipated to be required by future effluent limitations, and they recommended that the District convert to the step aeration A.S. mode for their existing and future A.S. systems. However, in this same report, M&E implied that if certain treatment options were adopted in the future for removal of nutrients (for example, heavy metal addition for phosphorous removal, ammonia stripping or biological processes for nitrogen removal), then it might be economically practical to use the modified A.S. process for BOD and TSS removal. With chemical addition (ferric chloride and polymer) it had been shown in pilot plant studies that the modified A.S. system was capable of 90% reduction of BOD and TSS.

CURRENT OPERATING STATUS

Subsequent to the 1968 M&E evaluations, several pilot plant studies convinced the District that metal ion addition for phosphorous removal and biological nitrification and denitrification reactors for nitrogen removal were the most reliable and economical nutrient removal processes. Once the District committed itself to these processes, modified A.S. became the most practical A.S. process for the plant expansion. As a result, the current secondary treatment portions of both the East and West plants are operated in the modified mode. Ferric chloride and polymer are added to the mixed liquor just before it enters the secondary settling tanks, both for phosphorous removal and to increase the BOD and TSS removal efficiency of the systems.

At the time of the NEIC inspection, the Blue Plains treatment plant consisted of two parallel, modified A.S. treatment plants with a total average design capacity of 13.6 m^3/sec (309 mgd) [Figure 1]. The West plant, the older of the two, has an average treatment capacity of about 5.5 m^3/sec (124 mgd); the newer East plant has an average treatment capacity of about 8.1 m^3/sec (185 mgd) [Table 1]. The treated effluents from the East and West plants are combined, disinfected with chlorine and discharged at Outfall 002 to the Potomac River estuary.

There is a considerable amount of construction underway at the plant site. The new nitrification reactors and related sedimentation tanks are estimated to be in operation in early 1979. The new Solids Processing Building, housing dissolved air flotation units for waste-activated sludge thickening and twenty-four new sludge dewatering vacuum filters, was essentially completed at the time of the NEIC inspection. The tertiary effluent filtration units are under construction but are not expected to be operating until 1980 or later.

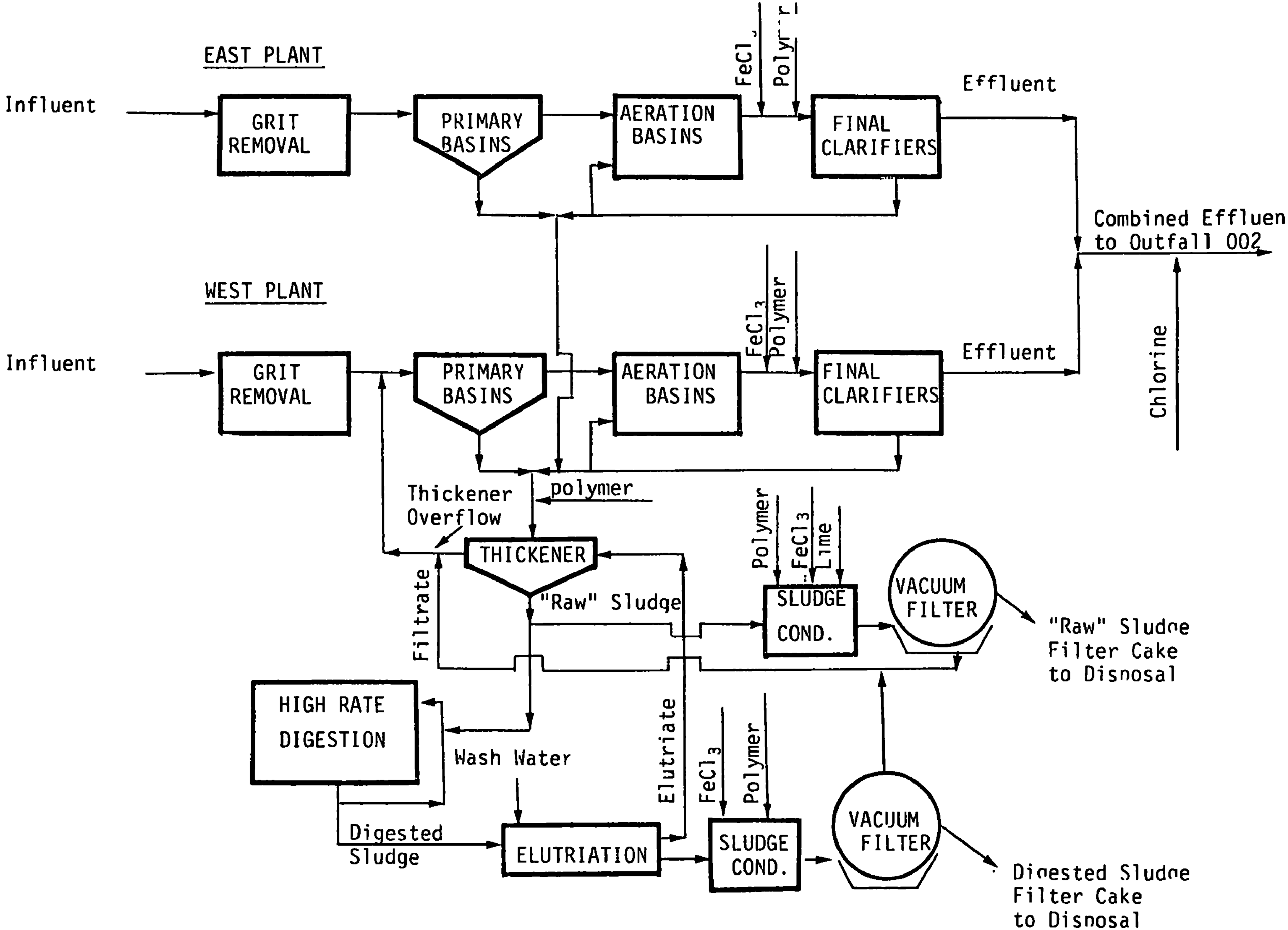

Figure 1. District of Columbia, Blue Plains Wastewater Treatment Plant Flow Diagram, as of July, 1978

Table 1

SUMMARY OF TREATMENT UNIT DESIGN PARAMETERS[2,3]
BLUE PLAINS WASTEWATER TREATMENT PLANT

Process and Parameter	West Plant	East Plant	Total
Grit Chambers			
Type			Aerated
Number of Chambers	4	12	16
Volume in Service, $m^3(ft^3)x10^3$	2.0 (71.0)	5.9 (210.0)	7.9 (281.0)
Primary Sedimentation Tanks (all circular)			
Number of Tanks	16	20	36
Diameter, m(ft)	32.3 (106)	36 5 (120)	
Total Volume, $m^3(ft^3)$ x 10^6	0 05 (1.93)	0 09 (3 23)	0.14 (5.16)
Total Surface Area, $m^2(ft^2)x10^3$	13.1 (141.2)	21 0 (226.2)	34.1 (367.4)
Secondary Aeration Tanks			
Number of Units	2	4	6
Total Volume, $m^3(ft^3)x10^6$	0.044 (1.54)	0.060 (2.11)	0.104 (3 65)
MLSS,[a] mg/l			
Average	1300	1300	
Peak	2000	2000	
MLVSS,[b] mg/l			
Average	800	800	
Peak	1000	1000	
Maximum Return Sludge Flow, m^3/sec(mgd)	1.6 (36)	2.1 (48)	3.7 (84)
Secondary Sedimentation Tanks (all rectangular)			
Number of Units	12	12	24
Total Volume, $m^3(ft^3)x10^6$	0.078 (2.77)	0.084 (2.98)	0.162 (5.75)
Total Surface Area, $m^2(ft^2)x10^3$	22 (237)	23 (248)	45 (485)
Gravity Thickeners			
Number of Units			6
Diameter, m(ft)			19.8 (65)
Sidewall depth, m(ft)			3 (10)
Anaerobic Sludge Digestion			
Number of Tanks			12
Type			Fixed Cover, High Rate
Total Volume, $m^3(ft^3)x10^6$			0 05 (1 71)
Operating Temperature, °C (°F)			35 (95)
Elutriation Tanks			
Number of Units			4
Total Volume, $m^3(ft^3)x10^3$			2.83 (100)
Vacuum Filters, Digested Sludge			
Number of Units			4
Diameter of Units, m(ft)			4.3 (14)
Total filtration area, $m^2(ft^2)$			186 (2000)
Vacuum Filters, "Raw" Sludge			
Number of Units			6
Diameter of Units, m(ft)			4 9 (16)
Total Filtration Area, $m^2(ft^2)$			334 (3600)

a MLSS = Mixed Liquor Suspended Solids
b MLVSS = Mixed Liquor Volatile Suspended Solids

IV. EVALUATION OF TREATMENT PLANT OPERATING AND MAINTENANCE PROCEDURES

The main objectives of this project involved evaluation of the District's operating and maintenance (O & M) procedures at the Blue Plains plant to determine if they were the cause of the NPDES permit violations experienced in early 1978. To accomplish these objectives, the NEIC engineers relied heavily on discussions with District operating personnel and review of the District's historical operating data for the plant. As mentioned in the Introduction and discussed in detail in the Appendix, the validity of the District's historical operating data is questionable. NEIC engineers, however, used these data extensively in evaluating the plant operations because no other data were available.

Three areas of operating problems at the Blue Plains plant were identified during the NEIC evaluation: the inherent limitations of the modified aeration A.S. system, the unreliability of the chemical feed systems used to improve the performance of the A.S. systems, and the limitations of the sludge processing systems. Deficiencies in the general plant maintenance program were also detected during the NEIC inspection. The O & M problems evaluated during this project are discussed below.

LIMITATIONS OF THE MODIFIED AERATION A.S. SYSTEMS

The modified aeration A.S. mode is characterized by a relatively short aeration period of from 1.5 to 3 hours, a high food-to-micro-organism ratio

(F/M) of 1.5 to 5.0 kg(lb) BOD/kg(lb) MLVSS*/day, a low biomass concentration (MLSS* = 200 to 500 mg/l), a low return sludge ratio (0.05 to 0.15) and a very low sludge age of 0.2 to 0.5 days. The process can achieve BOD removals of 60 to 80%. Some operational difficulties have historically been experienced with the process resulting in poor biomass characteristics and high suspended solids concentrations in the effluent[4].

The District's operating parameters for the East and West plants at Blue Plains approximate the general guidelines for the modified aeration systems discussed above. Table 2 summarizes the ranges for these parameters at the two plants from June 1977 to May 1978. The District runs slightly higher sludge ages, higher return sludge ratios, and substantially higher MLSS concentrations than normally employed in the modified aeration mode. The MLSS concentrations approach those encountered in the more conventional activated sludge systems.

Tables 3 and 4 summarize the BOD and TSS removal efficiencies for the East and West plants, respectively, from June 1977 to May 1978. These data reflect the plant's operations with chemical addition and are not indicative of true modified aeration A.S. systems. During this period, the BOD and TSS removal efficiencies for the East plant ranged from 78 to 86% and from 79 to 88%, respectively. Removal efficiencies for these pollutants at the West plant ranged from 67 to 79% and from 63 to 82%, respectively. Obviously, neither plant can consistently achieve 90% removal of these pollutants even with chemical addition. Also, the East plant apparently is more efficient in removing these pollutants than the West plant.

The plant removal efficiencies [Tables 3 and 4] were calculated solely on total plant influent and effluent pollutant mass loadings,

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* MLVSS = Mixed Liquor Volatile Suspended Solids; MLSS = Mixed Liquor Suspended Solids.

Table 2

COMPARISON OF TREATMENT UNIT OPERATING PARAMETERS
WITH GENERAL GUIDELINES FOR MODIFIED AERATION SYSTEMS
BLUE PLAINS WASTEWATER TREATMENT PLANT

Parameter	Normal Design[4]	East Plant	West Plant
Aeration Period, hr	1.5 to 3.0	1.3 to 1.9	1.7 to 2.5
F/M Ratio[a], kg(lb) BOD/kg(lb) MLVSS/day	1.5 to 5.0	0.17 to 2.10	0.87 to 1.64
MLSS, mg/l	200 to 500	1040 to 1940	1400 to 3800
Return Sludge Ratio, Q_R/Q[b]	0.05 to 0.15	0.13 to 0.19	0.14 to 0.31
Sludge Age, Day	0.2 to 0.5	0.62 to 1.38	0.5 to 0.95

a F/M Ratio = Food to Microrganism Ratio
b Q_R = Return Sludge Rate, m^3/sec(mgd); Q = Wastewater Influent Rate, m^3/sec(mgd)

Table 3

EAST PLANT POLLUTANT REMOVAL EFFICIENCIES
BLUE PLAINS WASTEWATER TREATMENT PLANT

Month	Primary Influent kg(lb) x 10³/day				Secondary Influent kg(lb) x 10³/day				Secondary Effluent kg(lb) x 10³/day				Removal Efficiency, %					
	TSS		BOD		TSS		BOD		TSS		BOD		Primary		Secondary		Total	
													TSS	BOD	TSS	BOD	TSS	BOD
1977																		
June	79	174	75	165	35	77	48	106	13	28	13	29	56	36	64	73	84	82
July	94	208	83	183	49	108	61	135	16	36	14	31	48	26	67	77	83	83
August	125	276	103	227	55	121	78	171	15	34	15	32	56	25	72	81	88	86
September	116	255	139	307	52	115	93	206	20	44	20	44	55	33	62	79	83	86
October	87	192	83	183	67	148	86	189	16	36	16	36	63	34	76	81	a	a
November	102	225	83	182	67	148	71	157	18	40	18	40	48	27	73	75	a	a
December	113	250	132	291	53	116	91	200	18	40	19	41	54	31	66	80	84	86
1978																		
January	113	250	103	228	72	159	85	188	24	52	22	48	36	18	67	74	79	79
February	88	194	97	214	62	137	78	173	18	40	18	39	29	19	71	77	79	82
March	125	275	90	199	59	131	68	149	17	37	18	40	52	25	72	73	87	80
April	153	337	97	214	67[b]	147[b]	69[b]	153[b]	20	44	19	41	56	29	70	73	87	81
May	116	255	93	206	59[b]	130[b]	64[b]	140[b]	21	46	21	46	49	32	65	67	82	78

a A portion of West plant primary effluent sent to East plant secondary influent.
b Recycle from flotation thickening included.

Table 4

WEST PLANT POLLUTANT REMOVAL EFFICIENCIES
BLUE PLAINS WASTEWATER TREATMENT PLANT

Month	Primary Influent kg(lb) x 10^3/day				Secondary Influent kg(lb) x 10^3/day				Secondary Effluent kg(lb) x 10^3/day				Removal Efficiency, %					
													Primary		Secondary		Total	
	TSS		BOD		TSS		BOD		TSS		BOD		TSS	BOD	TSS	BOD	TSS	BOD
1977																		
June	48	106	48	105	78	171	86	189	17	37	16	35	-61	-80	78	81	65	67
July	48	105	49	108	63	139	88	193	18	39	13	29	-32	-79	72	85	63	73
August	48	106	42	92	114	251	80	177	14	31	11	25	-137	-92	88	86	71	73
September	40	88	46	101	67	147	62	136	14	30	12	26	-67	-35	80	81	66	75
October	94	207	83	183	100	221	96	212	14	30	13	29	-45[a]	-53[a]	86	87	a	a
November	80	176	68	150	118	260	92	203	15	32	13	29	-66[a]	-51[a]	88	86	a	a
December	60	133	67	147	161	356	133	293	15	34	16	35	-168	-99	90	88	74	76
1978																		
January	91	201	84	185	186	411	139	306	16	36	18	40	-104	-65	91	87	82	78
February	79	174	83	183	117[b]	259[b]	91[b]	200[b]	17	37	17	38	-48	-9	86	81	79	79
March	71	157	68	149	200	440	147	324	23	50	20	43	-180	-117	89	87	68	71
April	64	142	50	110	186	409	143	316	17	38	15	32	-188	-187	91	90	73	71
May	56	123	51	113	101	223	94	208	16	35	14	31	-81	-84	84	85	72	73

a A portion of West plant primary effluent sent to East plant secondary influent.
b Sludge processing recycle stream returned directly to secondary influent part of month.

ignoring the effect of any process recycle streams. As will be discussed later, the West plant receives all the recycle loads from the sludge processing and dewatering units at the facility. The pollutant loads from these recycle streams are not reflected in the West plant influent sample data; hence the removal efficiencies shown in Table 4 do not take into account these additional loads.

Table 5 shows the removal efficiencies achieved by the West plant when the recycle loads are included in the calculations. The TSS removal efficiency ranged from 84 to 96% from June 1977 to May 1978. The BOD removal efficiency was consistent, ranging from 85 to 89% during this same period.

The sludge processing recycle stream has a dramatic impact on the operation of the West plant. This stream contributes from 1 to 5.5 times as much TSS and about the same amount of BOD to the West plant influent as does the raw wastewater [Table 5]. It is remarkable that the West plant operates as well as it does under these conditions. Reduction of this recycle load is the key to improving the operating performance of the Blue Plains plant.

The District personnel have made several physical changes at the East and West secondary plants in an attempt to compensate for the additional TSS and BOD loads contributed to the West plant by the sludge processing recycle stream. By using various valving arrangements, installing stop logs, etc. they have increased the aeration basin contact time and decreased the secondary settling tank overflow rates for the West plant. However, this has been accomplished at the expense of the East plant. Tables 6 and 7 summarize the impact of these parameters on the plants' operating performance. The West plant consistently achieves higher percentage removal rates for both TSS and BOD than does the East plant, often more than 10% higher.

Table 5

WEST PLANT POLLUTANT REMOVAL EFFICIENCIES
WITH SLUDGE PROCESSING RECYCLE LOAD
BLUE PLAINS WASTEWATER TREATMENT PLANT

Month	Primary Influent kg(lb) x 10³/day TSS		BOD		Sludge Recycle to Primary kg(lb) x 10³/day TSS		BOD		Secondary Influent kg(lb) x 10³/day TSS		BOD		Secondary Effluent kg(lb) x 10³/day TSS		BOD		Removal Efficiency, % Primary TSS	Primary BOD	Secondary TSS	Secondary BOD	Total TSS	Total BOD
1977																						
June	48	106	48	105	79	175	55	122	78	171	86	189	17	37	16	35	39	17	78	81	87	85
July	48	105	49	108	61	135	38	83	63	139	88	193	18	39	13	29	42	-1	72	85	84	85
August	48	106	42	92	108	237	52	114	114	251	80	177	14	31	11	25	27	14	88	86	91	88
September	40	88	46	101	108	237	65	143	67	147	62	136	14	30	12	26	55	44	80	81	91	89
October	94	207	83	183	146	322	49	109	100	221	96	212	14	30	13	29	43[a]	4[a]	86	87	a	a
November	80	176	68	150	212	469	60	132	118	260	92	203	15	32	13	29	55[a]	20[a]	88	86	a	a
December	60	133	67	147	320	705	68	150	161	356	133	293	15	34	16	35	58	1	90	88	96	88
1978																						
January	91	201	84	185	332	731	43	94	186	411	139	306	16	36	18	40	56	-10	91	87	96	86
February	79	174	83	183	133[b]	294[b]	37[b]	82[b]	117[b]	259[b]	91[b]	200[b]	17	37	17	38	64[b]	39[b]	86	81	92	86
March	71	157	68	149	330	727	66	145	200	440	147	324	23	50	20	43	50	-10	89	87	94	85
April	64	142	50	110	342	755	62	137	186	409	143	316	17	38	15	32	54	-28	91	90	96	87
May	56	123	51	113	280	617	62	136	101	223	94	208	16	35	14	31	70	16	84	85	95	88

a A portion of West plant primary effluent sent to East plant secondary influent
b Sludge processing recycle stream returned directly to secondary influent part of month.

Table 6

EAST PLANT OPERATING DATA
BLUE PLAINS WASTEWATER TREATMENT PLANT

Month	Aeration Basin Contact Time, hours	Secondary Settling Tank Overflow Rate, $m^3/m^2(gal/ft^2)/day$	Secondary Effluent Quality, mg/l TSS	Secondary Effluent Quality, mg/l BOD	Secondary Removal Efficiency,% TSS	Secondary Removal Efficiency,% BOD	MLSS Concentration, mg/l
1977							
June	1.90	28.2 689	19	20	64	73	1040
July	1.65	28.2 689	25	21	67	77	1276
August	1.34	31.3 766	22	20	72	81	1438
September	1.52	35.1 858	25	25	62	79	1134
October	1.56	27.4 669	26	26	76	81	1357
November	1.74	28.2 690	28	28	73	75	1642
December	1.69	34.0 832	25	25	66	80	1689
1978							
January	1.64	36.0 881	31[a]	29	67	74	1941
February	1.90	28.9 706	28	27	71	77	1618
March	1.69	34.0 831	23	25	72	73	1558
April	1.61	33.6 822	26	25	70	73	1678
May	1.51	34.6 847	26	26	65	67	1517

a Indicates effluent exceeded permit limitations.

Table 7

WEST PLANT OPERATING DATA
BLUE PLAINS WASTEWATER TREATMENT PLANT

Month	Aeration Basin Contact Time, hours	Secondary Settling Tank Overflow Rate, $m^3/m^2(gal/ft^2)/day$	Secondary Effluent Quality, mg/l		Secondary Removal Efficiency,%		MLSS Concentration, mg/l
			TSS	BOD	TSS	BOD	
1977							
June	2.03	22.6 553	37[a]	36[a]	78	81	1512
July	1.95	20.5 502	42[a]	31[a]	72	85	2183
August	2.28	18.0 441	38[a]	31[a]	88	86	2839
September	2.51	15.7 385	45[a]	39[a]	80	81	1413
October	2.08	21.3 521	33[a]	32[a]	86	87	1868
November	1.97	19.5 477	33[a]	31[a]	88	86	2302
December	1.84	20.5 502	34[a]	36[a]	90	88	2536
1978							
January	1.75	22.6 552	33[a]	37[a]	91	87	2969
February	1.90	23.6 576	40[a]	40[a]	86	81	2429
March	1.92	23.4 572	52[a]	45[a]	89	87	2617
April	2.27	15.2 371	50[a]	44[a]	91	90	3775
May	2.18	16.6 405	44[a]	39[a]	84	85	2006

a Indicates effluent exceeded permit limitations.

At least two factors probably account for the differences in the BOD removal efficiencies between the two plants. First, in biological systems, the removal rate of dissolved organics is proportional to the organics concentration in the substrate. Since the West plant has a higher organic loading, it logically would have a higher BOD removal efficiency. Secondly, the West plant contact period is about 0.4 hours longer than the East plant, a difference of 25% [Tables 6 and 7]. This additional contact period allows the West biomass to remove additional BOD.

Several factors can also affect the TSS removal efficiency of a secondary system, such as the age of the biofloc, the mass flux loading to the clarifiers, the physical constraints of the clarifiers, and the temperature of the wastewater. However, at Blue Plains, two items appear most critical, the chemical feed systems and the hydraulic loading rate of the clarifiers. The chemical feed systems are discussed below under Chemical Addition. The East plant clarifiers have overflow rates which are about 60% higher than those of the West plant [Tables 6 and 7], a factor which affects its TSS removal efficiency.

It should not be construed from the above discussions that the District has improperly operated the two plants by modifying the aeration period and clarifier overflow rates at the East plant. On the contrary, considering the constraints they are working under, they appear to have optimized the plants' available treatment capability. The East plant effluent exceeded the NPDES permit TSS concentration limitation only one month during the evaluation period and, as will be seen later, this resulted from a chemical feed system failure. The West plant, however, exceeded the permit limitations for both BOD and TSS every month. If District personnel had not effected the treatment modifications discussed, the West plant effluent would have been even worse, possibly resulting in more significant permit violations, at an earlier date.

CHEMICAL ADDITION

As previously mentioned, ferric chloride ($FeCl_3$) and polymer are added to the mixed liquor channels from the aeration basins just ahead of the point where the mixed liquor enters the final clarifiers. No sophisticated chemical addition systems or mixing tanks are used. The chemicals are pumped from storage through pipes which discharge directly to the mixed liquor channels. Mixing of the chemicals and mixed liquor is achieved solely by the flow turbulence in the channels.

Tables 8 and 9 summarize the chemical addition data at the plant from June 1977 to May 1978. The sensitivity of the treatment systems' TSS removal efficiencies to the range of chemical feed rates is not apparent from these tables. These data, however, only reflect average monthly chemical addition rates and removal efficiencies; hence, the daily fluctuations in effluent quality typical of chemical precipitation systems are masked in this data. It is also possible that, above certain minimum chemical feed rates, the variations in the secondary settling tank overflow rates have a more substantial effect on the effluent TSS concentrations than do the chemical addition rates. Tables 8 and 9 substantiate this to some degree.

Four significant chemical system malfunctions occurred during the evaluation period affecting the plant operations for the months of June, July and September 1977, and January and February 1978. In June and July 1977, a malfunction of the polymer preparation and feed systems resulted in loss of polymer feed to both plants for about 23 days. TSS removal efficiencies dropped to 64 - 67% in the East plant, and to 72 - 78% in the West plant. In September 1977, rupture of an $FeCl_3$ transfer line resulted in the loss of $FeCl_3$ feed to both plants for four days. Effluent TSS levels climbed to 79 mg/l during this outage and the monthly TSS removal efficiencies dropped to 62 and 80% for the East and West plants, respectively. High clarifier overflow rates for the East plant compounded the TSS removal problems. In

Table 8

EFFECT OF CHEMICAL ADDITION ON REMOVAL EFFICIENCY-EAST PLANT
BLUE PLAINS WASTEWATER TREATMENT PLANT

Month	Chemical Addition Rate, mg/l Polymer	$FeCl_3$	Secondary Settling Tank, Overflow Rate, m^3/m^2	$(gal/ft^2)/day$	Secondary Effluent Quality, mg/l TSS	BOD	Secondary Removal Efficiency,% TSS	BOD
1977								
June	0.16	28.6	28.2	689	19	20	64	73
July	0.04	27.0	28.2	689	25	21	67	77
August	0.31	27.9	31.3	766	22	20	72	81
September	0.23	26.9	35.1	858	25	25	62	79
October	0.22	34.2	27.4	669	26	26	76	81
November	0.25	31.1	28.2	690	28	28	73	75
December	0.24	30.2	34.0	832	25	25	66	80
1978								
January	0.28	24.0	36.0	881	31	29	67	74
February	0.004	27.4	28.9	706	28	27	71	77
March	0.20	28.8	34.0	831	23	25	72	73
April	0.46	23.0	33.6	822	26	25	70	73
May	0.31	17.8	34.6	847	26	26	65	67

Table 9

EFFECT OF CHEMICAL ADDITION ON REMOVAL EFFICIENCY-WEST PLANT
BLUE PLAINS WASTEWATER TREATMENT PLANT

Month	Chemical Addition Rate, mg/l		Secondary Settling Tank, Overflow Rate, $m^3/m^2(gal/ft^2)/day$		Secondary Effluent Quality, mg/l		Secondary Removal Efficiency,%	
	Polymer	$FeCl_3$			TSS	BOD	TSS	BOD
1977								
June	0.12	37.6	22.6	553	37	36	78	81
July	0.04	35.5	20.5	502	42	31	72	85
August	0.34	41.8	18.0	441	38	31	88	86
September	0.28	30.7	15.7	385	45	39	80	81
October	0.25	33.0	21.3	521	33	32	86	87
November	0.31	33.2	19.5	477	33	31	88	86
December	0.29	32.0	20.5	502	34	36	90	88
1978								
January	0.31	24.2	22.6	552	33	37	91	87
February	0.08	27.7	23.6	576	40	40	86	81
March	0.29	29.0	23.4	572	52	45	89	87
April	0.44	20.7	15.2	371	50	44	91	90
May	0.38	18.6	16.6	405	44	39	84	85

January 1978, another rupture of the $FeCl_3$ transfer lines resulted in a loss of $FeCl_3$ feed to both plants for seven days and excessive TSS discharges. The East plant TSS removal efficiency dropped to 67%; the West plant did not appear to be substantially affected. In February 1978, failure of a polymer transfer pump resulted in loss of polymer feed to both plants for essentially the whole month. TSS removal efficiencies declined to 71 and 86% for the East and West plants, respectively.

The secondary treatment systems obviously depend on the chemical feed systems to obtain good TSS removal efficiencies. District personnel are aware that the reliability of the existing systems leaves a lot to be desired. They feel that the addition of the new Chemical Building at the facility (being built as part of the plant expansion) will eliminate many of the chemical handling problems which have plagued the interim chemical handling equipment.

In March 1978, District personnel, being faced with an ever-increasing solids inventory in the treatment units, made the decision to reduce the $FeCl_3$ feed rate to both the East and West plants. It was their opinion that, by reducing the $FeCl_3$ feed, there would be less chemical sludge and wastewater solids to handle, albeit forfeiting some treatment efficiency. The TSS removal efficiencies for both plants have decreased since March 1978 as expected [Tables 8 and 9]. Region III's question as to whether the District's reduction in chemical feed rates constitutes a violation of its NPDES permit's general condition, which requires that the plant be operated as efficiently as possible at all times, is difficult to answer with the available data. Granted, the reduced chemical feed rates did apparently result in increased effluent TSS quantities. However, it is possible that even greater effluent deterioration would have occurred had the District not attempted to reduce the volume of sludge produced by the treatment systems and subsequently the sludge processing recycle loads to the

West plant. In view of the fact that the District's operating personnel were faced with a lesser-of-two-evils choice, NEIC concurs in their decision.

SOLIDS REMOVAL AND DEWATERING

The most persistent operational problem at Blue Plains is that of dewatering and ultimate disposal of the solids (sludges) removed from the wastewater stream. In simple terms, the plant is solids bound; the solids handling equipment has insufficient capacity to consistently dewater the amount of solids generated by the treatment processes. As a result, the solids that cannot be dewatered are recycled to the treatment process. Over a period of months, the solids storage capacity of the treatment processes is exceeded and the excess solids escape to the plant effluent.

The existing sludge processing systems at Blue Plains are shown schematically in Figure 1. Primary sludges and waste-activated sludges are pumped to six circular gravity sludge thickening tanks, the primary and secondary sludges being combined in the pipelines ahead of the thickener units. Polymer is added to the combined sludges where they enter the thickeners. The thickened sludge withdrawn from the bottom of the thickeners can be handled in two ways. A portion of the thickened sludge is sent to the anaerobic digesters for biological decomposition; the remainder is dewatered on rotary vacuum filters as "raw" sludge. The digested sludge is washed free of inorganic chemicals and fine solids in elutriation tanks and dewatered on separate vacuum filters. The "raw" and digested sludge filter cakes are ultimately hauled to land disposal sites. Wastewaters comprised of the sludge thickener supernatants, vacuum filter filtrates, and digested sludge elutriates are recycled to the influent of the West plant for treatment.

The gravity thickening tanks are severly overloaded, being operated at several times their design loadings. In normal practice, a gravity thickener used for combined primary and modified aeration waste-activated sludges can be loaded at 59 to 98 kg/m^2 (12 to 20 lb/ft^2)/day to effect a thickening of 3 to 4% incoming sludge to 8 to 11% underflow sludge. At Blue Plains, the gravity thickeners have been operated at loading rates of up to 370 kg/m^2 (76 lb/ft^2)/day during the past year. As a result, the thickener solids capture efficiencies have suffered, dropping into the 40 to 50% range and the supernatant recycle loads to the West plant have increased in pollutant strength. In April 1978, the recycle stream had TSS and BOD concentrations of 6,844 mg/l and 1,242 mg/l, respectively. The recycle load has increased significantly from June 1977 to May 1978, to the point where it contributes significantly more TSS loading to the West plant than does the raw wastewater [Table 5].

A second problem with the gravity thickeners is that they are being used to thicken combined primary and waste-activated sludges. Gravity thickening operates best with primary sludges. Waste-activated sludges are best dewatered using flotation thickening processes. Gravity thickening of combined primary and waste-activated sludges often results in decreased solids capture efficiency and heavy recycle loads.

The most serious problem affecting the solids handling systems appears to be the limited capacity of the sludge vacuum filtering systems. The existing units simply do not have sufficient filtering capacity to handle the Blue Plains solids production. Consequently, the sludge levels in the thickening tanks build up to the point where the supernantant quality deteriorates and recycle loads to the West plant increase. The recycle solids are removed in the West plant and sent back to the thickeners. The recycled solids plus the "virgin" solids removed in the East and West plants impose a still greater load on the thickeners and vacuum filters resulting in increased recycle loads and so on.

A summary of the solids handling data for the Blue Plains plant is presented in Table 10. The far right column tabulates the quantity of sludge solids which was consistently removed from the solids handling systems, as measured by the amount of thickened sludge solids sent to anaerobic digestion or directly to "raw" sludge vacuum filtration dewatering. Two separate data summaries are given for the total sludge solids produced by the East and West plants. The first column summarizes the actual sludge quantities reported by the District. These data include the recycle stream to the West plant. The second data column shows the calculated sludge solids load from both plants if the recycle solids load was not imposed on the West plant.

Table 10 emphasizes the fact that the plant cannot remove solids from the systems at the rate they are being generated, much less make any headway toward reducing the TSS inventory involved in the recycle stream. During only two months, July 1977 and February 1978, did the solids removal systems' production equal or exceed the solids generation systems' production. It was inevitable therefore that solids would build up in the recycle system and deteriorate the West plant effluent quality.

It can be deduced from the above discussions that the District must increase the solids removal systems' capacity in order to consistently meet the NPDES permit limitations. There are only a few areas that the District can address to accomplish this: a) the filter yield of the existing vacuum filters can be increased, b) the anaerobic digestion capacity can be increased, and c) the number of vacuum filters can be increased. These options are briefly discussed in the following paragraphs.

Table 10

WASTEWATER SLUDGE SOLIDS HANDLING SUMMARY
BLUE PLAINS WASTEWATER TREATMENT PLANT

Month	Total Sludge Solids Produced, kg(lb)x10³/day										Total Solids Removed from both Plants[b] kg(lb)x10³/day	
	East Plant		West Plant		West Plant w/o recycle[a]		Both Plants w/recycle		Both Plants w/o recycle			
1977												
June	112	246	172	380	78	171	284	626	190	417	142	313
July	97	213	154	340	65	143	251	553	162	356	163	360
August	146	323	159	350	77	170	305	673	223	493	141	311
September	132	290	163	360	52	114	295	650	184	404	117	259
October	117	258	206	455	79	175	323	713	196	433	142	313
November	114	252	280	617	77	170	394	869	191	422	161	356
December	124	273	403	888	77	170	527	1161	201	443	144	317
1978												
January	107	235	346	763	72	158	453	998	179	393	143	315
February	89	196	240	529	60	133	329	725	149	329	158	349
March	144	317	350	771	90	198	494	1088	234	515	165	364
April	158	349	446	984	74	163	604	1333	232	512	175	385
May	134	295	364	803	63	139	498	1098	197	434	178	392

a Computed based on East plant sludge production and ratio of wastewater flows between East and West plants

b Data includes solids sent to anaerobic digestion plus solids dewatered in "raw" form

The existing vacuum filters are operating at near-design capacity. Both the "raw" sludge and digested sludge filters are yielding nearly 15 kg/m^2 (3 lb/ft^2)/hour, which is comparable to other installations of this type. The existing filters have experienced some maintenance problems which have reduced their on-line time. However, the maintenance frequency has not been excessive considering the age of the equipment.

The anaerobic sludge digestion facilities at Blue Plains appear to be operating at near-design capacity. Within the last few years, the District has implemented a program to clean and renovate the digesters routinely. One problem noted with the digesters is that when $FeCl_3$ is added to the secondary treatment systems, the percent volatile solids in the sludge from the secondary systems decreases. As a result, the percent volatile solids reduction and the gas production of the digesters has decreased proportionately. In general, however, the anaerobic digesters at the Blue Plains facility appear to be well operated and performing at their capacity.

The last alternative, that of increasing the total number of vacuum filters available for dewatering the wastewater solids, appears to be the most logical remedial action.

As previously mentioned, the new Solids Processing Building is nearly completed. When this facility becomes available, the solids thickening and sludge dewatering bottlenecks should be eliminated. Eighteen new flotation sludge thickening tanks and 24 new rotary vacuum filters will be included in this facility. Waste sludges from the secondary activated sludge units and the new nitrification reactors will be thickened in flotation thickener units. The existing gravity sludge thickeners will be used only to thicken the primary sludges from the East and West plants. Having separate gravity and flotation thickeners should dramatically improve the sludge thickening process and minimize solids carryover in the recycle stream.

Present plans call for the continued use of the anaerobic digesters, at least until the new sludge handling facilities are on-line and de-bugged. A portion of the thickened primary sludge from the gravity thickeners will be anaerobically digested, elutriated and dewatered on the existing four digested-sludge vacuum filters. The remainder of the thickened primary sludge will be pumped to the new sludge handling building, blended with the thickened waste-activated sludge, and dewatered on the twenty-four new vacuum filter units. Piping provisions have also been made so that the elutriated digested sludge can be pumped to the new facility, blended with the other sludges and dewatered on the new vacuum filters. If this alternative proves feasible, the four old digested sludge vacuum filters will be abandoned.

There should be more than adequate sludge thickening and vacuum filtration capacity available with the addition of the new solids handling equipment. These facilities were designed with adequate capacity to handle not only the existing primary and secondary sludges and the sludges from nitrification reactors, but also full denitrification sludge loads, increased solids loads from the furture tertiary filtration backwash streams and blowdown of solids from a potable water treatment plant contributory to the District's sewerage system. Since the solids handling facilities were designed, decisions have been made to delay the Blue Plains denitrification system for several years and to not accept the potable water plant sludges into the sewerage system. . Therefore, the new facilities should have reserve capacity already built in. Lastly, the six vacuum filters currently used to dewater the "raw" sludge from the gravity thickeners can be reconditioned and moved to the new Solids Processing Building. Space has been allotted for them. With their addition, thirty vacuum filters would be available for dewatering the sludges.

GENERAL PLANT MAINTENANCE

It was not within the scope of this project to do an in-depth evaluation of the maintenance program at the Blue Plains plant. To effectively audit the manpower ledgers, spare parts inventory, lubrication schedules, and other items involved with the maintenance program for a plant this size would take an experienced team of 2 to 3 individuals a week or more. The NEIC evaluation of the plant's maintenance program was therefore based on observations made during the plant inspection and limited discussions with the District personnel.

It was the general opinion of the NEIC engineers that the plant was not well maintained. The condition of the plant grounds undoubtedly influenced this decision. Even allowing for the disruption to the plant site necessitated by the on-going construction, the condition of the plant grounds must be rated less than acceptable for a municipal wastewater treatment plant. Grass is almost non-existent, the ground being either bare or infested with tall weeds. Guardrails, above ground piping, exposed structural members and other readily visible items need paint. Large open areas are used for random storage of old mechanical parts, pipes and pipe fittings. In general, the plant's appearance did not instill confidence in the District's maintenance program.

Specific maintenance deficiencies noted during this inspection involved the condition of the scum removal systems at the West plant secondary clarifiers and the effluent weir adjustments for these clarifiers. The scum troughs on the majority of the units were observed to be choked with scum and floating items such as plastic bottles. The troughs require periodic operator attention to function properly. They did not appear to have received such attention for several days prior to the inspection. Scum build-up in a final clarifier can result in deterioration of the final effluent quality.

The effluent weirs in several of the clarifiers were not level and the weir elevations varied from clarifier to clarifier. Unlevel weirs within a given clarifier result in short circuiting of flow patterns within the clarifier. Differences in weir elevations between various clarifiers with a common inlet feed system result in uneven flow distribution to the clarifiers. Both conditions can result in decreased TSS removal efficiencies.

It is probable that the effluent quality problems created by the sludge processing recycle load overshadow those which could be attributed to the scum and weir situations discussed above. However, once the recycle load is significantly reduced, lesser problems such as these will have to be eliminated if the plant's effluent quality is to be maximized.

Plant operating personnel indicated to the NEIC engineers that general maintenance at the plant has deteriorated since the maintenance function was transferred from the control of the plant superintendent to a separate District bureau which supplies maintenance services for all of the District's functions. As an example of the maintenance restrictions at the treatment plant, the operating personnel cited the fact that electricians and mechanics are only on-site from 7:00 am to 3:00 pm, five days per week. If problems occur during other hours, off-duty personnel must be called in to perform the necessary repairs. On several occassions, this situation has resulted in increased downtime of critical process equipment.

V. EVALUATION OF DISTRICT'S NEEDS FOR ADDITIONAL LIME HANDLING FACILITIES

GRANT REQUEST

In April 1978, the District requested that EPA Region III approve additional construction grant funds to finance design and construction of lime handling facilities at the new Solids Processing Building. The District stated that the lime from these facilities was needed to condition the sludges prior to vacuum filtration, and thus improve their dewatering characteristics. Also, liming to elevate the final pH of the sludge is apparently required if the sludge cake is to be disposed of by landfilling. The District noted that the solids dewatering equipment had originally been designed (and in fact constructed) without lime facilities because original pilot studies had indicated that the sludges would dewater well with only ferric chloride and polymer addition. They stated that full-scale experience had proven these conclusions to be inaccurate. One factor contributing to this problem was that the addition of chemical treatment ($FeCl_3$ plus polymer) at the secondary treatment facilities had dramatically increased the secondary solids capture, thus increasing the secondary-to-primary sludge ratio and making sludge dewatering more difficult.

DESIGN STUDIES

Background information regarding the design of the new solids processing equipment (specifically the new vacuum filter units) is sparse. NEIC requested that Region III and District personnel supply copies of any design information regarding these units. Only two documents were provided: a brief report authored in 1973 by Whitman, Requart and Associates[5], the consulting firm which did the majority of the design work on the solids handling facilities, and a July 1977 memo report by Komline-Sanderson[6], the suppliers of the vacuum filtration equipment.

The Whitman, Requart and Associates report appeared to be only a preliminary conceptual design document. It addressed such items as the anticipated quantity of sludge solids to be handled at the new facilities, the use of flotation units for thickening of waste-activated sludge, and the recycle of thickening waste loads. No mention was made in this report of the specific types of sludge conditioning chemicals to be used with the dewatering vacuum filters.

Subsequent to 1973, the District and its consulting engineers must have made some pilot studies to determine the optimum sludge dewatering configurations for the new Solids Processing Building. However, no documentation of this work was provided to NEIC. Based on the information available, the new facilities were designed and constructed without lime addition equipment. It should be noted that the District did have the six "raw" sludge vacuum filters in operation during this period and were gaining operating experience with these units on various mixtures of primary and secondary sludges. Until recently (concurrent with the advent of increased secondary solids loads from the new East plant secondary systems) the "raw" sludge filters were operated without lime conditioning of the sludge solids. Only $FeCl_3$ and polymers were employed. New lime addition equipment has recently been installed at the existing sludge filtration site and is currently used for all "raw" sludge dewatering operations. District personnel report that at the current primary-to-secondary sludge ratios, the mixed sludges will not dewater effectively without lime.

In January and again in July 1977, Komline-Sanderson (K-S) conducted a series of dewatering studies at the Blue Plains plant to "demonstrate the vacuum dewatering step on full-scale equipment"[6]. A pilot plant 3x2 Flexibelt Filter was used for these studies. The sludge tested was a mixture of 67% secondary sludge and 33% primary sludge (note: it is unknown whether these sludges were obtained from the East, West or both plants and whether or not they contained the heavy solids recycle loads). The secondary and primary sludges were blended together within 14 hours of the filtration runs to approximate actual plant conditions. Nylon fabric (K-S 519) was used as the filtering medium. DuPont ferric chloride solution (12% solution strength) and one of two polymers, Nalco 610 or Allied Chemicals Percol 776 (both prepared at 0.1% solution strength) were used as sludge conditioning chemicals. The sludge mixtures were conditioned in a K-S Model 0 rotating conditioning tank prior to being introduced into the vacuum filter vat. The polymer was introduced into the sludge at the inlet to the conditioning tank; the $FeCl_3$ was added at the inlet to the conditioning tank's second chamber.

The test results obtained indicated that the filter could operate at specification standards with this sludge mixture and using only ferric chloride and the Percol 776 polymer. At $FeCl_3$ and polymer addition rates of 7.1 and 0.22%, respectively (weight-to-weight percent based on total solids), the filter yield ranged from 10.7 to 29.7 kg/m^2 (2.2 to 6.1 lb/ft^2)/hr with filter cake solids of 16.5 to 19.2%. No problems with cake release, cloth blinding, or solids capture were detected during these runs.

A.M. Fischer of Komline-Sanderson concludes in his letter to the District[6],

> "I believe that this testing totally met the objectives of providing a more realistic look at this vacuum dewatering step using polymer and ferric chloride for conditioning. We may proceed with the start up of the new Flexibelt Filters with additional confidence that lime conditioning is not required."

He continues however,

> "Confirming our conversation, however, Komline-Sanderson does not believe there is sufficient evidence that continued operation can be maintained without using lime as a sludge conditioning agent. Knowing the changing conditions of your biological solids, we feel that a lime supply should be provided at the solids handling building."

NEIC EVALUATION

The above conclusions by K-S seem to imply that the sludges can be dewatered under some conditions without lime, even at a secondary-to-primary sludge ratio of 2:1. The District's operating data for the East plant (the plant without recycle loads) for the period June 1977 to May 1978 indicate that the secondary-to-primary sludge ratio is about 1.2:1, significantly less than the 2:1 ratio tested. Since the ratio is lower, the blended sludges should dewater easier than those in the K-S tests of 1977, and the required frequency of lime usage could be even less critical.

The variability of the District's sludges is an important factor to consider. It is conceivable that the K-S tests were run under optimum sludge conditions, atypical of the normal sludge variability conditions experienced at the plant. It probably would be unwise to initiate operation of the new vacuum filters without some lime feed capacity being available.

One item not adequately covered by the K-S letter report is that of the solids capture efficiency of the filters during the 1977 tests. The types and amounts of chemicals used to condition the sludges will have a significant effect on this parameter. If the capture efficiency is not adequate, a significant solids recycle load could be applied to the wastewater/sludge treatment processes resulting in problems similar to those that currently exist at the West plant.

One vaccuum filter operating parameter at Blue Plains may need re-evaluation, that of filter cake solids content. High filter cake solids content (in excess of 20% solids) is important if the ultimate sludge disposal method is incineration or involves long truck haul distances. If incineration is used, it is important to maximize the solids content of the cake to minimize fuel costs involved with evaporating the cake water. High solids content is also important if long trucking distances are involved because it is desirable to minimize the weight and volume of sludge to be hauled. Wet sludges also result in more difficult handling and disposal problems in some landfill situations.

Current plans call for the District to use on-site composting techniques for ultimate disposal of a large portion of the Blue Plains sludge. Solids content of the filter cake may be less critical with composting. In fact, a wetter sludge may well be benefical to the composting process. If a wetter sludge cake can be tolerated, the frequency of lime conditioning needs may be decreased substantially.

In anticipation of the startup of the new solids processing equipment, the District has initiated purchase of equipment and construction of a temporary lime feed system at the Solids Processing Building. The District will purchase powdered lime which will be pneumatically transferred from the supplier's vehicle to a jet mixer located atop one of the four sludge blending tanks at the building. This jet mixer will mix the lime with water forming a lime slurry solution. This solution will be stored in the sludge blending tank until required for sludge conditioning. The lime solution will be added to the sludges ahead of the sludge storage/blending tanks. District personnel anticipated that these lime facilities would be available by August 15, 1978. In subsequent telephone conversations with them, it was determined that the equipment was operational the last week of August.

REFERENCES

1. "Development Plan for the Water Pollution Control Plant with Implementation Program for 1969-1972," Metcalf and Eddy Engineers, February, 1969.

2. "Wastewater Treatment Plant of the District of Columbia," Brochure ES-6, Government of the District of Columbia, Department of Environmental Services, March 1974.

3. "Report on Capacity Evaluation of the Wastewater Treatment Plant," Metcalf and Eddy Engineers, October 1976.

4. Wastewater Engineering, Metcalf and Eddy, Inc., McGraw-Hill, Inc., 1972, pp. 497, 498 and 501.

5. "Engineering Design Summary for the Solids Processing Building-Unit 33." Whitman, Requardt and Associates, December 4, 1973.

6. Letter of July 18, 1977 from A.M. Fischer, Komline-Sanderson to Alan F. Cassel, Chief, Research Division, Bureau of Wastewater Treatment, District of Columbia, Subject: "Pilot Plant Vacuum Dewatering Tests Run 6-17-77 thru 6-18-77 at Blue Plains."

APPENDIX A
EVALUATION OF PLANT OPERATING DATA

As a result of the NEIC's discussions with Region III and District personnel, and on-site observations made at the Blue Plains plant, three areas of concern related to the accuracy of the District's plant operating and Discharge Monitoring Report (DMR) data have been identified. These are laboratory analytical techniques, sampling procedures, and flow monitoring; each is discussed below.

LABORATORY ANALYTICAL PROCEDURES

Correct analytical procedures are essential to the production of reliable plant operating and DMR data. It has been known for at least two years that the analytical procedures and practices employed by the District's laboratory personnel were suspect and could lead to inaccurate data generation. Several memoranda and letters in the Region III files document the problems at the District's laboratory. In May 1976, personnel from the Region III Surveillance and Analysis (S&A) Division inspected the District's laboratory and noted the following serious deficiencies:

1. Staff - Serious employee-supervisor-management difficulties with routine employee insubordination were noted. The analytical staff does not receive outside training. Poor laboratory practices are employed by many of the analysts.

2. Facilities - The existing laboratory facilities are not suitable, being hampered by dust, ventilation and temperature control problems.

3. Safety - Several safety deficiencies were noted including inaccessible eyewash stations, improper employee use of lab coats, safety glasses, etc.

4. Sampling - Sample identification and logging procedures were so poor that some District personnel implied that they were unable to relate the data results to the plant operating conditions.

5. Quality Assurance - Only minimal quality assurance programs are practiced; employees resist use of quality assurance techniques.

6. Data Handling - Some analysts refuse to do final calculations, leaving these for the supervisors to complete.

7. Chemical Laboratory Methodology - Recommended analytical procedures are not followed, glassware is often dirty, water seals are not maintained on BOD bottles, etc.

These deficiencies were so serious that Region III's Regional Administrator, acting upon the advice of the Region's District of Columbia Team leader, withheld the District's FY 1978 grant funding for laboratory operations, pending marked improvement in the noted problems. Follow-up inspections by Regional personnel at the laboratory in early 1978 indicated that some improvements were being made, so grant funding was resumed. Region III personnel continue to conduct quarterly inspections at the laboratory. In a telephone conversation with these personnel in mid-November, NEIC engineers were informed that numerous deficiencies still exist, and that additional curtailment of grant funding is being considered.

The District's operating personnel are aware of their laboratory's deficiencies and have taken some steps to offset the problems. Where data are crucial to plant operations, redundant samples of process streams are obtained as cross-checks on data accuracy. Split samples are also periodically analyzed by contract laboratories to verify the District results. It was the opinion of the plant operating personnel that the data tabulations, material balances, and other statistics presented in the monthly summaries were reliable, particularly those for 1978.

SAMPLING PROCEDURES

The District uses manual sampling procedures exclusively at the Blue Plains plant. Grab samples are obtained hourly by the operating personnel using dip samplers. The hourly samples are refrigerated at the sampling site and then flow-composited daily. The District has evaluated numerous types of continuous, automatic sampling equipment configurations but, not being satisfied with their accuracy and reliability, has resorted to manual sampling throughout the plant.

It should be noted that the District does not actually sample the combined East and West plants' effluents discharged through Outfall 002. District personnel reported that it is not physically possible to obtain grab samples from this buried conduit. The data reported on the DMR forms for the Outfall 002 effluent are calculated values derived from East and West plant sample data and their respective flow data.

The District's use of manual grab sampling techniques and its methods of calculating and reporting DMR data are acceptable under the terms of the NPDES permit if all steps in the procedures are performed accurately. However, the sampling, analyzing, and flow monitoring duplication involved in the District's procedures does significantly increase the chance for error in the reported DMR data. It is the NEIC opinion that accurate and reliable continuous sampling equipment is available which could be installed at the Outfall 002 conduit. This equipment, if actuated by properly installed and maintained flow metering devices, would provide realistic composite samples of the true total plant effluent and minimize the chances for human error.

FLOW MONITORING

The accuracy of the flow monitoring equipment at a wastewater treatment plant has a significant effect on the reliability of the operating and DMR data generated by the facility. As previously noted, all of the composite samples at the Blue Plains plant are manually flow-composited. The accuracy of calculations based on these samples obviously depends, in part, on the accuracy of the flow monitoring equipment. The monthly plant operating summaries incorporate extensive mass balance computations and, hence, also depend on the accuracy of numerous in-plant flow monitoring systems.

It was not within the scope of this project for the NEIC engineers to evaluate the accuracy of the flow monitoring systems at the Blue Plains plant. However, in discussions with District personnel, one item of concern regarding these systems was noted. Plant operating personnel remarked that the influent flow meters for the East plant were not consistently reliable. The meters operate on a sonic, Doppler-effect principle and have been adversely affected by the flow patterns through them and downstream flow restrictions. Since these flow meters are the only devices available for determining the wastewater flow rate through the East plant, the accuracy of the DMR flow and pollutant mass data is suspect. Also, since the data from these meters are used to calculate the Outfall 002 effluent parameter concentrations, these values are also suspect.