INDIANA STATE BOARD OF HEALTH
DIVISION OF WATER POLLUTION CONTROL

CLARKSVILLE NORTH
WASTELOAD ALLOCATION

A SIMPLIFIED STEADY STATE MODEL

SEPTEMBER 1981

A. Waterway Description

Silver Creek is a small stream in Clark County which flows south past the Town of Clarksville to the Ohio River. At the Clarksville North Sewage Treatment Plant which discharges to Silver Creek, the drainage area of the stream is approximately 220 square miles, as calculated from the USGS gage station located 8 miles upstream at Sellersburg. The distance from the Clarksville North Plant to the Ohio River is 4 miles. According to USGS (telephone conversation), the updated calculation of the $Q_{7,10}$ values at the Clarksville plant are 0.3 cfs for summer and 0.0 cfs for annual. The downstream slope for the first 2 miles is approximately 5 feet/mile as measured by USGS. Telephone conversations with the STP operator revealed that during the summer low flow, the stream is approximately 35 feet wide and 9 inches deep with a fairly uniform depth, and that it has long pooled areas. Upstream ½ mile is a dam of 70 feet in width over which all water passes. Land use surrounding the stream is woodland, farmland, and residential. A map (Figure 3) showing the stream and Town locations is attached.

B. Municipal Wastewater Facility

The Clarksville North STP is a Class II, 0.9 mgd (1.4 cfs) activated sludge-type treatment plant with effluent clorination. Table 4 shows an operation report summary. The current effluent limits for BOD are 10 mg/1 monthly average and 10 mg/1 SS monthly average. Ammonia monitoring is required for 2 years beginning March 1980.

C. Applicable Water Quality Standards

Silver Creek is included in Indiana's Regulation 330 IAC 1-1. The water quality standard established by this Regulation for dissolved oxygen is an average concentration of at least 5 mg/1. The U.S. EPA recommendation for an un-ionized ammonia concentration of 0.05 mg/1 was used for the effluent ammonia limitation.

D. Model Parameter Estimation

Since the summer $Q_{7,10}$ is 0.3 cfs and the Town's discharge is 1.4 cfs; the stream flow during this period would be 1.7 cfs. The velocity was calculated using the data collected by USGS in surveys conducted in 1977 and 1978. Depth was estimated at 0.75 feet as per STP operator. The resultant K_2 selected of 7.72 day^{-1} at 20°C is based upon the O'Conner formula which EPA recommends for this type of slow moving stream with pooled reaches. CBOD, NBOD, and Benthic deoxygenation rate coefficients were determined according to EPA's formulas or recommendations. They are 0.3 day^{-1}, 0.42 day^{-1}, and 0.15 day^{-1}, respectively. Temperature selected was 25°C and pH selected was 7.5 su. Headwater BOD and ammonia-N values were based on data collected by ISBH in the 1977-78 surveys. Documentation of these values is presented in Table 1.

E. Sensitivity Analysis

The sensitivity analysis is presented in Figures 1 and 2. As seen in Figure 1, pH most greatly affects the allowable total ammonia discharge compared to temperature. The results of the analysis indicate that nitrification of the effluent is required for the entire range of pH values calculated. The toxicity of ammonia is a limiting factor in the stream.

The sensitivity of BOD to the variation of reaction rate coefficients one at a time is shown in Figure 2; the widest variation of effluent BOD_5 occurs with K_2. The range of weekly BOD_5 values obtained from this analysis vary from 2 to 32 mg/1.

Table 3 shows the effect of alternative levels of treatment on the receiving stream water quality. Advanced secondary treatment (AST) with filtration and nitrification of the effluent appears to be the alternative which best meets the stream water quality standards.

F. Recommended Effluent Limits

The effluent limits recommended by this analysis are presented in Table 2. The computer analysis outputs are shown in Appendix A. The recommended effluent limits for BOD_5 and S.S. would be 15/22.5 mg/1 (monthly/weekly) and 2/3 mg/1 (monthly/weekly) for NH_3-N in summer; and the winter limits would be 26/39 mg/1 (monthly/weekly) for BOD_5 and S.S., and 5.6/8.4 mg/1 (monthly/weekly) for NH_3-N.

TABLE 1

Documentation For Input Variable Selection
For Clarksville North

Input Variable	Base Value	Measured Value	Range For Sensitivity Analysis	Source
1. Headwater				
a. Flow $Q_{7,10}$ (cfs)	0.3			USGS
b. Temperature (^{o}C)	25			Estimated
c. pH (su)	7.5			Estimated
d. D.O. (mg/1)	7.54			Estimated/Survey
e. NH_3-N (mg/1)	0.2			Survey/Estimated
f. $CBOD_u$ (mg/1)	2.0			Survey/Estimated
2. STP				
a. Flow design (cfs)	1.4			Permit File
b. NH_3-N (mg/1), weekly	5.1			Calculated
c. BOD_5 (mg/1), weekly	18.0			Calculated
d. D.O. (mg/1), daily	6.0			Estimated
3. Stream				
a. Temperature (^{o}C)	25		23-25	Estimated
b. Velocity (ft/sec.)	0.15			Calculated
c. Slope (ft/mi)	5.0			USGS
d. Depth (ft)	0.75			STP operator
e. CBOD rate coefficient (K_1 day^{-1})	0.3		0.2-0.4	EPA recommended
f. NBOD rate coefficient (K_n day^{-1})	0.42		0.21-0.63	EPA recommended
g. Reaeration rate coefficient (K_2, day^{-1})	7.72		3.86-11.58	O'Conner
h. Benthic rate coefficient (K_b, day^{-1})	0.15		0.1-0.2	EPA recommended
i. pH	7.5		7.3-7.5	Estimated/survey

Figure 1
Clarksville North
Temperature and pH Sensitivity of Ammonia-N

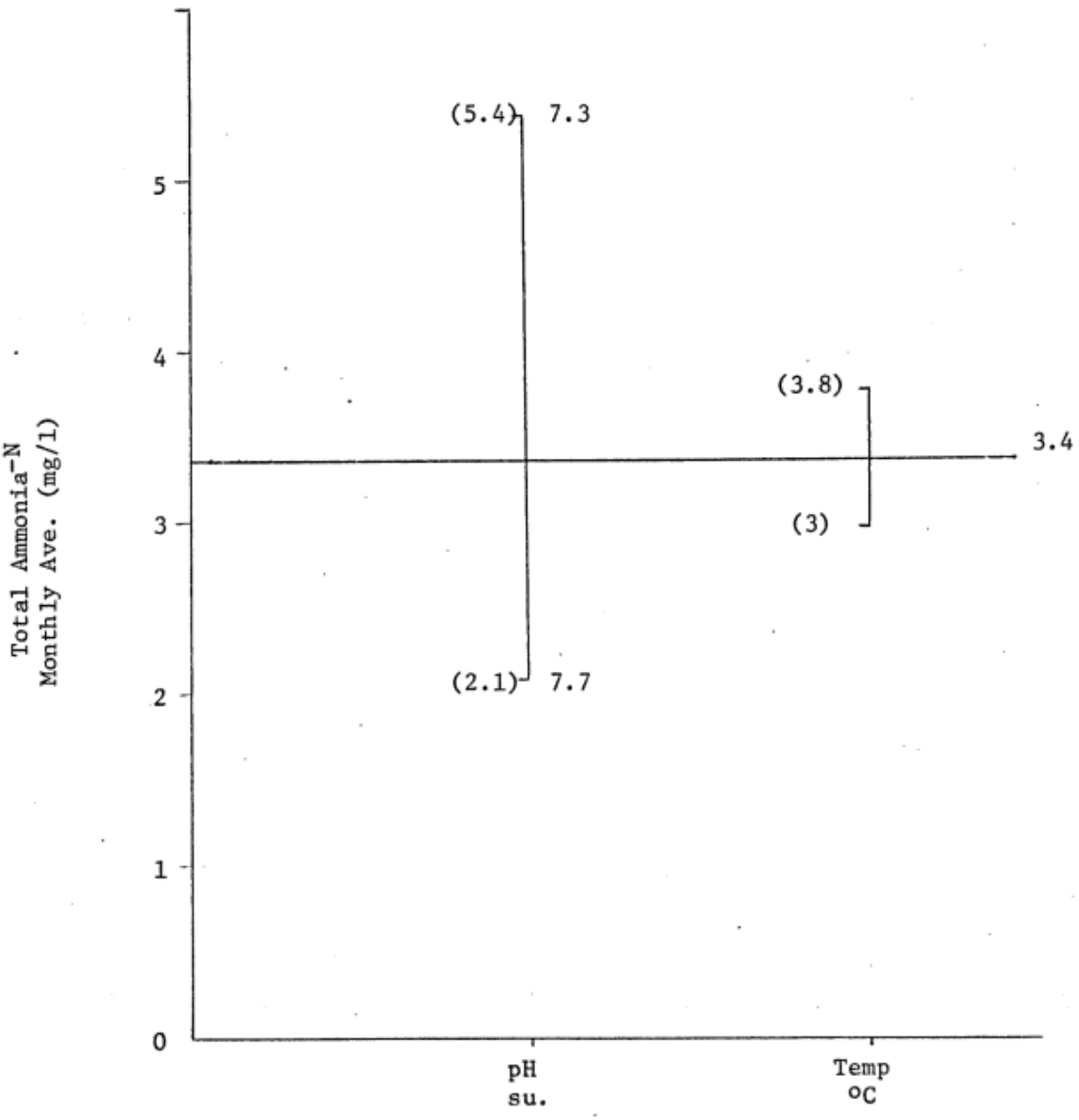

Figure 2
Clarksville North
Sensitivity of BOD_5 to Rate Coefficients

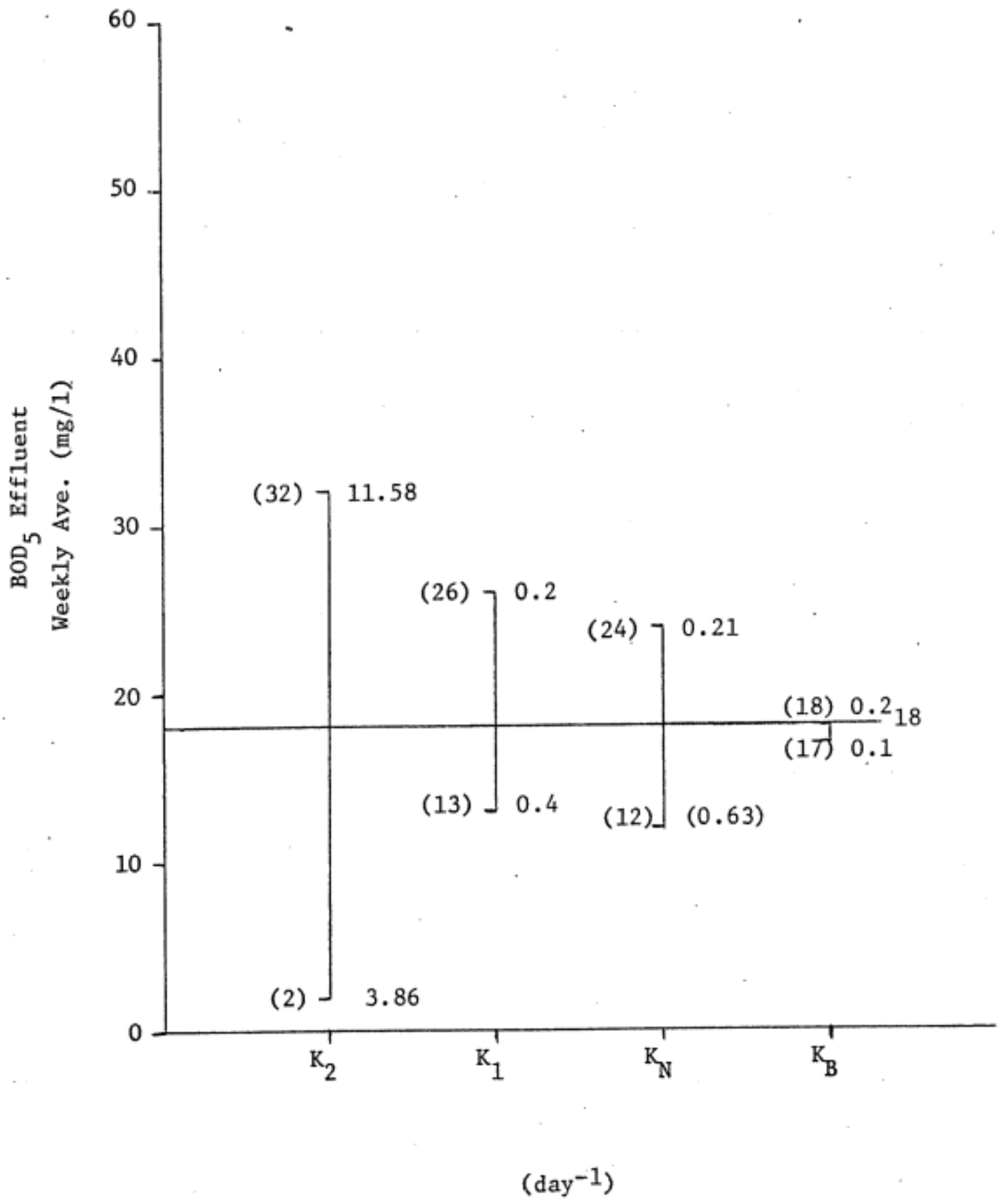

TABLE 2

Recommended Effluent Limits
Clarkesville North

Parameter	Summer*		Winter**	
	Weekly	Monthly	Weekly	Monthly
BOD_5 (mg/1)	22.5	15	39	26
SS (mg/1)	22.5	15	39	26
Ammonia-N (mg/1)	3	2	8.4	5.6
D.O. (mg/1)	6 (daily)		5 (daily)	

*April - November
**December - March

TABLE 3

Alternative Treatment Levels
Clarksville North

Treatment Level	Weekly/Monthly Ave BOD_5 (mg/1)	STP Effluent NH_3-N (mg/1)	Instream Water Quality Max NH_3-N (mg/1)	Min D.O. (mg/1)
Secondary (+)N	45/30	3/2	3	2.031
Secondary (-)N	45/30	22.5/15*	22.5	2.662
AST (-)F (+)N	30/20	3/2	3	4.417
AST (±)F (+)N	22.5/15	3/2	3	5.101
AST (+)F (-)N	15/10	22.5/15*	22.5	1.091
AST (+)F (+)N	15/10	3/2	3	5.768

*Selected Value, insufficient NH_3-N effluent data available at this STP

Ammonia Toxicity limit is 5.1 mg/1 weekly average and 3.4 mg/1 monthly average.

TABLE 4

Clarksville North
Operation Report Summary

Year	Month	Flow (MGD	BOD_5 (effluent,	SS mg/1)	NH_3-N	BOD Removal (%)	D.O. (mg/1)	SS Removal (%)
1981	July	0.635	29	33	ND	90	ND	95
1981	June	0.792	34	16	ND	88	1.3	93
1981	May	0.782	81	49	9.2	85	2.1	86
1981	April	0.791	78	79	6.1	90	1.6	80
1981	March	0.730	66	59	18.2	95	3.5	91
1981	February	0.830	68	24	ND	94	4.1	96
1981	January	0.581	86	40	ND	89	3.1	90
1980	December	0.690	67	26	ND	94	3.6	97
1980	November	0.678	62	23	ND	94	3.4	97
1980	October	0.630	41	21	ND	93	3.0	98
1980	September	0.650	41	18	ND	90	2.5	94
1980	August	0.690	33	16	ND	91	2.1	96
Yearly Average		0.707	57	34	11.2	91	2.75	93

ND = No Data

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SEWAGE TREATMENT PLANT = CLARKSVILLE NORT SUMMER WASTELOAD ALLOCATION ANALYSIS BASED ON USEPA SIMPLIFIED MODEL DATE = 9/17/81

COUNTY = CLARK RECEIVING STREAM = SILVER CREEK MAIN STREAM = ORIC RIVER SIMULATED BY = OLD

STREAM WATER QUALITY STANDARDS DISSOLVED OXYGEN 5.00 MG/L UN-IONIZED AMMONIA 0.05000 MG/L

	FLOW CFS	BOD MG/L	NH3 MG/L	DO MG/L	TEMP CC
HEADWATER WATER QUALITY	0.30	6.00	0.91	7.54	25.00
STP EFFLUENT WATER QUALITY	1.40	54.00	23.30	6.00	25.00
STREAM WQ AFTER MIXING BELOW STP	1.70	45.52	19.34	6.27	25.00

HYDRAULIC CHARACTERISTICS OF THE STREAM

VELOCITY IN FT/SEC = 0.150 HYDRAULIC DEPTH IN FT = 0.75 STREAM BED SLOPE IN FT/MILE = 5.0 MANNING'S COEFF = 0.035

DISTANCE TO BE MODELED IN MILES = 3 COMPUTATIONAL ELEMENT IN MILE = .25

REACTION RATES (1/DAY)

	AT 20 CC	AT STREAM TEMP IN CC 25.00	REMARK
REAERATION RATE	7.727	8.700	BY O'CONNER'S EQUATION
C-BOD DECAY RATE	0.300	0.377	
N-BOD DECAY RATE	0.420	0.076	
SEDIMENTATION RATE	0.000	0.000	"-" SUSPENSION , "+" SEDIMENTATION
SEDIMENT (BENTHIC) OXYGEN DEMAND	0.150	0.205	IN GM/SQ.M/DAY AT 20 CC

SIMULATED INSTREAM WATER QUALITY BELOW DISCHARGER

TIME (DAYS)	DISTANCE BELOW DISCHARGER (MILES)	DO (MG/L)	BODU (MG/L)	NODU (MG/L)
DAY = 0.00	MILE = 0.00	DO = 6.271	BODU = 45.529	NODU = 19.340
DAY = 0.10	MILE = 0.25	DO = 5.346	BODU = 43.612	NODU = 18.060
DAY = 0.20	MILE = 0.50	DO = 5.065	BODU = 42.159	NODU = 16.858
DAY = 0.30	MILE = 0.75	DO = 5.043	BODU = 40.569	NODU = 15.735
DAY = 0.40	MILE = 1.00	DO = 5.122	BODU = 39.039	NODU = 14.688
DAY = 0.50	MILE = 1.25	DO = 5.240	BODU = 37.567	NODU = 13.710
DAY = 0.61	MILE = 1.50	DO = 5.367	BODU = 36.150	NODU = 12.797
DAY = 0.71	MILE = 1.75	DO = 5.496	BODU = 34.787	NODU = 11.945
DAY = 0.81	MILE = 2.00	DO = 5.620	BODU = 33.475	NODU = 11.150
DAY = 0.91	MILE = 2.25	DO = 5.739	BODU = 32.212	NODU = 10.406
DAY = 1.01	MILE = 2.50	DO = 5.852	BODU = 30.998	NODU = 9.715
DAY = 1.12	MILE = 2.75	DO = 5.959	BODU = 29.828	NODU = 9.068
DAY = 1.22	MILE = 3.00	DO = 6.061	BODU = 28.703	NODU = 8.464

MINIMUM DISSOLVED OXYGEN 5.033 MG/L OCCURS AT 0.270 DAYS AND 0.662 MILES BELOW DISCHARGER

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COUNTY = CLARK RECEIVING STREAM = SILVER CREEK MAIN STREAM = OHIO RIVER SIMULATED BY = GED

STREAM WATER QUALITY STANDARDS DISOLVED OXYGEN 5.00 MG/L UN-IONIZED AMMONIA 0.05000 MG/L

	FLOW CFS	BODU MG/L	NGDU MG/L	DO MG/L	TEMP CG
HEADWATER WATER QUALITY	0.00	0.00	0.00	0.00	0.00
STP EFFLUENT WATER QUALITY	1.40	95.00	38.50	5.00	15.50
STREAM WQ AFTER MIXING BELOW STP	1.40	95.00	38.50	5.00	15.50

HYDRAULIC CHARACTERISTICS OF THE STREAM

VELOCITY IN FT/SEC = 0.130 HYDRAULIC DEPTH IN FT = 0.67 STREAM BED SLOPE IN FT/MILE = 5.0 MANNING'S COEFF = 0.035

DISTANCE TO BE MODELED IN MILES = 3 COMPUTATIONAL ELEMENT IN MILE = .25

REACTION RATES (1/DAY)

	AT 20 CG	AT STREAM TEMP IN CG 15.50	REMARK
REAERATION RATE	8.520	7.657	BY O'CONNER'S EQUATION
C-BOD DECAY RATE	0.300	0.243	
N-BOD DECAY RATE	0.420	0.273	
SEDIMENTATION RATE	0.000	0.000	"-" SUSPENSION , "+" SEDIMENTATION
SEDIMENT (BENTHIC) OXYGEN DEMAND	0.150	0.112	IN GM/SQ.M/DAY AT 20 CG

SIMULATED INSTREAM WATER QUALITY BELOW DISCHARGER

TIME (DAYS)	DISTANCE BELOW DISCHARGER (MILES)	DO (MG/L)	BODU (MG/L)	NODU (MG/L)
DAY = 0.00	MILE = 0.00	DO = 5.000	BODU = 95.000	NODU = 38.500
DAY = 0.11	MILE = 0.25	DO = 5.313	BODU = 92.314	NODU = 37.282
DAY = 0.23	MILE = 0.50	DO = 5.516	BODU = 89.705	NODU = 36.102
DAY = 0.35	MILE = 0.75	DO = 5.671	BODU = 87.169	NODU = 34.960
DAY = 0.47	MILE = 1.00	DO = 5.805	BODU = 84.705	NODU = 33.854
DAY = 0.58	MILE = 1.25	DO = 5.929	BODU = 82.311	NODU = 32.783
DAY = 0.70	MILE = 1.50	DO = 6.046	BODU = 79.984	NODU = 31.746
DAY = 0.82	MILE = 1.75	DO = 6.158	BODU = 77.723	NODU = 30.742
DAY = 0.94	MILE = 2.00	DO = 6.267	BODU = 75.527	NODU = 29.770
DAY = 1.05	MILE = 2.25	DO = 6.372	BODU = 73.392	NODU = 28.828
DAY = 1.17	MILE = 2.50	DO = 6.474	BODU = 71.317	NODU = 27.916
DAY = 1.29	MILE = 2.75	DO = 6.573	BODU = 69.301	NODU = 27.033
DAY = 1.41	MILE = 3.00	DO = 6.669	BODU = 67.342	NODU = 26.178

MINIMUM DISSOLVED OXYGEN 5.000 MG/L OCCURS AT 0.000 DAYS AND 0.000 MILES BELOW DISHARGER