INDIANA STATE BOARD OF HEALTH
DIVISION OF WATER POLLUTION CONTROL

ALBION
WASTELOAD ALLOCATION

A SIMPLIFIED STEADY STATE MODEL

OCTOBER 1982

General Description

The Town of Albion is located in central Noble County in northeast Indiana (Figure 1). Albion's wastewater treatment facility discharges its effluent to Croft Ditch, which is a tributary to the South Branch of the Elkhart River. The stream flow of Croft Ditch, above the Town of Albion's wastewater treatment facility, is regulated by the release of water from Skinner Lake. The $Q_{7,10}$ headwater flows used in the modeling analysis (0.0 cfs) for both the summer and winter allocations were estimated from the USGS gage on Forker Creek, approximately three miles south of Albion. The modeled stretch of Croft Ditch from the Albion wastewater treatment facility to the confluence of the South Branch of the Elkhart River is approximately seven-tenths of one mile.

At the present time, all waters of the State covered under Regulation 330 IAC 1-1 are classified for general use, including the protection of fish and aquatic life, and requires the maintenance of an average instream dissolved oxygen (D.O.) concentration of 5.0 mg/l. The recently adopted instream un-ionized ammonia criteria of 0.033 mg/l monthly average and 0.05 mg/l weekly maximum were used to compute the effluent ammonia toxicity limitations.

Point Source Discharges

The Town of Albion operates an existing 15.47 acre, 2-cell waste stabilization pond. The ponds are designed for a flow of 0.15 million gallons per day (mgd). The town's consulting engineer indicates that the current average daily flow is 0.24 mgd. The treatment facility's current final NPDES permit limitation for biochemical oxygen demand (BOD_5) is 10.0 mg/l for both the summer and winter months, with no limitation on ammonia or effluent dissolved oxygen. The permit contains an option for a controlled discharge during high stream flow conditions.

Water Quality

Croft Ditch and the Albion wastewater treatment facility have been included in several water quality surveys. None of the surveys revealed water quality violations in Croft Ditch below the Albion wastewater treatment facility, but it should be noted that the surveys were conducted at higher than normal stream flow conditions. The water quality surveys indicate a problem does exist in the South Branch of the Elkhart River near the confluence with North Branch. In the most recent survey the maximum instream dissolved oxygen concentration at this location was 4.8 mg/l, and the lowest value recorded was 2.3 mg/l. Lower dissolved oxygen values have been recorded in the South Branch of the Elkhart River in this area by both the Indiana Department of Natural Resources and the Indiana State Board of Health. The speculation as to the reason for these low dissolved oxygen values in this area is that this may be a naturally occurring phenomenon brought about by the physical characteristics of the stream, although this area has also been subject to several reported fish kills attributable to agricultural pesticide runoff from surrounding cropland. The fish kills and poor water quality

of this area suggest that the South Branch of the Elkhart River would be very sensitive to both point and non-point source wasteloads, and the waste assimilative capacity would be very low.

Attached to this report is a habitat evaluation of Croft Ditch and the South Branch of the Elkhart River that describes in further detail the physical characteristics of both streams.

Model Variables and Sensitivity Analysis

The water quality input variables for this modeling analysis were extrapolated from the field measurements obtained during the water quality surveys. These values are presented in Table 1. The State Board of Health does not have enough information available to make a modeling projection of the impact of Croft Ditch on the South Branch of the Elkhart River.

The sensitivity analysis of the allocated ammonia and BOD concentrations to the input variables are presented in Figures 2 and 3. Each input variable was changed separately, with the remaining input variables held constant at the base condition. Three sets of calculations were made for each input variable by using modeling input variables that represent the worst and best ends of their sensitivity ranges and the values actually selected for the wasteload allocation. The sensitivity analysis of ammonia-N is presented in Figure 2 and indicates that the ammonia limitations are more sensitive to changes in pH and less sensitive to changes in temperature. The sensitivity analysis of the input variables and their effect on the effluent $CBOD_u$ (ultimate biochemical oxygen demand) concentration is presented in Figure 3. This analysis suggests that the variables that require the most precision in the projected allocations are the estimates of the atmosphere reaeration (K_2) rate and the CBOD deoxygenation (K_1) rate. The remaining input variables in the model require somewhat less precision.

Effluent Limitations and Instream Water Quality

The recommended effluent limitations for both the summer and winter months are presented in Table 2. The upstream flow was not changed for the winter analysis because streams in the area often experience flows near the $Q_{7,10}$ during the winter months. The winter limitations allow a slight increase in ammonia and BOD loading, largely attributable to the change in stream temperature.

The computer output for the summer wasteload allocation is presented in Table 3, from which the instream water quality associated with the recommended effluent limitations are presented versus stream miles and time of travel.

Table 4 demonstrates the relationship between the various treatment levels and the predicted instream ammonia and dissolved oxygen concentrations.

Figure 4 is a graph that demonstrates the trade-off between $CBOD_u$ and NOD to maintain an instream dissolved oxygen value of 5.0 mg/l. The effluent quality that is representative of various treatment processes are also plotted on the graph to visually indicate the type of treatment that would be required to maintain an instream dissolved oxygen concentration above the required standard.

TABLE 1 DOCUMENTATION FOR INPUT VARIABLES SELECTION

SEWAGE TREATMENT PLANT ALBION SUMMER WASTELOAD ALLOATION ANALYSIS
COUNTY NOBLE
RECEIVING STREAM CROFT DITCH MAIN STREAM S.B. ELKHART R.

INPUT VARIABLES	MEASURED VALUE			SOURCE
RECEIVING STREAM FLOW DATA				
[A] STREAM FLOW (Q7,10)	0.00			FLOW IN CROFT DITCH IS REGULATED BY THE DISCHARGE FROM SKINNE LAKE. THE USGS GAGE ON FORKER CREEK (NOBLE CO.) WAS USED TO EST. THE Q7-10 FOR CROFT DITCH
[B] HEADWATER QUALITY				
[1] TEMPERATURE	0.00	CG		SEE TEXT FOR THE SELECTION OF INPUT VALUES FOR SENSITIVITY
[2] DISSOLVED OXYGEN	0.00	MG/L		
[3] pH	0.00	SU		ANALYSIS. VALUES WERE VARIED OVER A WIDE RANGE
[4] AMMONIA-N (NOD)	0.00	MG/L		
[5] BODU	0.00	MG/L		
[C] STREAM SLOPE	5.00	FT/MI		FROM USGS 7.5 MINUTE SERIES TOPOGRAPHICAL MAP
[D] TIME OF TRAVEL	0.130	MI/HR		
FLOW VELOCITY	0.190	FT/SEC	0.67 FT/SEC AT 9.70 CFS	VALUES ARE EST. FROM WATER QUALITY SURVEY DATA OF CROFT DITCH
	V2=V1(Q2/Q1)↑0.4			
[E] FLOW DEPTH	0.210	FT	1.34 FT AT 9.70 CFS	
	D2=D1(Q2/Q1)↑0.6			
[F] REACTION RATES			RANGE FOR SENSITIVITY ANALYSIS	
BOD K1	[1/DAY]	0.500	0.50 AVE IN REACH 0.40 TO 0.60	USEPA RECOMMENDED METHOD WAS USED WITH VARIOUS K2 - OPTION
NBOD K3	[1/DAY]	0.400	0.40 AVE IN REACH 0.30 TO 0.50	
BENTHIC Kb	[1/DAY]	0.500	0.50 AVE IN REACH 0.40 TO 0.60	
REAERATION K2	[1/DAY]	11.500	11.50 AVE IN REACH 9.20 TO 13.80	LANGBIEN
[G] SEWAGE TREATMENT PLANT				
DESIGN FLOW (YEAR 2000)	0.300 MGD	0.46 CFS		YEAR 2000 EST. POPULATION * 150 GAL/CAP.
DISSOLVED OXYGEN	6.000 MG/L		RANGE 5.00 TO 7.00	SELECTED VALUE

TABLE 2

SUMMER WASTELOAD ALLOCATION ANALYSIS

SEWAGE TREATMENT PLANT	ALBION		COUNTY	NOBLE
RECEIVING STREAM (S)	CROFT DITCH		MAIN	S.B. ELKHART R.

RECOMMENDED EFFLUENT LIMITATIONS

	SUMMER APRIL THROUGH NOVEMBER				WINTER DECEMBER THROUGH MARCH			
	WEEKLY		MONTHLY		WEEKLY		MONTHLY	
DESIGN EFFLUENT FLOW	0.300	MGD	0.300	MGD	0.300	MGD	0.300	MGD
cBOD5	30.000	MG/L	20.000	MG/L	37.500	MG/L	25.000	MG/L
AMMONIA - N	3.000	MG/L	2.000	MG/L	6.000	MG/L	4.000	MG/L
DISSOLVED OXYGEN	6.000	MG/L	DAILY		5.000	MG/L	DAILY	

Effluent limits approved by the AST Committee on October 12, 1982.

TABLE 3 INDIANA STATE BOARD OF HEALTH FINAL RUN
DIVISION OF WATER POLLUTION CONTROL

SEWAGE TREATMENT PLANT = ALBION SUMMER WASTELOAD ALLOCATION ANALYSIS BASED ON USEPA SIMPLIFIED MODEL DATE = 10/82

COUNTY = NOBLE RECEIVING STREAM = CROFT DITCH MAIN STREAM = S.B. ELKHART R. SIMULATED BY = STARKS

SIMULATION BY 8/82 US EPA GUIDELINES

STREAM WATER QUALITY STANDARDS

DISSOLVED OXYGEN = 5.00 MG/L UN-IONIZED AMMONIA IN MG/L = 0.050 [WEEKLY] 0.033 [MONTHLY]

HEADWATER AND EFFLUENT WATER QUALITY INPUT DATA REACH NUMBER 1

	FLOW CFS	BOD (ULTIMATE) MG/L	NBOD MG/L	DISSOLVED OXYGEN MG/L	TEMPERATURE CG
HEADWATER WATER QUALITY	0.00	0.000	0.000	0.000	0.00
EFFLUENT WATER QUALITY	0.46	46.000	9.100	6.000	25.00
STREAM WQ D/S OF STP	0.46	46.000	9.100	6.000	25.00

HYDRAULIC CHARACTERISTICS OF STREAM BELOW TREATMENT PLANT OR JUNCTION

VELOCITY IN FT/SEC = 0.190 HYDRAULIC DEPTH IN FT = 0.2100 STREAM BED SLOPE IN FT/MILE = 5.00 MANNING'S COEFF = 0.050

REACH CROFT DITCH MILES FROM 0.700 TO 0.000 COMPUTATIONAL ELEMENT 0.10000 MILE

REACTION AND REAERATION RATES

		AT 20 CG	AT INSTREAM TEMP 25.00 CG	REMARK
REAERATION RATE	[1/DAY]	11.54324	12.99653	BY LANGBIEN - DURUM'S EQ.
BOD DECAY RATE	[1/DAY]	0.50000	0.62907	
NBOD DECAY RATE	[1/DAY]	0.40000	0.64420	
SEDIMENTATION RATE	[1/DAY]	0.00000	0.00000	"-"SUSPENSION "+" SEDIMENTATION
SEDIMENT (BENTHIC) OXYGEN DEMAND		0.50000	0.68504	IN GM/SQ.M/DAY AT 20 CG

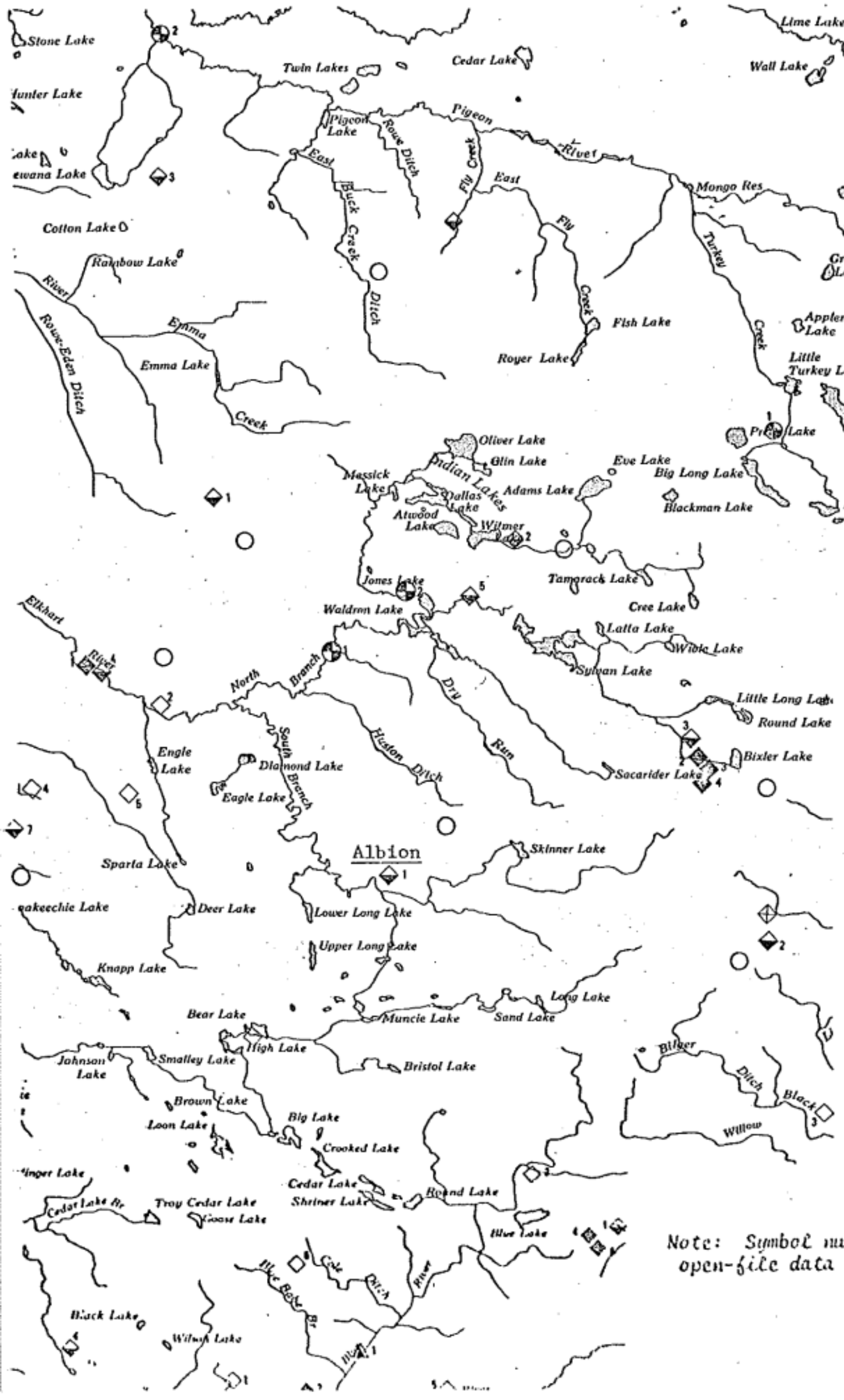
SIMULATED INSTREAM WATER QUALITY, DOWNSTREAM OF A DISCHARGER OR BELOW JUNCTION

TIME DAYS	DISTANCE BELOW DISCHARGER REACH MILE	FROM OUTFALL	DISSOLVED OXYGEN MG/L	BOD (ULTIMATE) MG/L	NBOD MG/L
0.00	MILE = 0.70	MILE = 0.00	6.000	46.000	9.100
0.03	MILE = 0.60	MILE = 0.10	5.558	45.078	8.913
0.06	MILE = 0.50	MILE = 0.20	5.286	44.175	8.730
0.09	MILE = 0.40	MILE = 0.30	5.124	43.290	8.551
0.12	MILE = 0.30	MILE = 0.40	5.035	42.423	8.376
0.16	MILE = 0.20	MILE = 0.50	4.994	41.573	8.204
0.19	MILE = 0.10	MILE = 0.60	4.983	40.741	8.036
0.22	MILE = 0.00	MILE = 0.70	4.993	39.925	7.871

MINIMUM DISSOLVED OXYGEN 4.98 MG/L OCCURS AT 0.195 DAY AND 0.6062 MILES BELOW DISCHARGER OR JUNCTION

TABLE 4 TESTING OF ALTERNATVE TREATMENT LEVELS FOR SUMMER WASTELOAD ALLOCATION ANALYSIS

SEWAGE TREATMENT PLANT	ALBION					COUNTY	NOBLE						
RECEIVING STREAM (S)	CROFT DITCH					MAIN	S.B. ELKHART R.						
TREATMENT LEVEL	Ult. cBOD MG/L MONTHLY		NH3-N [NOD] MG/L MONTHLY		SIMULATED INSTREAM WATER QUALITY FOR A SELECTED ALTERNATIVE MONTHLY								
SECONDARY EFFLUENT LIMITS	50	MG/L	54	[12 Monthly]	MAX AMMONIA	12.00	MG/L	DOSAG	1.85	MG/L	OCCURS AT	0.680	MILES
Single Stage NITRIFICATION	46	MG/L	9	[2 Monthly]	MAX AMMONIA	2.00	MG/L	DOSAG	4.98	MG/L	OCCURS AT	0.610	MILES
Two Stage NITRIFICATION	35	MG/L	6.75	[1.5Monthly]	MAX AMMONIA	1.50	MG/L	DOSAG	5.52	MG/L	OCCURS AT	0.510	MILES
Rapid Sand FILTER	21	MG/L	54	[12 Monthly]	MAX AMMONIA	12.00	MG/L	DOSAG	4.39	MG/L	OCCURS AT	0.640	MILES
RECOMMENDED EFFLUENT LIMITS	46		9		MAX AMMONIA	2.00	MG/L	DOSAG	4.98	MG/L	OCCURS AT	0.610	MILES



SURFACE DRAINAGE

Figure 1

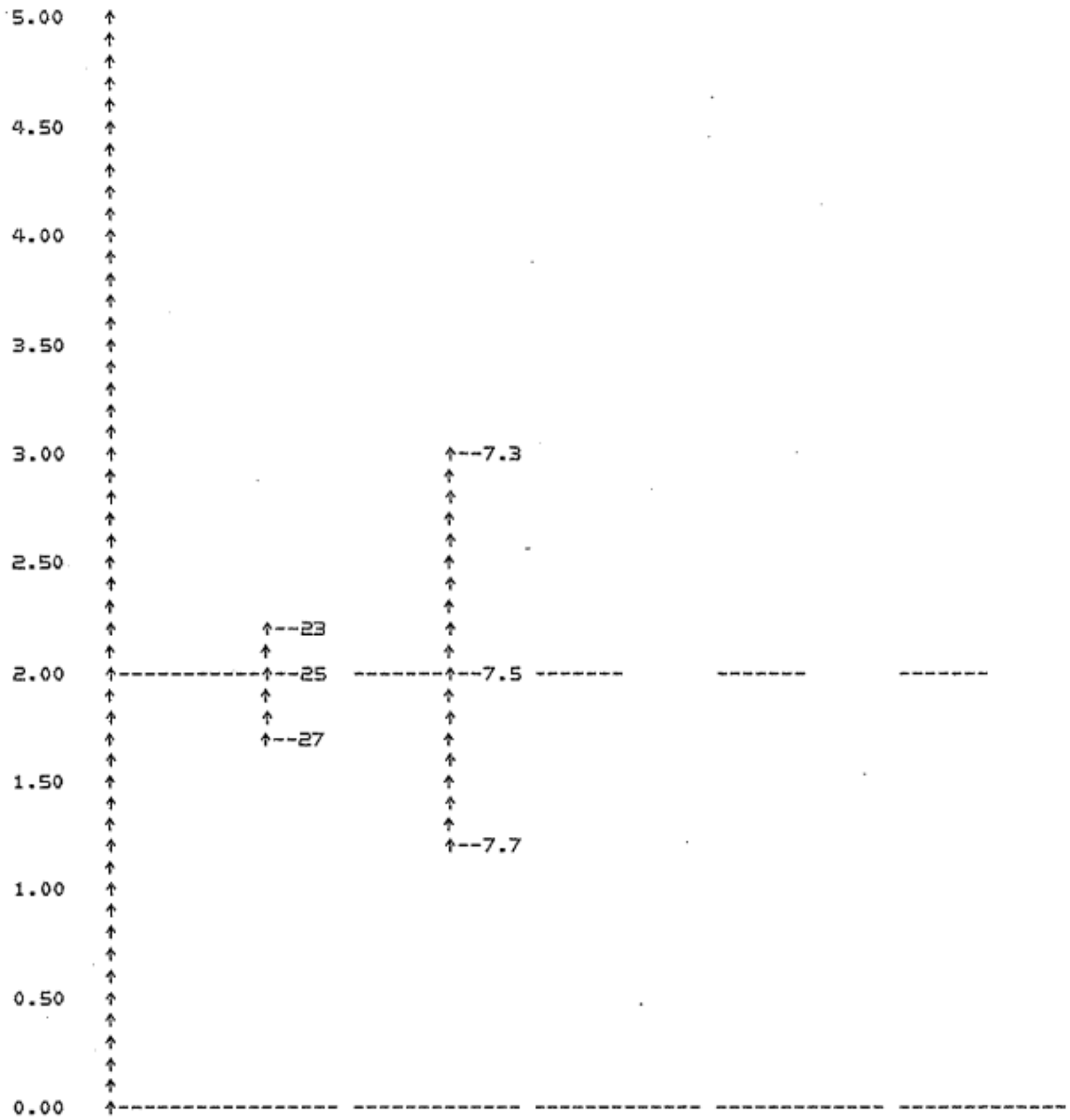
POINT-SOURCE DISCHARGES

- MUNICIPAL
- INDUSTRIAL
- SEMIPUBLIC
- WATER-TREATMENT PLANT DISCHARGE

Note: Symbol numbers refer to ISBI in-he
open-file data collection search, PDR 3A.

SENSITIVITY OF AMMONIA FOR SEWAGE TREATMENT PLANT = ALBION COUNTY = NOBLE FIGURE 2

Y - AXIS REPRESENTS AMMONIA VARIATION MG/L WRT TO TEMPERATURE AND pH



INSTREAM AMMONIA TOXIC LIMIT = 2.0 MG/L CORRESPONDING EFFLUENT AMMONIA LIMITATION = 2.0 MG/L

SENSITIVITY OF BOD5 FOR SEWAGE TREATMENT PLANT = ALBION COUNTY = NOBLE FIGURE 3

EFFLUENT REQUIREEMENT RANGES

K1 0.6 0.5 0.4
K3 0.5 0.4 0.3
K2 13.8 11.5 9.2

SELECTED INPUT VARIABLES

K1 0.5
K3 0.4
K2 11.5
LANGBIEN

SUMMER EFFLUENT LIMITS

FLOW 0.3 MGD
CBOD5 20.0 MG/L
AMMONIA 2.0 MG/L
EFFLUENT DO 6.0 MG/L

Y - AXIS REPRESENTS MONTHLY EFFLUENT cBODU REQUIRED TO MEET INSTREAM DO OF 5 MG/L

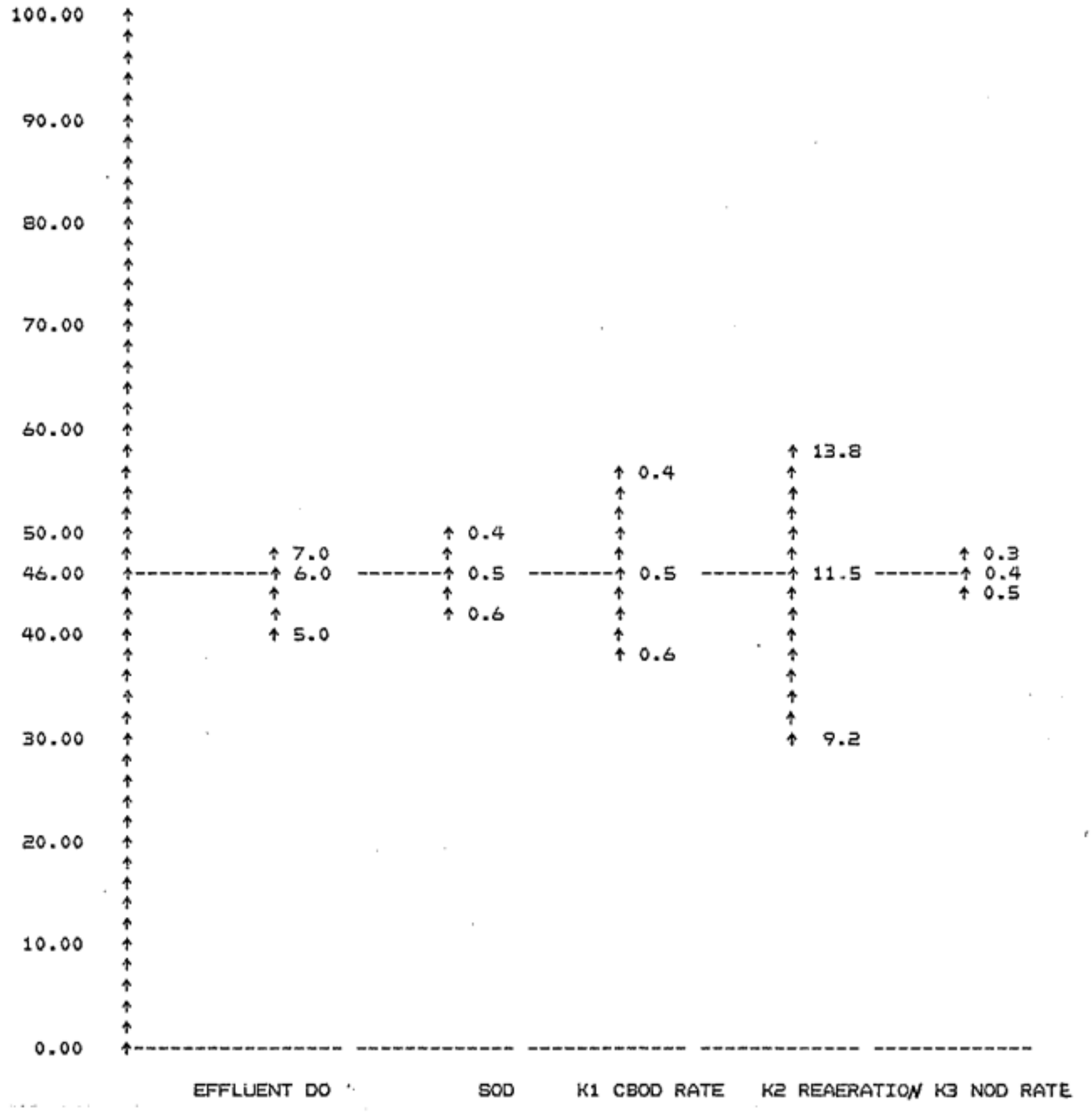
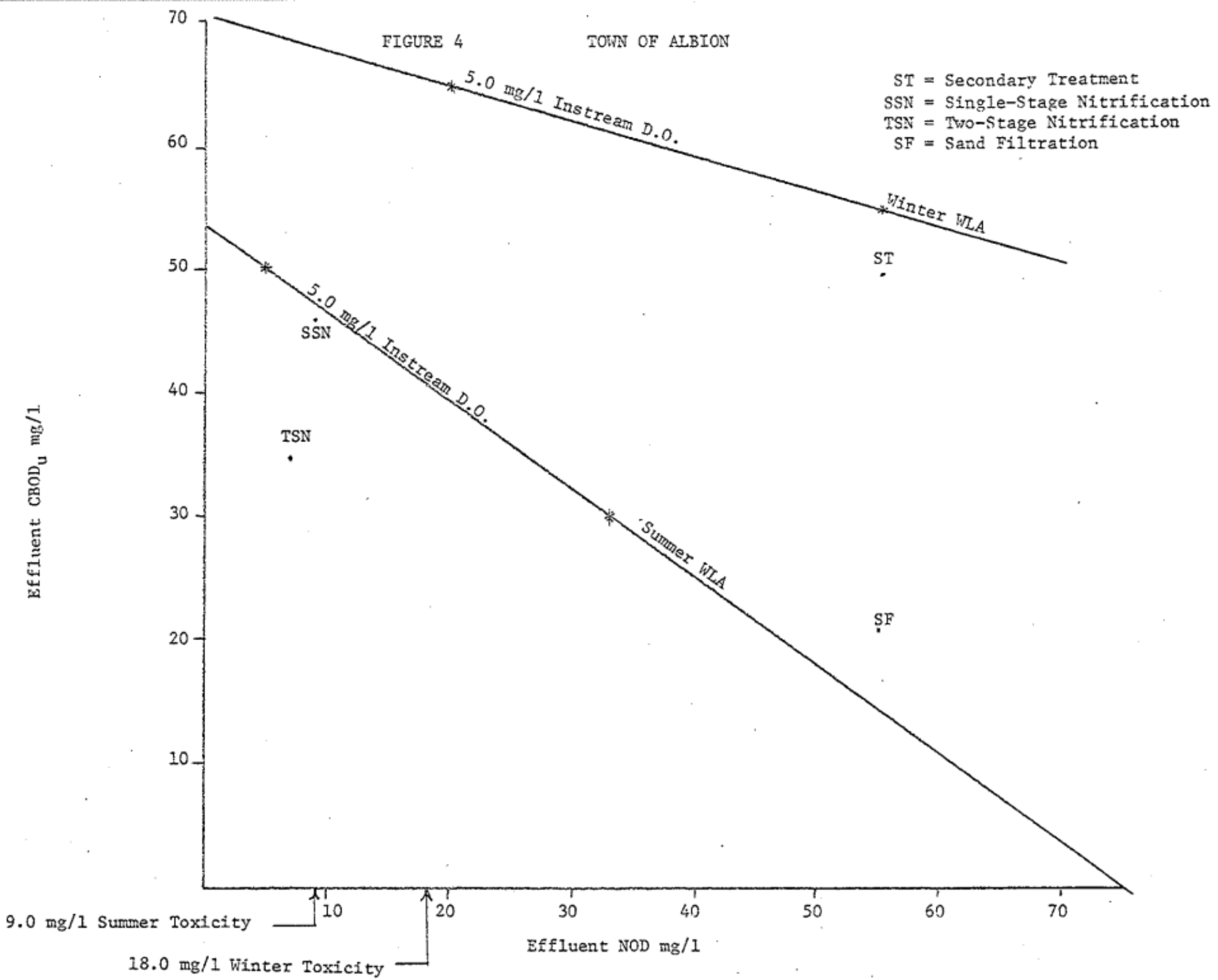


FIGURE 4 TOWN OF ALBION



HABITAT EVALUATION

Croft Ditch and the South Fork of the
Elkhart River Near Albion, Noble County
November 19, 1981

Croft Ditch originates at the outlet of Skinner Lake, two miles northeast of Albion. From that point down to State Highway 9, the stream is about 10 feet wide and appears to have been channelized. However, the stream is characterized by riffles with pools several feet deep. The substrate in this reach is composed of sand, gravel, and cobble. Gradient in this area is moderate and there appears to be permanent flow. Stream banks are bordered by trees or pasture. Evidence indicates that Croft Ditch is used for livestock watering at several locations.

The invertebrate population was dominated by Hydropsychid caddisflies which were very abundant in the riffles. Mayflies and midges were also present in significant numbers.

Downstream from State Highway 9, stream gradient is very low, there are no riffles and current velocity is generally slow. The channel has obviously been modified and the stream is surrounded by forest.

The Albion Wastewater Treatment Plant discharges to Croft Ditch at a point approximately one mile southwest of town and about one-half mile upstream from its confluence with the South Fork of the Elkhart River. During the habitat evaluation study, the water in Croft Ditch was clear downstream from the STP outfall and there was no evidence of a recent water quality problem.

On November 19, 1981, the South Fork of the Elkhart River was sampled just downstream from Croft Ditch at 11:00 a.m. The following conditions were noted:

Temperature -	7.5°C
Dissolved Oxygen	9.3 mg/l
pH	7.3
Conductivity	625 umhos/cm

In this area, the South Fork of the Elkhart River is about 20 feet wide and several feet deep. The water was turbid. Wetlands and/or forests line both banks. Although the river channel has been straightened near its confluence with Croft Ditch, it soon begins to meander through an extensive wetland. Although the stream was reportedly dredged before the turn of the century, there was little or no evidence that this had occurred.

About one mile of the South Fork meanders through the Lloyd W. Bender Memorial Forest and other swamp-forest land owned by the Nature Conservancy and ACRES, Inc. Most or all of the South Fork of he Elkhart River downstream from this point has been considered for designation as a natural and scenic stream by the DNR. However, there is little, if any, local support for such designation, since it would prevent future

dredging and/or channel work which some local land owners believe may be necessary to promote better drainage.

Observations made during the habitat evaluation study and during many previous visits indicate that the South Fork of the Elkhart River has a good game fish population, provides exceptional habitat for waterfowl and other wildlife, and could be an excellent canoeing stream. Fishery potential is also very good in Croft Ditch.

During a number of surveys in the area conducted over the past 10-15 years, staff has discovered that summer dissolved oxygen concentrations decline sharply in the South Fork as one progresses downstream from Croft Ditch. As an example, during one survey in 1968, dissolved oxygen concentrations were greater than 7.0 mg/l upstream from Croft Ditch but ranged between 0.2 and 4.5 mg/l downstream. This condition was found to persist for several weeks.

During this period, electrofishing disclosed that an abundant and diverse fish population was present even under these highly unsatisfactory conditions. Species collected in the area where the oxygen concentrations were at or near the lowest point included: northern pike, yellow perch, largemouth bass, various species of sunfish, minnows, carp, and catfish. It should also be pointed out that sport fishermen were taking fish with rod and reel during this period and good catches were observed by our investigators.

Fairly detailed surveys of the area have failed to explain how the resident species are able to withstand conditions that would cause extensive fish kills in other streams. One hypothesis is that the fish present in this stream reach have evolved in this area of remnant lakes and marshes, and have over the centuries developed a peculiar resistance to low dissolved oxygen. It is also likely that they are near the limit of their ability to survive and could not withstand added stress that would be induced by ammonia, heavy metals, or other potentially harmful substances. Since dissolved oxygen presently drops to extremely low levels in this area, it is obvious that all external organic loads should be reduced to the extent possible.

It is possible that some species found in this reach are physiologically unique and might represent separate subspecies. Because of this possibility, we have encouraged a number of researchers to make detailed investigations of some of the fishes. To date, little or only mild interest has been generated, since the area is fairly remote from any large university or biological station.

In view of the above, we believe that Croft Ditch should be classified as general use and that the South Fork of the Elkhart River should be given special consideration in establishing the WLA. In fact, the South Fork might be considered for exceptional use designation.

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