LPL-409

PIKE LAKE
PLANNING GRANT REPORT

INVENTORY & RECOMMENDATIONS

COMPLETED BY

PIKE LAKE SPORTSMEN CLUB, LTD.

&

RAND ATKINSON
AQUATIC RESOURCES, INC
BIRNAMWOOD, WI

IN COOPERATION WITH

WISCONSIN DEPARTMENT OF NATURAL RESOURCES
LAKE PLANNING GRANT PROGRAM

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INTRODUCTION

Pike Lake is a 205 acre drainage lake with hard, alkaline water that is light brown in color. The maximum depth is 34 feet with 10% of the lake under 3 feet and 12% over 20 feet. The shallow water substrate is mainly sand with some rubble/gravel areas. present. Muck substrate is present in a small bay in the southwest and at the outlet. Average secchi depth during the open water period is 6 to 7 feet and aquatic plants are abundant to this depth.

Rice Lake Creek enters Pike Lake from the north after passing through a mile of wooded wetlands. Rice Lake Creek originates in Rice Lake, a 25 acre spring fed lake. A second, smaller, unnamed creek enters Pike Lake from a northeast wooded wetland area. After passing through a low head dam Pike Lake Creek leaves Pike Lake and travels over two miles to the Plover River.

Pike Lake and it's watershed are located on and near the terminal moraine of the Late Wisconsin glacier. The Western Green Bay ice lobe of this glacier deposited sand and loam on the watershed's ridges and plains and left many undrained areas that wetlands developed in. Agriculture and forestry are the main land uses on the upland soils. Wetlands are common borders to these upland areas providing forestry and many types of recreational opportunities.

The most of the shoreline of Pike Lake has been developed with over 75 residents and cottages bordering the lake. A town road borders the lake dwellings on the north and east sides of the lake. County Trunk Highway Y skirts the northwest side connecting another town road and several private drives that access lake dwellings. Public access is from a boat landing off the town road on the southeast side of the lake and from a resort on the north side of the lake. It appears that several wetlands that at one time were connected to the lake were filled or isolated from the lake by the road development.

Lake management activities on the lake in the early years were centered around improving the fishery and controlling the abundant aquatic plants found in the lake. A dam that raised the lake approximately 1.2 feet was constructed in 1949 to prevent movement of fish downstream at times of high water and to maintain a ordinary lake levels. Aquatic plant treatment began in 1940 and continues to today. Fish planting also began in the 1940's. A walleye spawning reef was built in the early 1980's to try to establish a self-sustaining walleye population.

Recent lake management activity includes Pike Lake in the DNR's Long Term Lake Monitoring Program that began in 1986. Water quality and biological data have been gather from the lake under this program since this time. Volunteer water clarity data has also been collected on the lake since 1988 by members of the Pike Lake Sportsmen Club, Ltd. In 1992 the Club installed an aeration system to alleviate partial winter fish kills that often occur. In 1996, a partial winter fish kill occurred.

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ACKNOWLEDGEMENTS

Lake planning is a complicated process of taking existing knowledge on a lake, adding missing knowledge, and using this knowledge to make good decisions for the health of a lake. This mass task cannot be done economically and effectively without partners in the lake management process.

Pike Lake was fortunate to be a part of the Long Term Lake Monitoring Program that began in 1995. Only a few lakes were chosen lake wide and an abundance of data was collected on the lake using state funds. Department of Natural Resources employees, especially BOB YOUNG can be credited for gathering essential data that was important in understanding how Pike Lake is changing.

Current knowledge to meet the objectives of this planning grant had to be gathered by the consultant and lake volunteers. Members of the PIKE LAKE SPORTSMEN CLUB, LTD. joined in to monitor winter oxygen conditions under the ice and closely observe changing conditions during the open water period. A special thanks to STEVE VERA and DAN ERICKSON who were instrumental in monitoring oxygen- temperature conditions under the ice over two long winters. Also a special thanks to JOHN EBERLING for recording summer oxygen- temperature conditions, secchi water clarity data , and making important observations through the growing season of 1997.

A planning grant always involves organization that involves meetings and newsletters as well as coordination of grant fund distribution. Both JENNY VERA and DAN BUCHER did an excellent job in making sure these functions happened.

A thank you must also go out to the state lake's programs: WISCONSIN ASSOCIATION OF LAKES for securing funds for the lake grant program and the WISCONSIN DEPARTMENT OF NATURAL RESOURCES LAKE GRANT PROGRAM for their coordination of the program.

LAND RESOURCES OF THE PIKE LAKE WATERSHED

GEOLOGY AND WATERSHED CHARACTERISTICS

The largest area of the Pike Lake watershed extends northeast across County Highway II and east southeast beyond the Elderon fire tower. A smaller area extends to the west beyond the irrigated fields. **SEE FIGURE 1**.

The topography of the watershed landscape and the surrounding areas was formed from the last advance of the Green Bay Lobe of the Late Wisconsin Glacier 13,000 to 25,000 years ago. The high northeast to southwest running ridges west of the Plover River is the terminal moraine marking the farthest advance of this Green Bay Lobe of this glacier. This terminal moraine is known as the Hancock moraine. A second band of the terminal moraine was formed as the glacier receded and readvanced. Pike Lake and other area lakes are located in this moraine. This moraine is known as the Almond moraine. **SEE FIGURE 2.**

It is now believed that the outer 3 to 12 miles of this ice sheet was frozen to it's bed during the formation of these two terminal moraines. Tunnel channels of water cut through the Hancock and Almond moraines when melt water from thawed-bed areas 3 to 12 miles behind the ice margin drained through this frozen bed zone. Water leaving the earlier Hancock moraine through these tunnels help cut the Little Eau Claire and Eau Claire river channels. The tunnels channels that cut through the Almond moraine helped form the Plover River. One ice tunnel was located due west of Rice Lake where CTH Y now has a wetland to the west and small ponds on the east side of the road. A second ice tunnel was located where Pike Lake Creek now crosses CTH Y south of Pike Lake.

As the glacier receded further a third moraine area was formed called the Elderon moraines. By this time the glacier was no longer frozen to it's bed and was sliding and producing drumlins. Drumlins are streamlined hills and ridges of glacial material dropped by the glacier with their long axis paralleling the flow of glacial movement. Traveling from the intersection of State highways 29 & 49 to Elderon the hill you pass over is one of the first drumlins formed as the glacier retreated east.

The features of the landscape and soils in the Pike Lake watershed all have origin in the retreat of this glacier. Basically, the soils in the watershed are of four types: wetland sediment, stream sediment, glacial sediment, and lake sediment. These glacial soils are identified on the Pleistocene Geology map in **FIGURE 2**.

Wetland sediment is the same peat and muck organic materials that makeup our wetland areas today. They were deposited in the bogs swamps, and marshes of the watershed even during this glacial retreat period. The oldest and most primitive plants on the landscape today can be traced to their glacial origin and their ability to stand these harsh conditions. These sediments are shown on the map in areas marked with the letter p.

FIGURE 1 . Map of Pike Lake's Watershed Boundary.

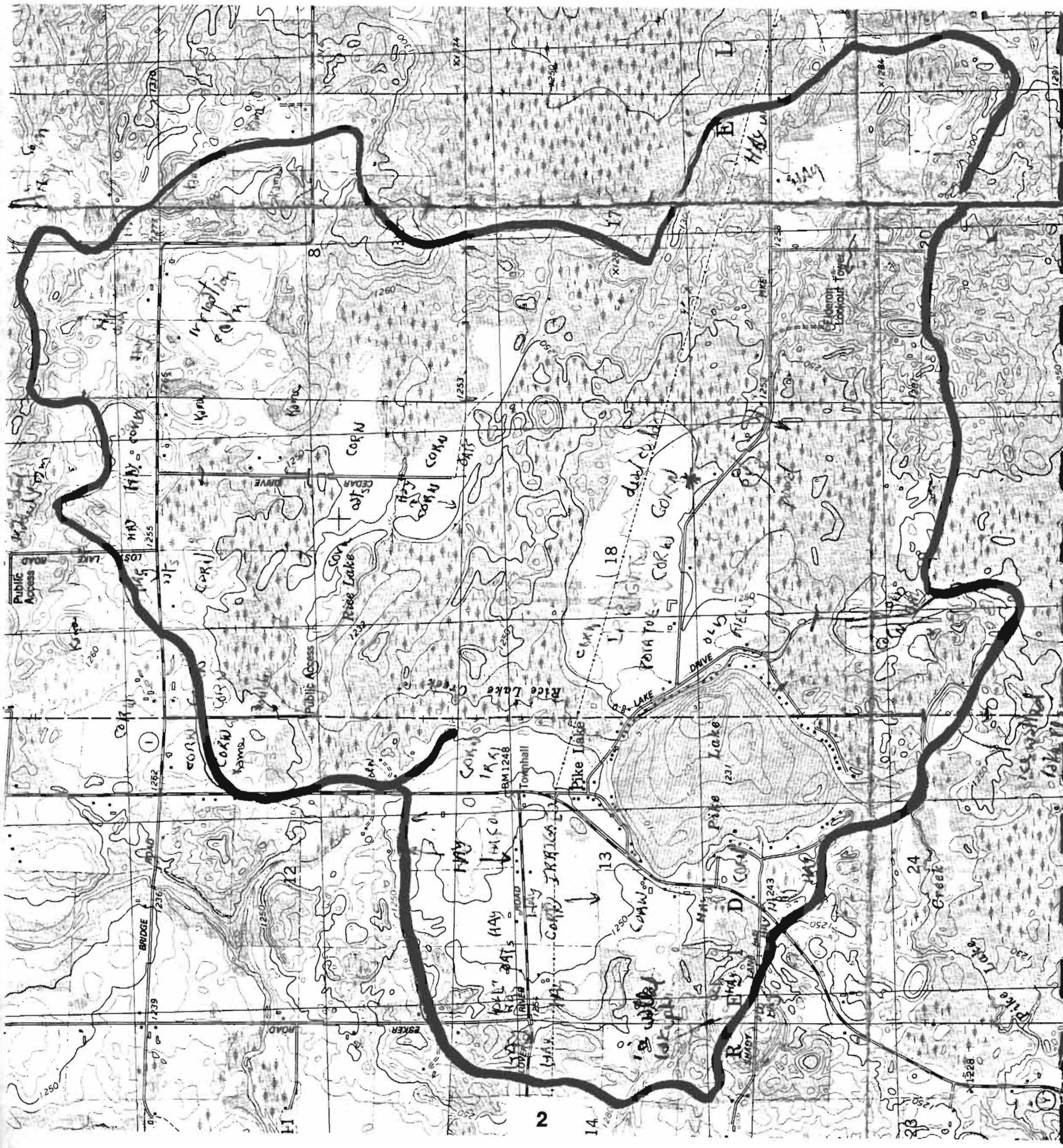


FIGURE 2. Map of Pleistocene Geology of the Pike Lake Area.

Stream sediment consists of glacial melt water stream sediment made of dolomitic sand, gravely sand, and sandy gravel. In the Pike Lake area these deposits can be over 50 feet deep. On the map these areas are marked either as sh or shc. The unit sh indicates the original deposited surface today is much the same as it was after the retreat of the glacier. The irrigated fields in the Pike Lake watershed are examples of this type of sediment area. The unit shc shows where the original deposited surface has been destroyed by collapse due to melting of buried ice. Typically, the areas immediately adjacent to the upper end of wetland areas that drain to Pike Lake have these collapsed soils.

Glacial sediment is till or non-sorted, non-stratified sediment deposited directly by glacial ice. This till is made up of brown, gravelly to slightly gravelly, clayey, silty sand deposited as ice-marginal deposits, as broad areas of hummocky deposits , and in drumlins. The letters gh are shown in areas of gently rolling topography where the letters ghh is shown in areas of hummocky topography. This hummocky land form contacts Pike Lake on the southwest and make up the hills to the west, southeast , and northeast. These glacial till sediments created barriers that encompassed the glacial melt water sediment that Pike Lake was formed in.

Lake sediment is offshore lake sediment consisting of fine sand and silty fine sand, some slightly gravelly. These soils can be found in areas called ice-walled-lake plains. A lake-plain consist of flat to nearly flat areas, the centers of which are underlain by offshore lake-bottom fine silt and sand. The flat areas are high in the landscape because these lakes were bounded by ice. When the ice melted the sediment that had accumulated in the lake basin was left as a high area. Most of these areas are marked with the letters lh. One of these hills can be found southeast of the Theodore Milanowski residence south of the lake.

How do these sediments of glacial origin effect Pike Lake today? The stream sediment soils adjacent to the lake on both northwest and east sides are very porous They have not changed much from the glacial period. Ground water moves from these areas to Pike Lake. Ground water movement from these soils to the lake can become contaminated with pesticides or intercepted by agricultural irrigation or by residential pumping.

Also the wetland sediment of the watershed are bordered by collapsed melt water stream sediments that have dolomitic sand. Dolomite, is calcium magnesium carbonate. It is fairly easily dissolved by underground water movements that are high in CO_2, therefore, these dissolved minerals can enter both the lake and the wetlands, increasing the pH and biological productivity of each. If water movement is not hampered by an obstruction or irrigation oxygen that it received while on the surface is retained and less of these minerals are picked up. Therefore, water quality entering Pike Lake can decrease because of movement through both mineral and wetland soils before passing through Pike Lake.

SOILS AND LAND USE

The soils and corresponding land uses of the landscape of the Pike Lake watershed are reflective of the glacial deposits described above. Fifteen soil types are found in the watershed. **SEE TABLE 1**. The soil locations vary from level and low wetlands to steep slope areas with flattened rocky hilltops. Soil type symbols from Table 1 can be used to locate soil types locations in **FIGURE 3**. Slope of the land increases as suffix symbols proceed from A to D.

Sandy loam soils are the dominant soils in the watershed. They are found on tops and sides of hills and knolls as well as on glacial outwash stream terraces and outwash plains. Few of the flatter, less bouldery soils, are farmed but most of the soils are forested due to slope and rocky characteristics. These soils are well drained to excessively drained. It is these soils that dominate the borders of the wetland drainage ways that enter Pike Lake from the Rice Lake and the unnamed stream drainage that enters Pike Lake on the southeast side.

The loamy sand soils are mainly found on glacial stream terraces, outwash plains, and lake plains. Most of these soils are moderately well to excessively drained unless located on flats around modern drainage ways or depressions. These soils in the Pike Lake watershed are used as irrigated farm land. The irrigated fields adjacent to Pike Lake on the northwest and east -northeast sides and in the southwest corner of CTH II and Hickory Road intersections are areas where these soils can be found.

The loam and silt loam soils are found in concave, convex, and depressed areas on glacial lake plains, delta kames and stream terraces. A delta kame is an irregular short ridge or conical hill of stratified gravel or sand glacial drift. Some of these soils are farmed adjacent to wetland areas. One silt loam soil is very bouldery. This bouldery soil can be found in the Pike Lake watershed northeast of Pike Lake on the uplands adjacent to the wetlands. These rocky uplands are forested.

Three wetland soil are found in the Pike Lake watershed. In lowland areas where reduced ground water flow and minerals are scarce sphagnum moss has develop which over time has partially decomposed into peat. Muck soil is the more dominant wetland soil in the watershed and is found in both drainage ways that enter Pike Lake. On the other hand, these muck soils developed where water has seeped through and picked up minerals from the upland soils. Combined with this mineral enrichment, surface and ground water flows are adequate to provide enough oxygen for decomposition of organic matter into muck.

TABLE 1a-d. Soils of the Pike Lake Watershed, Marathon County

WATERSHED						
SOIL NAME	Kennan	Kennan	Kennan	Chetek	Chetek	Rosholt
	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
Hydro Group	B	B	B	B	B	B
SYMBOL	KaC	KaB	KaD2	CkC	CkE	RoB
Slope	8 to 15%	2 to 8%	15 to 30%	6 to 15%	15 t0 30%	2 to 6%
SOIL			-eroded			
DESCRIPTION						
Surface	0 to 8"	0 to 8"	0 to 7"	0 to 8"	0 to 3"	0 to 10"
	-drk brn	-v.drk gryish	-brn sndy loam	-drk brn	-v.dark brn	v.drkgryishbrn
	sandy loam	brn sandy loam		sandy loam	sandy loam	sandy loam
	9 to 18"	9 to12"	8 to15"		4 to 7"	11 to 18"
	-br & drk brn	-br sandy loam	drk brown &		-subsoil brn	brn & dark brn
	sandy loam		brn sndy loam		sandy loam	sandy loam
	-some places					
	upper silt loam		-if not eroded			
	or loam		surface lyer of			
	or loamy sand		drk brn slt lm,			
			lm, or sdy lm			
			sbsrfc drk brn			
			sltlm,lm,sdylm			
Subsoil	19 to 22"	13 to 27"	16 to 33"	9 to 20"	8 to 25"	19 to 32"
	-drk brn	-brn & drk brn	-upper drk brn	-upper drk brn	-Drk brn sandy	-drk brn gravly
	sandy loam,	sandy loam	sandy loam	sandy loam	loam upper	sand loam uppe
		-some places	-lower drk brn	-lower strg brn	-strg br grvly	v.grvlylmy
		upper silt loam	loamy sand	grvly lmy snd	lmy snd lower	coarse snd lwe
		or loam				
		or loamy sand				
Substratum	23 to 60"	28 to > 60"	34 to 60"	21 to 60"	25 to 60"	33-60"
	-brn loamy snd	-drk brn	-brwn loamy	-reddish yellow	-yellowish brn	-brn&rdishyelw
		sandy loam	sand	gravely sand	gravelly sand	v. grvly sand
					- some places	
					upper lmy sand	
Location		-knolls,sides &	-deep hilly to	-sides of knolls	-sides of hills,	
&		tops of ridges&	v.hilly,w drned	&rdges on strm	escarpments on	
Description		hills of termina	-sids of hills	terraces & out	stream terrace	in convex &
		&recessional	&rdges on term	wash plains	& outwash	concave areas
		morraines &	&res.moraines	-irreg. shape	plains, long &	on outwashplan
		on drumlins	&on drumlins	4-40 acres	narrow or	&strm teraces
		-irregularshape	-irregular shpe		irregular shapes	
		10-200 acres	or long &narrw		4 to 20 acre	10 to 400 acre
		-someplaces	-4-20 acres		-someplaces	-someplaces
		<2 or > 8%	-cultvted areas		slpe>30or<15%	<2 & >6"
			srfcelyer erodd			
Comments:	-someplaces	-deep,rolling, & hilly, well		--deep,smewht	-deep,excessive	deep, gently
	slp<8 or>15%	drained		excsvly drned	drained	sloping, well
	well drained					drained

TABLE 1a-d. Soils of the Pike Lake Watershed, Marathon County

WATERSHED						
SOIL NAME	Keenan	Keenan	Plover	Hatley Cobbly	Rosholt	Alban
	Sandy Loam	Sandy Loam	Sandy Loam	Silt Loam	Silt Loam	Loam
	Bouldery	Bouldery		Bouldery		
SYMBOL	KeB &KeC	KeE	Po	HyB &HtB	RsB	AbB
Slope	2-8% & 8-15	15 to 30%	0 to 2 %	1 to 6%	2 to 6%	1 to 6%
Hydro Group	B	B	C	C	B	B
SOIL DESCRIPTION						
Surface	0 to 3"	0 to 3"	0 to 7"	0 to 5"	0 to 7"	0 to 7"
	-blk sandy loam	-blk sandy loam	-v.drk grysh	-v.drk grysh bn	-dark brown	-v.drk gryish
	4 to 9"	4 to 9"	brn sdy loam	cobbly silt loam	silt loam	brown loam
	-dark brown	-dark brown	7 to14"	6 to 9"	8 to 19"	8-12"
	sandy loam	sandy loam	-brn, mottled	-drk brwn cobl	-upperbrn&drk	brown loam
	10 to 33"	10 to 33"	sandy loam	silt loam	brn silt loam	13 to 37"
	-brn & dk brn	-brn & dk brn	15 to 28"	10 to 22"	-lwerbrn&drk	-upper brn lm
	sandy loam	sandy loam	-drk brn & brn	-upper mottld	brown loam	&drk brn fine
	-many boulders	-many boulders	motled sdyloam	brn &drk brn	-someplaces	sandy loam
	& stones on	& stones on	-someplaces	cobbly silt loam	f.sndy lm or lm	-lower drk brn
	surface layer	surface layer	lmy sd,lm, or	-lower drk brn		f. sndy loam
	- someplaces silt loam, loam,		silt loam	& brn loam		&brn sdy lm
	or loamy sand			-someplaces		- in places
				sdy lm to loam		sandy loam or
						silt loam
Subsoil	33 to 56"	33 to 48"	29 to 42"	23 to 34"	20-36"	38-42"
	- dark brown	upper slt lm or	-upper drk brn	dark brown	-upper dark	drk brn,motled
	sandy loam	loam or lmy sd	motled sndy lm	mottled loam	brown loam	f. sandy loam
		-drk brn	-lower drk brn	35 to 47"	-lower drkbrn	
		sandy loam	mottled loam	-drkbrn motled	grvly sdy lm	
				sandy loam		
Substratum	56-60"	48" to 60"	43 to 60"	48 to 60"	37 to 60"	43- 60"
	-brown loamy	-brn loamy snd	-upper drk brn	-brown mottled	-strng brn	brn motled f.sd
	sand		motled stratfd	sandy lom	v. gravly sand	w/ strata of
			sdylm&lmyfsnd.			drk brn loamy
			-lower yelwbrn			fine sand
			mtled stratified			
			snd &sdy loam			
Location	deep,rolling.&	-knolls,sides &	-slghtlyconcav	-in slight	-in concave &	-insmall conve
&	hilly on knolls&	tops of ridges&	flats in glacial	deprssions and	convex areas o	areas on flts &
Description	sides & tops of	hills of termina	lake basins, on	in areas adjct	outwash plains	knolls on glacia
	ridges & hills	&recessional	delta kames, &	to drngways on	&strm terrace	lake plains,
	on terminal &	morraines &	on stream	terminal, reces	irregularshape	delta kames, &
	recessional	on drumlins	terraces	sional & ground	-4 to 120 acre	strm terraces
	morraines	-irregularshape	-irregular shpe	morraines		-circular or
	& drumlins	10-640acres	4 to 80 acres	-irregularshape		irregular in shp
Comments:	-irreg shape	-someplaces		10-320 acres		4 to 80 acres
	10 to 640 acre	<8 or>15%	deep,nrly level	-somewhat	-deep, gently	deep,nearly lvl
		-deep,rolling,	poorly drained	drained	sloping	&gently slopng
	-well drained	hilly,well drnd			well drained	

TABLE 1a-d. Soils of the Pike Lake Watershed, Marathon County

SOIL NAME	Mahtomedi	Mahtomedi	Mahtomedi	Meehan	Graycalm	Mahtomedi
	Loamy Sand	Loamy Sand	Loamy Sand	Loamy Sand	Loamy Sand	Loamy Sand
Hydro Group	A	A	A	B	A	A
SYMBOL	MbB	MbC	MbE	Mm	Gm-GcB	McA
Slope	0 to 6%	6 to 15%	15 to 45%	0 to 2%	0to2%-2to6%	0 to 3%
SOIL DESCRIPTION						
Surface	0 to 8"	0 to 6"	0 to 3"	0 to 10"	0 to 9"	0 to 7"
	-drk brown	-drk brown	-v.drk brown	-v. drk grayish	-dark brown	-v.drk gryish
	loamy sand	loamy sand	loamy sand	brn loamy sand	loamy sand	brn lmy sand
	-someplaces	-someplaces		to brown loam	-someplaces	-someplaces
	sndy loam or	sndy loam or		-some places	sandy lm or sd	sandy lm
	grvly lmy sand	grvly lmy sand		sndy loam or		-some places
				grvly lmy sand		see <
Subsoil	9 to 24"	7 to 24"	4 to 17"	11 to 22"	10-25"	8 to 20"
	-upper drk brn	-upper drk brn	-upper drk brn	-drk brn loamy	-drk brown &	-upper dark
	loamy sand	loamy sand	loamy sand	sand upper	yellowish brn	ylwish brown
	-lower drk brn	-lower strg brn	-lower drk brn	-strong brown,	loamy sand	loamy sand
	grvly lmy sand	grvly loamy	grvly loamy	mottled sand	25 to 49"	-lower drk brn
	-someplaces	coarse sand	coarse sand	lower,	-brn,mottled	gravely loamy
	sand or thin	-someplaces	18 to 23"	23 to 30"	sandy loam w/	coarse sand
	strata oflmysd	sand or thin	-strg brn grvly	-strong brown	lamellae of drk	21 to 28"
	lmy f. sand or	strata oflmysd	coarse sand	mottled sand	brown mottled	drk brn grvly
	f. sndy loam	lmy f. sand or			f. sandy loam	coarse sand
		f. sndy loam				
Substratum	25 to 60"	25 to 60"	24 to 60"	31 to 60"	26 to 60"	29 to 60"
	-lght brn grvly	-ylwsh brgrvly	light ylwsh brn	-grayish brown	-yellwish brwn	upper strng brn
	coarse sand	coarse sand	grvly crse snd	mottled sand	mottled sand	gravely sand
	-someplaces	-someplaces	-someplaces	-someplaces		-lower light
	sand or thin	sand or thin	sand or thin	sand or thin		ylwsh brown &
	strata oflmysd	strata oflmysd	strata oflmysd	strata oflmysd		motledgrvlysd
	lmy f. sand or	lmy f. sand or	lmy f. sand or	lmy f. sand or		-some places
	f. sndy loam	f. sndy loam	f. sndy loam	f. sndy loam		see <
Location	on broadnarrow	- on sides of	on escarpments	on flats around	in small,slghtly	-broad &narow
&	flats&knolls on	rdges&knollson	& on side hills	depressions and	concave areas	flats adj. tolwr
Description	strm terrace&	strm terraces&	&ridges onstrm	along drngwys	on flats on	depression
	outwash plains	outwash plains	terraces &	on outwash	recessional	areas on strem
	-irregular in	-long & narrow	outwash plains	plains,stream,	moraines,glcial	terraces &
	shape	or irregular		terraces, &	lake plains, or	outwash plains
	10-800 acres	shape & range		glcl lake plains,	outwash plains	
		-4 to 80 acres		4-80 acres	-circular or	-irregular shpe
			-deep,modertly		irregular shape	4 to 480 acres
Comments:		-deep,sloping&	steep,to very	-deep,nearly	-4 to 200 acre	deep,nearly lvl
		modertly steep	steep	level		&gently slopng
	deep,nearly lvl	-excessively	-excessively	-somewhat	-deep,nearly	-moderately
	&gently slopng	drained	drained	poorly drained	level,modertly	well drained
	excesvly drnd		8		well drained	

TABLE 1a-d. Soils of the Pike Lake Watershed, Marathon County

WATERSHED						
SOIL NAME	Oesterle	Seelyeville	Cathro	Greenwood		Udorthents
	Loam	Muck	Muck	Peat		Gently Sloping
Hydro Group	C	A/D	A/D	A/D		
SYMBOL	Oe	Se	Ch	Gr		UoB
Slope	0 to 2%	0 to 1%	0 to 1%	0 to 1%		0 to 6%
SOIL						
DESCRIPTION						
Surface	0-7"	0 to 60"	0 to 28"	0 to 4"		- original soil
	-v. drk grayish	-black muck	-upper drkrdish	- v.drk grysh		excavated
	brown loam	-some areas	brown muck	brown peat		& filled > 3 fee
	8-15"	peat on surface	-lower blk&drk	w/ sphagnum		
	-brn,drk ylwish		rdish brn muck	moss on srfc		lmy,sand,grvl
	brn, & drk brn		-someplaces	5 to 60"		sd & grvl pits
	mtled sdy loam		peat	-v. drk brn &		reshaped
	-some places		-some areas	drk rdish brn		
	sandy loam,		organic layer	mucky peat		
	loamy sand,		16 to 51"			
	or silt loam					
Subsoil	16-32"	16 to 51 "				
	-motled drk brn	- some areas				
	sdy loam upper	sandy or loamy				
	-motled lght	deposits				
	yellowish brown					
	loamy sand					
Substratum	33-60"		29 to 34"			
	-lght yellowish		-dark gray			
	brown mottled		silt loam			
	sand,		35 to 60"			
	-someplaces		-gry motled lm			
	thin strata of		-someplaces			
	sdy to silt loam		sd,lmy sd, grvly			
			sd,grvlylmysd,			
			sdy lm,sdy cly			
			loam,or clyloam			
Location	on flats adj. to	in bogs,	-in drngeways	in bogs,		urban areas &
&	depressions &	depressions, &	& depressions	depressions on		hwy interchnge
Description	drainageways	drainageways	on grd moraine	grnd moraines,		
	on outwash	on outwash	glcl lake plains,	outwash plains,		irregular shape
	plains &stream	plains,4 to 400	&outwashplains	&glcl lake plains		4 t0 200 acres
	terraces	acres	-4 to 300 acre	-4-640 acres		
CommentS:	-deep,nearly	deep, nearly	deep, nearly	deep, nearly		-nearly level&
	level	level,v. poorly	level,v. poorly	level,v. poorly		gently sloping
	-somewhat	drained	drained	drained		poorly drained
	poorly drained	high H20 table	9			to well drned

FIGURE 3. Soil Map of the Pike Lake Watershed.

Pike Lake's watershed covers approximately 6.4 square miles or 4,092 acres. The watershed and lake are in two townships. The Town of Elderon has a majority of the watershed land while the Town of Reid contains the most lake surface acreage. The break down of land use in both townships can be found below in **TABLE 2**.

TABLE 2. Pike Lake Watershed Land Use Acreage in 1996 Listed by Township.

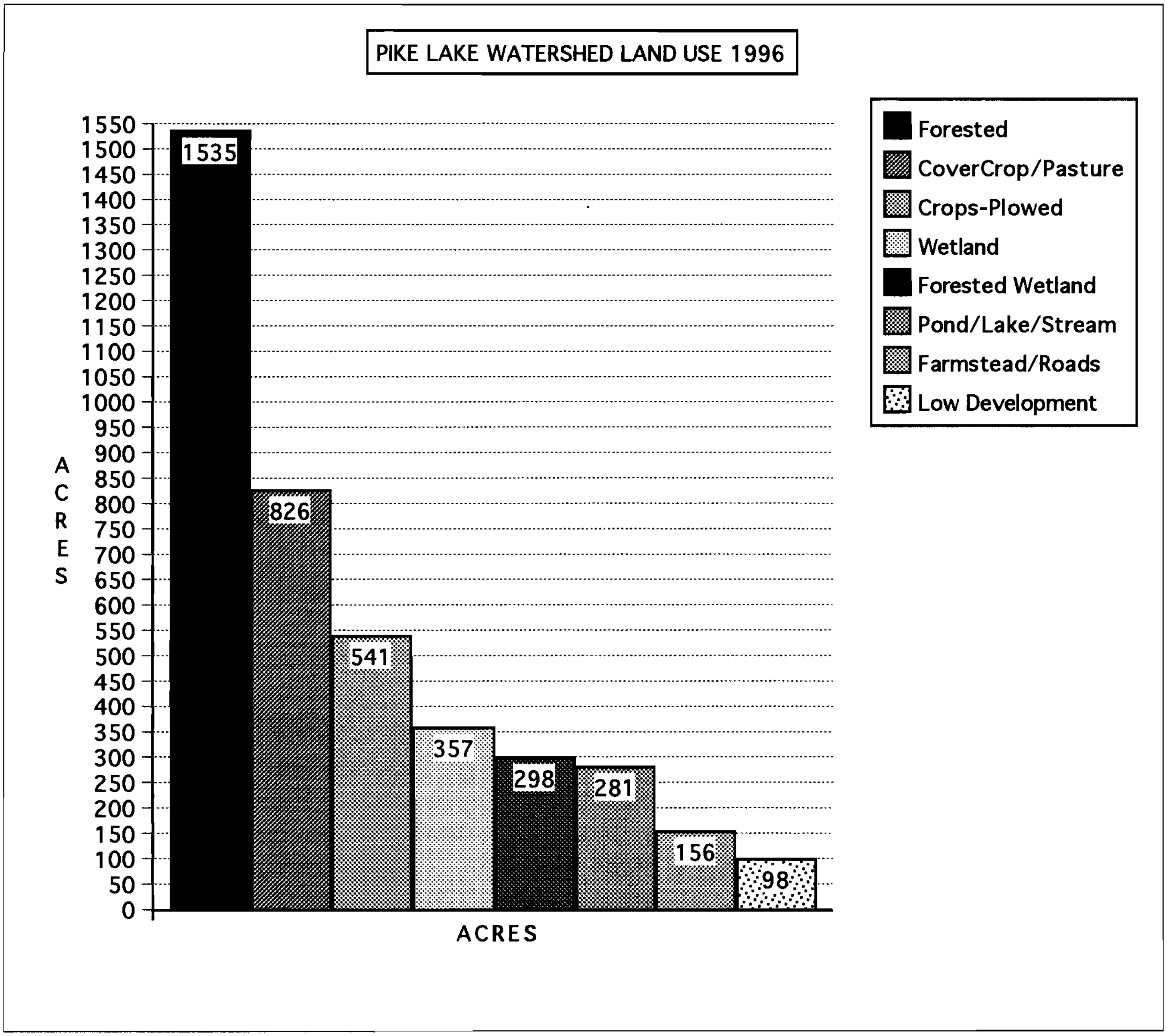
	Elderon Township		Reid Township	
		Acres		
Cover Crop or Pasture	629		197	20%
Crops or Tilled	463		78	13%
Farmsteads and Roads	102		54	4%
Light Residential	10		88	2%
Forested	1363		172	38%
Open Wetland	336		21	9%
Forested Wetland	264		34	7%
Ponds	49		12	2%
Stream	3		0	
Pike Lake	17		200	5%
Total Watershed Township Acreage	3,236		856	
Total Watershed Acres		4,092		

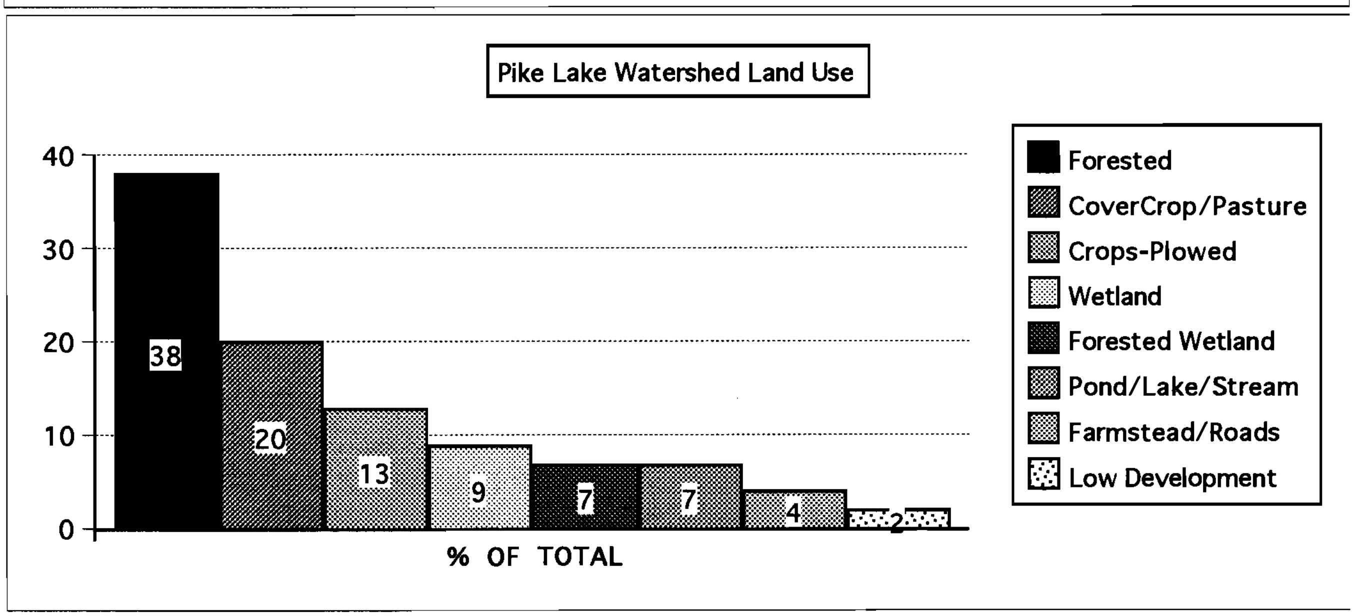
Thirty-eight percent or of the Pike Lake watershed is upland forest. **SEE FIGURE 4.** Much of this northern hardwood forest is on rocky soils and steep slopes adjacent to wetlands. These rocky, forested slopes provide a buffer area to protect the wetlands and waterways that flow to Pike Lake. Future land use changes on these slopes is limited, therefore their value in protecting water quality should not be effected by development or other land use practices.

Another 20% of the watershed is in cover crop or untilled pasture. It is this land that will probably face residential development in the near future with the upgrade of State Highway 29 to a 4 lane roadway decreasing travel time to the Wausau area. As a result low development or light residential watershed land use will increase as will roadway development. Access roads to these rural residents can effect wetland drainage to Pike Lake due to illegal filling activity or the improper placement of drainage culverts. These disturbances already have affected the area developed around the Pike Lake shoreline.

Three tilled or crop areas in the watershed are irrigated. Two are adjacent to Pike Lake on very well drained to excessively drained soils. Irrigation pumping intercepts ground water moving towards Pike Lake. Any pesticide or dissolved contaminates can easily enter ground water on these very porous soils. Several ponds have been developed in the Pike Lake drainage area. These open water areas have converted wetlands and/or intercepted ground water springs which in turn increase evaporation rates and decrease surface and ground water movement to Pike Lake.

FIGURE 4. PIKE LAKE WATERSHED LAND USE 1996





PROPERTY OWNER'S SURVEY & RESULTS

A property owner's survey was presented at the Pike Lake Association's annual meeting on July 5, 1997 to assess current lake use and gather opinions on the lake's problems and possible solutions to them. Those not present at the meeting received it through a district mailing. The survey can be found in in Appendix I.

Results

Question 1 ask" How long have you owned property on Pike Lake?" The answers ranged from 1 to 61 years. The survey represents and wide range of time of ownership. The breakdown was a follows:

Length of Time with Property Respondents	# Respondents	%
0-5 years	3	17%
6-10 years	4	22%
11-15 years	3	17%
16-20 years	3	22%
21-25 years	1	6%
25-61 years	4	17%

	18	

Question 2 owners were ask to check one of several options that describe their property and dwelling type. The majority of the respondents were year-round residents and in general represented the "newest" members of the lake community. Their responses were as follows:

Dwelling or Property Use Description Respondents (Years owned property)	# Respondents	%
Year-round Home(32,7,13,4,11,1,21)	7	39%
Three-season Home(10,61,19)	3	17%
Summer Cottage(17,40,50,10,36)	5	28%
Winterized Cottage(3,8,20)	3	17%
Vacant Land	-	
Business	-	
	------	---------
	18	

Question 3 & 4 related to lake property use. These questions gave several options on how often they used their property and how many people used the facility during that period. The options were: Vacation weeks, Weekends/ year, and Weekdays/ years. The second question ask on an average how many people use the property during the time indicated in the previous question.

The results were interpreted and broken down into categories to describe weekend vs. weekday use. Vacation weeks was added to the other two category data. The "year- round residents" were separated from the other categories from Question 2 to clarify lake use. The results are as follows:

All Other Respondents Except Year- round Home(11 Total)

Weekends/ year (ave. people use)	Weekdays/ year (ave. people use)
?(4)	?(2)
6(3)	2(3)
12(4)	5(3)
12(4)	2.5(1)
15(4)	-
9 (2)	-
12(2)	10(2)
10(4)	50(2)
16(2)	-
16(3)	80(2)
20(2)	10(2)
128(34)	**159.5(17)**

Number of Year-round Homes (Occupants)

52(4)	261(4)
14(3)	50(2)
52(5)	261(2)
52(2.5)	261(2)
25(5)	30(2.5)
52(2)	261(2)
52(2)	261(2)
299(23.5)	**1385(16.5)**

Question 5 related to lake use and recreational value of their Pike Lake property. Respondents were ask to number their priorities 1 to 9 (1 being highest value, 9 being lowest value) on a list of brief recreational descriptions. The response was as follows:

Description	**#1**	**#2**	**#3**	**-**	**#4**	**#5**	**#6**	**-**	**#7**	**#8**	**#9**
Swimming	0	4	6	-	2	3	1	-	0	1	0
Pleasure Boating	1	3	2	-	4	6	0	-	1	0	0
Fishing	4	2	4	-	3	1	2	-	0	1	0
Duck Hunting	0	0	0	-	2	0	1	-	2	6	6
Wildlife Viewing	0	4	5	-	2	3	3	-	0	0	0
Scenic Beauty & Tranquility	11	3	1	-	0	2	0	-	1	0	1
Water Skiing	0	0	0	-	2	3	3	-	4	0	0
Jet Skiing	1	1	0	-	0	1	2	-	2	1	8
<u>Other</u>											
See Old Friends	1										
Work	1										

Question 6 ask what type of waste disposal system does your dwelling have? Also questions were ask regarding the age of their waste disposal system and the maintenance that it required. This question was compared with the background information regarding dwelling use in questions number 2 & 3.

Type	**No. of Respondents**
Septic System	11
Holding Tanks	6
Mound System	1
Age	
1-10 years	9
11-15 years	0
16-20 years	2
21-25 years	2
26+ years	5
Maintenance	
Clean Periodically	1
Pumping	11
Ridex	2
Minimal	1

Question 7 related to understanding of ground water table elevations around the Pike Lake through the lake community providing available information regarding well reports.

WELL TYPE	**# RESPONDENTS**	**WELL DEPTHS**
Lake View Drive		
Sand Point	9	15 to 30'
Drilled	3	30 to 45'
Koskey Road		
Sand Point	3	20 to 45'
Drilled	1	57'
Lakeside Lane		
Sand Point	1	45'
Drilled	1	70'

Question 8 ask the lake community" What do you feel is the major problem facing Pike Lake at this time?" The results and comments are as follows:

Problem	# of Responses
Too many Weeds(Aquatic Plants)	9
Muck or Silt	4
Poor Fishing	3
Water Quality	2
Jet Skis	2
Algae	1
Jet Boats	1
Low Water	1
Shoreline Erosion	1
Litter on Ice	1
Empty Snail Shells (Spraying)	1
Need More Weeds	1
Weed Control is Fine	1
None	1

Question 9 ask " The fertility of Pike Lake cause many problems for the recreational use of the lake. What priorities would you give to solve, prevent, or keep these problems from worsening?". Several options were listed and the opportunity to add options were offered. The respondents was ask to number the options from 1 to 6 with 1 being highest priority and 6 being the lowest. The results were as follows:

Possible Solutions	#1	#2	#3	#4	#5	#6
Water Level and Flow Management	4	4	5	2	2	0
Machine Harvest of Aquatic Plants	0	3	1	4	2	2
Chemical Treatment of Aquatic Plants	7	6	3	1	1	1
Dredging/ Removal of Lake Bed Material	2	1	2	3	5	0
Long- term Shoreline Stabilization, Restoration, and Protection	4	2	4	3	2	0
Other						

WATER RESOURCE APPRAISAL AND ANALYSIS

WATER QUALITY

Introduction

This water resource appraisal was designed to interpret and analyze the existing and developing surface water inventories of Pike Lake and adjacent waters. This information was used to develop protection and rehabilitation objectives to stabilize or restore the ecosystem. For efficient data gathering and hands on education tools Aquatic Resources,Inc. worked with Pike Lake Association members to conduct a current appraisal. The consultant analyzed the water resource data base created and wrote the reports contributing to this lake management plan.

Specifically, the water resource appraisal evaluated the fish and aquatic plant communities. It developed a water quality data base, analyzed the fish and aquatic data bases, and documented surface water conditions in the watershed.

From this information the problems that are causing imbalances in the ecosystem were identified. This new information was analyzed and used to determine the existing and potential management practices that would stabilize and restore the ecosystem.

Procedure

Assessment of the water quality of Pike Lake will be made by compiling, reviewing, and interpreting any existing water quality data. Long Term Lake Monitoring Program data, volunteer secchi water clarity data, and fish management data was included in this process.

The assessment of the water quality included compiling, reviewing, and interpreting any existing water quality data on the tributary water ecosystem entering and leaving Pike Lake. This included Rice Lake Creek and it's head water lake, Rice Lake, and the exit stream, Pike Lake Creek. To address the current chemical conditions of the head water system water samples of Rice Lake Creek were taken at the outlet of Rice Lake and the inlet to Pike Lake during spring runoff, summer low flow, and a summer storm event. Stream flows, and oxygen/ temperature sampling were combined with water chemistry sampling at these sites and at the outlet dam to assess physical/ chemical interactions.

A third aspect of water quality assessed the physical effects the current operation of the aeration system has on the lake. Pike Lake's bottom sediments have a large biochemical oxygen demand and even after aeration system installation partial fish winter kill from low oxygen still occurs periodically.

The oxygen/ temperature profiling, observations, and secchi disc readings were taken by volunteers with a new YSI 85 meter from December 1996 to March 1998. This included profiling to assess if total fall mixing occurs before freeze up, the rate at which oxygen depletion of bottom sediments occurred after freeze up, and the physical effects of the aeration system operation. The area affected by the operation of the current aeration system was identified by oxygen/ temperature profiling at several peripheral and concentric sampling rings around the aeration hole and at inlet and outfall stream areas. Spring and summer profiling were combined with secchi observations to complete the year long profile. This data was then entered into the computer for later analysis and interpretation.

Results and Discussion

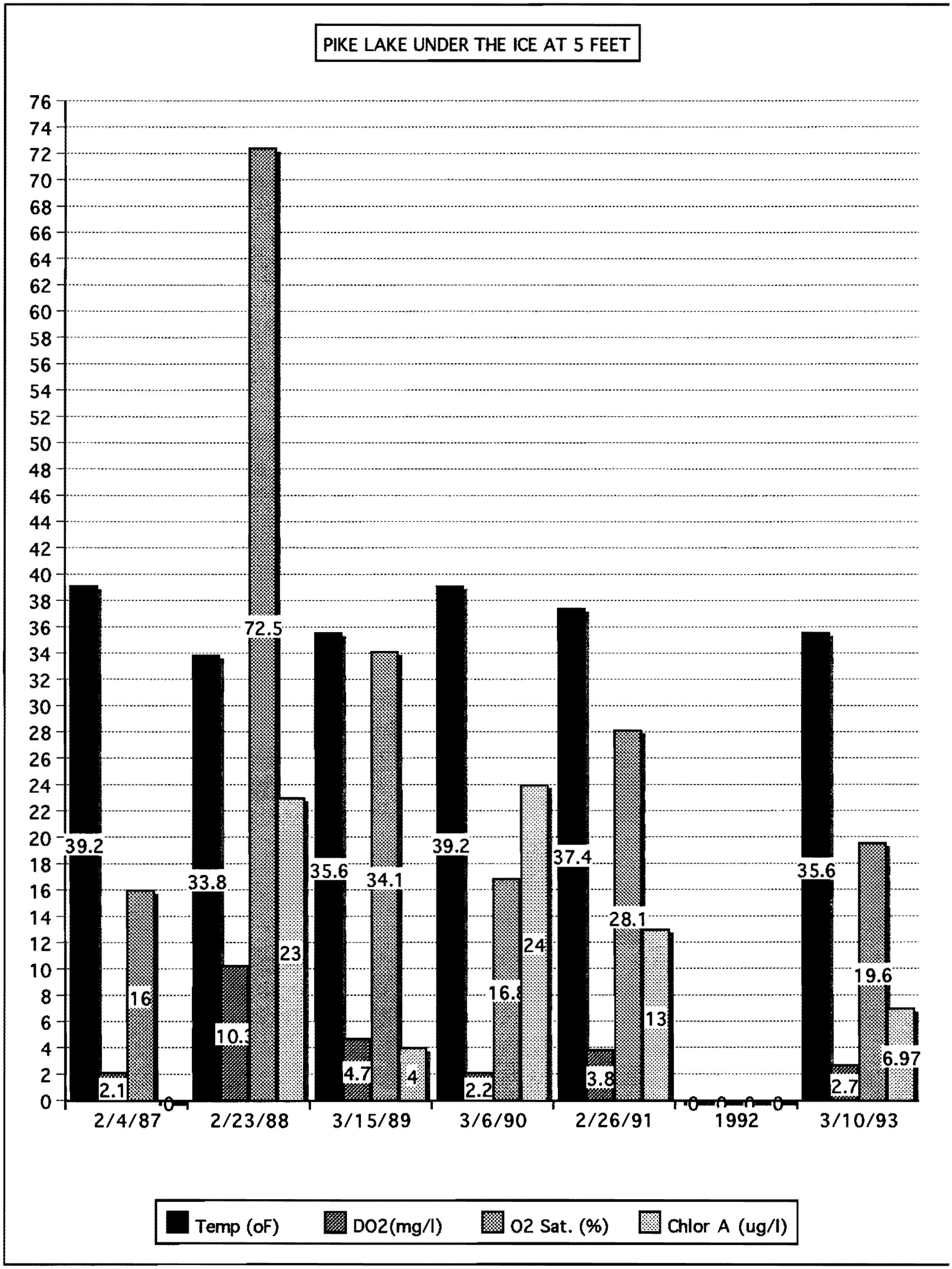
The water quality history of Pike Lake is well documented as part of the DNR Long Term Lake Monitoring Program data collected since 1986. Water chemistry and physical sampling has occurred up to six times per year since that year. These sampling periods correspond to changing conditions and seasons to include: late winter under the ice, spring turnover, summer growth months, and fall turnover. Analysis of this data was made by following each of these periods through the time of 11 years.

UNDER THE ICE

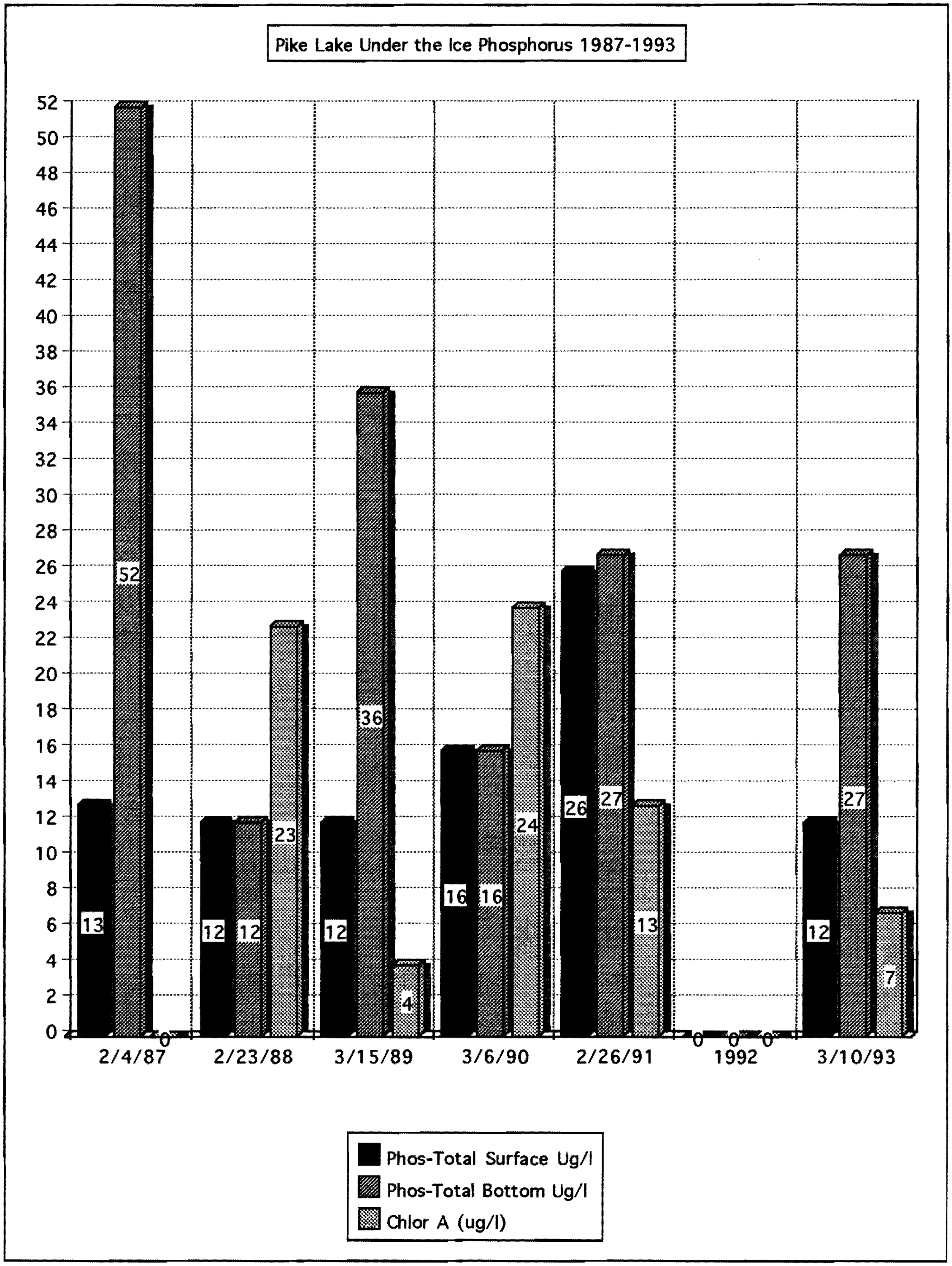
Late winter under the ice sampling was completed from 1987 to 1993 except in 1992. Oxygen/ temperature profiles were taken beneath the ice to the bottom. Chlor *a* and total phosphorus samplings were taken beneath the ice with another total phosphorus sample taken near the bottom 27 feet. See the results in **FIGURE 5a and 5b**.

Low oxygen also affects **phosphorus** levels. **Phosphorus** is the most important nutrient limiting the amount of plant growth in a lake. **Phosphorus** is not highly soluble in water and precipitates with **iron** to the lake sediments when oxygen is present. But when Pike Lake looses oxygen in winter or bottom sediments are without oxygen during the summer, phosphorus and iron become soluble again. These element are then released to the water column for plant growth. **Total Phosphorus** is the amount of phosphorus dissolved in the water and the phosphorus in plant and animal fragments dissolved in the water.

Figures 5a&b. PIKE LAKE UNDER THE ICE 1987- 1993



Figures 5a&b. PIKE LAKE UNDER THE ICE 1987- 1993



Oxygen levels under the ice ranged from 2.1 to 10.3 mg/l. The highest reading corresponded to a high chlor a concentrations on February 23, 1988. Chlorophyll *a* is a green pigment present in all plant life and necessary for photosynthesis that produces oxygen. The amount present in lake water depends on the amount of algae in the water. It would appear on this date that the algae or phytoplankton were contributing to the elevated oxygen in the lake. The sky was clear and the ice had no snow cover so light could reach the phytoplankton for photosynthesis and oxygen production. Yet on another clear day, on March 6, 1990, with thicker ice and snow cover the highest chlor *a* reading corresponds to the second lowest dissolved oxygen reading. Light penetration through the ice and snow was limited and the phytoplankton respiration appeared to be utilizing oxygen under these low light conditions.

A look at corresponding **total phosphorus** conditions under the ice finds phosphorus levels nearly the same on top and bottom when phytoplankton activity (represented by greater chlor *a* concentrations) is higher. The low **chlor *a*** concentration in 1989 has the greatest difference from top to bottom not only in **total phosphorus** concentration but in temperature. **Chlor *a*** was not taken in 1987, the only other year with large differences in total phosphorus from top to bottom. Perhaps a larger data base would clarify these trends further.

Certain nitrogen compounds can be toxic to both fish and fish food organisms if they do not break down in an oxygen rich environment. Decomposing organic matter on the bottom of Pike Lake releases **ammonia** that quickly converts to **nitrite**, and then **nitrate** if oxygen is present and temperatures and pH are adequate. Under the low oxygen/ temperatures that Pike Lake has during the winter, **ammonia-N** can build up under the ice and further stress fish and other organisms.

The water chemistry sampling of ~~Pike L~~ake Creek as it enters Pike Lake was completed on March 13, 1990 a week after the lake sampling that year. **Total phosphorus** levels were nearly the same as the lake sample. A high organic load of dissolved nutrients and suspended solids ~~with a large oxygen demand~~ were found entering the lake from this stream. **SEE TABLE 3** below.

Table 3. Rice Creek at Pike Lake Inlet on March 13, 1990.

BOD 5	Ammonia-N	NO2-NO3	Phos-Dis Ortho	Phos-Total	S. Solids
7.1	0.51	0.66	0.053	0.015	28

SPRING TURNOVER

Spring turnover represents a time when the lake mixes completely recharging the bottom water with oxygen and bringing nutrients up to the surface. Nutrients released from winter decaying of plant and animal matter under the ice are now released into the water column. Most chemical elements and compounds available for growth in the upcoming season are dissolved in the water at this time when the water is still cool. Further warming is necessary before the biological activity that absorbs these nutrients and minerals begins. Extensive water sampling was completed from 1986 to 1997.

The minerals sampled at spring turnover include **calcium, magnesium, sodium, potassium, iron manganese, silica, phosphorus , chlorine,** and **sulfur**. These elements are usually present in the water column as ions or in complex organic or inorganic compounds. These minerals enter Pike Lake when water percolates through the surrounding land soils and enter through ground water springs. They also enter Pike Lake from surface water runoff from adjacent lands that enter Pike Lake, Rice Lake, and the tributary streams.

Many of these minerals enter the ground water aquifer at the water table where many mix with carbon dioxide to form carbonic compounds. **Calcium** and **magnesium** are the principle sources of **alkalinity** and **hardness** in the water. **Calcium** concentrations at the surface at spring turnover varied from 27 to 39 mg/l. from 1986 to 1997. **Magnesium** concentrations varied during this same time period from 12-19 mg/l. **Alkalinity**(expressed as CaCO3) and **hardness** concentration changes corresponded to concentration changes of calcium and magnesium and ranged from 112 to 143 and 117 to 149, respectively. Pike Lake is not sensitive to acid rain with these high mineral concentrations.

The mineral concentrations also associated with water's ability to conduct electricity which is the **conductivity** of the water. The conductivity of Pike Lake ranged from 217 to 297 from 1989 to 1997. Fall levels ranged from 260 to 292 during the same period. These **conductivity** values are about 2 times the **hardness** values indicating the water is receiving very little human induced contaminants.

Acidity levels fluctuated from a neutral **pH** of 7.0 under the ice in February (under low oxygen conditions beneath the ice) to 9.3 during late summer when an algae bloom created supersaturated conditions on Pike Lake's surface. These extremes occurred during the drought year of 1986. These wide range **pH** conditions, or acid level conditions, are due to chemical reactions that occur in water that release or take up Hydrogen ions (h+). The low or zero oxygen conditions under the ice releases hydrogen sulfide (HIS) and methane gas (CH3) that react with the low buffered water to release hydrogen ions and lower the pH. Both of these released compounds are toxic to fish and other organisms.

The high **pH** corresponded to high supersaturated levels of dissolved oxygen from photosynthesis of algae and aquatic plants that used up all the available carbon dioxide (CO_2). Carbon dioxide in combination with lake water forms carbonic acid that normally lowers **pH,** but with a tremendous amount of plant growth on sunny summer days the CO_2 is used up and the pH rises sharply. These wide fluctuations in **pH**, oxygen, and associated water chemistry can stress aquatic organisms (e.g. fish, aquatic insects, clams, leeches, and zooplankton) and limit their growth, survival, and increase their susceptibility to parasites and disease.

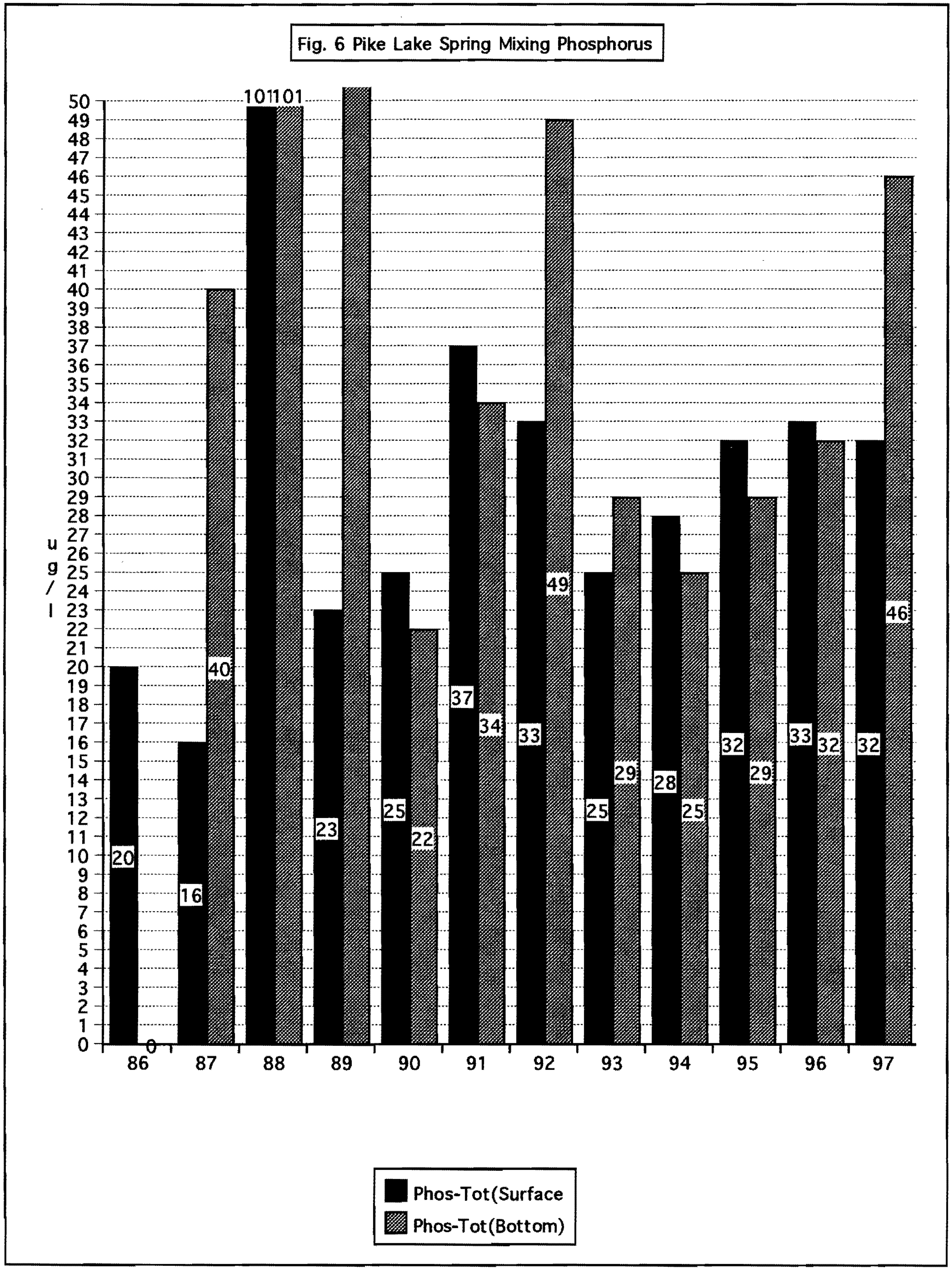
As the **pH** fluctuates the solubility of minerals change. In Pike Lake where water percolates through the surrounding land soils and enters Pike Lake through ground water springs there is an abundance of minerals available for chemical and biological activities. The levels of these dissolved minerals that include **iron, silica, sulfate, sodium, manganese** and **potassium** changed little from spring to fall sampling.

At spring mixing these conditions quickly change with the addition of oxygen and warmer water from the surface. . In 1987 & 89 spring mixing or turnover had not occurred by spring sampling and oxygen and **total phosphorus** levels were different from top to bottom. Elevated **total phosphorus** levels and low oxygen could be found in the bottom sampling during those years. Lower levels of **nitrite-nitrate-N** were also found at the surface those years as the bottom nutrients had not mixed to the surface. These bottom nitrogen compounds were from the break down of organic matter that had accumulated on the bottom from plant decay and organic particles entering from Rice Creek and other adjacent flooded organic soils.

Pike Lake is subject to summer algae blooms. It has been documented that a concentration of **total phosphorus** below 0.02 mg/l (20 ug /l) for lakes and 0.03 mg/l (30 ug /l) for impoundments should be maintained to prevent nuisance algal blooms. Pike Lake has consistently had **total phosphorus** levels greater than 20 and 30 ug /l every year except 1987 when the lake had not mixed yet. In the last three years Pike Lake has exceeded 30 ug /l or at spring turnover. See **FIGURE 6**.

Nitrogen is second only to phosphorus as an important nutrient for plant and algae growth. Nitrogen exist in lakes in several forms. Analysis usually includes **nitrate** (NO_3^-) plus **nitrate** (NO_2^-). **ammonium** (NH_4^+) and organic plus ammonium (**Kjeldahl nitrogen**). **Total Nitrogen** is calculated by adding nitrite-nitrate nitrogen to the Kjeldahl nitrogen. **Nitrogen** does not occur naturally in soil minerals, but is a major component in all organic (plant and animal) matter. Decomposing organic matter releases **ammonia**, which is converted to **nitrate** if oxygen is present. All inorganic forms of nitrogen (NO_3^-, $N0_2^-$, and NH_4^+) can be used by plant and algae If these inorganic forms of nitrogen exceed 0.3 mg/l in spring, there is sufficient nitrogen to support summer algae blooms. Pike Lake seldom has exceeded this level in inorganic nitrogen sampling. The summer and and fall algae blooms are more likely to be caused by decay of plants that have matured by midsummer.

FIGURE 6. Pike Lake Spring Mixing Phosphorus 1986-97.



Most **nitrogen** in Pike Lake comes from **organic nitrogen** which is the major element in the **Kjeldahl nitrogen** sampled during spring mixing. Spring sampling in 1997 of the tributary drainage to Pike Lake confirms the source of this organic load of **nitrogen** is the mainly Rice Lake and Rice Lake Tributary to Pike Lake. Both of these water bodies are surrounded by muck soils that are high in organic content and easily eroded. When these muck soils are flooded they release humus -well decomposed particulate matter- to adjacent waterways. This humus is both high in **phosphorus** and **nitrogen. SEE FIGURE 7a & b**. There was also some organic load coming into the lake from the east tributary.

The phosphorus-nitrogen ratio average at spring turnover over time is approximately 23/1. Pike Lake appears to phosphorus limited - or algae growth is controlled by the amount of phosphorus in the water. **SEE TABLE 4.**

Chlor a is a green pigment present in all plant life and necessary for photosynthesis. The amount present in lake water depends on the amount of algae and is therefore used as a common indicator of water quality. **Chlor a** concentrations varied during spring mixing from 12 to 26 ug/l. These are very high levels of **Chlor a** that indicate that nutrient levels are creating very productive and fertile conditions in Pike Lake more than necessary for healthy aquatic production.

TABLE 4. SPRING TURNOVER PHOSPHORUS & CHLOR A (ALGAE INDICATOR)

Date	Phos-Total Surf	Phos-Total Bott	Chlor A (ug/l)	Secchi(feet)
4/22/86	20	-	-	5.5
4/20/87	16	40	-	4.3
4/20/88	70	101	25	5.2
4/26/89	23	117	11	9
4/24/90	25	22	20	5
5/5/92	33	49	24	6
5/6/93	25	29	12	6
5/4/94	28	25	17.8	4.5
4/26/95	32	29	17.3	5.6
5/23/96	33	32	20	4.5
5/6/97	32	46	18.2	5

FIGURE 7a & b. Pike Lake 1997 Spring Nutrient Load

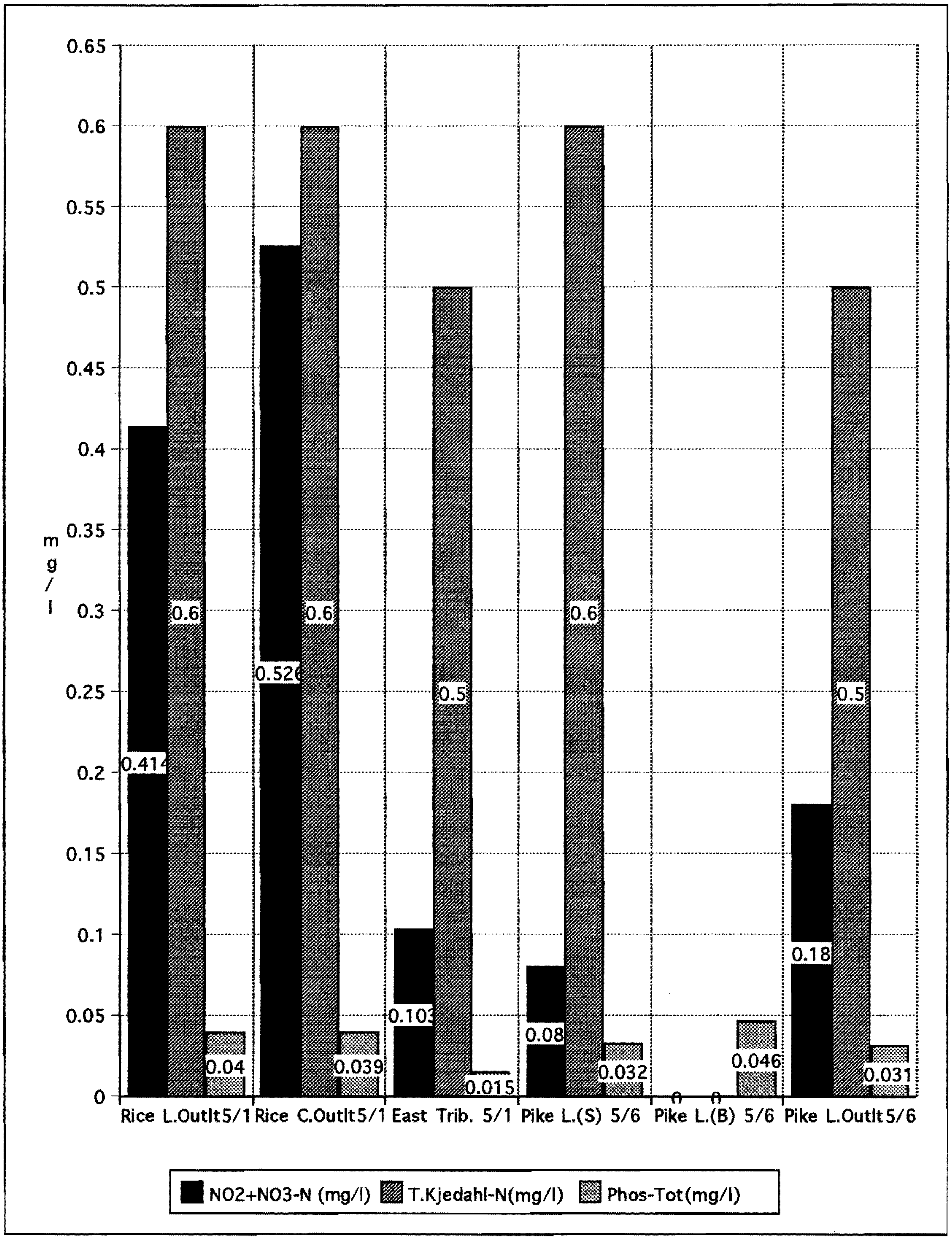
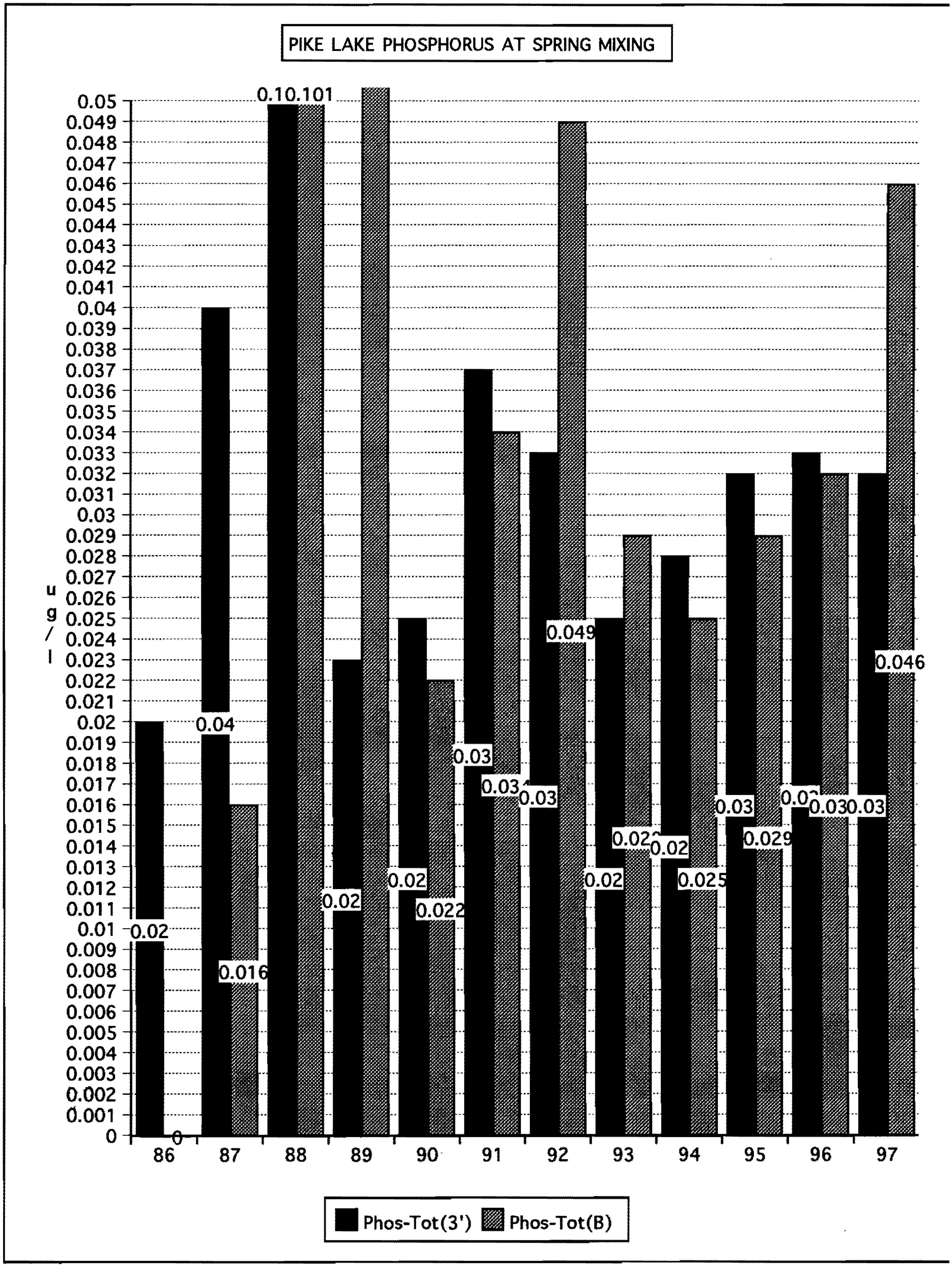


Figure 7a & b. Pike Lake Spring Phosphorus



JUNE

After spring mixing most of the oxygen is quickly depleted from bottom waters of Pike Lake. In June water below 15 feet drops significantly in temperature and dissolved oxygen. Water temperature above this thermocline is from 69 to 77 oF and nearly saturated with oxygen. Water clarity as indicated by secchi disc sampling ranges from 4.1 to 9.0 feet with little correlation to algae production as indicated by **Chlor a** readings from 1986 to 1997 ranged from 1.3 to 31.7. There appears to be very little correlation at this time between secchi and chlor a readings over this 11 year period.

Volunteer temperature/ oxygen saturation profile sampling in June 1997 indicated a sharp drop in oxygen saturation from 71% beginning at the 10' depth and plummeting to 1.9% at the 18' depth. From June 8 to the 22 volunteer water clarity secchi readings decreased from 11 to 9.5'. By the time of long term monitoring sampling on June 25 the secchi reading had dropped to 8 feet with a Chlor a reading of 9 ug /l. Aquatic plants grow to this 10' depth in Pike Lake. Early abundant plant growth and the presence of large chloroplast of blue green algae as observed by the volunteer in 1997 appears to keep oxygen near saturation in this light zone.

A record surface total phosphorus for June occurred in 1997. **SEE FIGURE 8**. Very little rain fell during the weeks prior to sampling so phosphorus appears to originate from in lake sources. Spring turnover phosphorus levels at the surface were also the highest in 11 years of sampling. The aeration system did not function properly during the winter of 1996-97 and heavy snow fall contributed to very low oxygen under the ice. It is probable that more phosphorus was released from the bottom sediments under the anaerobic (without oxygen) conditions without the aeration system operating properly and the lack of light penetration that would provide plants to produce it.

It also appears that there is a larger oxygen demand at the 18' depth than below to the 24' depth - as the percent saturation of oxygen rises as you go deeper. This event occurred throughout the summer in 1997. This is more likely be explained as a result of oxygenated spring seepage to the lake as the temperature at 24' remained constant until July 21. **SEE FIGURE 9.**

Figure 8. Pike Lake June Phosphorus & Chlor A 1986-97.

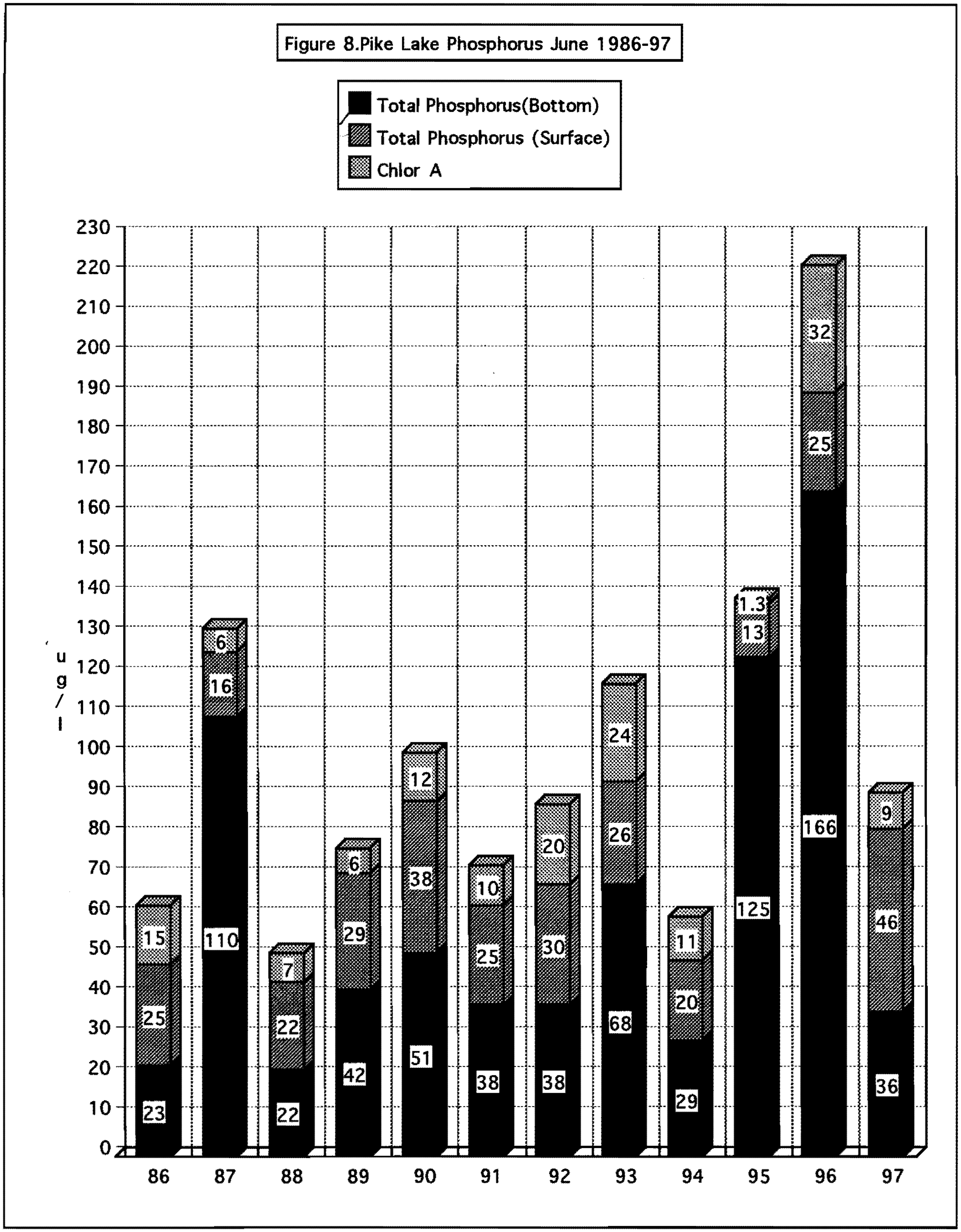
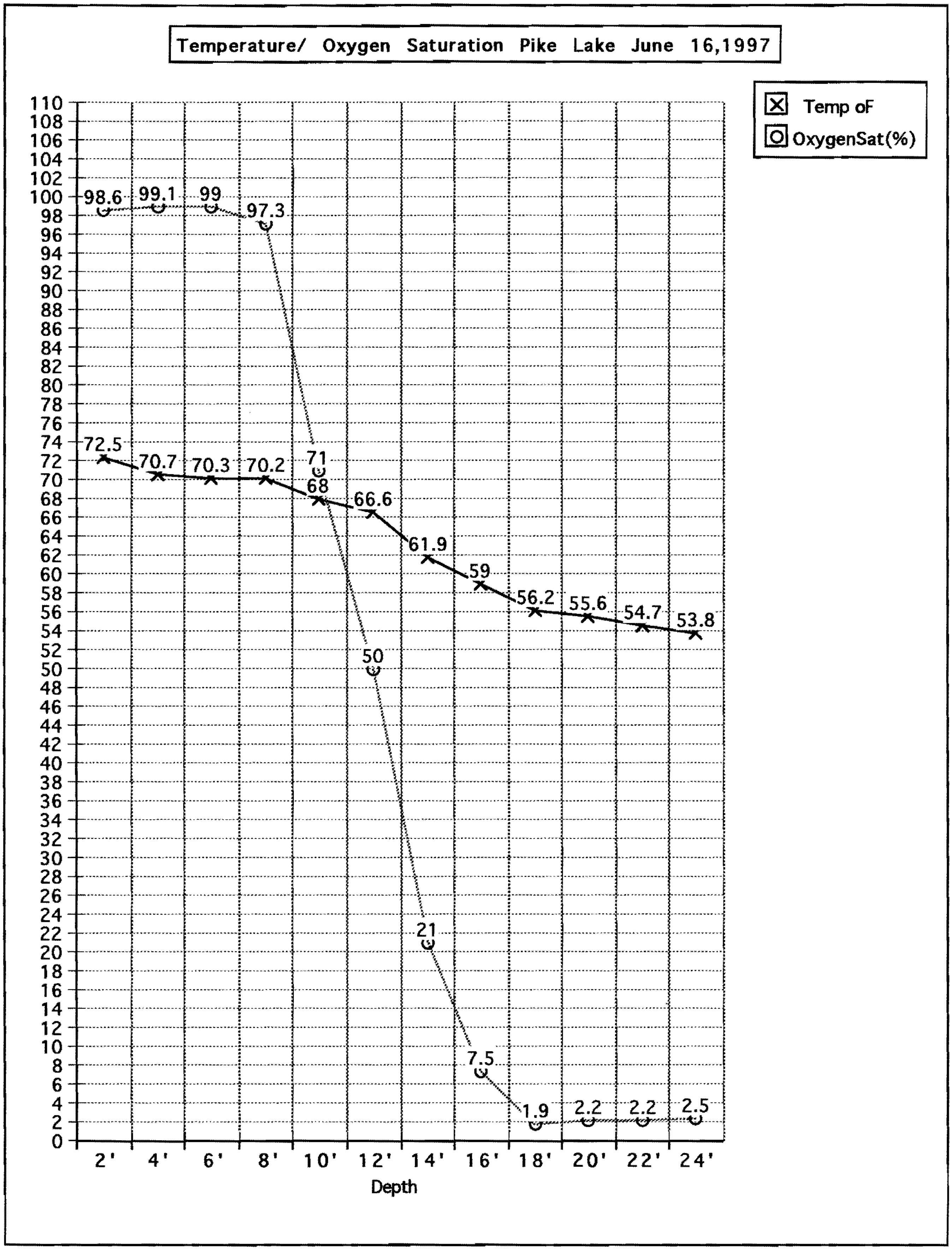


FIGURE 9. Pike Lake Temperature Oxygen Profile June 22, 1997.



Secchi: 10' Comments: Clear Water w/ Large Chloroplast(BG Algae)

Weather: Prtly Cloudy 83oF

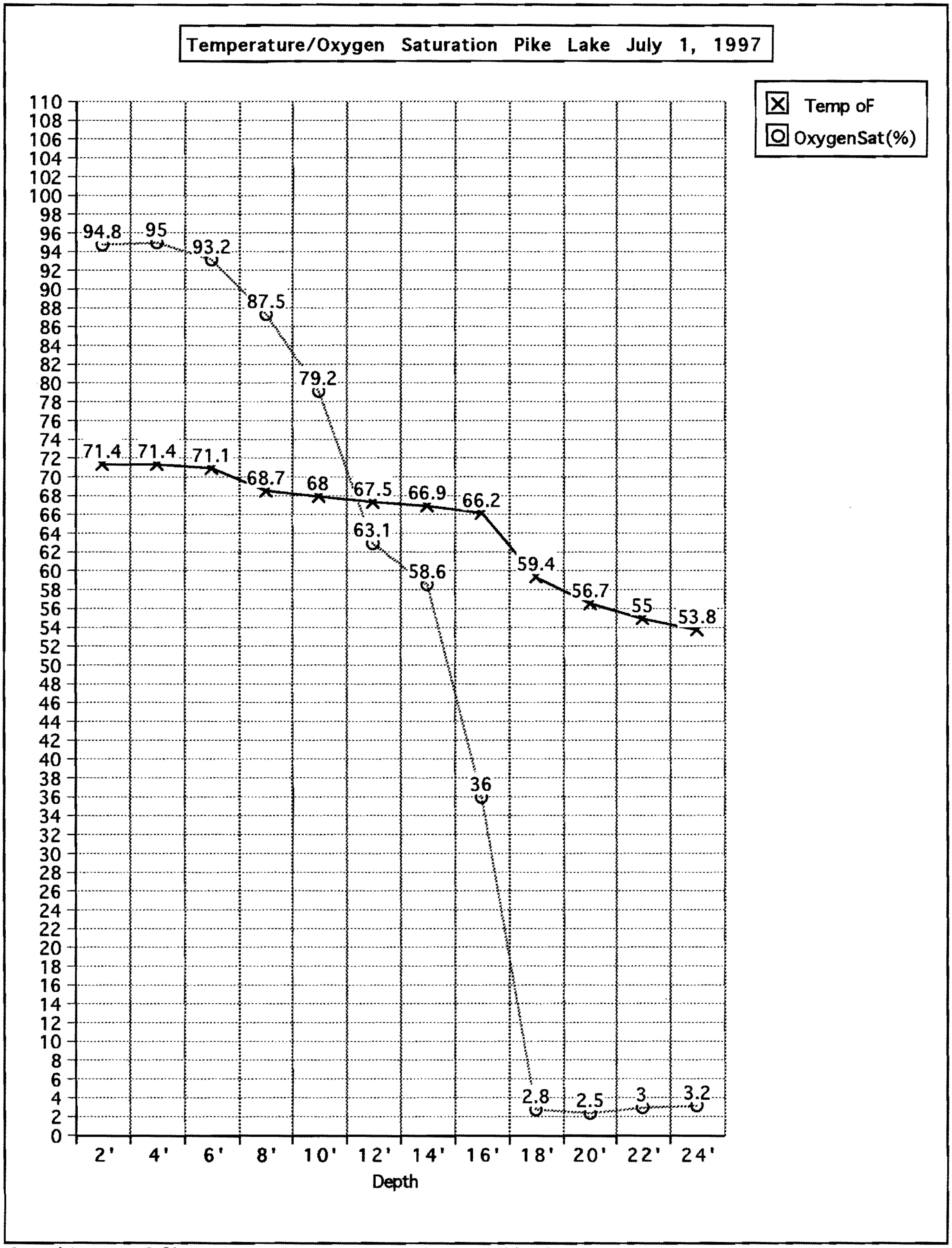
JULY

Four temperature/ oxygen profiles with secchi observations were taken by a lake volunteer in 1997. Surface temperatures of the upper six feet of Pike Lake warmed from 71 oF on July 1 to 77 oF by the third week. By the fourth week of July the 77 oF the warm surface water mixed to the 12 depth. A 10% drop in oxygen saturation corresponded to the warming of this surface water. Chloroplast were observed in the surface water after the water warmed the last three weeks. **SEE FIGURE 10.**

A **thermocline** (a narrow transitions zone where a sudden drop in temperature and/or oxygen saturation) developed at the 12' depth at the same time of this surface temperature warming. Over this three week period in July oxygen saturation between 12' and 18' dropped from 60% to 3%. In deep water from 16 to 24' water temperatures below the thermocline increased in temperature yet was further stratify from top to bottom. The oxygen saturation from 16 to 24' increased from top to bottom corresponding to colder water's ability to holds more oxygen. It appears that spring seepage of oxygenated water into the bottom sediments exceeds the oxygen demand of bottom sediments. The decrease in oxygen saturation of bottom sediments decreased only slightly the 1st three weeks and increased the 4th week.

Phosphorus levels were measured a meter from the surface and at the 28-30 foot depth from 1986 to 1997. The surface phosphorus levels range only slightly from 16-33 ug /l over that period of time. **Chlor a** ranged from 3 to 25 ug /l during the same period with little correlation with surface phosphorus. Bottom phosphorus ranged widely from 23 to 440 ug /l during the same period. **SEE FIGURE 11.**

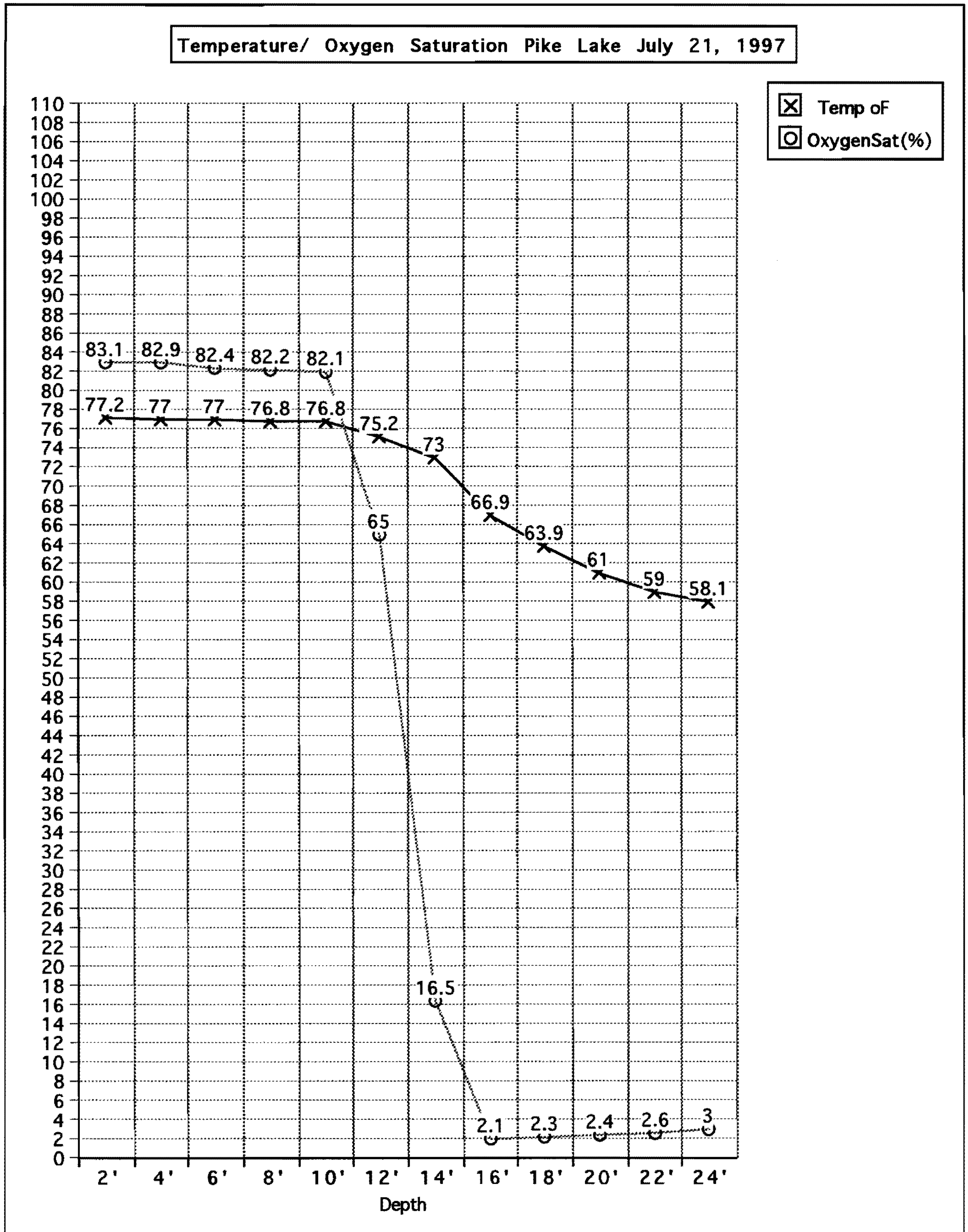
Figure 10a-d. Pike Lake Oxygen/ Temperature Profiling in July, 1997



Secchi: 8.0' Comments: Clear No Chlorplast

Weather: Clear Sunny 80oF

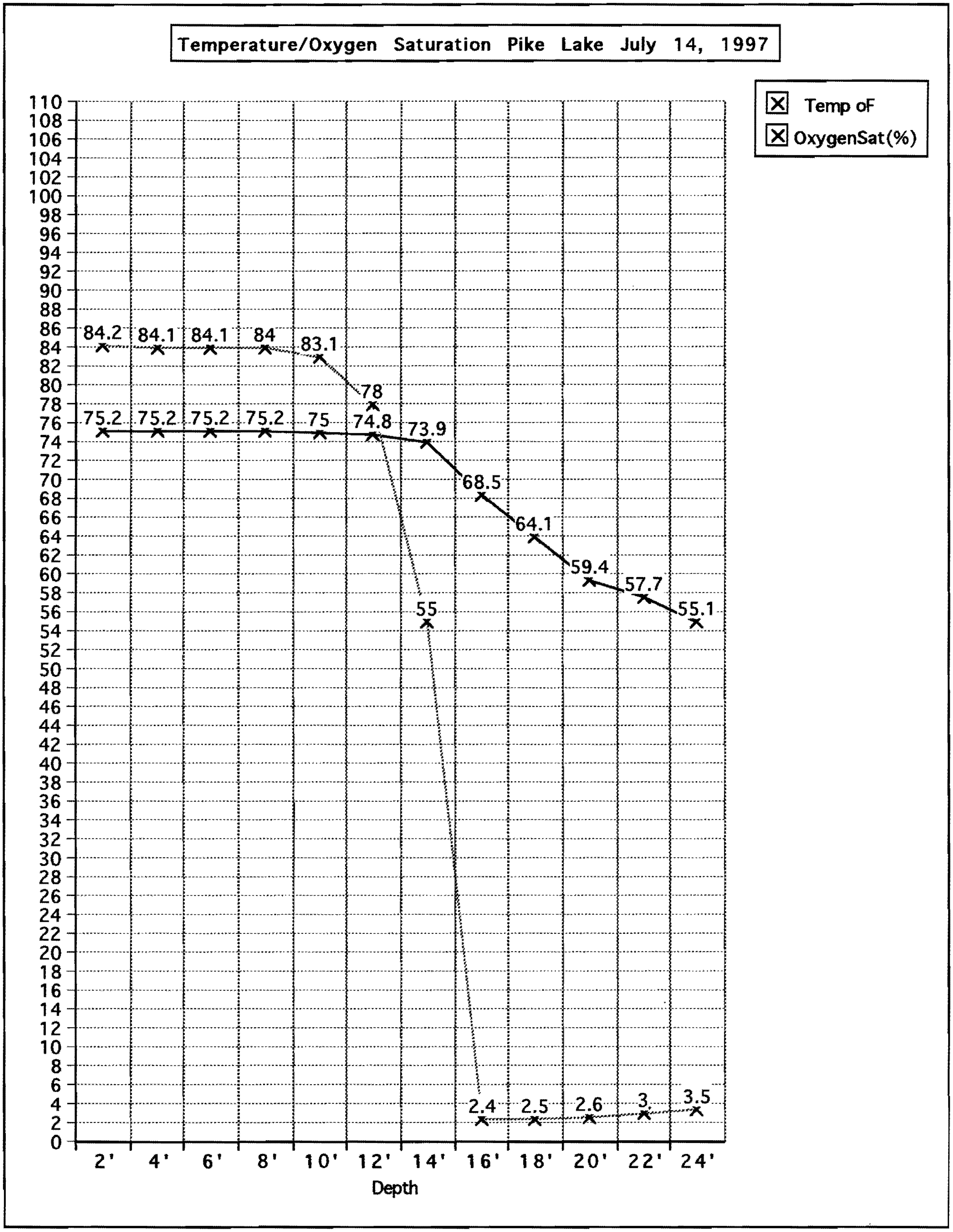
Figure 10a-d. Pike Lake Oxygen/ Temperature Profiling in July, 1997



Secchi: 7.0' **Comments:** Clear, Few Chlorplast

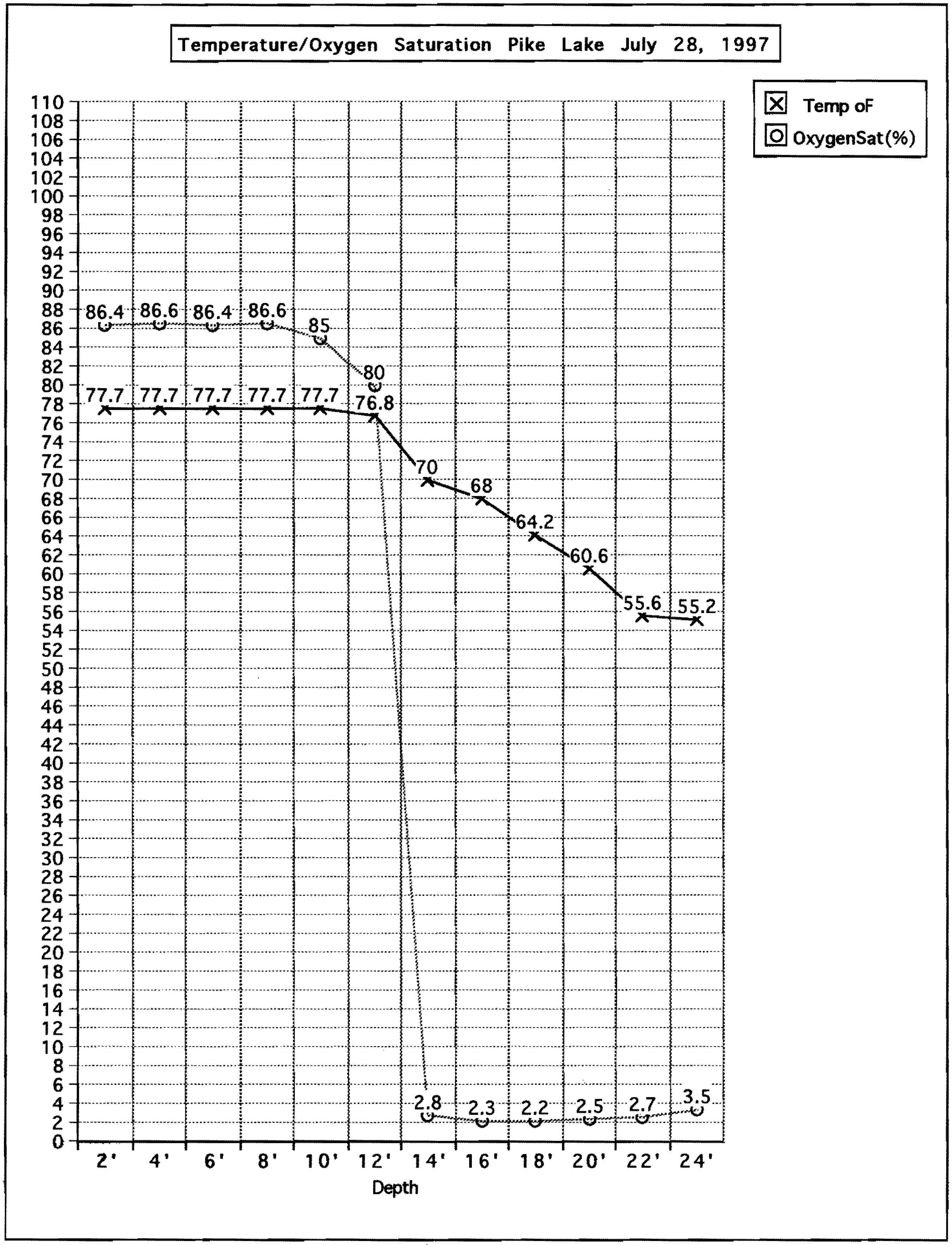
Weather: Partly Cloudy

Figure 10a-d. Pike Lake Oxygen/ Temperature Profiling in July, 1997



Secchi:	7.0'	Comments:	Clear, Few Chlorplast
Weather:	Partly Cloudy		

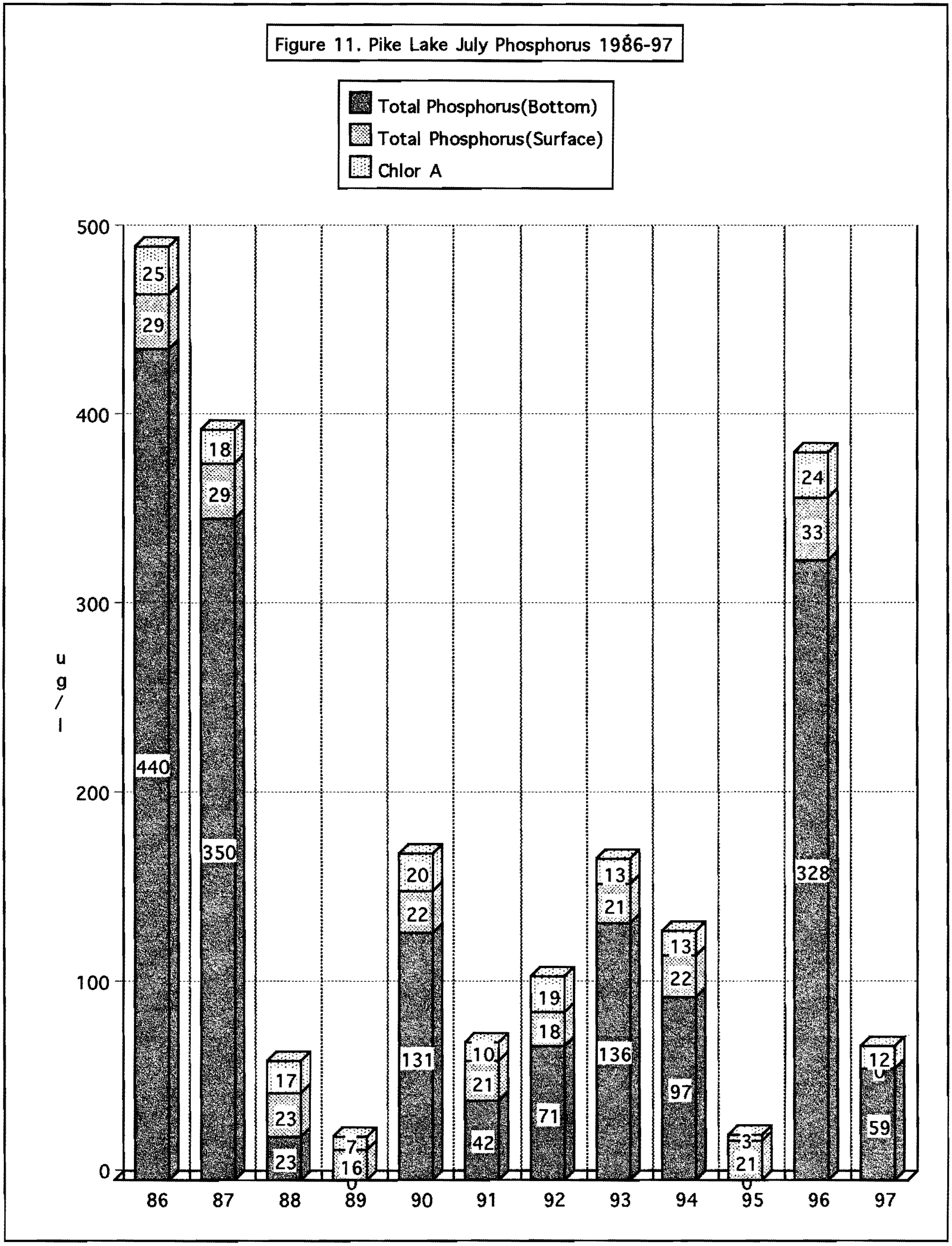
Figure 10a-d. Pike Lake Oxygen/ Temperature Profiling in July, 1997



Secchi: 7.0' **Comments:**

Weather: Mostly Clear 70 oF

Figure 11. Pike Lake July Phosphorus & Chlor A 1986-97.



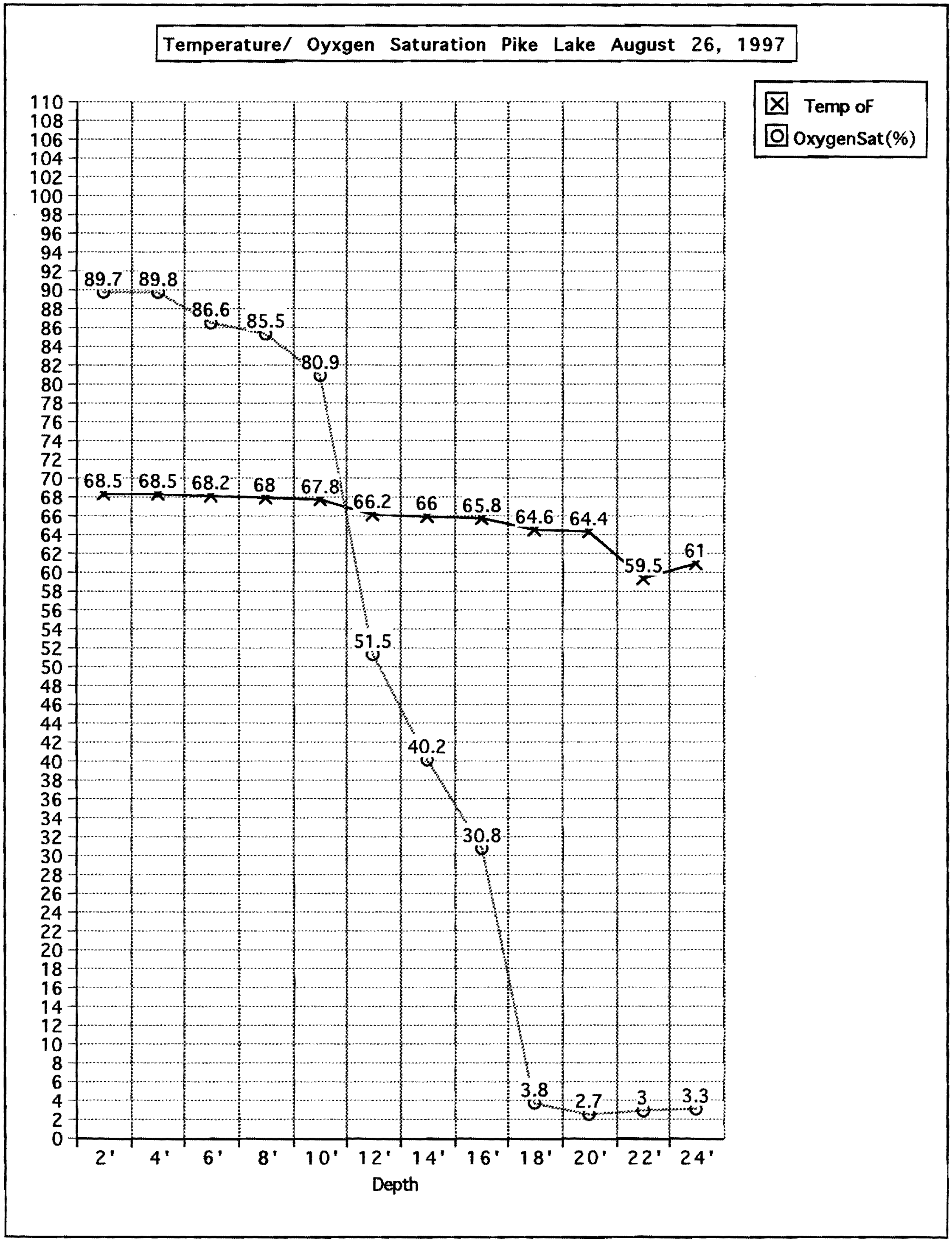
AUGUST

By August 26 surface temperatures cooled from late July yet varied less than a degree from surface to 10 feet. **SEE FIGURE 12** Oxygen saturation levels ranged from 89.7% near the surface and dropped to 80.9 % at 10 feet. A phytoplankton or algae bloom was occurring limiting secchi clarity to 6 feet . Through photosynthesis this heavy bloom of algae added oxygen to the top 10 feet of the water column. Oxygen and saturation levels below the 10' thermocline to 16 feet increased from the end of July to the present. Was oxygen restored to this depth by water temperature density mixing with surface water or was it from the phytoplankton photosynthesis? Phytoplankton was abundant and limited secchi disc clarity to 6' at time of the August 26 sampling. On August 18, 8 days prior, during long term lake monitoring sampling chlor a concentration was 13 ug /l with a water clarity of only 5 feet. **Total phosphorus** readings were 48 ug /l at 3' from surface and at the 24' depth.

From 18 to 24 feet the temperature was only 4 to 9 oF cooler than the surface waters. Oxygen saturation levels varied from 2.7% to 3.3% With of highest levels of saturation at 18' and 24' with the lower levels in between. Seepage through the sand or gravel bottom would account for the higher oxygen in the greatest depth in the lake.

Phosphorus levels were measured a meter from the surface and at the 24-29 foot depth from 1986 to 1997. The surface phosphorus levels range from 20 to 62 ug /l over that period of time. **Chlor a** ranged from 12 to 42 ug /l during the same period with little correlation with surface phosphorus. Bottom phosphorus ranged widely from 48 to 700 ug /l during the same period. **SEE FIGURE 13**. Phosphorus levels for the bottom sediments probably varied as the sampling depth varied.

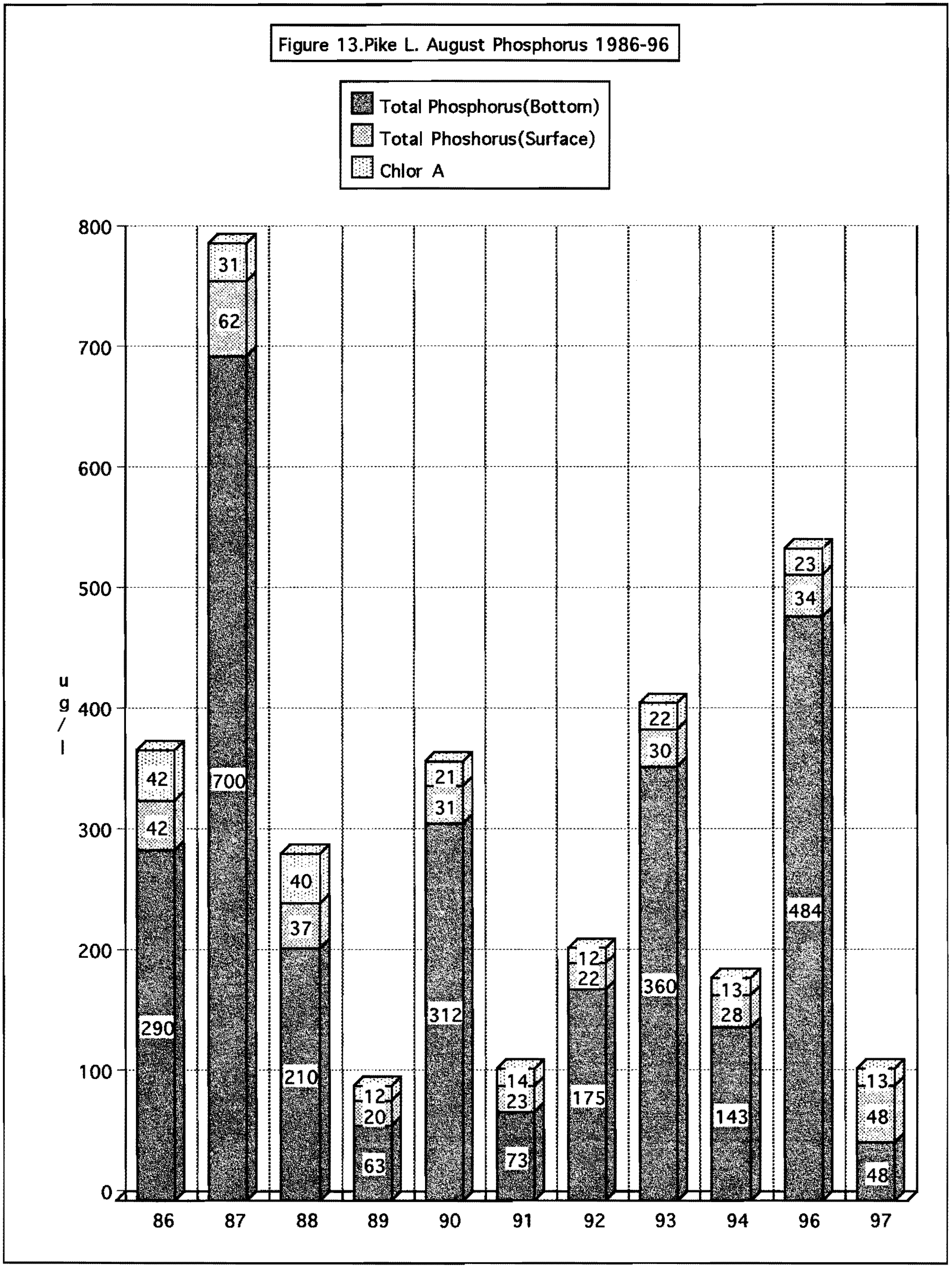
Figure 12. Pike Lake Oxygen/ Temperature Profie on Aug 26, 1997.



Secchi: 6.0' **Comments:** Abundant Plankton

Weather: Clear Calm 72 oF

Figure 13. Pike Lake August Phosphorus & Chlor A 1986-97.



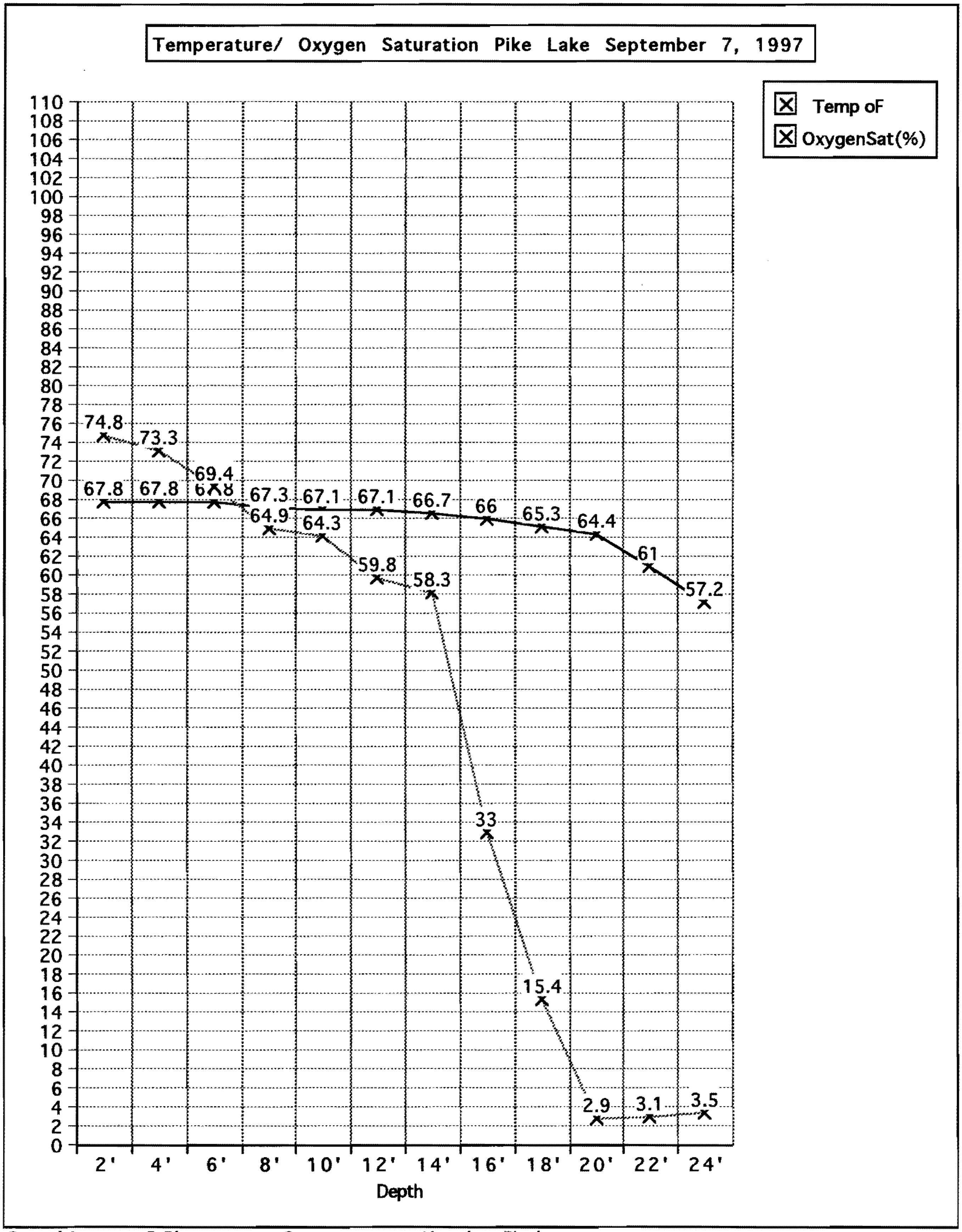
FALL TURNOVER PERIOD

Oxygen- temperature profiling from August 26 to September 7, 1997 indicated a gradual oxygenation of the water column near the soft loose bottom ooze at 18', Oxygen saturation had gone from 3.8% to 15.4% in that 4 week period. Oxygen saturation at the bottom (24') remained higher than at 22 and 20' depth. **SEE FIGURE 14**. This oxygen saturation change at the bottom accompanied a bottom temperature change from 61 oF to 57 oF. On September 7 the secchi clarity dropped to 5.5 feet with and abundant plankton bloom.

By September 27 Pike Lake's water temperature varied less than one degree from top to bottom. Oxygen saturation from 20-24' began to rise from around 3% to 43%. Bottom oxygen saturation levels remained slightly higher than those in the ooze above. Spring seepage at the 24' appeared to providing oxygen in excess what would be utilized by the oxygen demand of the bottom ooze. Secchi depth decreased further to 4.5 feet with a dense plankton bloom. **SEE FIGURE 15**.

By October 2 the lake had began to turned over and mix elevating bottom oxygen to over 50% saturation Oxygen from the surface to 10' was greater than 80% saturation. A heavy phytoplankton that limited secchi visibility to 4.5' appeared to elevate surface saturation levels. Temperature and oxygen stratification from top to bottom returned to Pike Lake in the short period from September 27 to October 2, 1997. **SEE FIGURE 16**. Long term motoring data indicates that Pike Lake surface and bottom waters mix in October and November with oxygen saturation levels reaching the bottom.

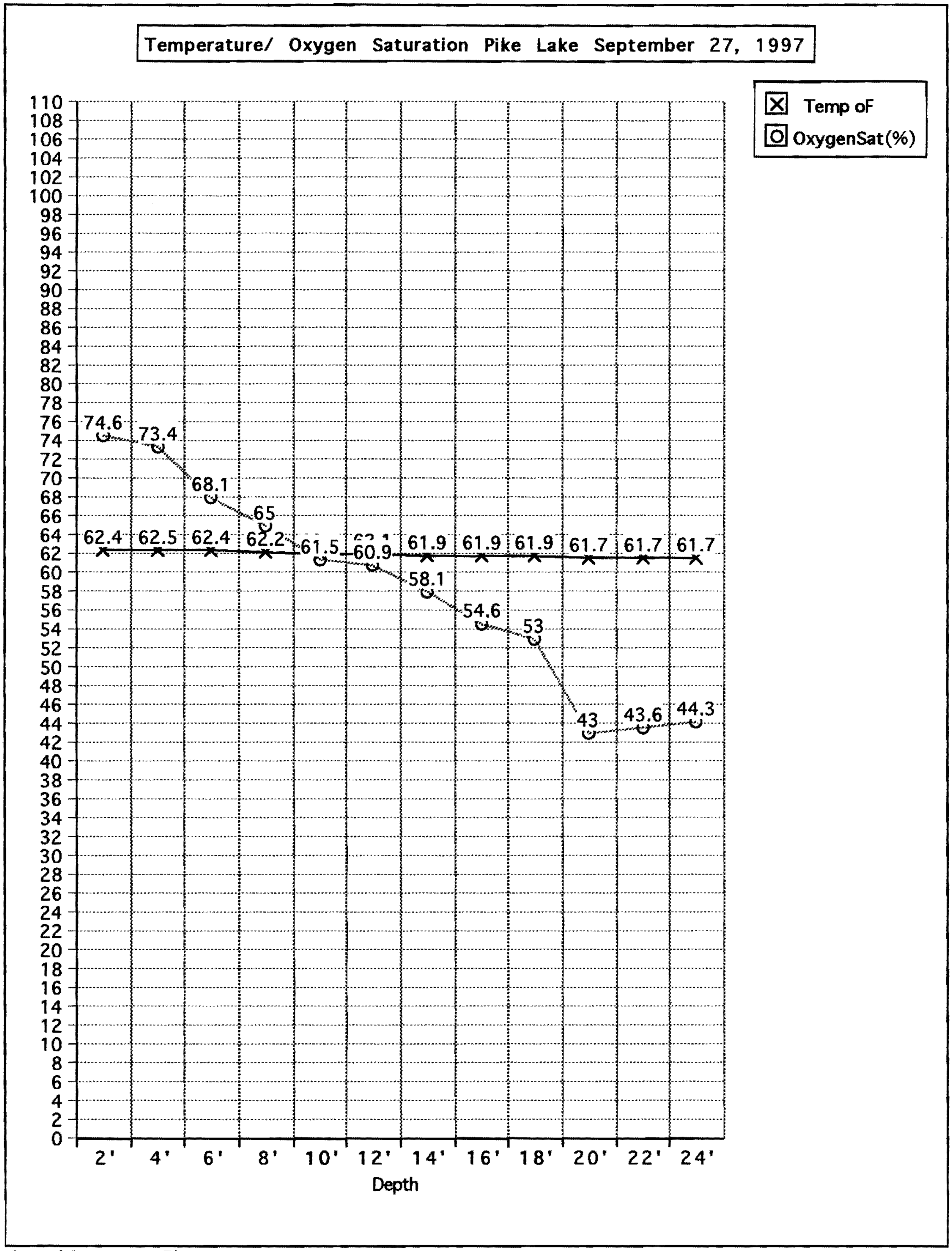
Figure 14. Pike Lake Oxygen/ Temperature Profie on Sept 7, 1997.



Secchi: 5.5' Comments: Abundant Plankton

Weather: M. Cloudy, Calm 61 oF

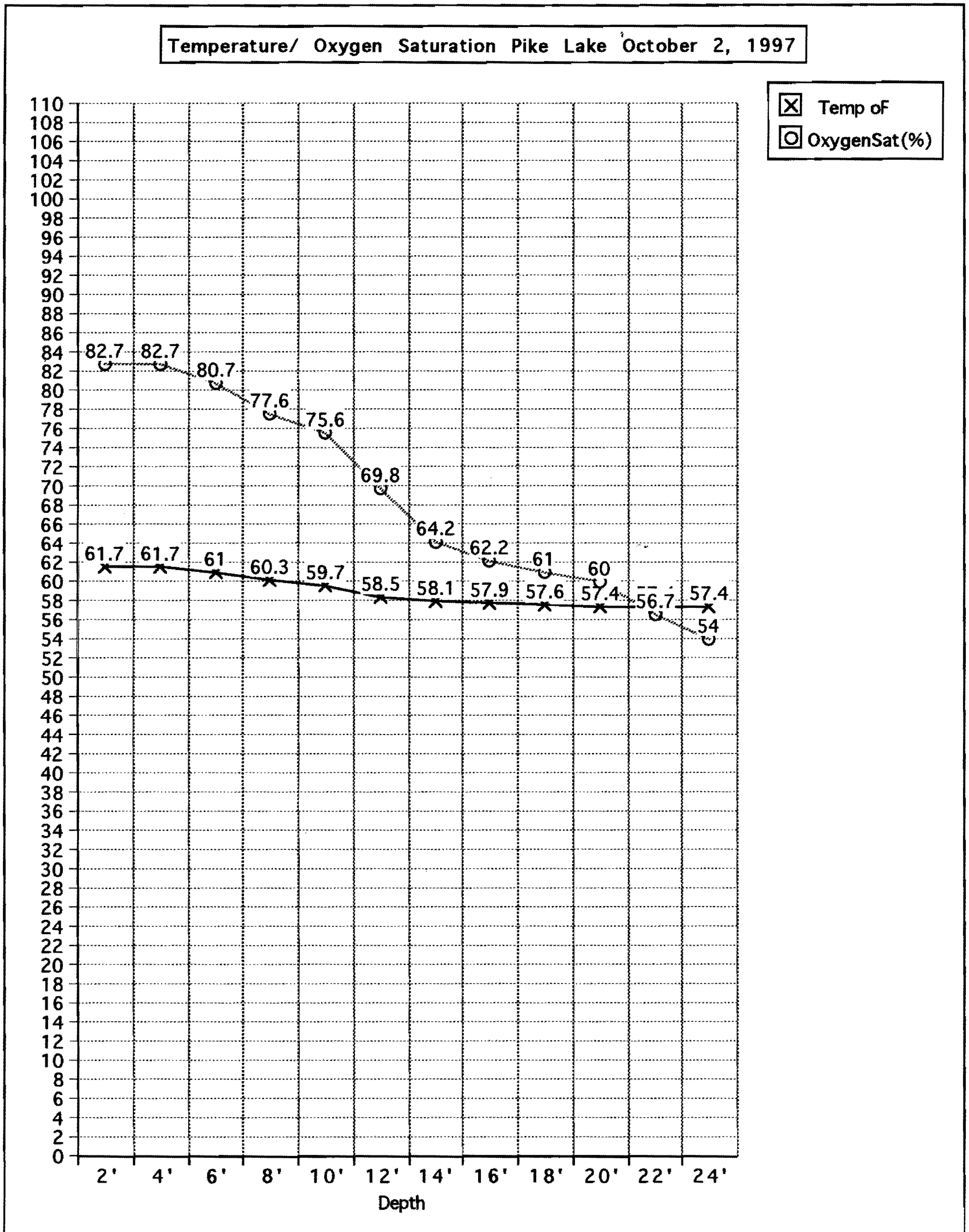
Figure 15. Pike Lake Oxygen/ Temperature Profie on Sept 27, 1997.



Secchi: 4.5' **Comments:**

Weather: M. Cloudy Wind 10-12mph

Figure 16. Pike Lake Oxygen/ Temperature Profie on Oct 2, 1997.



Secchi: 4.5' **Comments:** Abundant Plankton

Weather: Sunny Calm 75oF

Re.

SPRING RUNOFF AND SUMMER STORM EVENTS

Water sampling after storm events was conducted on the two tributaries entering Pike Lake and at the outlet dam to assess the nutrient load to the lake from the watershed. This water sampling data was added to lake sampling, water levels data, and past sampling data to analyze the long term effects. An overview of this data is found in **Appendix 2.**

Spring runoff sampling on May 1, 1997 was completed after 1" of rain and snow fell over a 24 hour period when the upland ground was still frozen and waterways and marshes were flooded from snow melt. Dissolved organic nitrogen and ammonium (**Kjeldahl Nitrogen**) were highest coming out of Rice Lake and at Rice Lake Creek before it enters Pike Lake. **Total Phosphorus** levels were also highest coming from Rice Lake. The east tributary and outlet dam levels for both these nutrients were lower. During sampling at the Rice Lake outlet and Rice Lake Creek outlet at the Lake View Drive bridge peat debris was observed rolling along the bottom being carried by the current into the creek and Pike Lake. This debris was not suspended in the water so was not recognized in the suspended solid testing.

Lake sampling of the near surface and near bottom waters of Pike Lake as part of the Long Term Monitoring sampling 5 days later were compared to this spring runoff sampling. **Total Phosphorus** and **Kjeldahl Nitrogen** levels at the Rice Lake outlet and Rice Creek inlet to Pike Lake were identical to the near bottom sampling of Pike Lake. Near surface sampling of Pike Lake were the same as the dam outlet reading five days prior. Water levels measured at the dam during this spring runoff sampling were highest of those sampled.

An early spring storm sleet storm under ground freezing conditions on March 13, 1990 documented an event when increased flow carried larger amounts of suspended peat and organic matter and dissolved organic matter into Pike Lake from Rice Lake Creek. During this sampling a 5 day biochemical oxygen analysis was completed indicating the high oxygen demand of this sample.

Water sampling during a summer storm event occurred on August 21, 1997. This sample was taken after 1.3" of rain fell over a 24 hour period. Sampling results for nutrients in Rice Lake Creek and at the Pike Lake Dam outlet were nearly the same as the spring runoff levels. The east tributary sampling nutrients increased significantly.

The placement of a dam at the outlet of Pike Lake has flooded peat and muck lands in Rice Lake, Rice Lake Creek, and in the east tributary area adjacent to the lake. Most nutrients in <u>unflooded</u> peat are stored in the vegetable matter and held in place by the roots of peat bog plants and not released to the water below. When flooding occurred this peat land the peat material is loosened and broken from the peat mats and eroded by wind, wave, and spring and summer flood events.

These nutrients have been carried into Pike Lake for over 40 years. These storm and spring runoff measurements document that the main source of nutrients is the flooded peat and muck wetlands of the Rice Lake, Rice Lake Creek and the east tributary areas.

A third aspect of water quality assessed the physical effects the current operation of the aeration system has on the lake. Pike Lake's bottom sediments have a large biochemical oxygen demand and even after aeration system installation partial fish winter kill from low oxygen still occurs periodically.

The oxygen/ temperature profiling, observations, and secchi disc readings were taken by volunteers with a new YSI 85 meter from December 1996 to March 1998. This included profiling to assess if total fall mixing occurs before freeze up, the rate at which oxygen depletion of bottom sediments occurred after freeze up, and the physical effects of the aeration system operation. The area affected by the operation of the current aeration system was identified by oxygen/ temperature profiling at several peripheral and concentric sampling rings around the aeration hole and at inlet and outfall stream areas. Spring and summer profiling were combined with secchi observations to complete the year long profile. This data was then entered into the computer for later analysis and interpretation.

<u>AERATION SYSTEM ANALYSIS</u>

The effects of the operation of the aeration system of Pike Lake was monitored during the winters of 1996-97 and 1997-98. Pike Lake's bottom sediments have a large biochemical oxygen demand that negatively effects oxygen levels beneath the ice. Partial fish winter kill still occurred after aeration system installation in 1982. The original aeration system installed was a 15 hp rotary compressor with a 4" feed line that T- ed to 2- 1 1/2' lines with 5/6" holes drilled in them at various intervals at a 20 feet depth. This system was designed to create three acres of open water in winter. Two additional 3/4 hp compressors were added to the existing system in 1996-97. New distributors were purchased and added to these compressors in 1997-98.

The winter of 1996-97 was a severe winter with early ice and snow accumulation that prevented light from penetrating for photosynthesis and oxygen production. Oxygen/ temperature profiling began on November 13, 1996 at freeze up and continued until April 16, 1997 at which time half of Pike Lake had open water.

<u>November 12, 1996</u> In the night Pike Lake froze over with a 1/2" layer of ice. A canoe was used to profile the lake over the nonoperating aeration system site. The lake was well mixed with temperatures and oxygen levels varying only slightly from the surface to two feet from the bottom. **SEE FIGURE 17**. Percent saturation of oxygen was scattered in the water column varying from 83 to 95%. The bottom temperature was 35.3 oF and was the warmest temperature in the water column. Oxygen level on the bottom was 2.9 mg/l or 21% saturation. Water secchi clarity was 6.5 feet at which depth there was a slight increase in oxygen saturation.

__November 27, 1996__ With 6" of Ice and 2" of snow temperature stratification had begun with an under the ice temperature of 34.2 oF and 38 oF at 18 feet. **SEE FIGURE 18**. Oxygen levels generally declined from surface to the near bottom but were still above the 5 mg/l necessary to support aquatic organisms. Bottom sediment oxygen levels dropped to zero. The weather was sunny and a secchi disc dropped through the ice could be seen at 7.5', again there was a slight increase in oxygen saturation at that depth.

__December 11, 1996__ 8" of ice had formed and 3-6" of snow covered it. The temperature was fully stratified to the denser water at near 40 oF near the bottom and 33.8 oF under the ice. **SEE FIGURE 19**. Water near the surface was near oxygen saturation but began to drop off quickly at the 6' depth. Below 10 feet the oxygen level dropped below 5 mg/l and saturation levels varied from 0% at the bottom to 40% at 8 feet from the surface. Secchi clarity remained at 6.5 feet. Weather was cloudy as it had been the three days prior. Zooplankton was appeared in the ice augered sampling hole. The aeration system had not been started yet

__December 14, 1996__ The ice was 8" thick but warmer air temperatures had melted the snow and been replaced by water. Three oxygen profiles were taken on this day prior to aeration system start up. The first was taken 40 feet from prior sampling station in the vicinity of the aeration system, the second 100 yards southwest, and a third 225 yards further southwest. **SEE FIGURES 20-22**. The first site profile was similar to the profile taken on December 11 except there was more oxygen present on the surface, bottom, and 2 feet off the bottom than above it. Spring seepage containing oxygen could account for the oxygen near the bottom. At the second sampling site in 20 feet of water the temperature was stratified but oxygen was near saturation down to 8'. Oxygen levels did not drop down below 5 mg/l until between 12 and 14 feet but steadily declined to the bottom sediments. At the third sampling site at a depth of 14 feet the temperature was stratified and oxygen levels were above 5 mg/l to the 10' depth. The increase in surface oxygen above saturation probably occurred from phytoplankton (algae activity) activity that produces oxygen through photosynthesis. Water clarity also increased to 9.5' with the disappearance of the snow cover.

__December 29, 1996__ This profile was completed two weeks after aeration system startup. **SEE FIGURES 23-25**. Ice depth 40' from the edge of the aeration hole was now 12" with 1" of water and 6" of snow on top. Water temperature varied by less than 1.5 degrees form 2' from the surface to the 20' bottom. Oxygen levels were stratified from 6.1 mg/l at the surface to 3.5 mg/l on the bottom. At the second sampling point 100 yards to the southwest, the surface 4 feet were colder but the rest of the temperature profile was the same as at the first location. At 225 yards from the aeration hole in 14' feet of oxygen saturation near the surface declined from 100 feet from the aeration hole but oxygen levels in the 14' depth were slightly higher. Secchi clarity dropped from 10 feet to 9.5 to 9.0 feet as you moved away from the aeration hole.

January 12, 1997 The ice increased to 14" with 3" of snow above. By this date temperature and oxygen stratification was similar at all three sampling sites. **SEE FIGURES 26-28**. Oxygen levels dropped to below 5 mg/l throughout the column and decreased from the surface to the bottom. Air temperatures had dropped to below zero. Secchi readings at all three locations were now at 10 feet.

January 26, 1997 The depth of ice increased to 18 - 20" with a snow depth above of 6". Temperature stratification did not change but oxygen levels and percent of oxygen saturation continued to decline. **SEE FIGURES 29-31.** Low oxygen was still present on the bottom. Secchi disc readings through the ice declined was at 10.5 feet 80' from the edge of open water but dropped to 9.5 feet at the greater distances from the open water. The reading near the edge of open water, at 100 yards, and 225 yards from the aeration hole were all similar.

February 9, 1997 Ice thickness increased to 22" with 8" of snow cover. Again, there was little change in the temperature stratification but the dissolved oxygen and saturation percentage slowly continued to drop. **SEE FIGURES 32-34**. Secchi clarity was 9.5 feet at all locations. A oxygen-temperature profile at the deepest part of the lake on that date found conditions nearly identical to the three sample locations near the aeration system. **SEE FIGURE 35**.

February 23, 1997 ice increased to 24" but snow cover was now gone or was limited to 2-3". Temperature stratification remained the same and oxygen parameters continued to decline slowly at all three sample locations plus the deepest area of the lake. Low oxygen readings were still detectable on the bottom where the oxygen probe could reach(25'). **SEE Figures 36-39**.

February 27, 1997 By this date the Pike Lake Sportsmen purchased an additional compressor to add to the volume of air delivered to the aeration system. 24 hours after the additional compressor was added there was a slight increase in oxygen levels and at the bottom in the open water sampling location 80' from ice edge. **SEE FIGURE 40.**

February 28, 1997 The next day oxygen levels throughout the water column increased only slightly with 1.45 mg/l at the bottom and 1.76 mg/l at the surface. Temperature stratification or difference in temperature from the surface under the ice to the bottom was narrowed to 1.9 oF. **SEE FIGURE 41**.

March 2, 1997 Three days later the oxygen levels in the lower 4 feet had returned to those found 24 hours after startup. Additional aeration was not alleviating the low oxygen conditions of Pike Lake. **SEE FIGURE 42**.

__March 15, 1997__ A snow storm occurred before the next sampling date leaving from 12 to 24" of snow on the ice. Ice on this date was now 22" at the aeration hole and 25" and other locations sampled on the lake.

A secchi disc reading through the ice 50' from the edge of the aeration hole indicated a water clarity of 9 feet in 20' 6" of water. Oxygen saturations beneath the ice were slightly higher than the uniform saturations found from 4 feet to the bottom. Oxygen levels had raised approximately 0.5 ppm since the March 2 reading. Was this from the aeration or snow melt in the tributaries above? The same seechi readings were found 125 and 250 yards west south of this site. Near bottom oxygen saturations were slightly lower as you moved from the aeration hole but this probably due to the shallower water encountered rather than the effects of the aeration system. **SEE FIGURES 43-45.**

At the deepest hole in the lake, far away from the aeration system, temperature stratification was the same as at the aeration hole. Oxygen levels ranged from 1.95 ppm just beneath the ice to 0.8 at 25 feet (the deepest the probe cord could reach). This was further verification that the aeration system was not working. **SEE FIGURE 46.**

Dissolved oxygen levels were also recorded at the Rice Lake outlet and the Rice Creek inlet to Pike Lake, and at the dam outlet during the aeration system evaluation system. Temperature and oxygen levels at the Rice Creek inlet and dam outlet were similar to those found near the surface of Pike Lake under the ice. The outlet of Rice Lake had lower oxygen levels earlier in the winter than the Pike Lake readings but were 1.0 mg/l higher later in the winter. If Rice Creek was clear of debris and did not act as an oxygen barrier, Rice Lake could become an oxygen refuge under the ice for fish in the Pike Lake system.

__March 31, 1997__ Spring snow melt was occurring that opened up Rice Lake Creek. The creek entered Pike Lake at 4.91 mg/l of oxygen at 38.1 oF for a saturation of 37%. The readings at the dam outlet after passing through the still froze over Pike Lake was 3.95 mg/l at 37.4 oF for a saturation of 29%. Over the next two weeks oxygen levels in Pike Lake Creek raised to 9.12 mg/l as the temperature rose to 49.1 oF for a oxygen saturation of 80%. Ice off on Pike Lake did not occur until two weeks later on April 15. **SEE FIGURE 47.**

Inspection of the aeration system in the spring revealed that the main oxygen distribution line had been twisted and broken and compressor oxygen had been released at a single point. This added very little oxygen to the lake during the severe winter. The data collected did document the extent of low oxygen conditions beneath the ice during severe winter conditions.

FIGURE 17 . Pike Lake Oxygen/ Temperature Profile 11/12/96.

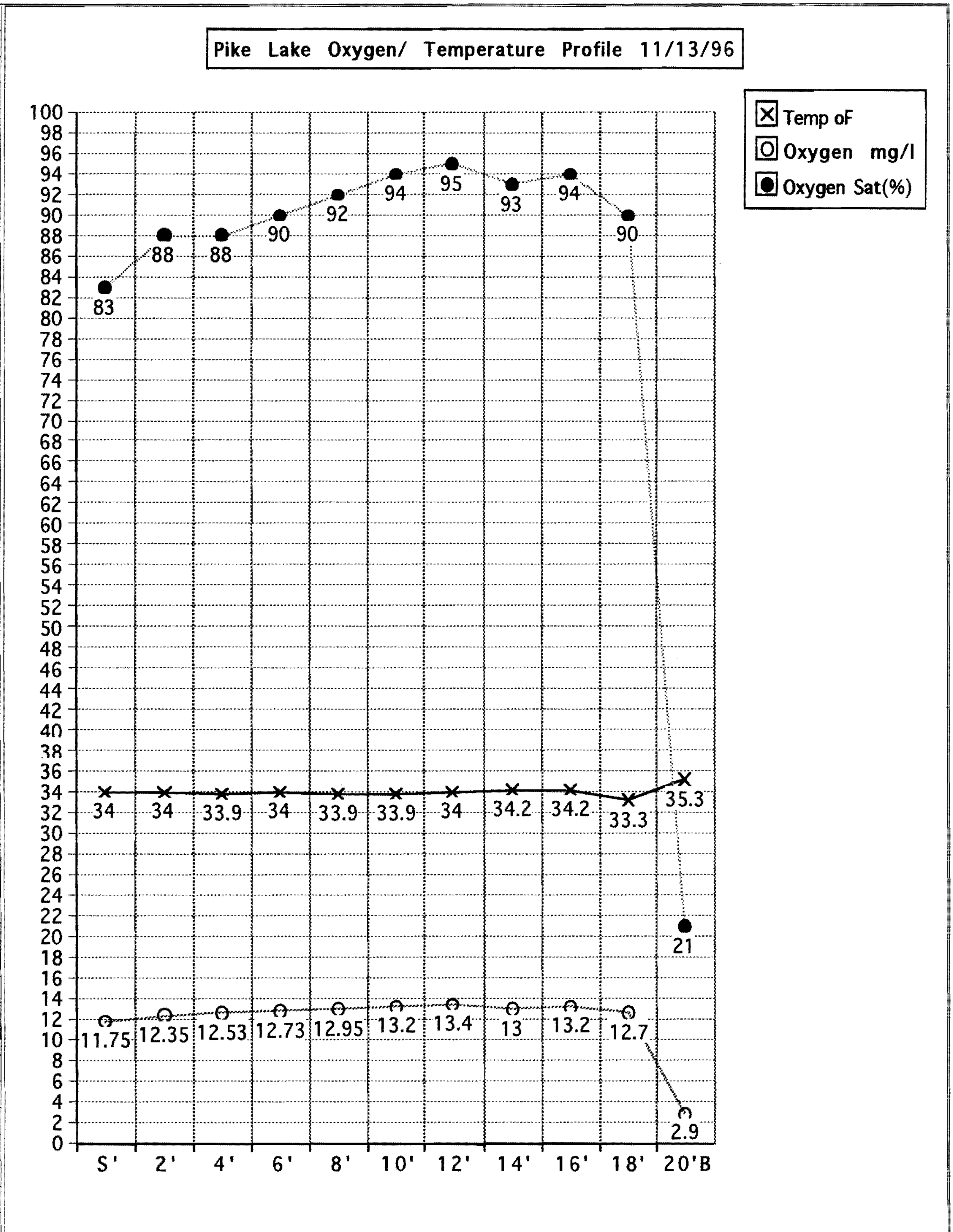
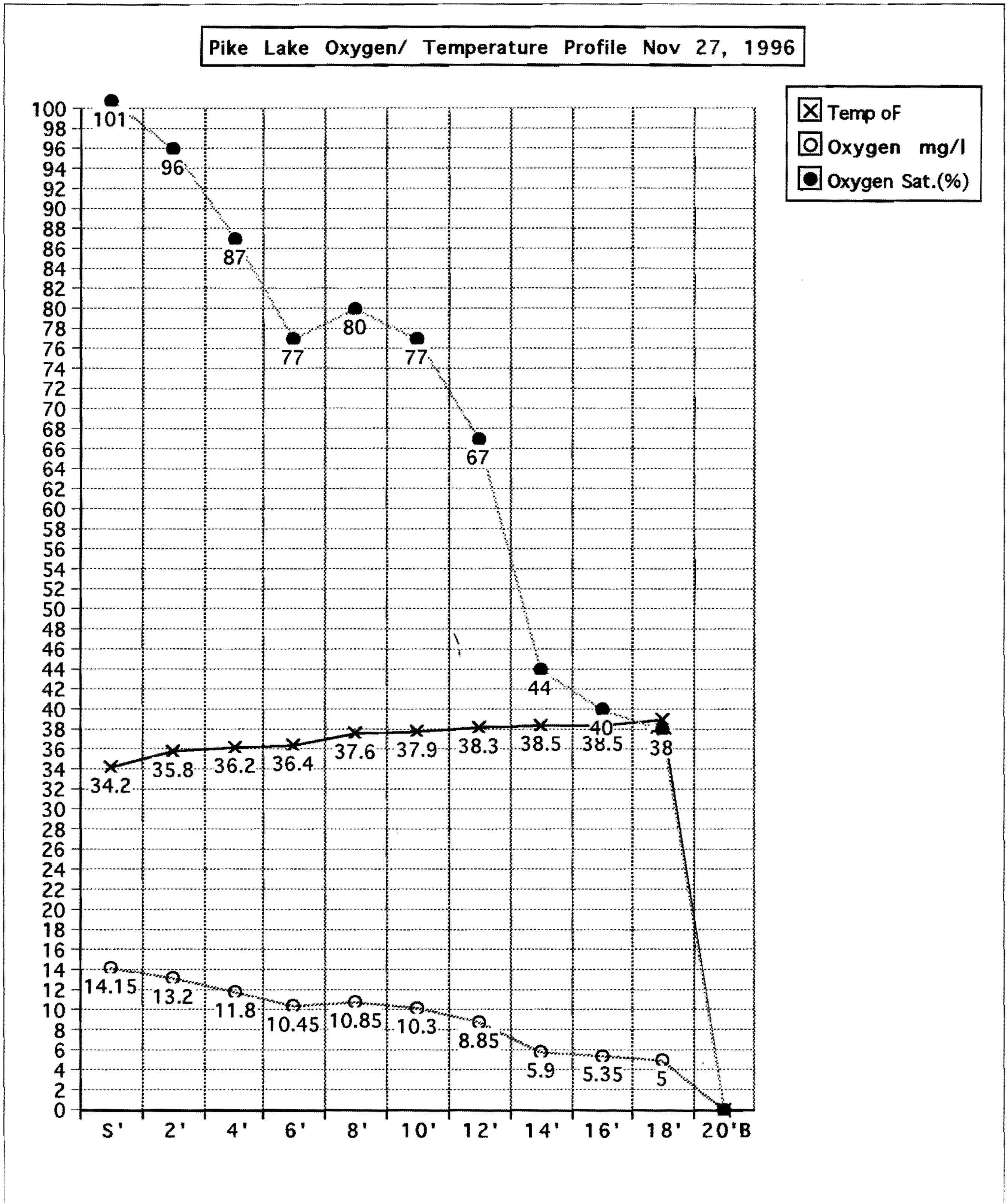


Figure 18. Pike Lake Oxygen/ Temperature Profile 11/27/96



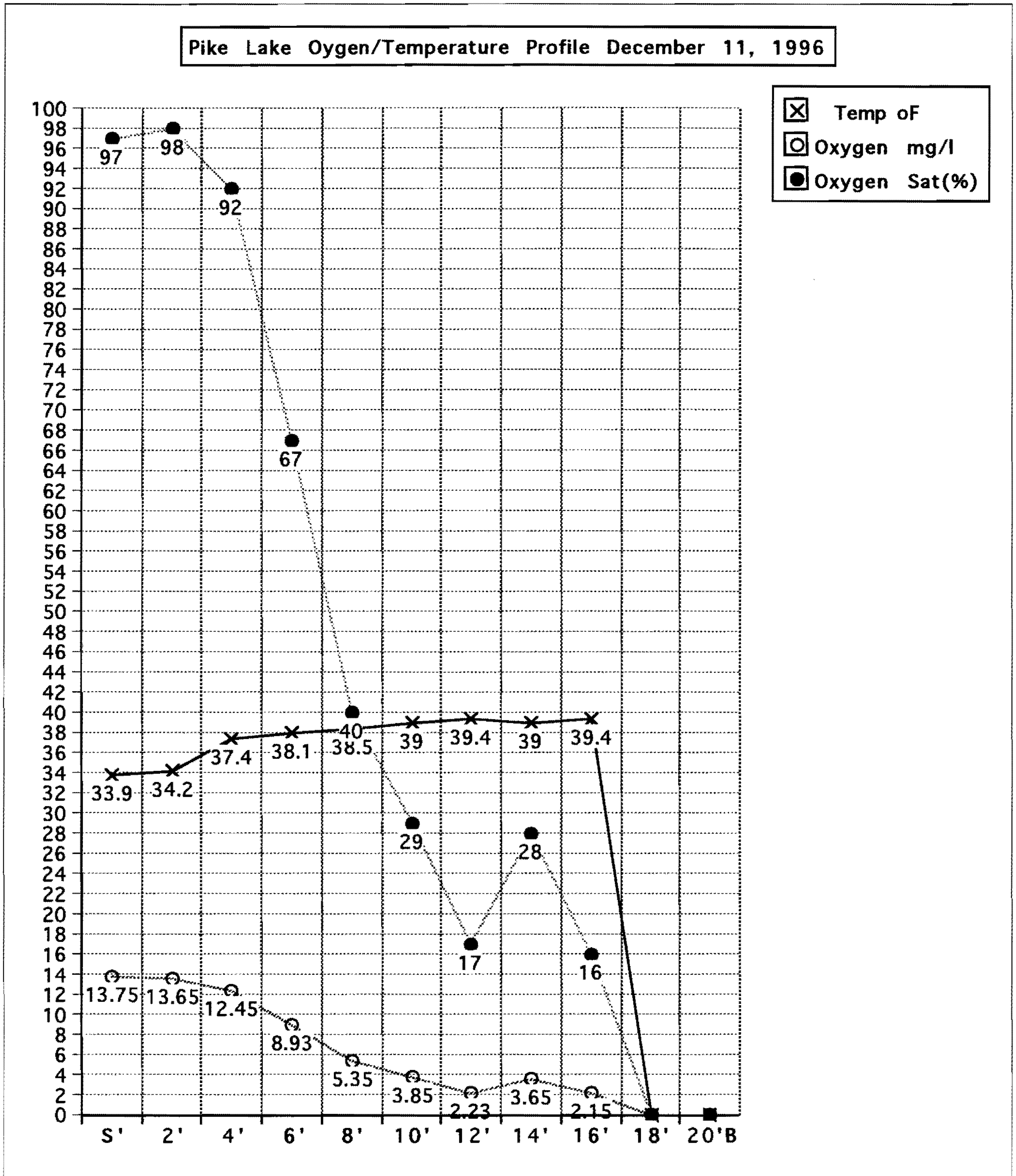
Notes: 6"Ice, 2" Snow

Weather: Mostly Sunny 19 H,7 L, 11-26-96 Sunny 20H,2L, 11-25-96 Sunny 25H,8L

Time: 9:30-12:30

Water Clarity: Secchi 7.5'

Figure 19 . Pike Lake Oxygen/ Temperature Profile 12/11/96.



COMMENTS: Water under Snow in Areas of Pike Lake

-open water around bridge where sampled

Weather Prior

12-8 Cloudy, H 29oF, L 24oF

12-9 Cloudy, H 27 oF, L 20oF

12-10,Cloudy, H 33oF, L 29oF

12-11, Mostly Cloudy

-zooplankton in hole

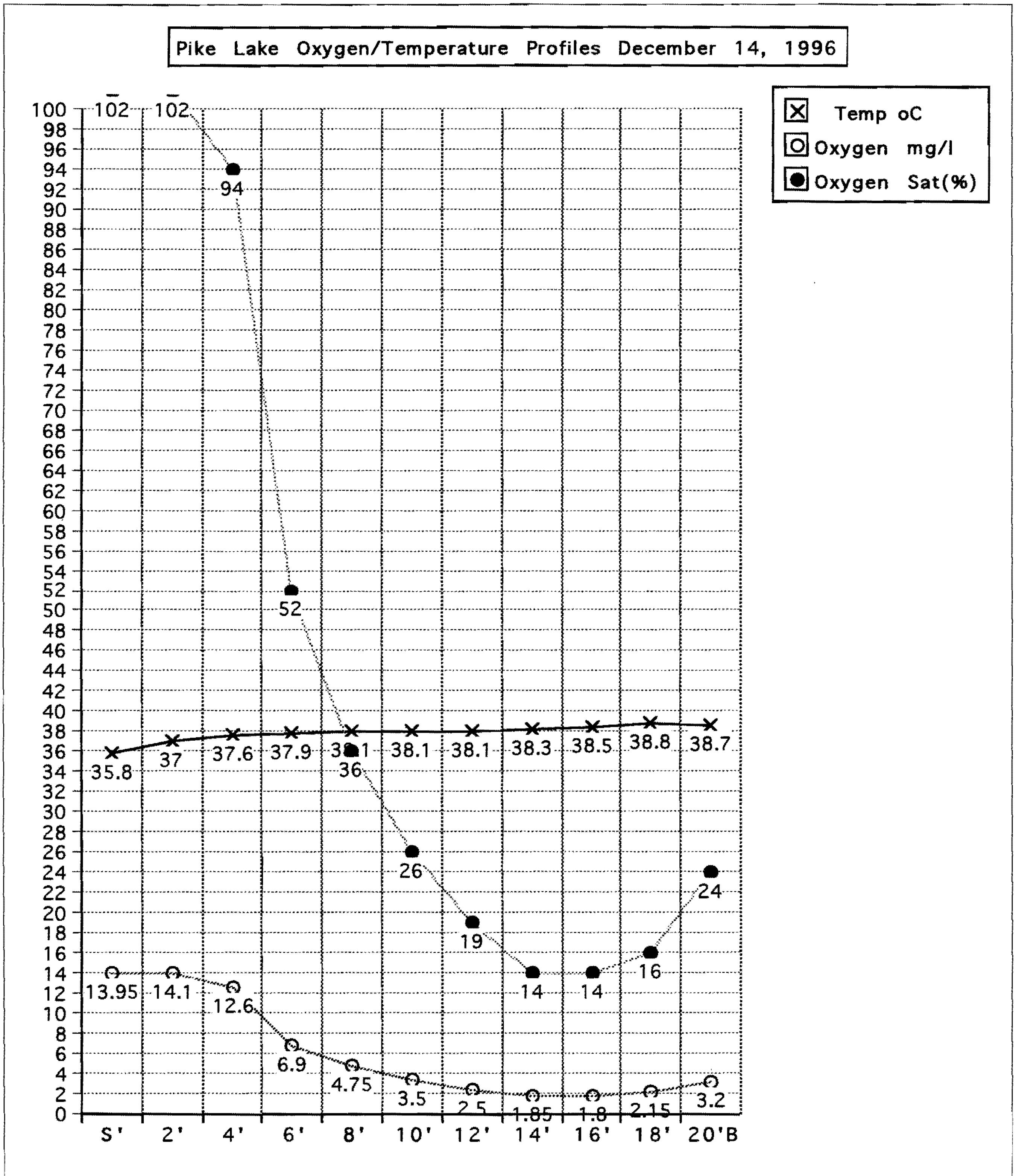
-Lake w/ 8" ic 3-6" Snow

Secchi Readi 6.5'

Depth of Ice 8"

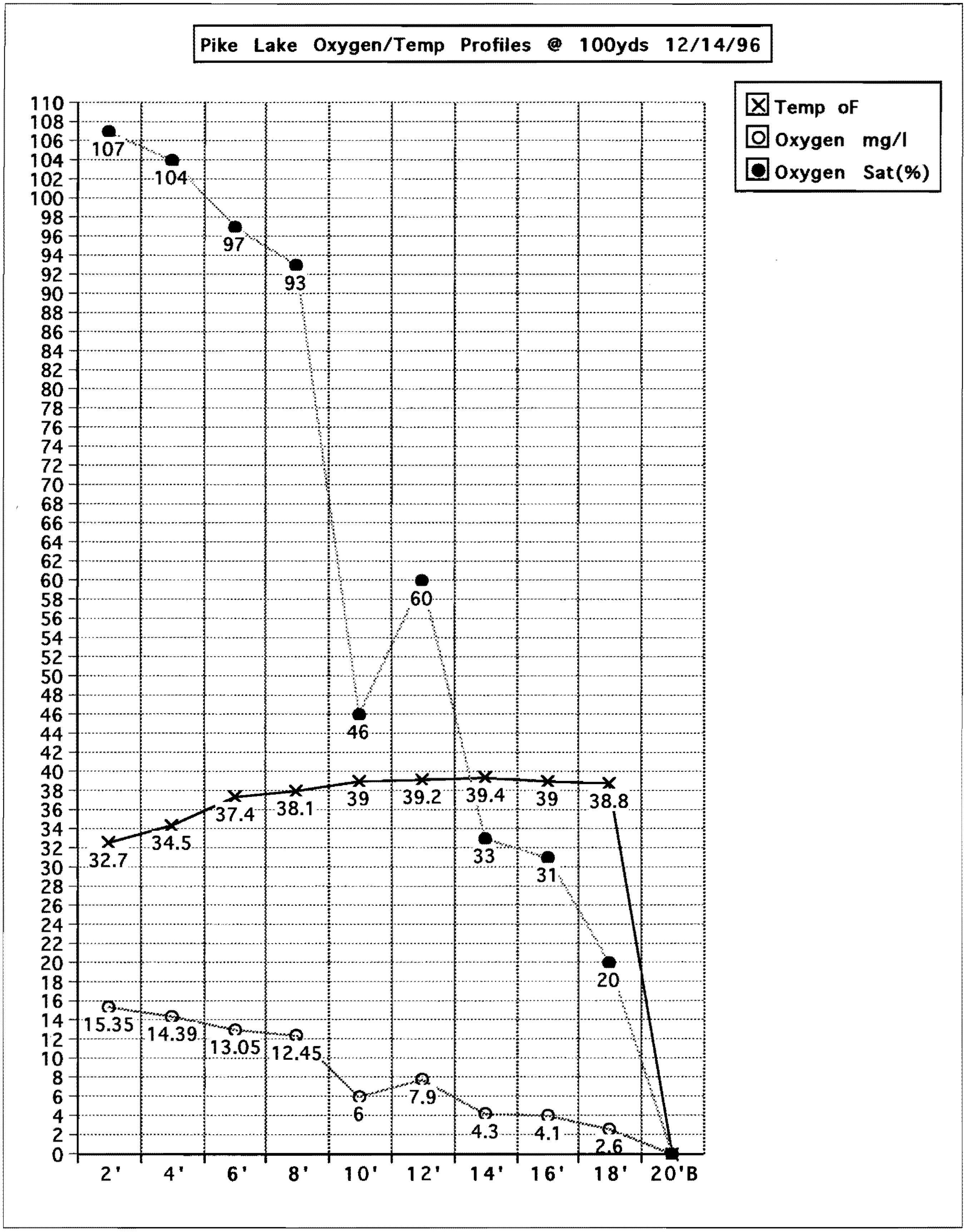
Depth of Sno 3"

Figure 20. Pike Lake Oxygen-Temperature Profiles 12/14/96



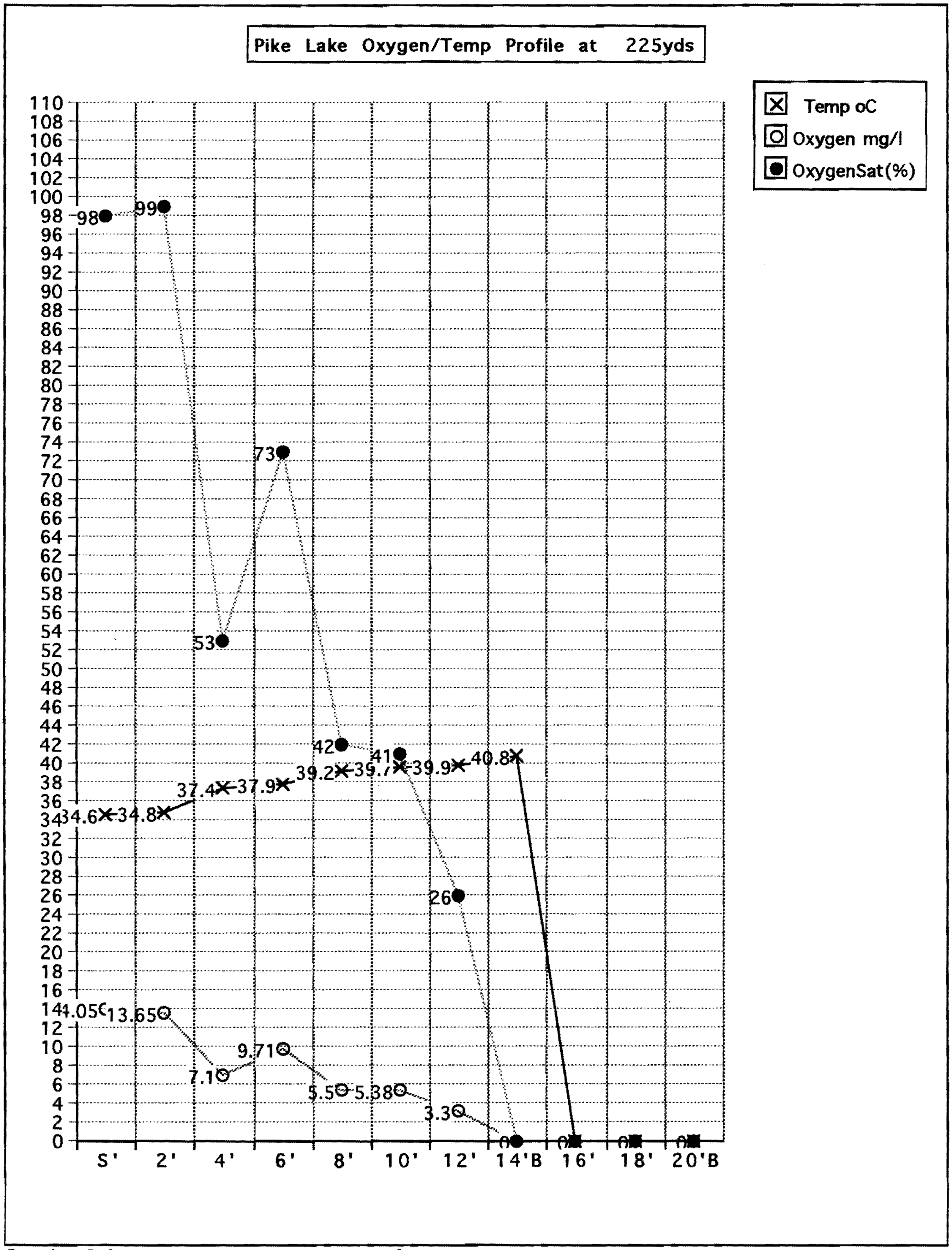
Aeration Area:	Center/Hole Edge
40' frm ice edge	
Secchi Reading:	9.5'
Depth of Ice	8" w/ water
Depth of Snow	0

Figure 21. Pike Lake Oxygen-Temperature Profiles 12/14/96



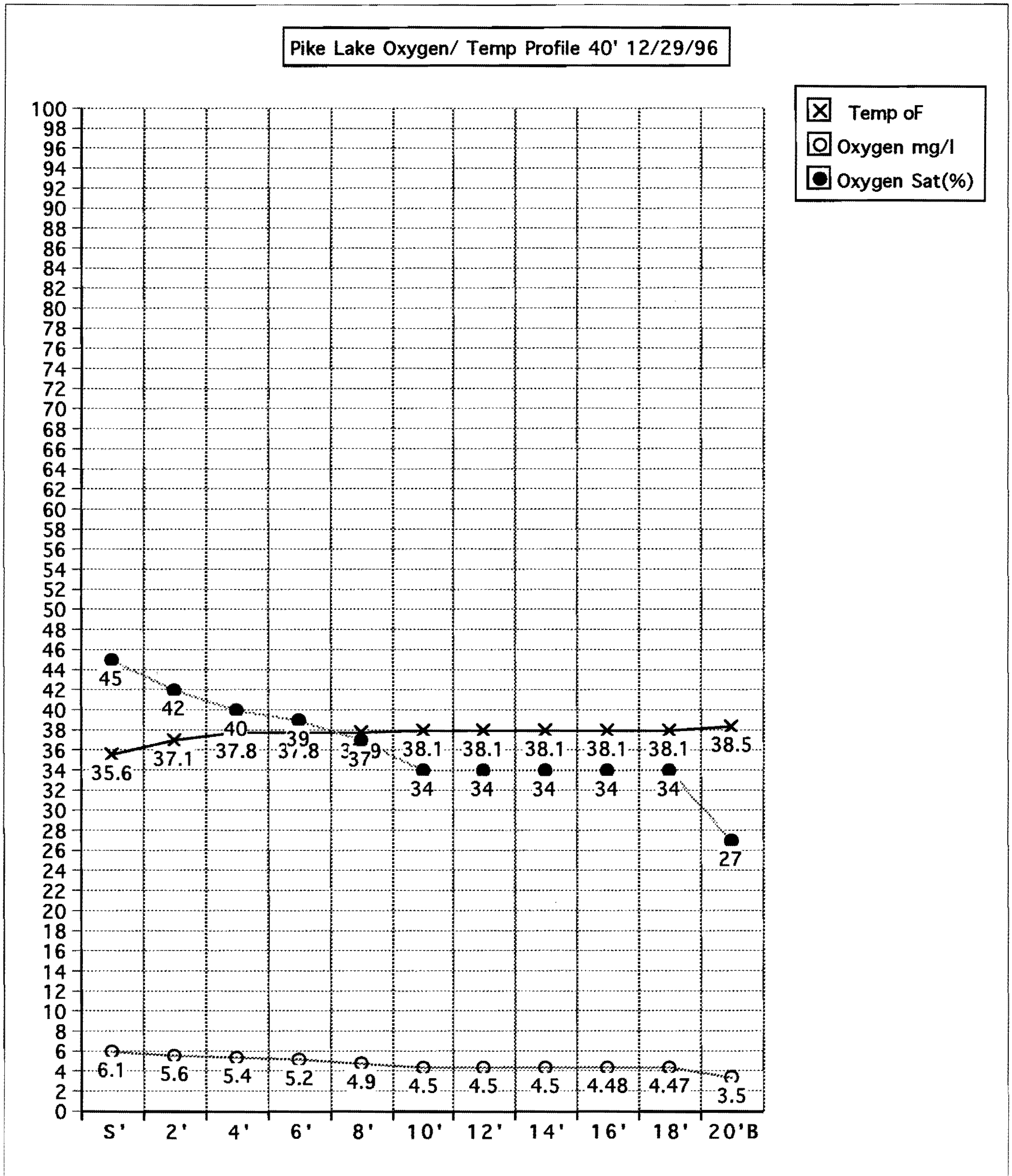
Secchi Readi 9.5'
Depth of Ice 8" w/ water
Depth of Sno 0 54

Figure 22. Pike Lake Oxygen-Temperature Profiles 12/14/96



Depth of Snow 0

Figure 23. Pike Lake Oxygen/ Temperature Profiles 12/29/96

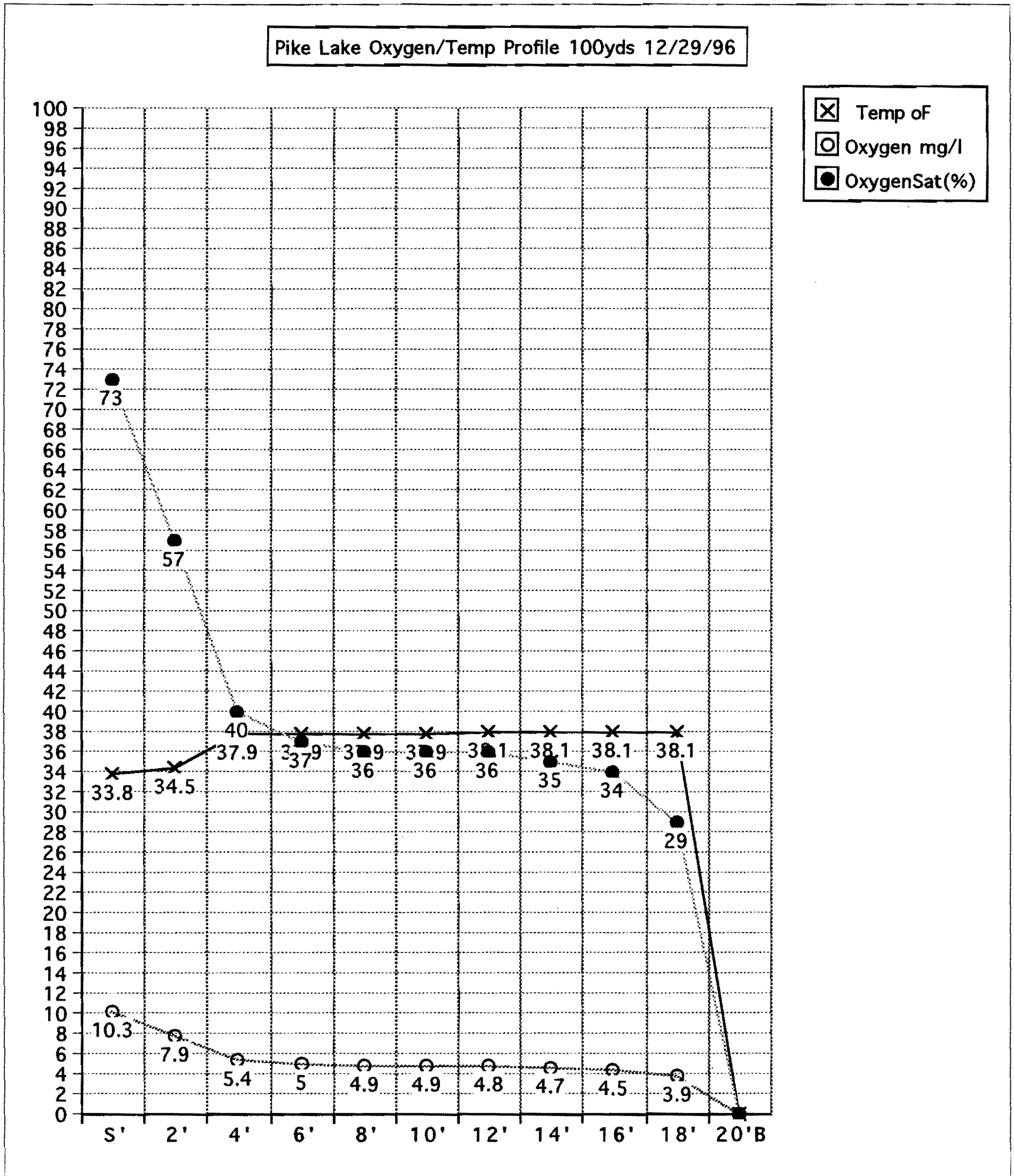


Dist fr Edge of Open H20
40 feet
Dist fr Cter of Open H20

Secchi Readi 10'
Depth of Ice 12"w/1"H20
Depth of Sno 6"

COMMENTS: Lake Level Down 9" from Bench Mark
WEATHER: 20oF at 1200-1300
12/28 High 27 Low 19 Cloudy
12/29 High 20 Low 10 Mostly Cloudy

Figure 24. Pike Lake Oxygen/ Temperature Profiles 12/29/96

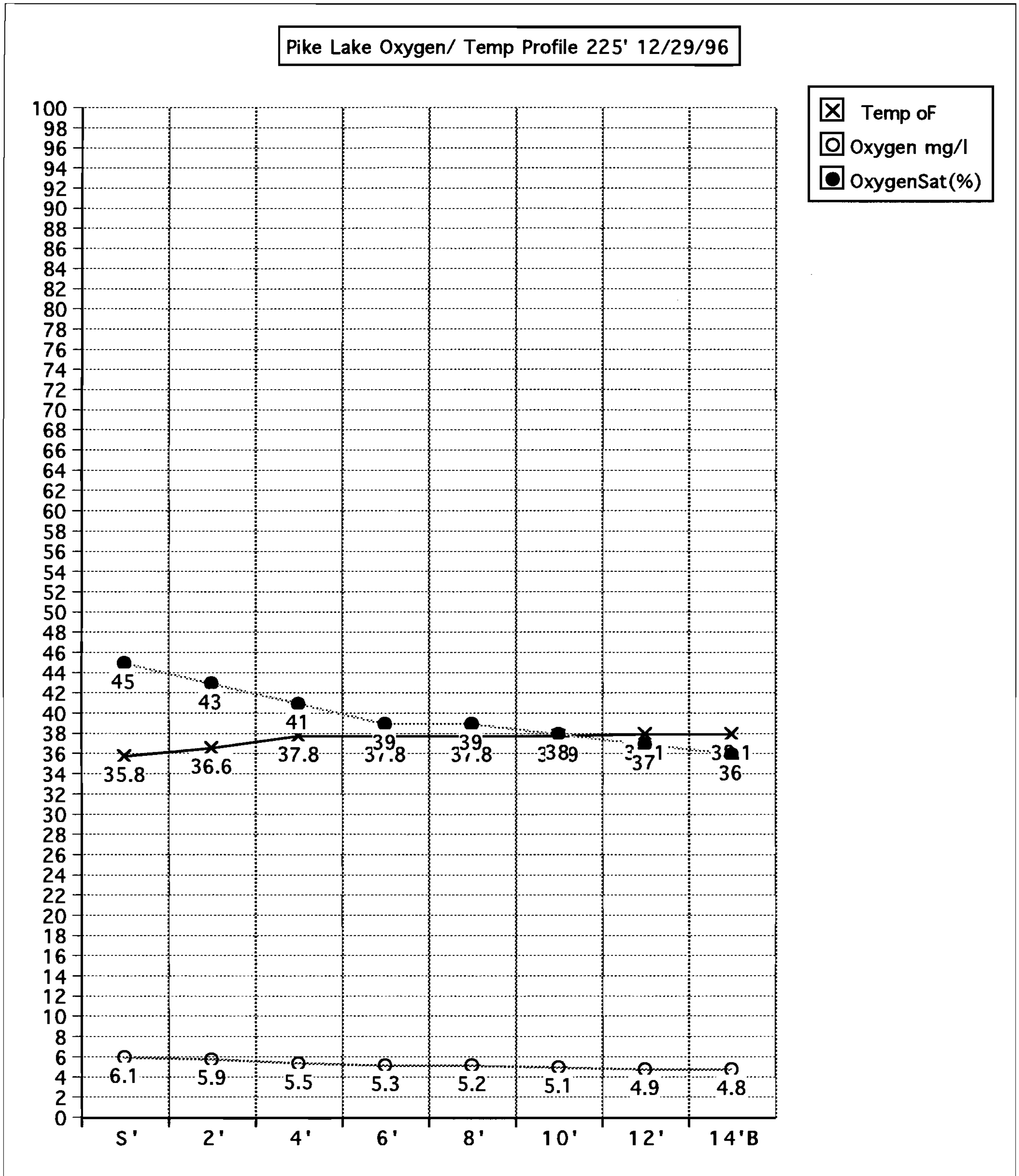


Dist fr Edge of Open H20
100 yards
Dist fr Cter of Open H20

Secchi Readi 9.5'
Depth of Ice 12"w/1"H20
Depth of Sno 6"

COMMENTS: Lake Level Down 9" from Bench Mark
WEATHER: 20oF at 1200-1300
12/28 High 27 Low 19 Cloudy
12/29 High 20 Low 10 Mostly Cloudy

Figure 25. Pike Lake Oxygen/ Temperature Profiles 12/29/96

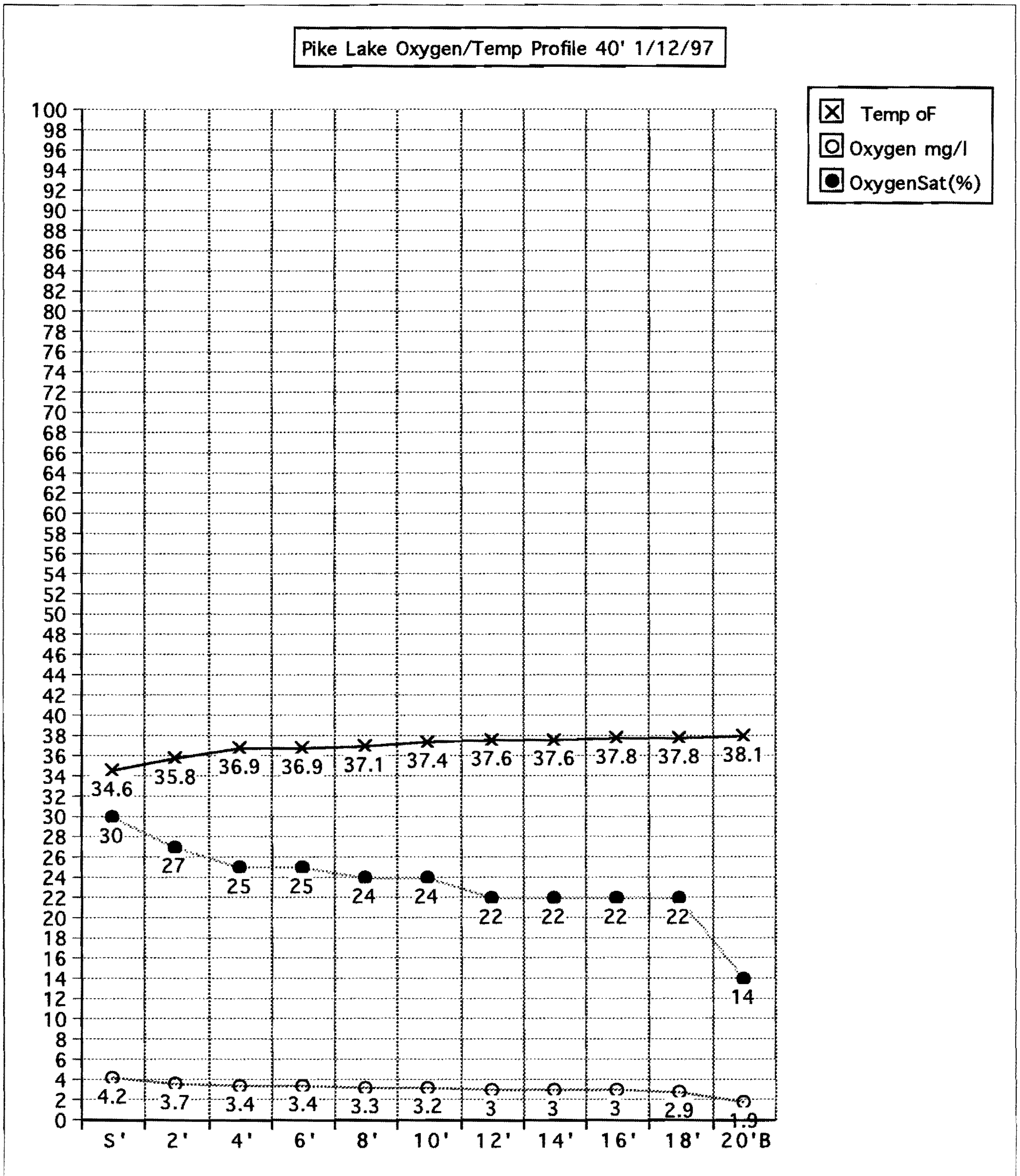


Dist fr Edge of Open H20
225 yards
Dist fr Cter of Open H20

Secchi Readi 9.0'
Depth of Ice 12"w/1"H20
Depth of Sno 6"

COMMENTS: Lake Level Down 9" from Bench Mark
WEATHER: 20oF at 1200-1300
12/28 High 27 Low 19 Cloudy
12/29 High 20 Low 10 Mostly Cloudy

Figure 26 . Pike Lake Oxygen/ Temperature Profiles 1/12/97

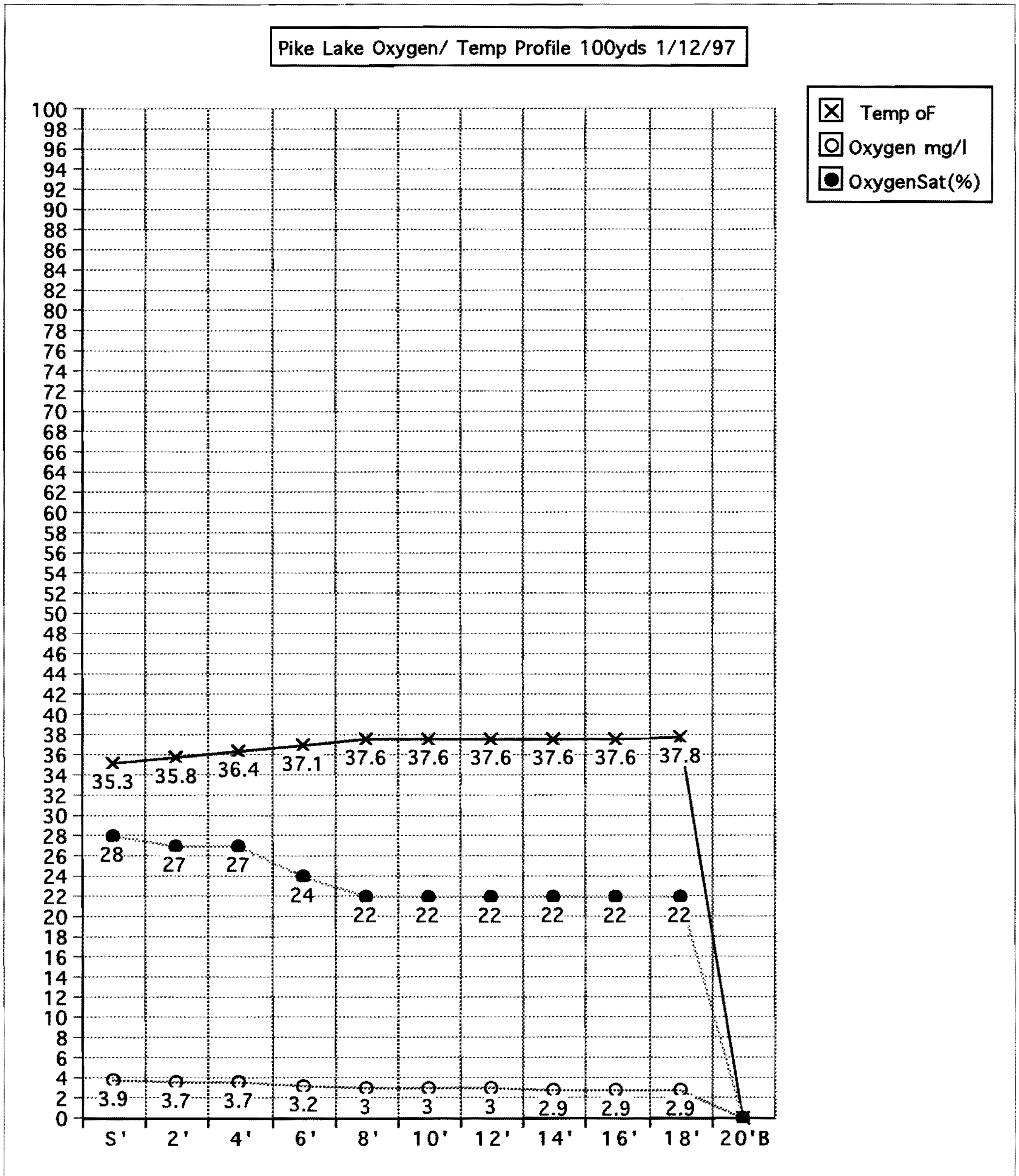


Dist fr Edge of Open H20
40 Feet
Dist fr Cter of Open H20

Secchi Readi 10'
Depth of Ice 14"
Depth of Sno 3"

COMMENTS:
WEATHER" -10 oF at 8:30-10:30
11/11 High 6, Low -6, Partly Cloudy
11/12 High 10, Low -10, Partly Cloudy

Figure 27. Pike Lake Oxygen/ Temperature Profiles 1/12/97

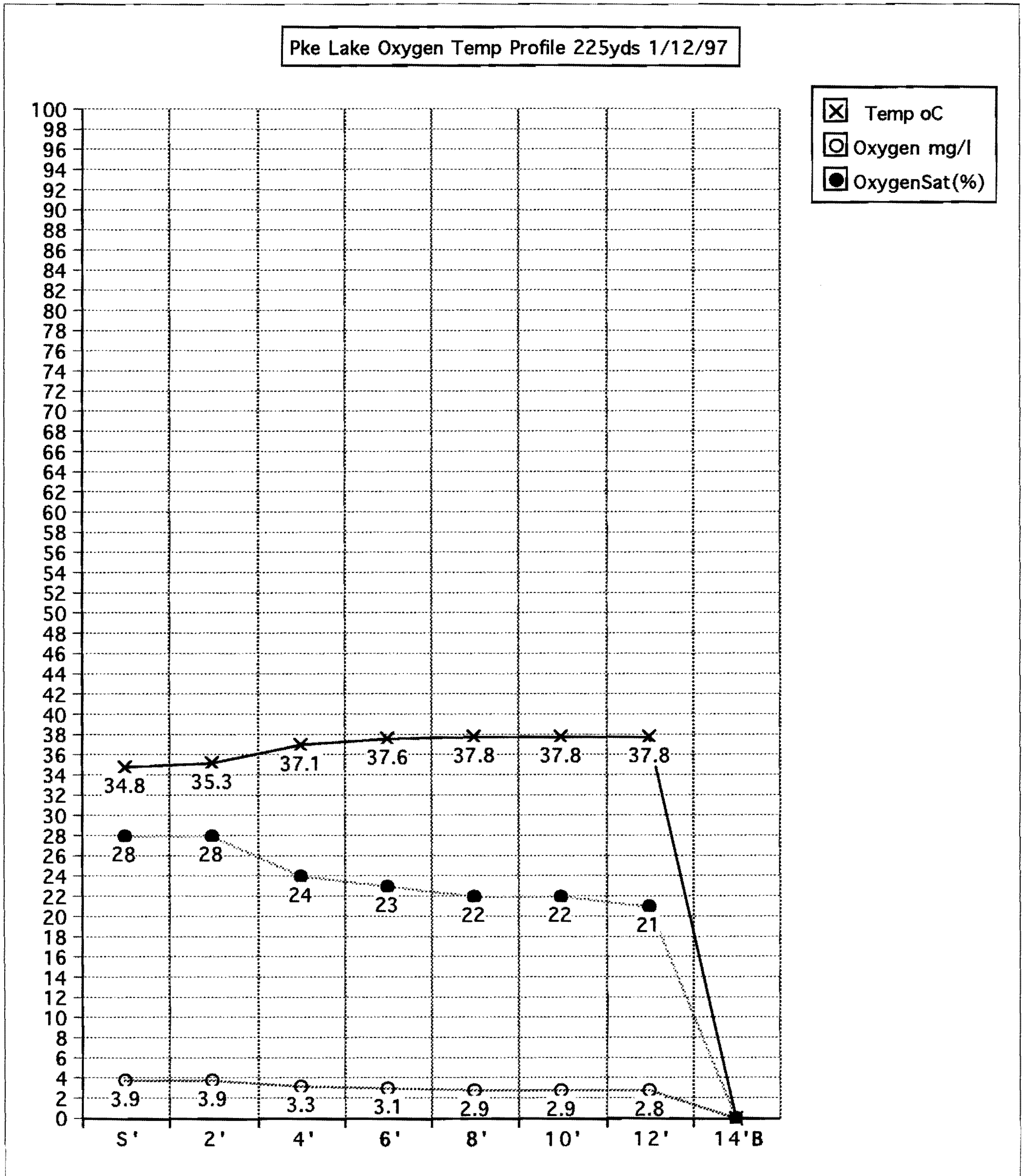


Dist fr Edge of Open H20
100 yards
Dist fr Cter of Open H20

Secchi Readi 10'
Depth of Ice 14"
Depth of Sno 3"

COMMENTS:
WEATHER" -10 oF at 8:30-10:30
11/11 High 6, Low -6, Partly Cloudy
11/12 High 10, Low -10, Partly Cloudy

Figure 28. Pike Lake Oxygen/ Temperature Profiles 1/12/97

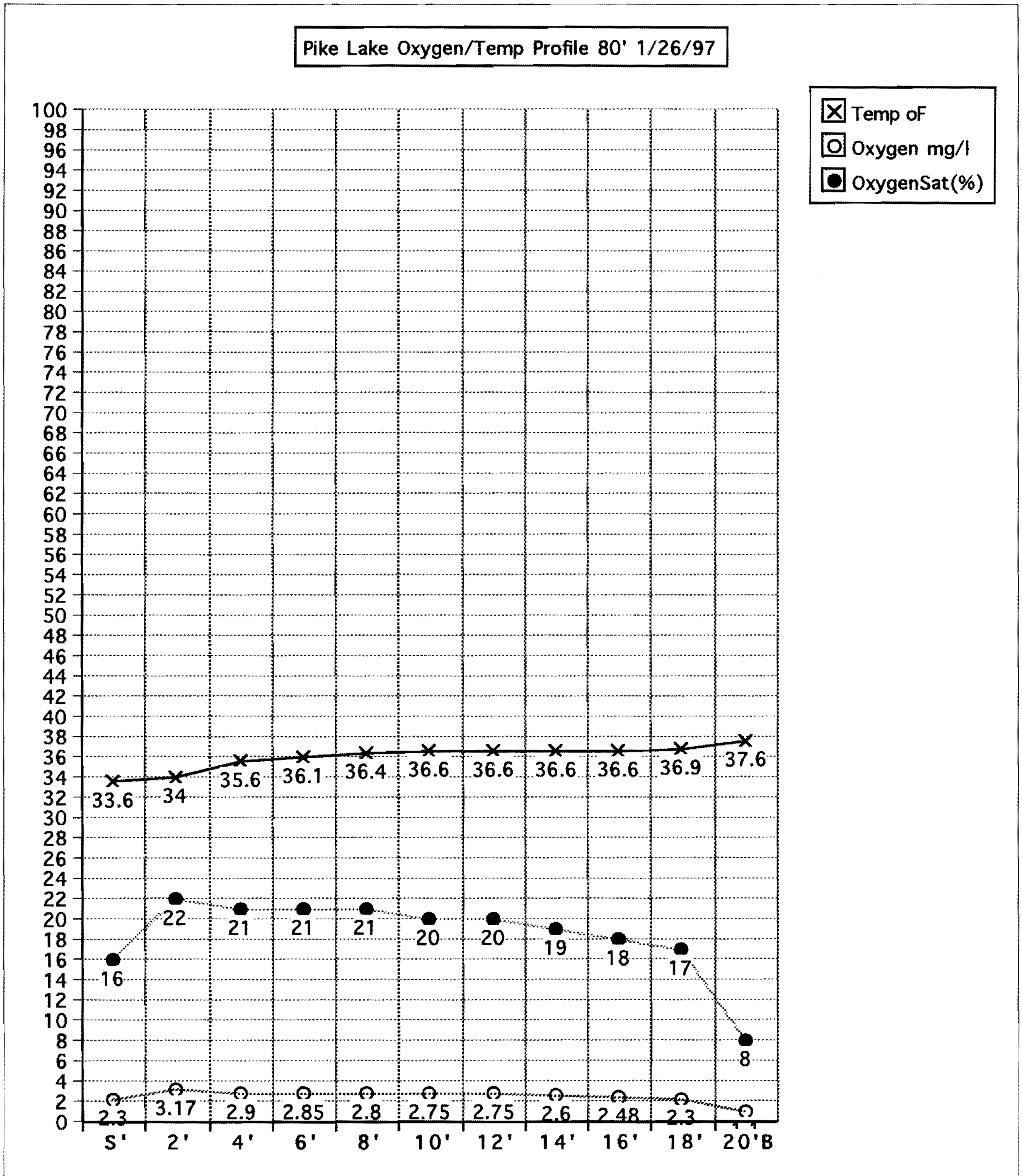


Dist fr Edge of Open H20
225 yards
Dist fr Cter of Open H20

Secchi Readi 10'
Depth of Ice 14"
Depth of Sno 3"

COMMENTS:
WEATHER" -10 oF at 8:30-10:30
11/11 High 6, Low -6, Partly Cloudy
11/12 High 10, Low -10, Partly Cloudy

FIGURE 29. Pike Lake Oxygen/Temperature Profile 1/26/97

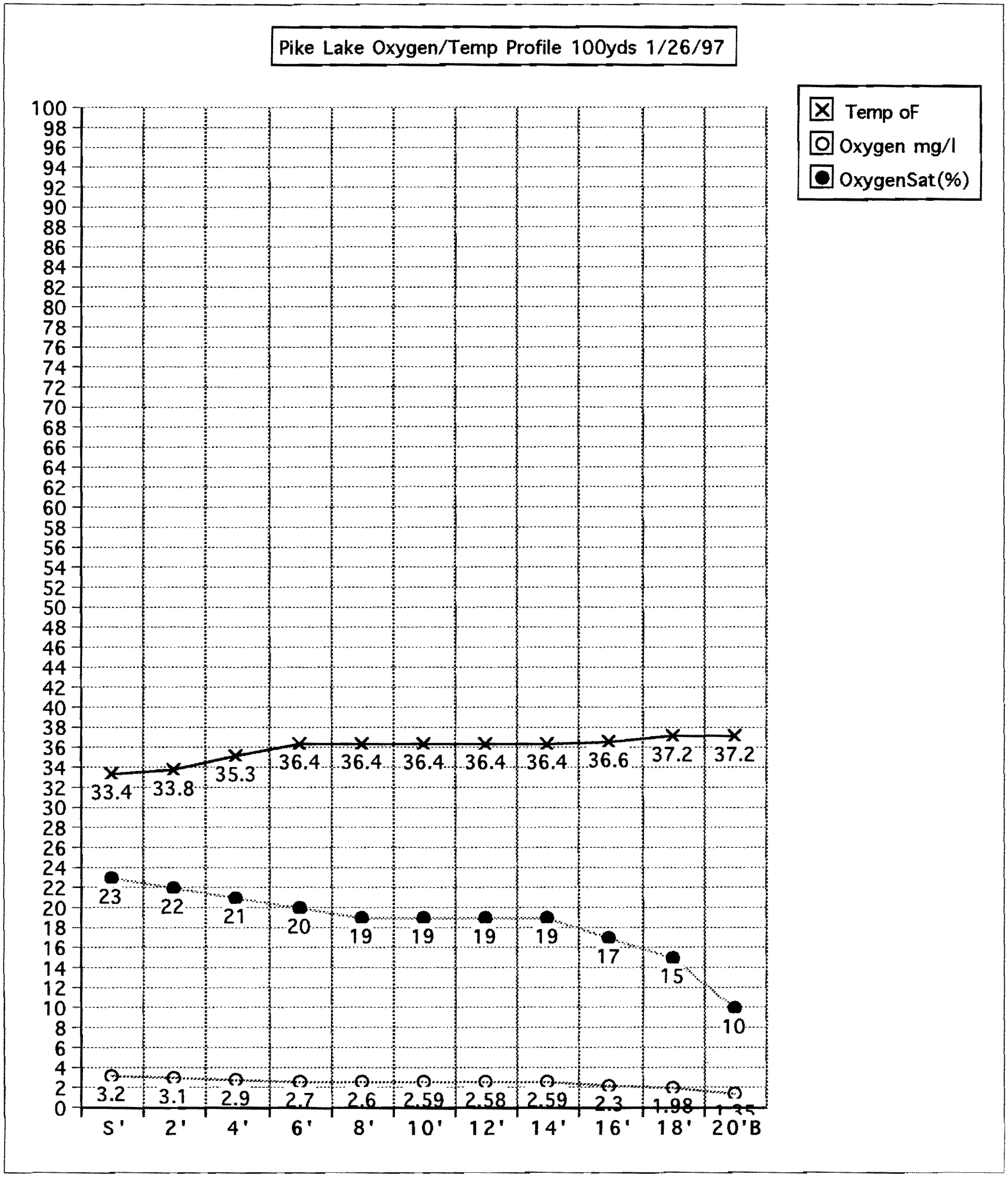


Dist fr Edge of Open H20
80 feet
Dist fr Cter of Open H20

Secchi Readi 10.5'
Depth of Ice 19"
Depth of Sno 6"

COMMENTS: 1/26 Temperature:-10 oF

FIGURE 30. Pike Lake Oxygen/Temperature Profile 1/26/97

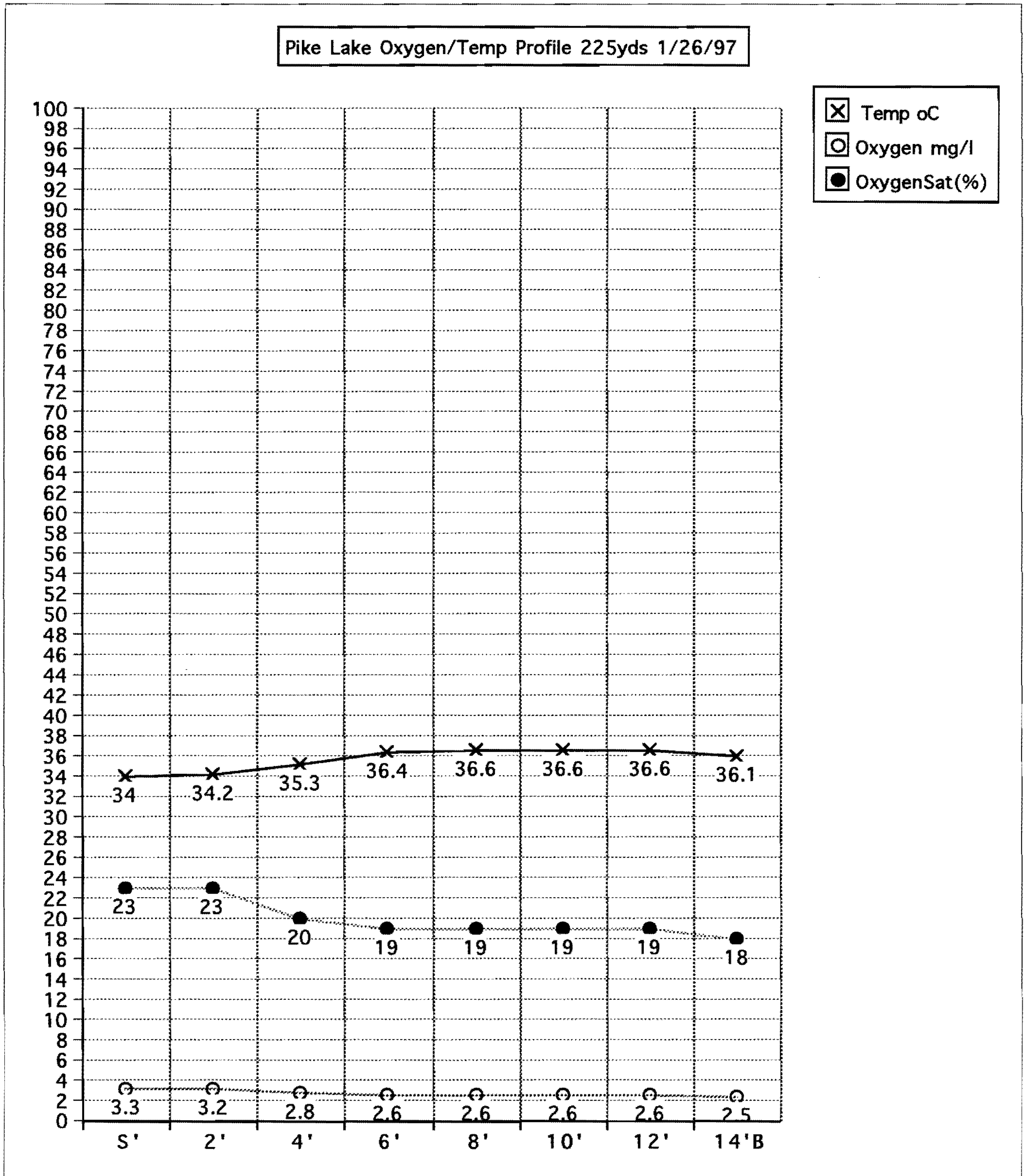


Dist fr Edge of Open H20
100 Yards
Dist fr Cter of Open H20

Secchi Readi 9.5'
Depth of Ice 20"
Depth of Sno 6"

COMMENTS: 1/26 Temperature:-10 oF

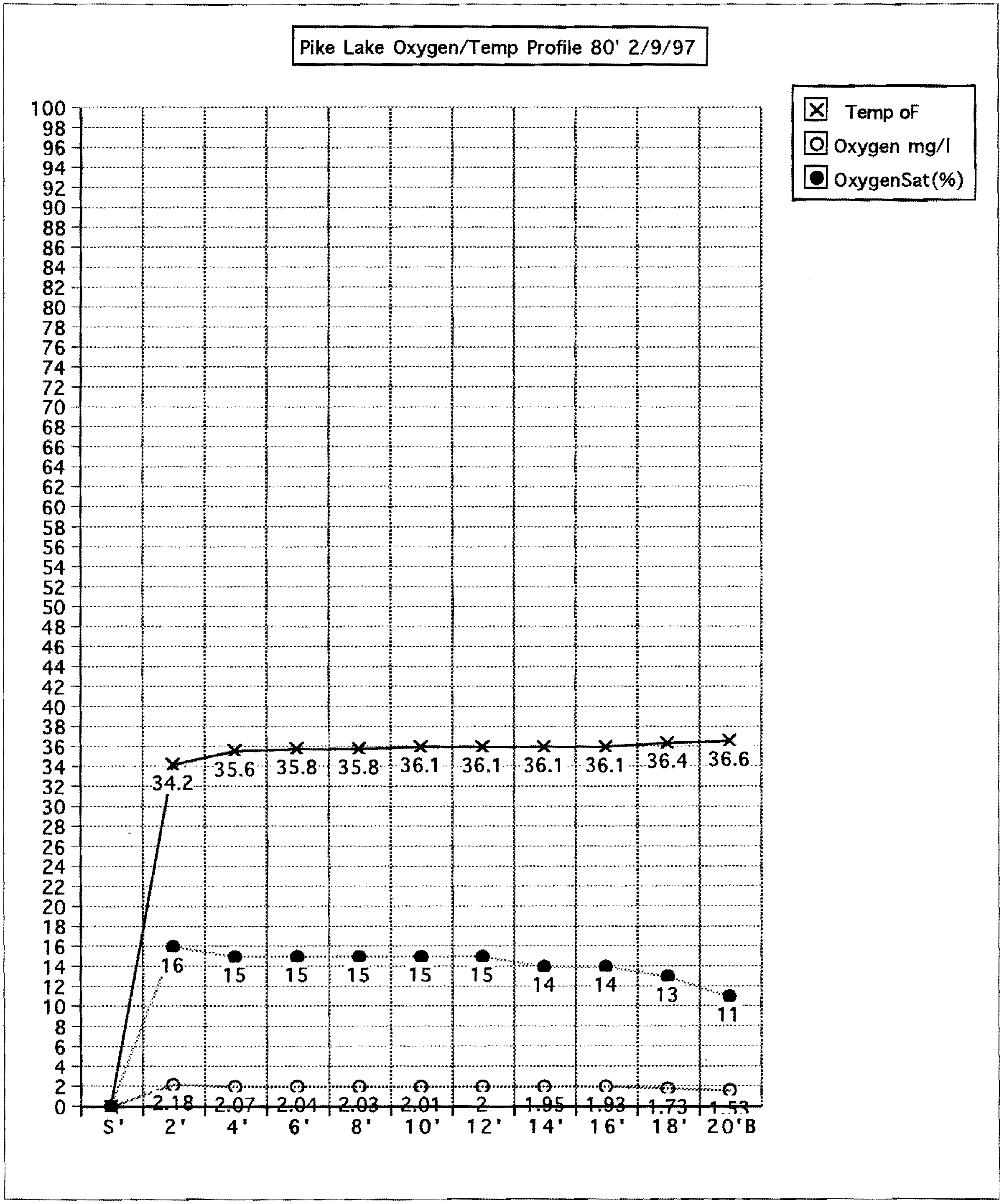
FIGURE 31. Pike Lake Oxygen/Temperature Profile 1/26/97



Dist fr Edge of Open H20
225 Yards
Dist fr Cter of Open H20

Secchi Reading:	9.5'	COMMENTS: 1/26 Temperature:-10 oF
Depth of Ice	18"	
Depth of Snow	6"	

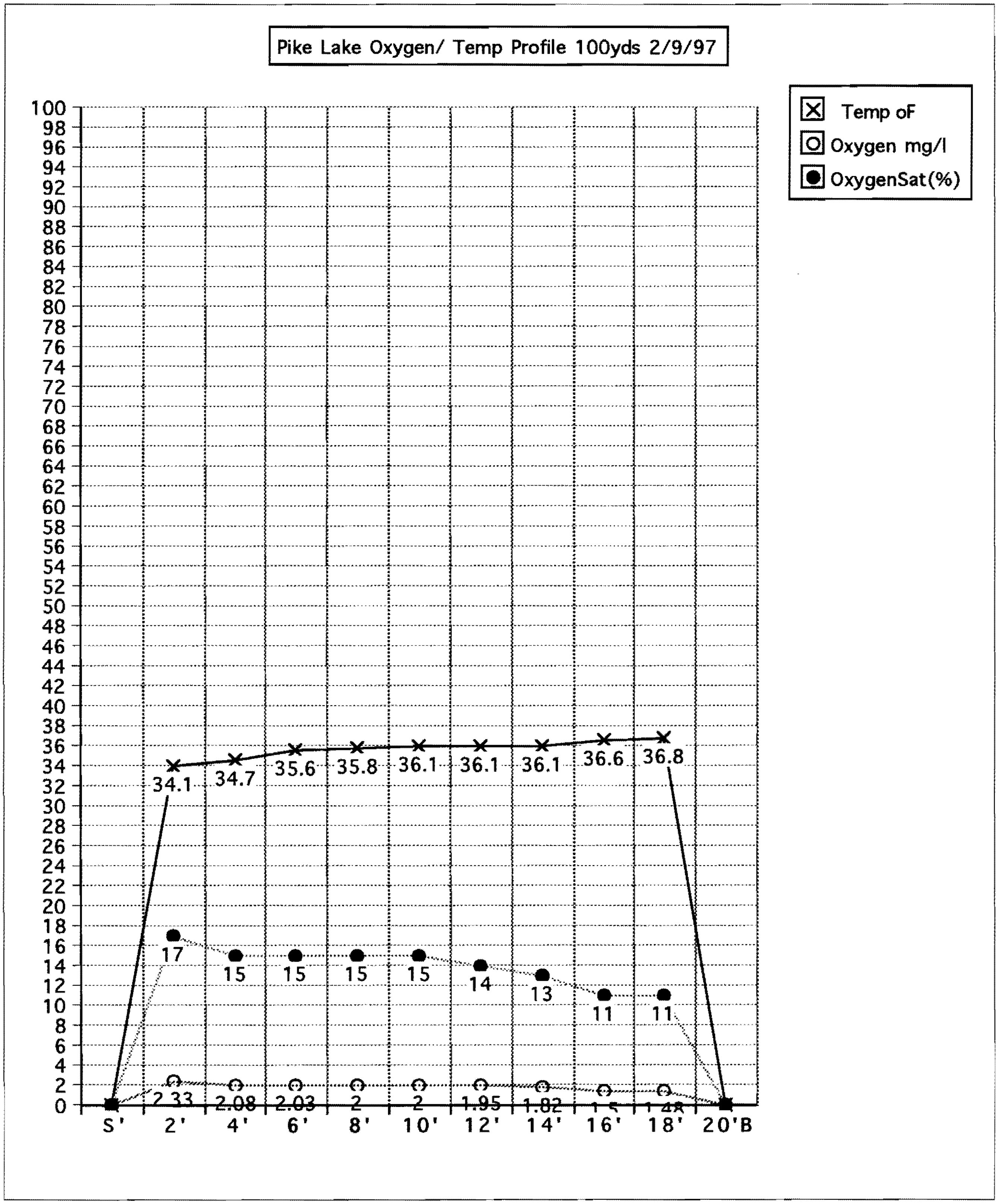
Figure 32. Pike Lake Oxygen/ Temperature Profiles 2/9/97



Secchi Readi 9.5'
Depth of Ice 22"
Depth of Sno 8"

COMMENTS: 15 oF, Sunny

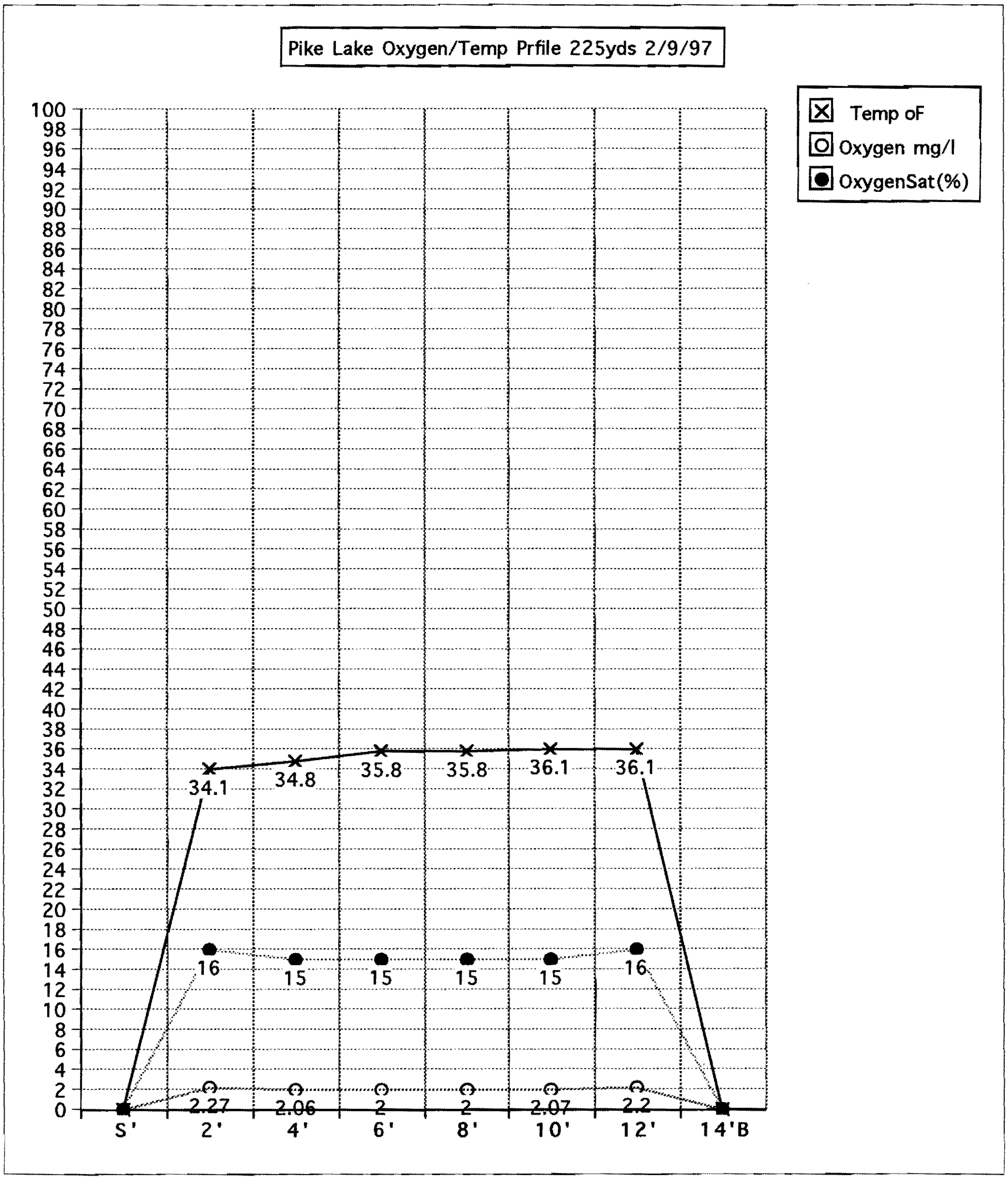
Figure 33. Pike Lake Oxygen/ Temperature Profiles 2/9/97



Secchi Reading:	9.5'
Depth of Ice	22"
Depth of Snow	8"

COMMENTS: 15 oF, Sunny

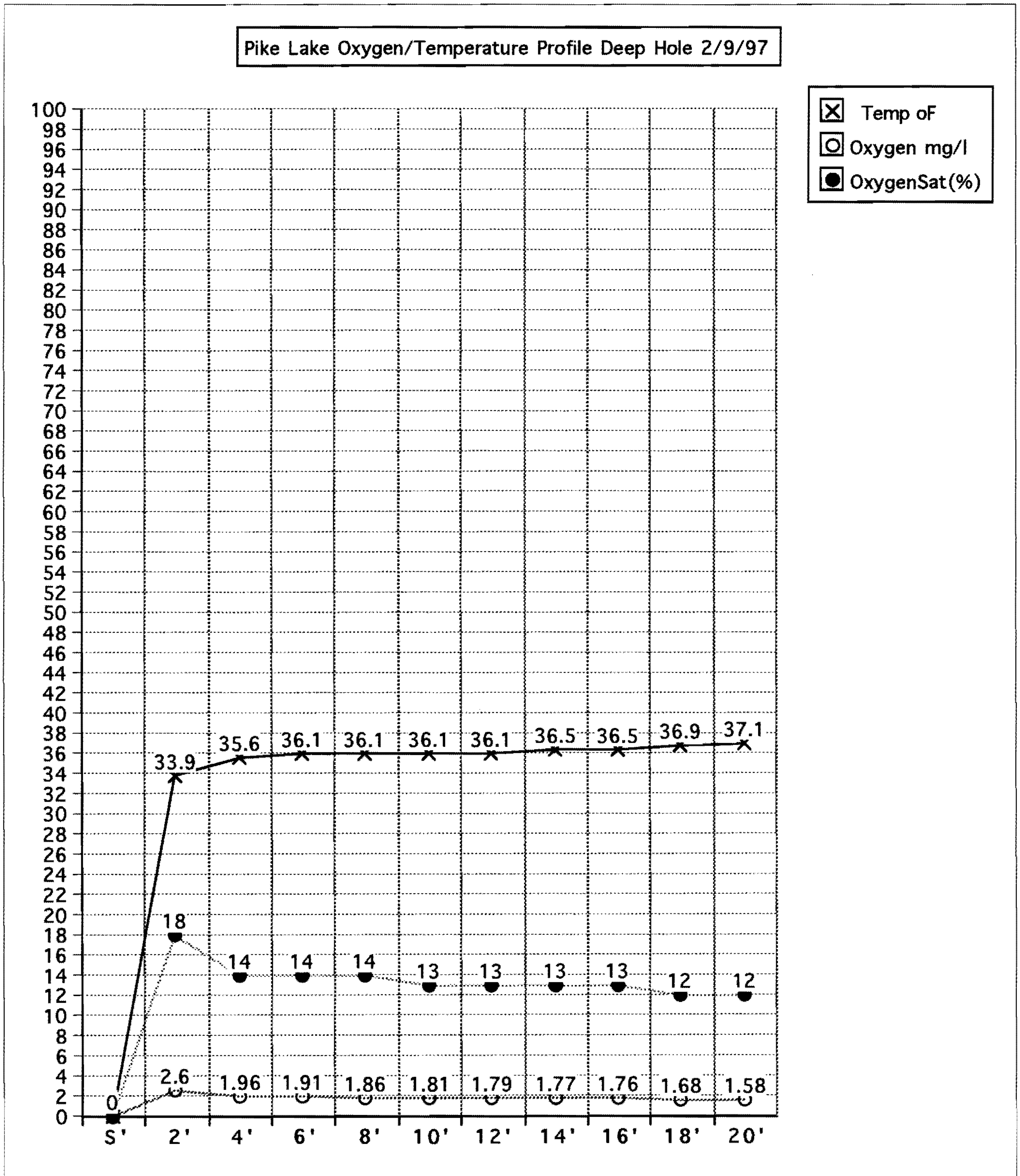
Figure 34. Pike Lake Oxygen/ Temperature Profiles 2/9/97



Secchi Reading:	9.5'
Depth of Ice	22"
Depth of Snow	8"

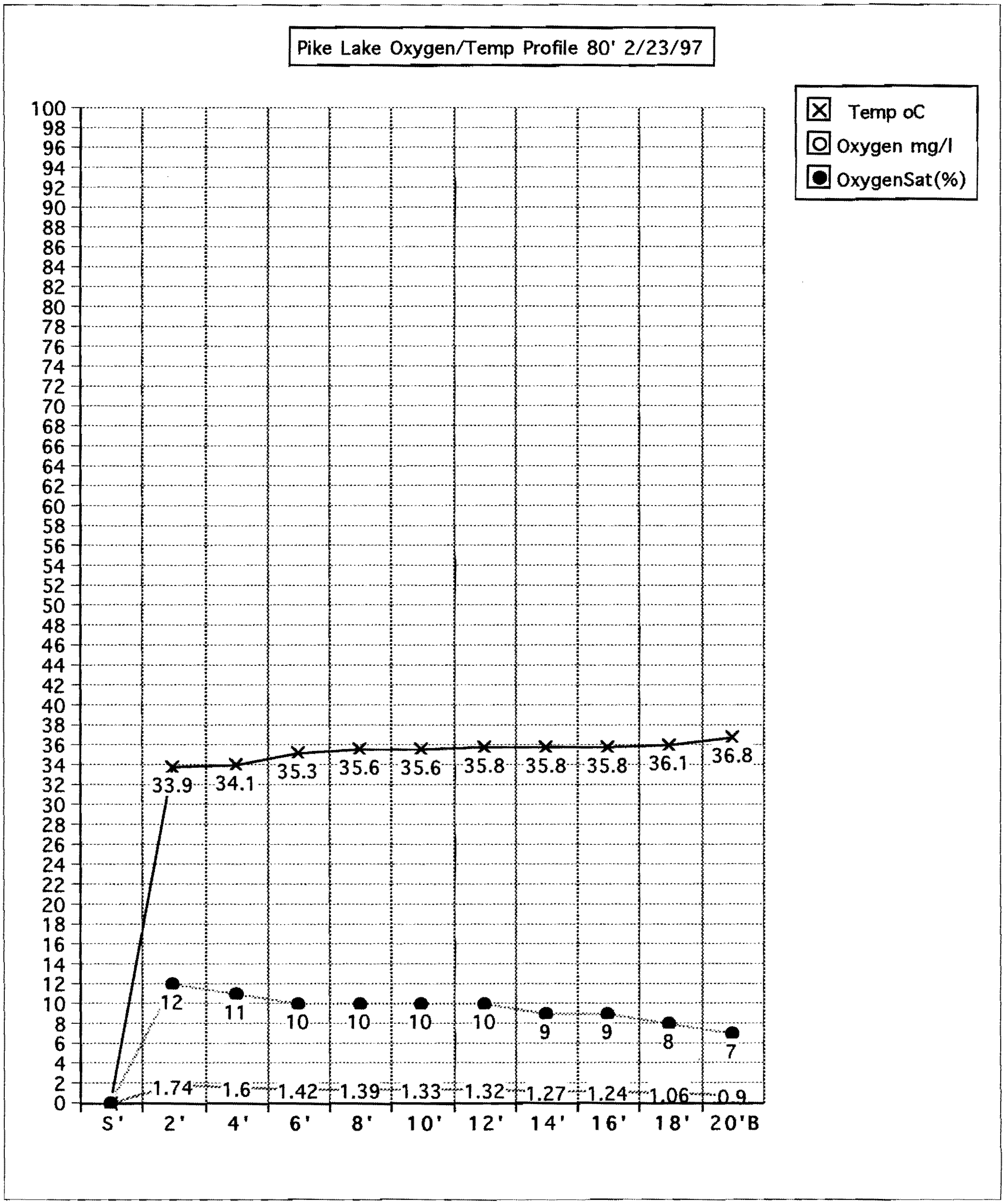
COMMENTS: 15 oF, Sunny

Figure 35. Pike Lake Oxygen Temperature Profiles 2/9&23/97 & 3/15/97



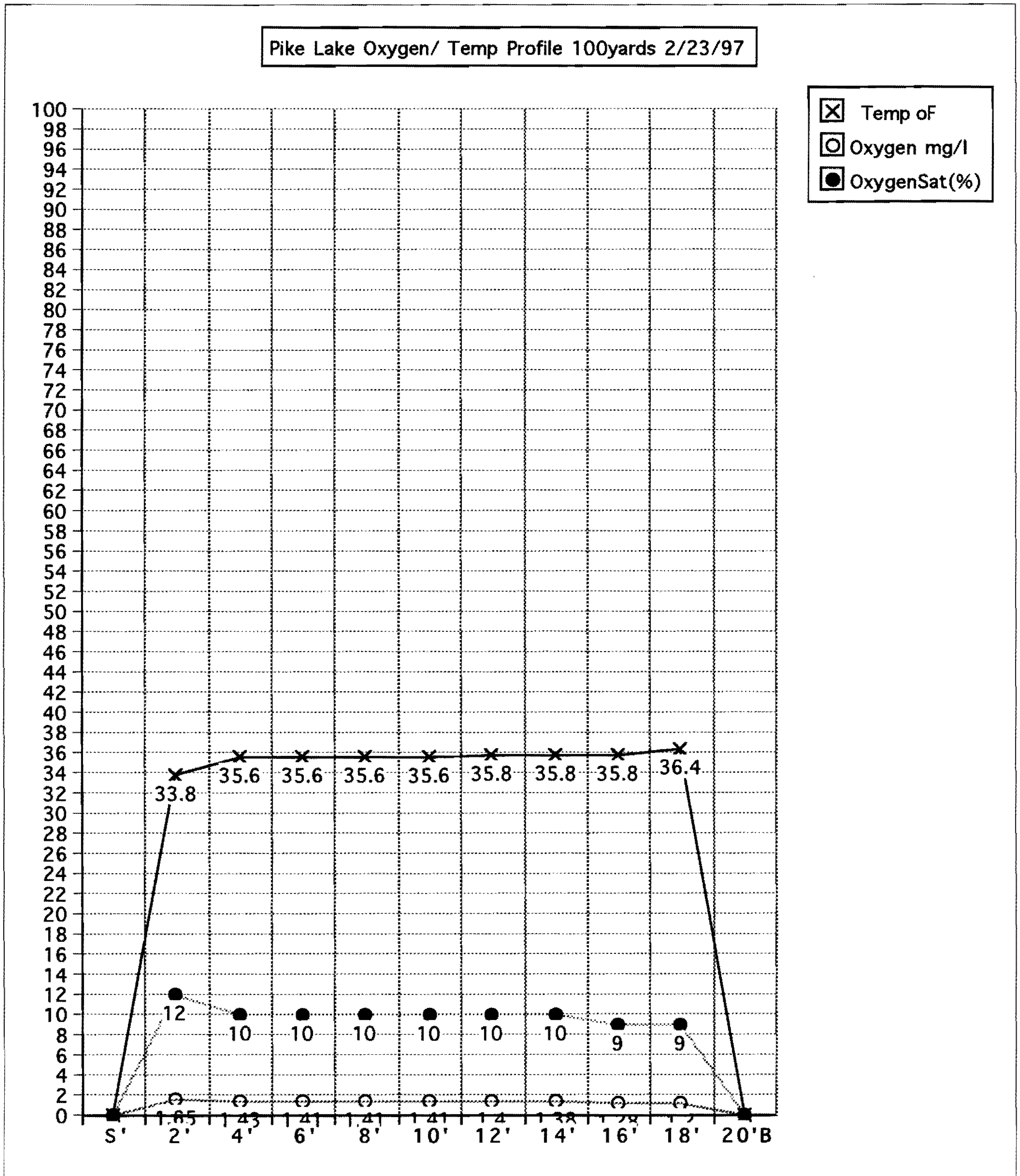
Secchi: 9.5'
Ice: 22"
Snow: 8"

FIGURE 36. Pike Lake Oxygen/Temperature Profiles 2/23/97



Secchi Reading:
Depth of Ice 24"
Depth of Snow 0-3"

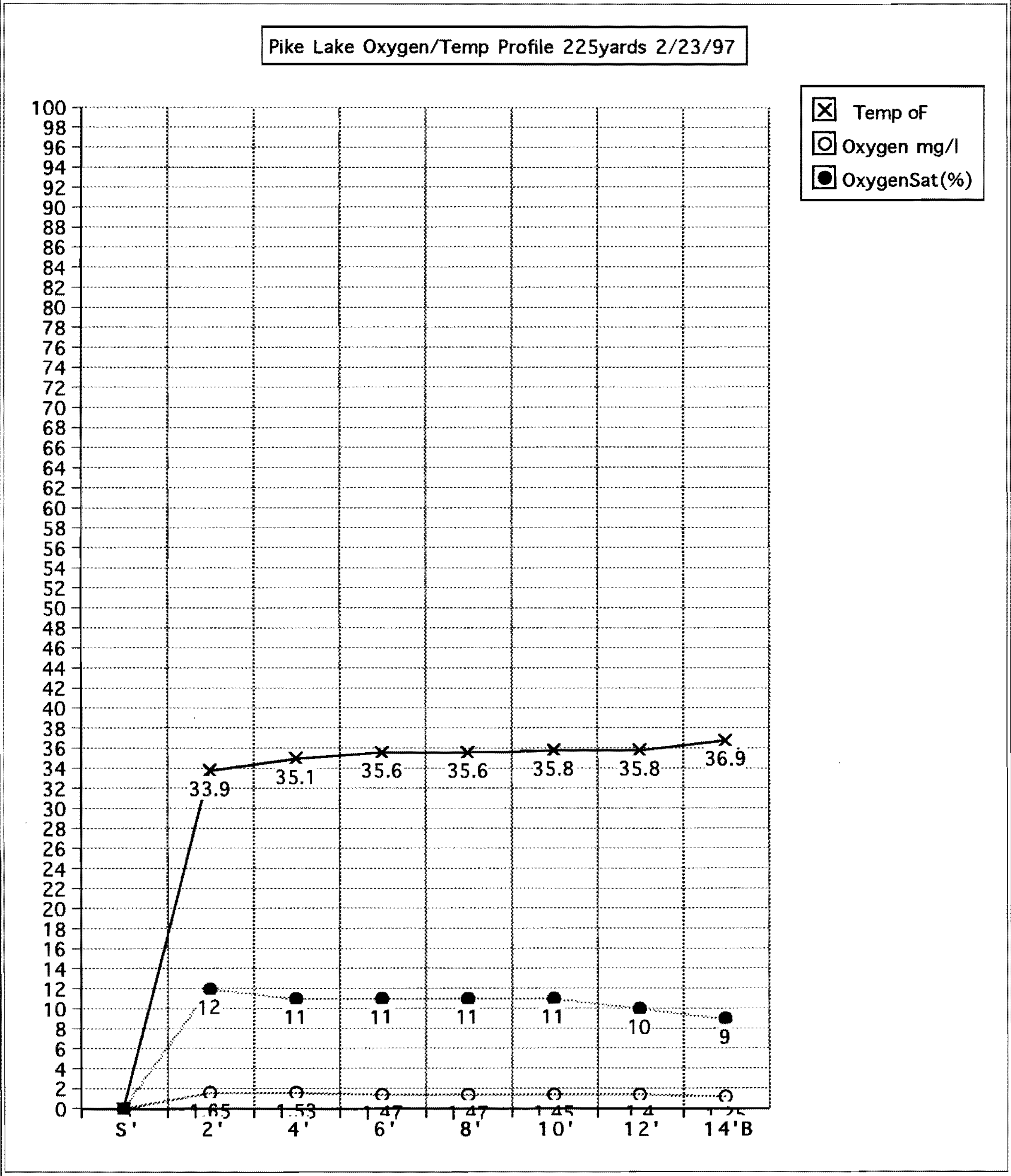
FIGURE 37. Pike Lake Oxygen/Temperature Profiles 2/23/97



Secchi Reading:
Depth of Ice 24"
Depth of Snow 0-3"

FIGURE 38. Pike Lake Oxygen/Temperature Profiles 2/23/97

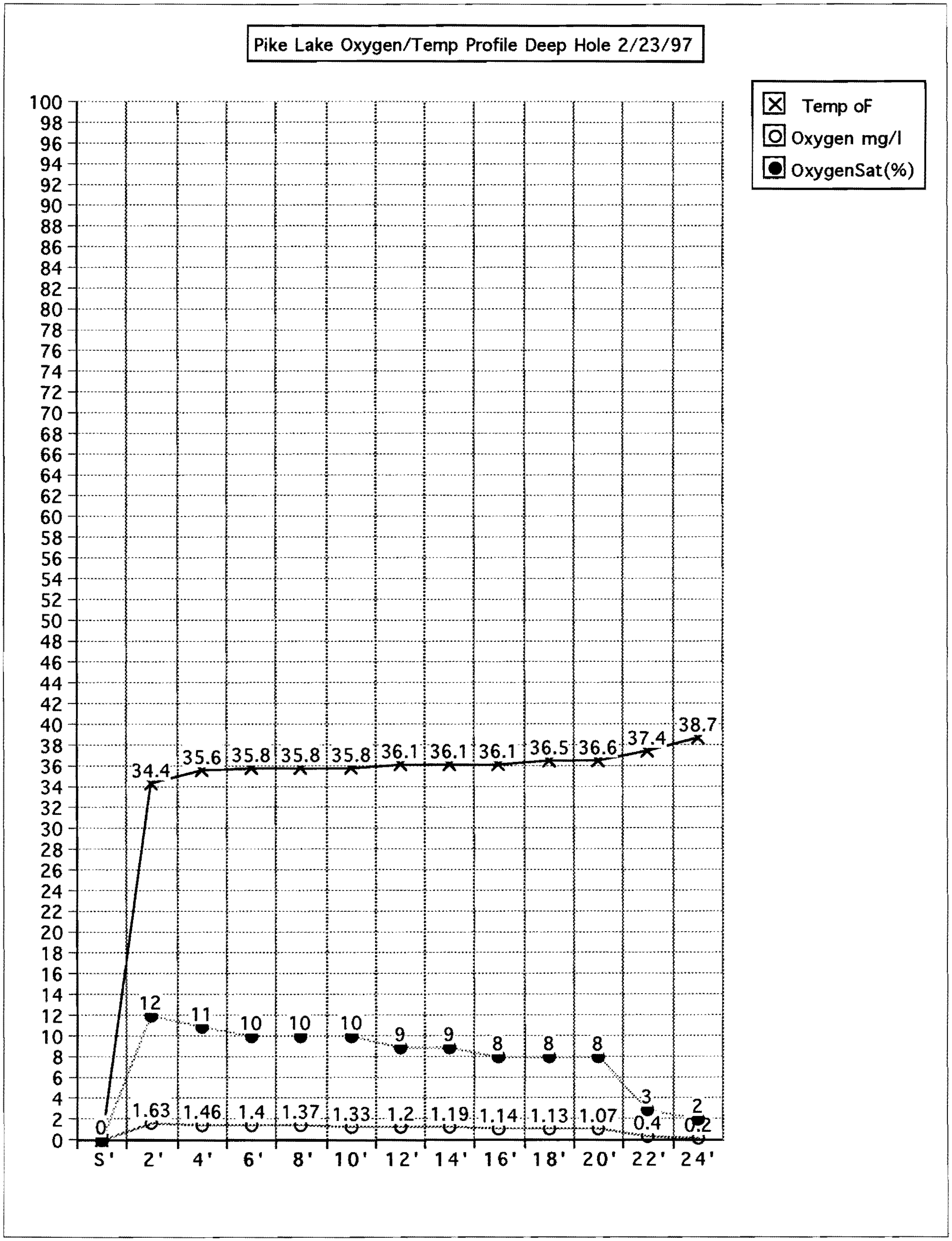
O	P	Q	R	S	T	U



Secchi Reading:
Depth of Ice 24"
Depth of Snow 0-3"

COMMENTS: 15 oF Sunny

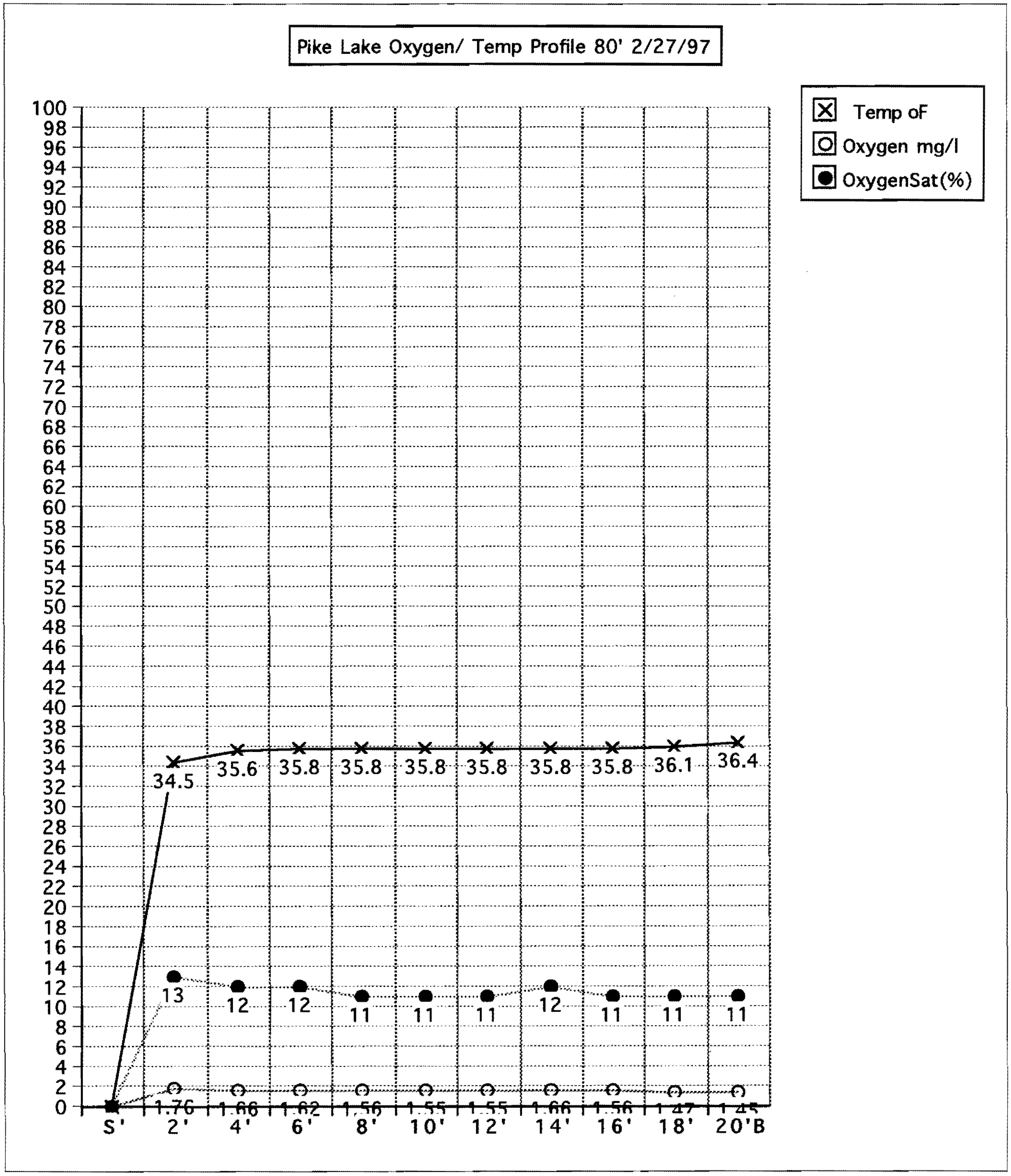
Figure 39 . Pike Lake Oxygen Temperature Profiles 2/9&23/97 & 3/15/97



Ice: 24"

Snow: 0"

FIGURE 40. Pike Lake Oxygen/ Temperature Profiles on 2/27&28 and 3/2/97



24 hours after additional compressor added

FIGURE 41. Pike Lake Oxygen/ Temperature Profiles on 2/27&28 and 3/2/97

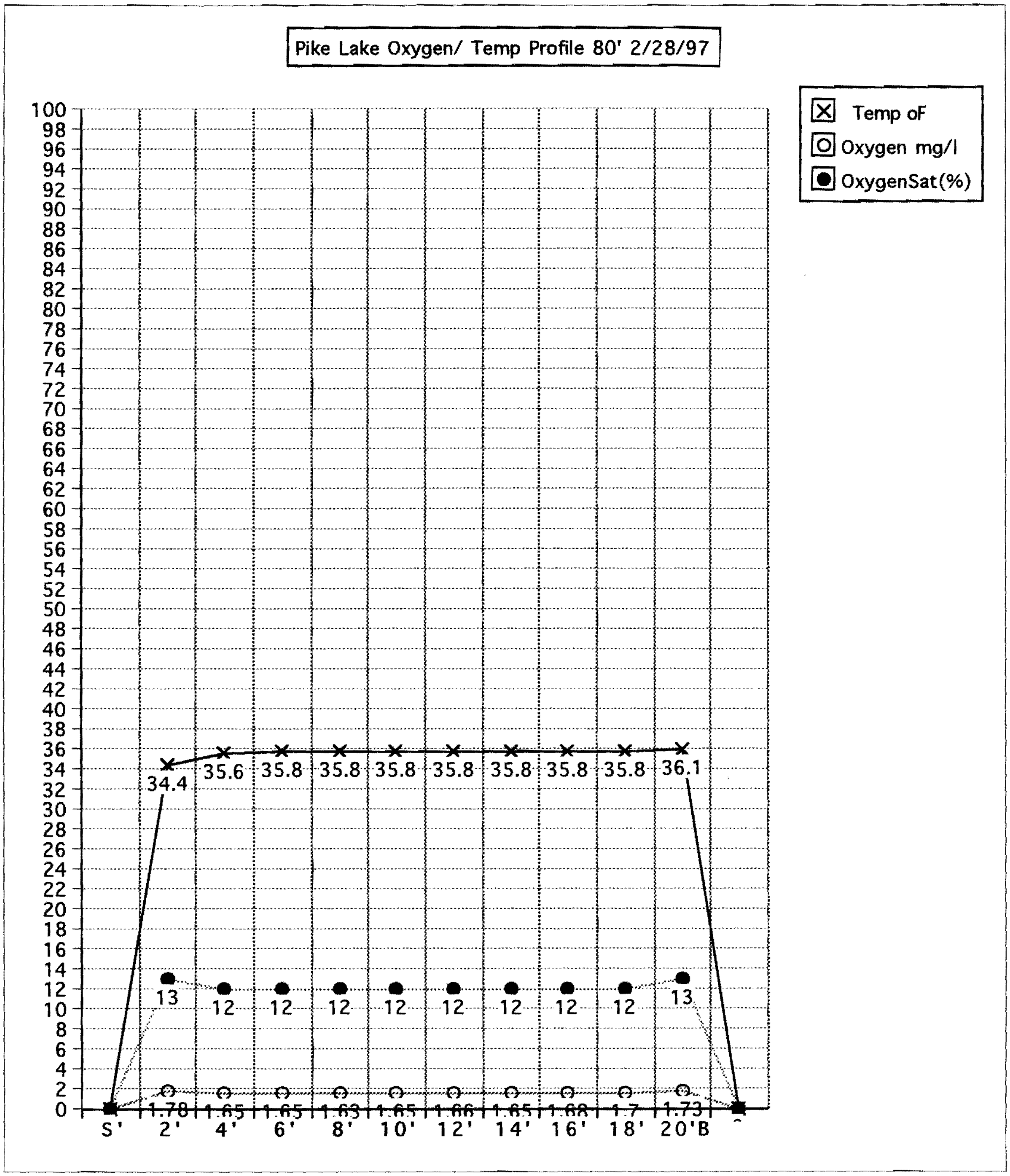


FIGURE 42. Pike Lake Oxygen/ Temperature Profiles on 2/27&28 and 3/2/97

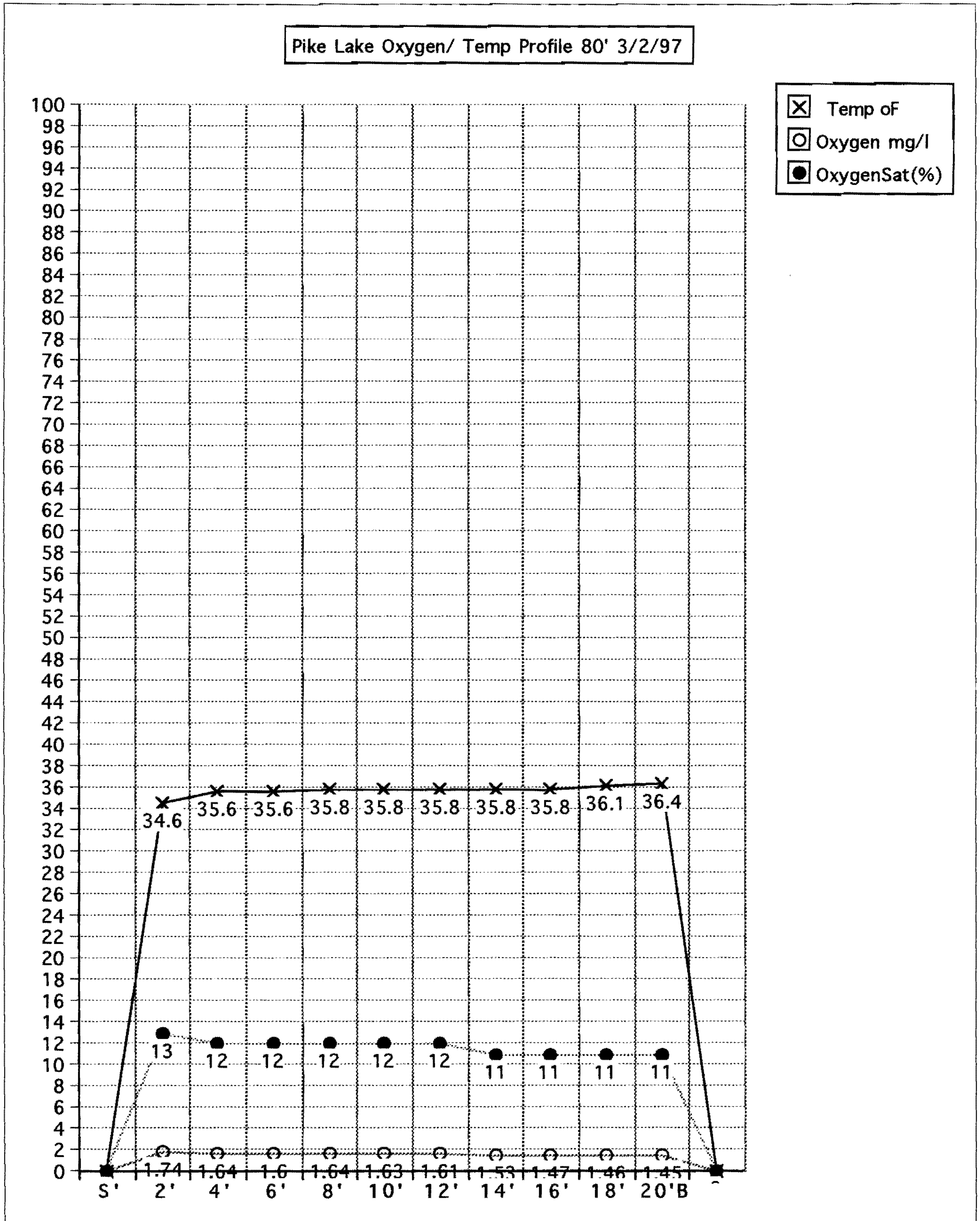
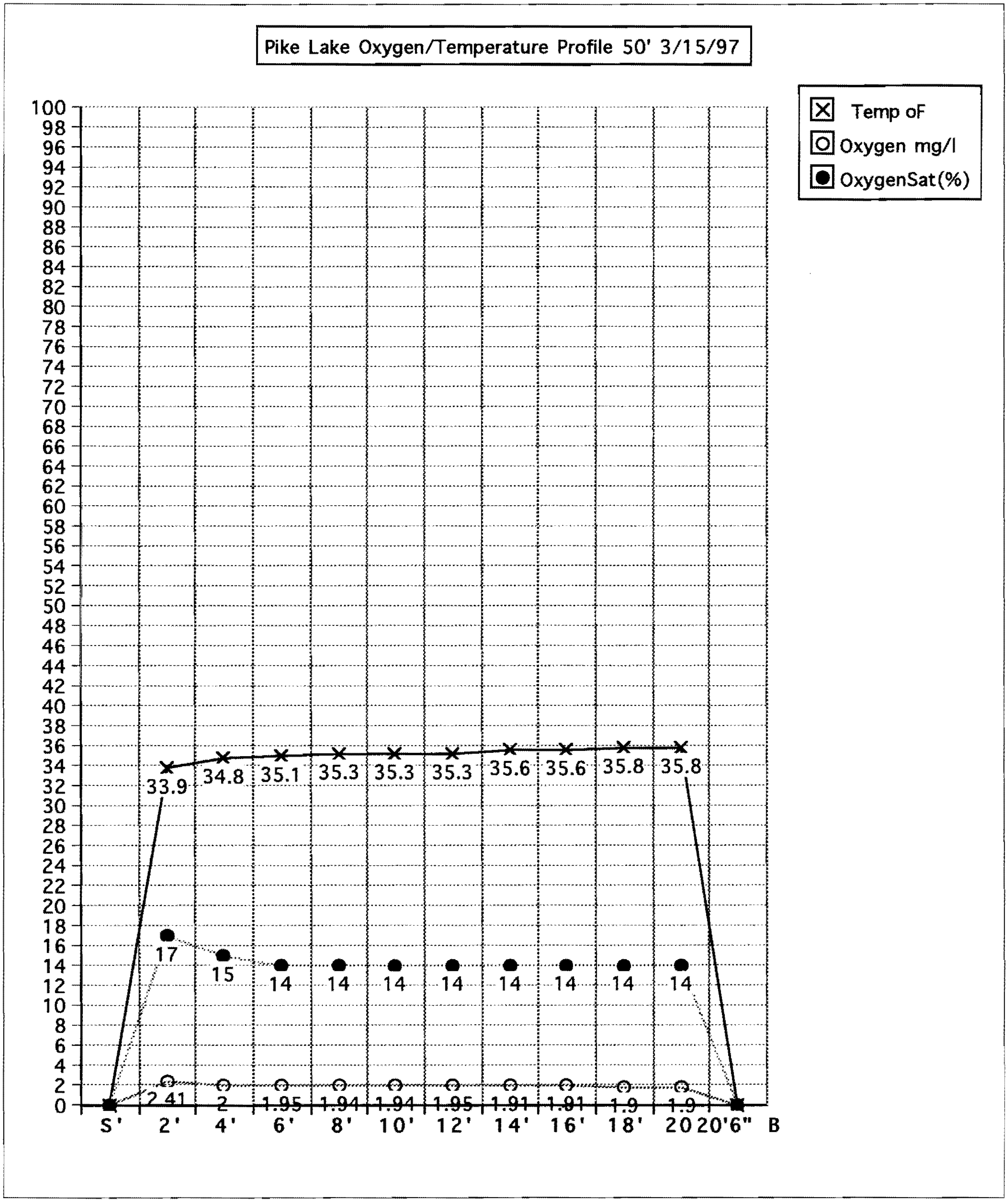


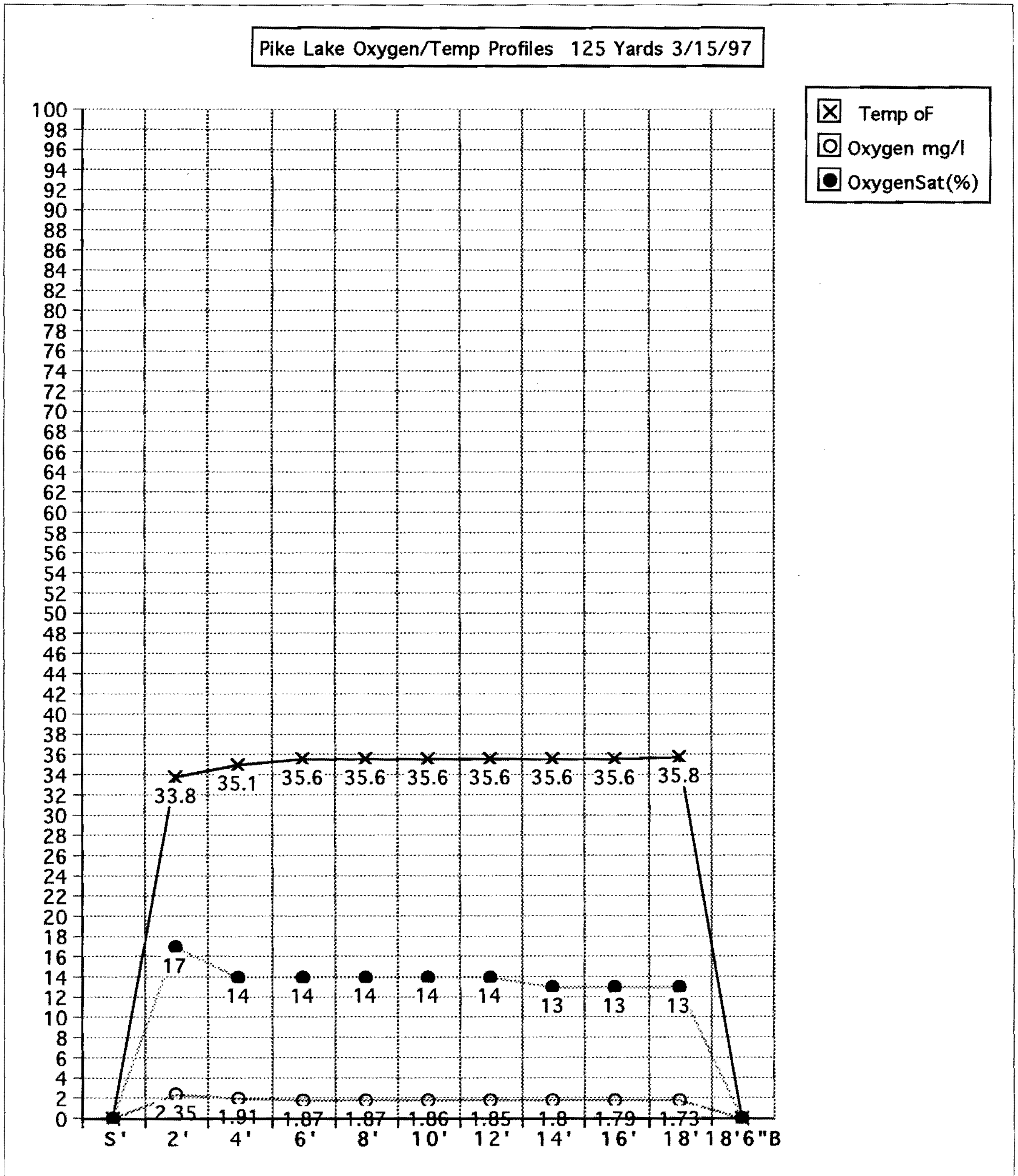
FIGURE 43. Pike Lake Oxygen/ Temperature Profiles on March 15, 1997



Secchi Readi 9'
Depth of Ice 22"
Depth of Sno 12-24"

COMMENTS: 25 oC, Partly Sunny

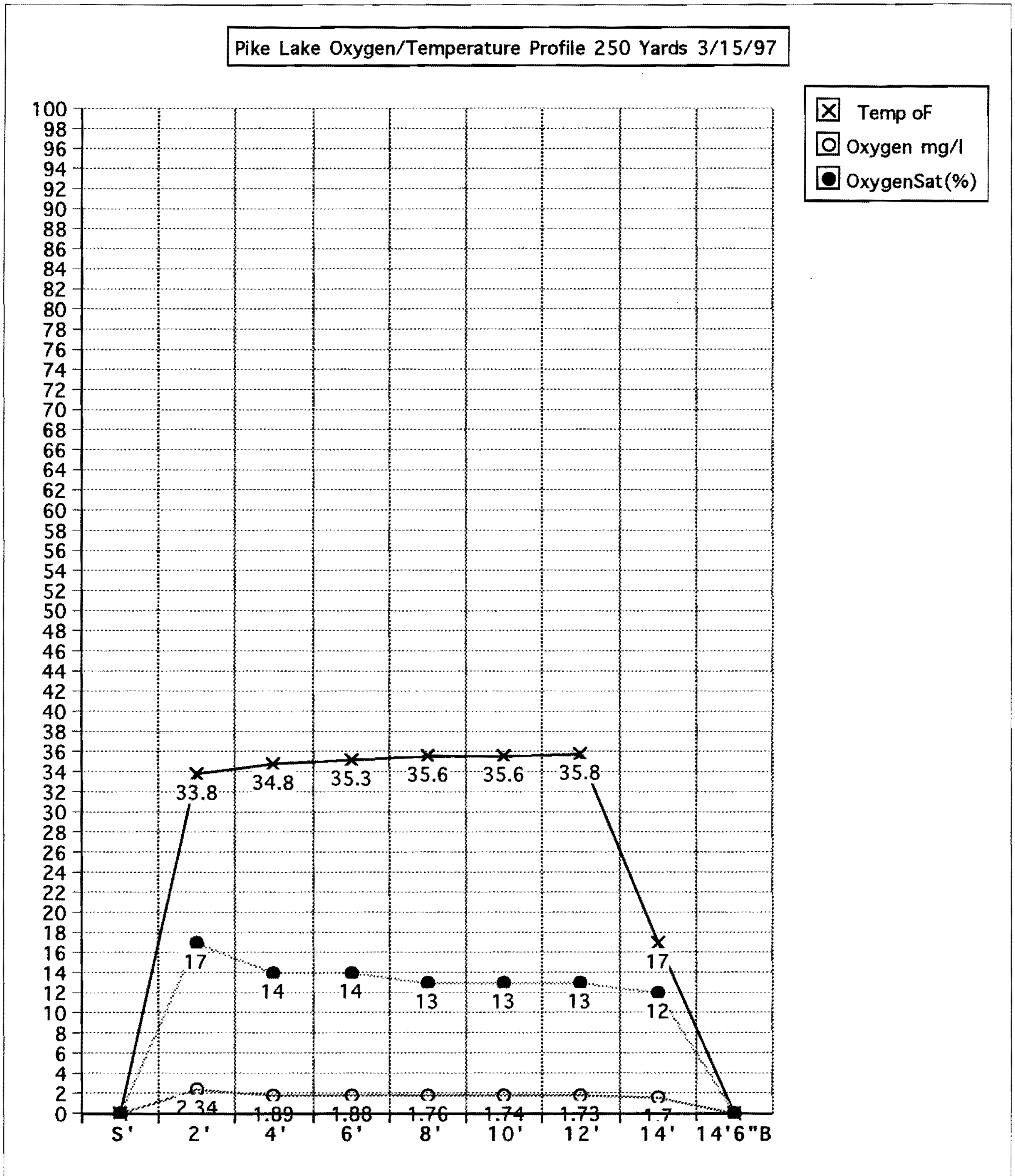
FIGURE 44. Pike Lake Oxygen/ Temperature Profiles on March 15, 1997



Secchi Readi 9'
Depth of Ice 25"
Depth of Sno 12-24"

COMMENTS: 25 oC, Partly Sunny

FIGURE 45. Pike Lake Oxygen/ Temperature Profiles on March 15, 1997



Secchi Readi 9'
Depth of Ice 25"
Depth of Sno 12-24"

COMMENTS: 25 oC, Partly Sunny

FIGURE 46. Pike Lake Oxygen/ Temperature Profiles on March 15, 1997

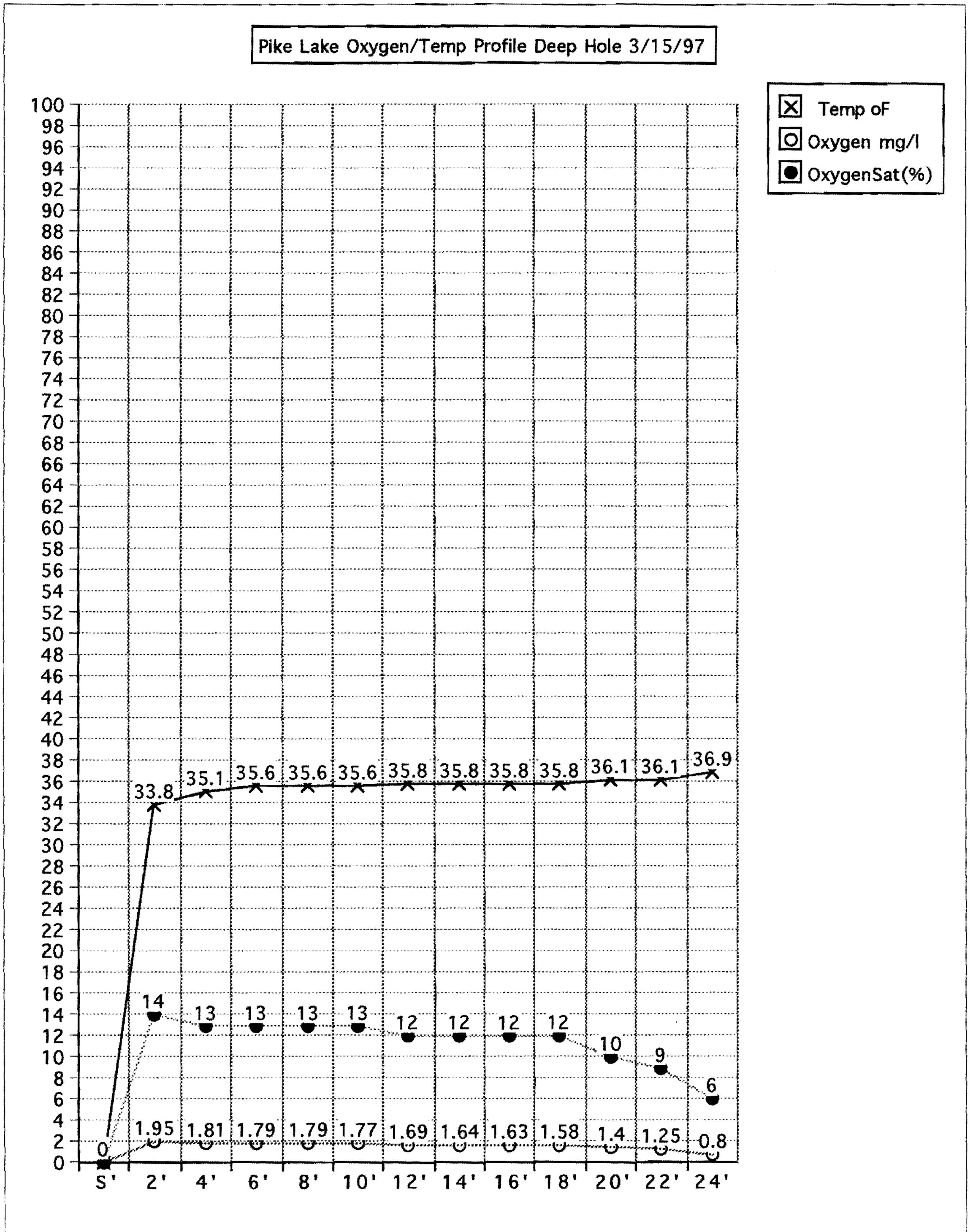


FIGURE 47. PIKE LAKE OXYGEN / TEMPERATURE PROFILING MARCH 31, 1997

3/31/97	DEPTH feet	TEMPERATURE	OXYGEN mg/	OXYGEN % S	OTHER DATA	WEATHER
LOCATION					Ice Depth	Snow Depth
Rice L. Outlet						
Rice L. Cr@ Lake Dr						
	.75'	3.4	4.91		Open Water	
E. Creek below Lake Drive						
- in Culvert					Still frozen over	
- in pool below						
PikeL.Cr.@ Dam						
	12"	3	3.95		W.L.7" from Top of Bench Mark	
LOCATION						
Rice L. Outlet						
Aeration Area: 100' fron Shoreline towards Rice Lake Creek E of Aeration Field						
Depth						
S'						
2'		3.5	4.06			
4'		3.8	3.8			
6'						
8'						
10'						
12'						
14'						
16'						
18'						
20'B						
22'						
24'						
26'						
28'						
30'						
	Dist fr Edge of Open H20		Dist fr Edge of Open H20		Dist fr Edge of Open H20	
	Dist fr Cter of Open H20		Dist fr Cter of Open H20		Dist fr Cter of Open H20	
	Secchi Reading:		Secchi Reading:		Secchi Reading:	
	Depth of Ice	7"	Depth of Ice		Depth of Ice	
	Depth of Sno	4" slush	Depth of Snow		Depth of Snow	
	COMMENTS:	Ice not Safe				
	WEATHER"	Sunny, Air Temperature 52oF				

__January 1, 1998__ The aeration system was reevaluated during the mild winter of 1997-98. This assessment began before the aeration system was turned on. Ice on the lake was from 10-12" thick with just a trace of snow cover. At the aeration sight oxygen levels below 14 feet were already beginning to drop. There was little stratification as the temperature only varied from 38.7 oF below the ice to 39.6 oF at 20 feet of water. In the middle of the lake 250 yards from the aeration sight oxygen levels began to drop at 12 feet with little temperature change from beneath the ice to the bottom. **SEE TABLE 7.** When compared to December 28, 1998 levels of oxygen were much higher. Ice up had occurred much later and there was less snow accumulation.

__January 9, 1998__ A week later on oxygen/ temperature profiles were taken at the same locations prior to aeration system start up later that day. Ice thickness had increased to 9-11" and 2 to 4" of snow now covered the ice. Temperatures in the water column began to drop but there still was little stratification from top to bottom. Oxygen levels dropped only slightly since New Year's day. **SEE TABLE 8**. Rice Creek entering Pike Lake had not frozen over by this date. The aeration system was started at 4:00 pm that day.

__January 13, 1998__ The ice thickness had increased to 11 or 12" and snow depths varied from 1" to 8" where drifting had occurred. Rice Lake Creek was now frozen over with clear weather and near zero air temperatures. **SEE TABLE 9**.

Water temperatures 200 feet from shore, just east of the aeration system were 38.5 oF from below the ice to the 12 foot depth. More oxygen was found just beneath the ice, and only decreased slightly from 4' to 12'.

Near the southwest edge of the aeration hole there was no change in temperature from the January 9 recordings that were taken before the aeration system startup. But the oxygen levels had changed with aeration system startup. Oxygen levels from 14 to 20 feet climbed above 5 mg/l, while those towards the surface dropped in saturation. At 8 feet there was a sag in oxygen level that corresponded to the depth where the secchi disc visibility was lost. There was still a drop in oxygen levels from surface to the bottom.

In the middle of the lake, away from the aeration system, the water temperature had cooled only one degree since January 9 and no stratification was evident. Oxygen levels in the 12 to 18' depth had increased since January 9.

__January 24, 1998__ Snow had accumulated to 11" and the ice only thickened 12". Water temperatures between the shore and the aeration hole were again uniform from beneath the ice to the bottom as the temperature dropped only 0.5 oF since January 13. **SEE TABLE 10.**

At the edge of the aeration hole temperatures were nearly the same as on January 13, 1998. Oxygen levels near the bottom on both dates were slightly lower than in the column. On this date the oxygen levels from 4 to 18' appeared uniform where on January 13 this was not the case.

In the center of the lake, where there was a decrease in oxygen from beneath the ice to the bottom on January 13, now the oxygen levels were nearly uniform. At the same time the temperature did a reversal; Nearly uniform temperatures were found from top to bottom on January 13 and some stratification was occurring on this date.

February 6, 1998 The ice had gained another inch in thickness (13") as the snow depth decreased to 4". The weather was mild and cloudy. Between the aeration hole and the shoreline the water temperature was again uniform from the surface to the bottom and had only dropped 0.1 oF from January 24. **SEE TABLE 11.**

At the edge of the aeration hole temperatures dropped 2 degrees from under the ice to 12' but remained nearly the same from there to the bottom. Despite the drop in temperature the oxygen levels dropped over a mg/l or part per million from top to bottom. A water clarity secchi depth of 7 feet was found at this location.

In the middle of the lake there was no temperature drop between periods. The oxygen levels dropped over a mg/l as it did by the aeration system.

February 15, 1998 Mild weather by this date had opened up Rice Lake Creek. Ice was now 15" thick and snow cover was reduced to 2". Between the shoreline and the aeration hole there was no change in water temperature and a drop of 0.8 mg/l of oxygen. **SEE TABLE 12.**

At the edge of the aeration hole there was also no change in water temperature or oxygen from the readings taken a week prior. Even with aeration mixing saturation levels were lower near the bottom and the highest saturation that could be attained by aeration was 54% just below the ice.

In the middle of the lake temperatures were nearly identical as a week prior. Oxygen beneath the ice increased slightly but oxygen below this dropped nearly a part per million. Oxygen saturation percentages dropped from surface to bottom even a temperatures dropped (colder water can normally hold more oxygen).

March 22, 1998 Mild weather continued through March. Oxygen and temperatures at the edge of the aeration hole were nearly the same as on February 15, 1998. Ice was now growing thinner. **SEE TABLE 13.**

As one moved from the aeration hole towards the center of the lake it appears that there was slight decrease in mixing in the profiles but no substantial differences. In the middle of the lake oxygen levels improved since the February 22, 1998 readings.

The mild winter of 1997-98 did not provide conditions that could test the adequacies of the aeration system. Oxygen levels above 5 mg/l were maintained at the aeration hole test site and at water depths in the middle of the lake comparable to the aeration site. In general, it does appear that the aeration system slightly improves water quality in the immediate area by mixing oxygenated surface water with bottom water. Slight increases in oxygen levels in bottom waters were noted when compared to areas away from the aeration system. Yet even during this mild winter, as winter progressed there was a comparable decrease in oxygen levels at the aeration site and well away from the aeration site. Secchi disc visibility appeared higher at the aeration hole but background light from open water of the aeration hole could account for these differences. There appears to be some relationship between oxygen levels in Pike Lake and whether Pike Lake Creek is froze over or not.

The key to prevention of winter kill of the fishery is to provide areas where oxygen levels are adequate. As oxygen levels decline under the ice fish will seek areas where there is water movement which may or may not have oxygen levels levels in amounts that will support them. Seepage areas along the shoreline and on the bottom of Pike Lake and the river flows of Rice Creek entering and Pike Lake Creek leaving at the outlet dam area, as well as the aeration system all provide moving water. Which are critical in the long term survival of the lake? Oxygen is key to the decomposition and recycling of the lake nutrients. If oxygen is present under the ice the key nutrient in growth

TABLE 7. Pike L. on 1/1/ 1998, 100 feet from Shore

Jan1, 1998	100' From S.Shore	
Depth	Temp oF	Oxygen mg/l
2'	38.1	13.7
4'	38.7	13.7
6'	39	12.2
8'	39	12.02
10'		
12'		
14'		
16'		
18'		
20'B		
Ice:	12"	
Snow:	trace	
Comments:	1:30 pm, mostly sunny, before aeration systen turned on	
Jan1, 1998	Outside Fence to Southwest	
Depth	Temp oF	Oxygen mg/l
2'	38.7	11.47
4'	38.8	11.33
6'	38.8	11.38
8'	38.8	11.4
10'	39	11.1
12'	39.4	10.1
14'	39.2	6.6
16'	39.2	4.4
18'	39.6	2.8
20'B	39.6	2.8
Ice:	10"	
Snow:	trace	
Comments:	1:30 pm, mostly sunny, before aeration systen turned on	
Jan1, 1998	Middle of Lake	
Depth	Temp oF	Oxygen mg/l
2'	38.5	11.5
4'	38.8	11.3
6'	38.8	11.4
8'	38.8	11.3
10'	38.8	10.8
12'	39.4	7.6
14'	39.4	3.87
16'	39.2	4
18'	39	3.7
20'B		
Ice:	7"	
Snow:	trace	

TABLE 8. Pike Lake 1-9-98

Jan 9, 1998	100' From S.Shore	
Depth	Temp oF	Oxygen mg/l
2'	36.3	15.1
4'	39.1	13.7
6'	39	12.7
8'	39	12.1
10'		36.3
12'		
14'		
16'		
18'		
20'B		
Ice:	11"	
Snow:	4"	
Comments:	1:30 pm, mostly sunny am, cloudy pm, before aeration systen turned on	
Jan 9, 1998	Outside Fence to Southwest	
Depth	Temp oF	Oxygen mg/l
2'	37.2	14.3
4'	39	12.7
6'	39	12.3
8'	38.8	11.9
10'	38.8	10.5
12'	39	6.2
14'	39	4.4
16'	39	2.9
18'	39.2	2.3
20'B	39.6	1.7
Ice:	10"	
Snow:	2"	
Jan 9, 1998	Middle of Lake	
Depth	Temp oF	Oxygen mg/l
2'	35.2	14.1
4'	39	12.9
6'	39	12.3
8'	39	11.2
10'	39	9.5
12'	39.2	6.7
14'	39	4.7
16'	39	4.5
18'	38.7	6.8
20'B		
Ice:	9"	
Snow:	2"	

TABLE 9. Pike Lake Oxygen-Temperature Profiles on January 13, 1998.

Jan 13 , 199	200' From S.Shore	
Depth	Temp oF	Oxygen mg/l
2'	38.5	12.1
4'	38.5	9.9
6'	38.5	9.7
8'	38.5	9.6
10'	38.5	9.6
12'	38.5	9.5
14'		
16'		
18'		
20'B		
Ice:	11"	
Snow:	4"	
Comments:	2:00 pm, sunny, 4 days after aeration system startup	

Jan13, 1998	Outside Fence to Southwest	
Depth	Temp oF	Oxygen mg/l
2'	37.6	12.5
4'	39	10.9
6'	39	9.6
8'	39.7	6.6
10'	38.5	9.3
12'	38.5	9.1
14'	38.7	9
16'	38.7	8.3
18'	38.2	7.7
20'B	39.2	6.5
Ice:	11"	
Snow:	1"	
Comments:	2:00 pm, sunny, 4 days after aeration system startup	

Jan13, 1998	Middle of Lake	
Depth	Temp oF	Oxygen mg/l
2'	38.3	12.1
4'	39	11.5
6'	38.8	8.2
8'	38.1	9.6
10'	38.1	9.6
12'	38.1	9.6
14'	38.5	9.2
16'	38.7	8.8
18'		
20'B		
Ice:	12"	
Snow:	2"	
Comments:	2:00 pm, sunny, 4 days after aeration system startup	

TABLE 10. Pike lake Oxygen-Temperature Profiles on January 24, 1998

Jan24,1998	150' From S.Shore		
Depth	Temp oF	Oxygen mg/l	
2'	37.9	8.6	
4'	37.9	8.6	
6'	37.9	8.6	
8'	37.9	8.6	
10'	37.9	8.6	
12'			
14'			
16'			
18'			
20'B			
Ice:	12"		
Snow:	11"		
Comments:	Sunny, Air Temp 10 oF		
Jan24,1998	Outside Fence to Southwest		
Depth	Temp oF	Oxygen mg/l	
2'	37.2	10.6	
4'	39.9	8.8	
6'	39.9	8.4	
8'	39.9	8.3	
10'	38.3	8.3	
12'	38.3	8.3	
14'	38.5	8.4	
16'	38.5	8.3	
18'	38.7	8	
20'	38.8	7.6	
22'B	38.8	6.6	
Ice:	12"		
Snow:	11"		
Jan24,1998	Middle of Lake South of Resort		
Depth	Temp oF	Oxygen mg/l	
2'	36.1	9.2	
4'	37.9	8.6	
6'	37.9	8.5	
8'	37.9	8.6	
10'	38.3	8.5	
12'	38.3	8.5	
14'	38.3	8.4	
16'	38.3	8.1	
18'			
20'B			
Ice:	12"		
Snow:	11"		

TABLE 11. Pike Lake Oxygen-Temperature Profiles on February 6, 1998

Feb 6, 1998	100' From S.Shore		
Depth	Temp oF	Oxygen mg/l	
2'	37.8	7.2	
4'	37.8	7.2	
6'	37.8	7.2	
8'	37.8	7.2	
10'	37.8	7.2	
12'			
14'			
16'			
18'			
20'B			
Ice:	13"		
Snow:	4"		
Comments:	Cloudy, Air Temp 30 oF		
Feb 6, 1998	Outside Fence to Southwest		
Depth	Temp oF	Oxygen mg/l	
2'	34.6	7.8	
4'	37.6	7	
6'	37.6	7	
8'	37.9	7	
10'	37.9	6.9	
12'	37.8	6.8	
14'	38.1	6.3	
16'	38.3	5.2	
18'	38.3	5	
20'B	38.5	4	
Ice:	13"		
Snow:	4"		
Feb 6, 1998	Middle of Lake		
Depth	Temp oF	Oxygen mg/l	
2'	34.8	8	
4'	37.6	7.4	
6'	37.8	7.3	
8'	37.8	7.3	
10'	38.1	7.1	
12'			
14'			
16'			
18'			
20'B			
Ice:	14"		
Snow:	4"		
			88

TABLE 12. Pike Lake Oxygen-Temperature Profiles on February 15, 1998

Feb15,1998	100' From S.Shore		
Depth	Temp oF	Oxygen mg/l	
2'	37.8	6.4	48.00%
4'	37.8	6.4	
6'	37.8	6.4	
8'	37.9	6.4	
10'	37.9	6.4	
12'			
14'			
16'			
18'			
20'B			
Ice:	15"		
Snow:	2"		
Comments:	Cloudy, Air Temp 40 oF		
Feb15,1998	Outside Fence to Southwest		
Depth	Temp oF	Oxygen mg/l	O2 Sat.
2'	35.2	7.4	54.00%
4'	37.6	7.1	53.00%
6'	37.9	6.7	51.00%
8'	37.9	6.4	48.00%
10'	37.9	6.4	48.00%
12'	37.8	6.3	47.00%
14'	37.9	6.1	46.00%
16'	38.3	5.2	39.00%
18'	38.5	4.7	35.00%
20'B			
Ice:	15"		
Snow:	2"		
Feb15,1998	Middle of Lake		
Depth	Temp oF	Oxygen mg/l	O2 Sat.
2'	34.3	8.9	64.00%
4'	37.8	6.6	49.00%
6'	37.8	6.5	48.50%
8'	37.8	6.4	47.80%
10'	37.9	6.3	47.40%
12'	38.1	6.1	45.80%
14'			
16'			
18'			
20'B			
Ice:	15"		
Snow:	2"		

TABLE 13. Pike Lake Oxygen-Temperature Profiles on March 22, 1998

Mar22,1998	100' From Hole SW		
Depth	Temp oF	Oxygen mg/l	
2'	35.3	8.3	
4'	37.8	7.4	
6'	37.9	7.2	
8'	38.1	7.1	
10'	38.1	7.1	
12'	38.1	7.1	
14'	38.1	7	
16'	37.3	6.7	
18'	38.7	5.2	
20'B			
Ice:	13"		
Snow:	2"		
Comments:	Sunny, 40oF		
Mar22,1998	Outside Fence to Southwest		
Depth	Temp oF	Oxygen mg/l	
2'	37.9	7.6	
4'	37.9	7.3	
6'	38.1	7.3	
8'	38.1	7.3	
10'	38.1	7.2	
12'	38.1	7.1	
14'	38.3	6.9	
16'	38.3	6.9	
18'	38.5	6.6	
20'B	38.7	6.5	
Ice:	13"		
Snow:	2"		
Secchi:	6.5'		
Mar22,1998	Middle of Lake		
Depth	Temp oF	Oxygen mg/l	O2 Sat.
2'	34.7	9	65.00%
4'	37.9	7.8	58.00%
6'	37.9	7.6	57.00%
8'	38.1	7.4	55.00%
10'	38.1	7.5	56.00%
12'	37.9	7.6	57.00%
14'			
16'			
18'			
20'B			
Ice:	13"		
Snow:	2"		
Secchi:	7'		

FISH & AQUATIC COMMUNITY OF PIKE LAKE

Procedure

Several fishery and aquatic plant surveys have been completed on Pike Lake during the last ten years as part of the operations of the DNR Fisheries and Long Term Lake Monitoring Programs. Also as a part of the Water Resources Long Term Lake Monitoring Program plankton sampling also has been completed but not analyzed. These surveys and sampling data were reviewed and analyzed with other resource data collected for ecological interpretation.

AQUATIC PLANTS OF PIKE LAKE

Introduction and History

The earliest mention of the vascular aquatic plants of Pike Lake was the presence of wild rice at the inlet and outlet in 1959. Dense algae blooms have a longer history as sodium arsenic was used to control algae as early as 1940. These very dense plankton bloom continued into the 1960's where in 1962 the algae reduced visibility to 18" and caused a summer fish kill on August 22.

The first aquatic plant survey of Pike Lake was part of the surface water inventory of Marathon County in 1969. Heavy algae blooms occurred that year and several years after yet aquatic plants grew to an 8' depth. By the time of this first survey the wild rice had already disappeared from the lake. Secchi depth on the clear day of the plant survey was 4 feet. The results of the 1969 survey can be found below.

TABLE 14. Aquatic Plant List and Abundance of Pike Lake on August 14, 1969

Plant Species	Abundance
Submergent	
Potomegeton Sp.	A
Coontail	A
Water Millfoil	A
Elodea	C
Floating	
Yellow Water Lily	A
White Water Lily	A
Watershield	S
Emergent	
Sagittaria(Duck Potato or Arrowhead)	C
Bullrush	C
Cattails	S

A = Abundant C = Common S = scarce

In 1986 Pike Lake became a lake that was to be studied as part of a Long Term Trend Study involving 50 lakes throughout Wisconsin. Water quality data has been collected yearly since this time with aquatic plant studies completed every 3 years. Aquatic plant surveys were conducted in July 1989, August 1993, and July 1996. A total of 39 different species of macrophtyes (aquatic plants) were found during these three surveys. Of the 39 species found 21 were submergent, 6 floating leaf, and 12 emergent. The only non native specie found was curly-leaved pondweed.

Results and Discussion

Aquatic plants compete with each other for space and nutrients and have specific physical requirements for there growth and reproduction. Type of substrate, amount of light, water temperatures, changes in depth of water, and methods of plant reproduction are all factors in which plants will survive, grow and reproduce.

The recent surveys have documented several short term changes in the aquatic plant community. The change in the plant community over the longer term have not been documented. But past histories and observations by local citizens combined with an understanding of each plant's ecology can give important keys to changes in the lake and plant communities over a longer time.

For example, in 1959 wild rice was in the inlet and outlet areas. Today it is not present in the lake. When and why did it disappear from Pike Lake? It is also assumed that a one time wild rice was abundant in Rice Lake or it's namesake would not have occurred. It is known that ideal conditions for wild rice are: 1.) Shallow water that is from a few inches to 2.5 feet, 2.) a muck bottom, 3.) sufficient water movement to prevent substrate stagnation, 4.) no appreciable amount of alkali in the water, and 5.) little changes in water level at critical times in plant development.

Which of these factors changed over time that cause the complete disappearance of wild rice in Pike Lake and Rice Lakes? All of these changes have occurred with the dam to include: deeper water, change in substrates & water movement that cause stagnation due to change in wind and shoreline hydraulics, alkalinity changes due to CO_2 changes related to accumulation and decomposition of accumulated organic matter. Biological systems are resistant and resilient to changes. To eliminate a plant from a lake may take decades of one or two of the condition changes above.

The plant surveys of the past decade in Pike Lake have documented small changes in the plant community over a short period of time. Many of these short period changes can be caused by climatic and weather conditions or even changes in sampling procedure or exact location of sampling. Other changes are a progression of water level and water quality changes brought about by made made actions of the present and past.

These plant surveys describe plant species by the depth they occur at and what type of substrate they grow on. At each sample location - along a transect line that extends perpendicular from the shoreline to deeper water- plants are identified and their density determined. After 21 transects, that represent varying habitat around a lake are sampled, frequencies of occurrence and densities are determined for each specie of plant. From this distribution of dominant plants by substrate and depth are recognized.

Vegetation was found at all depths up to the 10 feet ; which is 2 feet less than the maximum secchi depth found in Pike Lake in 1997. This zone that extends from the shoreline is known as the littoral zone. Vegetation growth in this zone has increased significantly at all sampling sites around Pike Lake from the 1989 survey to the 1996 survey. Plant occurrence has increased from 69% in 1989, to 76.2% in 1993 , and 84% in 1996.

The shallowest water areas of Pike Lake contain emergent vegetation such as cattails and bulrushes. The plants have narrow ranges of substrate types that they prefer and do well on. Cattails (*Tough latifolia*) which grows in disturbed areas with brackish water has appeared and increased its frequency since 1989. Yet hardstem bullrush that shows a preference for firm substrate and good water movement has declined.

The highest percent of vegetated sites have been in the 1.5 to 4 foot zone or the area most occupied by the shoreline owners. This zone had the highest total occurrence and density of plants.

The most frequent specie of plant in this zone in 1989 was Northern or common water millfoil (*Myriophyllum sibiricum*). It frequency dropped to third in 1993 and 12 in 1996. Common water millfoil is sensitive to reduced water clarity and has declined in lakes that are becoming eutrophic (more enriched).

This millfoil is most often found in soft sediment . In Pike Lake this plant was found mostly over area where there was 2 feet of muck but was also found in one area with a base of sand. This plant reproduces from a winter bud that is drop on the sediment from the decaying plant in late fall. The leaves and fruit of this plant are consumed by a variety of waterfowl. The feathery leaves trap suspended organic debris and provides food and habitat for aquatic insects, snails, clams, and other invertebrates.

Coontail (*Ceratophyllum demersum*) and forked duckweed (*Lemna trisulca*) replaced millfoil as the most frequent specie in 1993 and 1996. Both of these species are not rooted and can drift between depth zones. These plants were found at all depths on muck substrate but were also found invading sand and rock areas.

Coontail has a tolerance for low light conditions and cool water. If water clarity permits during the open water growing season it will grow in water over 10 feet deep. It will also over winter under the ice as an evergreen plant, continuing photosynthesis under the ice at a reduced rate. The coontail's over wintering stiff whorls of leaves offer prime habitat for many invertebrates where many other plants die back. In Pike Lake this plant can contribute to the depleted oxygen conditions in the shallow waters during heavy snow and ice cover winters. It would also do well during the growing period after light snow winters with it's ability over winter and get an early start before other plants. Coontail also spreads when fragments are broken from the plant and drift to a new area. Cutting of these plants by power boats would free these fragments to drift to new areas of the lake.

Forked Duckweed is found just beneath the surface in quiet water. Because it is free floating, it drifts with the wind or current and is not dependent on depth, sediment type or water clarity. However, it thrives on suspended nutrients to sustain its growth.

Coontail and forked duckweed have the ability to draw nutrients from the water therefore they are competing with algae (phytoplankton) for phosphorus and nitrogen. These nutrients are stored in their leaves and other plant parts in the water column. The plants they are replacing were able to store nutrients in their roots beneath the bed and did not reach nuisance levels to effect recreational uses of Pike Lake. Waterfowl, fish and invertebrates utilize coontail and forked duckweed for food and shelter. But in dense stands prevents predator fish from reaching the panfish. Stunting of the panfish, which Pike Lake is now facing , is one result of the high abundance and densities of these plants.

The most dense specie of plant in the 1.5 to 5 foot zone in 1989 and 1993 was muskgrass (*Chara* sp.) The density of this plant decreased drastically in 1996. It appears that muskgrass has been replaced by it's close relative stonewort (*Nitella* sp) in 1996. Both of these plants grow near the bottom and grows in thick mats to a maximum of 18". But muskgrass prefers hard water spring seepage areas of sand or mud where stonewort is limited to soft sediments. Has the bottom sediments been altered and spring seepage flow reduced in Pike Lake to favor stonewort over muskgrass?

Water lilies have also increased dramatically from 1989 to 1996. These plant require quiet water of 6 feet or less in depth. With the increase in denser and nuisance levels of plant in deeper water, wave action from deeper water does not reach their habitat and they are able to spread through roots and seed pod distribution. Floating plants are adapted to higher turbidity conditions as their leaves are kept near the surface to receive the sun.

Their has also been drastic changes in the deep water plants of Pike Lake. There has been a shift in plants that require good water quality such as Illinois pondweed (*Potamogeton illinoensis*) to plants that can tolerate more turbid conditions such as the exotic curly-leaf pondweed (*Potamogeton crispus*). The frequency of occurrence of curly- leaf has increased from 8% in 1989 to 12% in 1993 to 33% in 1996, Where Illinois pondweed had declined severely from 1993 to 1996. Curly-leaf pondweed as does coontail can over winter as an evergreen plant and have rapid growth in early spring. But midsummer die offs can cause a sudden loss of habitat and release nutrients into the water column that can trigger algae blooms and create turbid water conditions.

Conclusions

Overall the plant community of Pike Lake has changed significantly from 1989 to 1996. Clasping-leaf pondweed (*Potamogeton richardsonii*), a plant that is tolerant of disturbance like coontail has increased 129.5% between 1989 and 1996. At the same time the more sensitive plant species have declined over the short period that this survey cover. This accelerated change in the plant community is a warning that changes in water quality are impacting the plant community.

These changes in the plant community appear to be caused by an increased organic load throughout the lake as plant abundance appears to be increasing at all depths. Increased number of sample sites with sand mixed with organic muck substrates have increased further favoring more plants that do well on soft sediments or disturbed areas. Sensitive rooted plants have been replaced by non rooted plants that can take low light conditions and absorb nutrients from the water. Yet these same plants die in mid and late summer and release nutrients for algae blooms and create turbid water conditions.

The flooding of organic soils in Pike Lake, Rice Lake Creek, and Rice Lake by the low head dam over 50 years ago has released a steady flow of nutrients into Pike Lake. The lake has reached a peak load of nutrients it can assimilate into plants, invertebrates,fish, and waterfowl. Negative changes in water quality will continue to affect fish and plant diversity and numbers that will effect the recreational use of the lake.

FISHERIES OF PIKE LAKE AND RICE LAKES

Introduction & History

The 1930's fishery of Pike Lake was dominated by walleye and perch as described by Doc Proknow who grew up and still owns property on the lake. Written history of the Pike Lake fisheries extends from the recording of the first stocking of fish in the lake in 1941 to the 1996 boom shocker winter kill assessment in May 1996. The first assessment of the fisheries occurred in 1956.

Rice Lake's recorded fish history began with electroshocker survey as part of a county wide water inventory in 1960. The last fisheries assessment was in 1975.

The earliest mention of Pike Lake fisheries in written history was in 1949 permit that legally allowed the creation of a dam on the outlet stream. The purpose of the dam was " to prevent the movement of the fish population and maintain the ordinary water level of the lake. It was noted in the permit proceedings that without the obstruction (dam) fish migrate downstream during high water and cannot return when stream flow returns to normal volume.

Apparently a dam had existed at the site prior to May 21, 1937 when Mike Stillman, owner of the dam site wanted to remove existing dam because water damage to some 25 acres of his land. At the time the dam was controlled by a long term lease by the town and Mr. Stillman wanted a release from this agreement. What has been the long term effect of the dam on fish species composition and the water quality that supports them?

Results and Discussion

Prior to the first fisheries assessment in 1956 bluegill and black crappie adults and walleye, largemouth bass, and smallmouth bass fingerlings were stocked in Pike Lake from 1941 to 1954. **SEE TABLE 15.** The 1956 fishery assessment described that the dominate game fish was northern pike and the dominate panfish was bluegill. Largemouth bass, yellow perch, black crappie, small northern, and white sucker, and golden shiners were also found.

No fish management activities including stocking occurred from 1956 until 1962 when a summer fish kill occurred on August 22. Visibility in the lake had been reduced to 18" for three weeks prior to this date with a very dense phytoplankton bloom. The bulk of the fish kill were small yellow perch but a small northern and two walleyes were also found. Water chemistry and dissolved oxygen profiling near noon on August 22 and predawn on the August 23 revealed adequate oxygen levels to support fish. The phytoplankton (algae) was analyzed and toxic emitting alga, *Oscillatoria* & *Anabaena* , were present. That same year 300 thousand fingerling northern pike were stocked in Rice Lake.

TABLE 15. PIKE LAKE FISH STOCKING HISTORY

DATE	SPECIES	# PLANTED	SIZE		REMARKS	
1941	BG & BLCR	ADULTS				
1944	SMALLMOUTH	50	FINGERLINGS			
1945	LARGEMOUTH					
1951	LARGEMOUTH					
1954	WALLEYE	5400	?			
1956	NP,LMB,YP,BLCR,BG,GS,WS					
1963	NORTHERN PKE	711	ADULTS			
1965	NORTHERN PKE	296,898	FRY			
1965	YELLOW PIKE	1,000,000	FRY			
1965	WALLEYE	45,000	FINGERLING			
1967	WALLEYE	12,000	FINGERLING			
SEPT 3, 1970	WALLEYE	7,125	FINGERLING			
AUG 9,1972	WALLEYE	26,000	FINGERLING			
JUL 23,1975	WALLEYE	20,000	FINGERLING			
1978	WALLEYE	ON QUOTA BUT NO PLANTING MADE- FISH NOT AVAILABLE				
AUG 16,1979	WALLEYE	20,000	FINGERLING			
JUL 29.1980	WALLEYE	10,040	FINGERLING			
AUG 25,1983	WALLEYE	20,000	FINGERLING			
AUG 22,1984	WALLEYE	16,200	FINGERLING-STANDARD PRODUCT			
AUG 9,1985	WALLEYE	20,400	FINGERLING-STANDARD PRODUCT			
AUG 6,1986	WALLEYE	13,300	FINGERLING-100/LB REQUESTED			
AUG 12,1986	WALLEYE	6,700	FINGERLING-100/LB REQUESTED			
JUN 24,1987	WALLEYE	20,000	FINGERLING	3"		
JUL 27,1990	WALLEYE	66,480	FINGERLING 2.9-8.4"(AVE 3.8")			
AUG 1987	WALLEYE	2,040	6"FINGERLINGS ACCEL.GROWTH			
OCT 29,1989	WALLEYE	2,040	6"FINGERLINGS ACCEL. GROWTH			LV CLIP
JULY 27,1990	WALLEYE	66,480	2.4",240/LB, 277 LBS			
SEPT 20,1990	WALLEYE	2,040	FINGERLINGS EXTENDED GROWTI		Poor/fair Cond	RV CLIP
OCT 28,1993	WALLEYE	400	9" AVE PRIVATE STOCKING			
1994	WALLEYE	2,040	FINGERLINGS EXTENDED GROWTH			RV CLIP

TABLE 16. FISH HISTORY OF PIKE LAKE, MARATHON CO

1956	FISHERIES ASSESSMENT
	- Northern Pike dominate gamefish, Bluegill dominate panfish
	-Largemouth Bass,Yellow Perch, Black Crappie, Golden Shiners and White Suckers present
1962	SUMMER FISH KILL AUGUST 22 VISIBILITY 18" FOR 3 WEEKS W/VERY DENSE PLANKTON BLOOM
	-Bulk of Dead fish small yellow perch, small northern, & two walleyes
	-Water Chemistry: MOA 112 mg/l,pH 8.4, conductivity 237, surface Temp 74oF
	-Dissolved O2 Aug 22 11:30, S' 5.4ppm,5' 5.3ppm. 10' 2.5ppm, 15' 1.0ppm
	-Dissolved O2 Aug 23, predawn, Just below the surface at 5 locations Range 5.0 to 6.7ppm
	-Algae analyzed & toxin emitting alge present, Oscillatoria & Anabaena
1964-65	PARTIAL WINTERKILL
1968	LAKE MAPPED on March 21 &22
1969	FISHERIES ASSESSMENT
1969	UNDER THE ICE DISSOLVED OXYGEN ASSESSMENT
	-March 19, DO 4 to 9ppm to 8' of water at several locations
	- June 17 Tremendous mayfly hatch
	-Heavy Algae Blooms in Summer, Plants to 8' contour,
	-Aug 14 (Clear Day)Water Chemistry: MPA 103.5, Seechi 4', Upper Thermocline depth of 18'
1971	FISHERIES ASSESSMENT
	-Northern Pike dominate gamefish, Yellow Perch & Bl Crappie dominate panfish
	-Walleye population strong(from stocking after fish kill)
	-Black Bullhead abundant, LMB Present in small numbers
	-Jan 11, Algae Blooms under the ice
1976	
1978	FISHERIES ASSESSMENT
	-poor walleye growth (? due to dense plant growth)
	-Walleye pop. estimate >11" is low compared with 6-12 adults/ acre in N. Wis. Walleye Waters
	-Walleye reproduction occuring in most years as there is no gaps in size distribution
1981	-March, rock rubble spawning reefs built
	- Walleyes eggs on reef on April 16
1981-83	-walleyes used spawning reefs in 1981,82, & 83,no fall fingerlings captured in fall of each yr
1992	RUNNING INVENTORY
1993-1994	UNDER THE ICE OXYGEN EVALUATION
1994	COMPREHENSIVE SURVEY
1996	Boom Shocker Sampling May 2 to May 22 (4 Samplings) Winterkill Check

The following year in 1963 711 adult northern pike and and 300 thousand fry were stocked in Pike Lake. 1965 also began the long history of walleye stocking in Pike Lake that continues until this day. **SEE TABLE 15**.

Oxygen conditions under the ice began to worsen and in the spring of 1965 the first reported partial winter fish kill was reported. This began the era of when water quality conditions were decreasing and being documented. Shoreline development and habitat destruction from grading, to filling, to septic pollution was noted in the DNR fishery files on Pike Lake.

Rice Lake was mapped and inventoried in 1960 and Pike Lake followed in 1968 and 1969. The original surveys produced the following information:

	Pike Lake	**Rice Lake**
Area:	205 acres	22.6 acres
% Under 3' Deep:	10%	15%
% Over 20' Deep:	12%	0%
Volume:	2405.5 acre feet	-
Shoreline:	2.4 miles	1.34 miles
Maximum Depth:	34'	12'
Shoreline Substrate:	80% sand,15%gravel, 5% silt	100% muck

Water Chemistry	8-14-69	9-12-60
Alkalinity	103.5(MPA)	170(MOA)
Upper Thermocline Depth:	18'	Good Oxygen to 10'

During the 1968-69 comprehensive survey of Pike Lake heavy algae (phytoplankton) blooms were occurring and an abundance of attached plants (macrophytes) were now growing from the shallowest water to the 8' contour.

By 1971 northern pike became the dominant game fish with an ever increasing walleye population after stocking of 67,000 fingerlings in 1965 & 67. Yellow perch and black crappie became the dominant panfish. Largemouth were present in small numbers. Decreasing water quality supported a black bullheads population as the most abundant fish in total of pounds captured in the survey.

During the spring of 1973 the dam washed out and walleyes northern pike, yellow perch and suckers were noted to be taken by hand as these fish tried to move upstream into the lake. The dam was repaired that summer. During a low water period in 1978 the dam was raised to maintain water levels in Pike Lake. A citizen complaint that water was not moving from Rice Lake to Pike Lake and water in Rice Lake was stagnating was noted.

Walleye surveys dominated the 1970's with spring electroshocking surveys to assess population numbers and growth in 73,75,76,78 and surveys in 76,77,80 to assess if walleye reproduction was occurring. By the mid 70's the walleye population grew with the stocking of another 53,000 walleye fingerlings from 1970 to 1975. Bad weather was blamed for poor spawn survival of walleye. In August 1979 another 20,000 walleye fingerlings were stocked. Assessments of natural reproduction in the walleye population found very limited numbers of natural fingerlings.

The average size (mean length) of the walleye increased through the 1970's. The increased length was attributed to poor survival (low recruitment) of the stocked walleye as their was little competition for food between the survivors.

Two rock rubble walleye spawning reefs were built on the Miller & Haull property on the east shores of Pike Lake in 1981 to improve natural reproduction. Walleye spawned on these reefs from 1981 to 1983. but no fall fingerlings were found in each of these years. Both of these locations were in areas that walleyes had been observed spawning in the past. Possible reasons for failure for the reef were: inadequate water circulation over reefs or scum (periplankton) growth on the reefs that would negatively effect egg and fry development, wrong size zooplankton for post larva fingerlings, or predation by black crappie.

Stocking of walleye fingerlings continued through the 1980's into the 1990's. Another 106,000 fingerling walleyes were stocked from 1981 to 1987. In 1989 and 1990 six inch extended growth fingerlings were planted in Pike Lake. Survival of these extended growth walleyes were also limited.

The mean length of the walleyes continued to grow in spite of large stocking quotas. By 1992 walleye was the dominant game fish with nearly three times as many were collected in the fish surveys that year than northern pike. Yet , by 1992 the population of spring adult walleyes (>12") had decreased 1.9/ acre which was 1/2 of the 1976 abundance but similar to the 1978 & 1981 populations.

By the 1994 comprehensive survey walleye had become 4 times as abundant as northern pike. The spring standing crop of adult walleye rose only slightly to 2.0/ acre (419 + or - 96). These statistics indicate that the 1994 number of walleyes found is half of 1976 (799 + or- 210), but similar to 1976 (425 + or - 112) and 1981 (392 + or -90). Walleye growth in 1994 decreased slightly from 1992.

The 1992 running inventory and 1994 comprehensive fishery survey also provide information on changes in other fish when compared to earlier surveys. Growth of 1994 northern pike was slower than in 1992 with comparable population estimates. The size structure of the entire northern pike population (mean length) and had decreased over 4 inches from 1969 to 1994 while the population has decreased.

These same surveys indicated a high quality largemouth bass population exists in Pike Lake. Mean length of these bass remained the same between 1992 and 1994. The largemouth population has increased it's abundance from 1969 to 1992 and remained stable between 1992 and 1994. In 1992, 78% of the largemouth sampled exceeded the 14 inch minimum length limit. By 1994, 64% of the sample were legal fish.

The 1992 and 94 surveys indicate that bluegill were the most abundant panfish in the Pike Lake. In 1994 nearly 4 times the bluegill were captured than in 1992. Very few bluegill were in the lake in 1969 as the lake was dominated by yellow perch at that time. When comparing the 1969 bluegill population to the 1992 & 94 surveys and DNR district age growth averages there has been a loss in quality in the population. This loss in quality includes a decrease in mean length and a reduced maximum length.

At the same time the yellow perch population of 1994 was 9 times the 1992 population but had similar mean lengths and sample size ranges. When comparing the 1994 population to the 1969 dominant panfish population a reduction in the quality of the perch population is occurring just as in the bluegill. The mean length declined a minimum of 1.0" from 1969 to the 1994.

The black crappie fishery is also declining in quality and number. From 1992 to 1994 the netting success declined from 322 (10.7/net night) to 108 (3.9/ net night). 88 black crappies were captured in 1969 (5.9/ net night). From 1969 to 1992 to 1994 the mean length of the samples declined from 8.0" to 7.6" to 6.9" respectively.

A almost nonexistent pumpkinseed population in 1969 has grown to a sizable population in 1996. Between 1994 and 1996 the average length had grown from 4.9" to 5.2" and catch per unit effort had increased from 122 (4.1/net night) to 206 (7.4/net night).

Rough and forage fish were also sampled in the 1994 comprehensive survey. The bullhead population was low compared to the 1969 population. 87 white suckers were captured with the largest sample in the 14 to 21" range. Large golden shiners were captured in the large mesh fyke nets and during electroshocking. Mudminnows, fathead minnows, Iowa darters, bluntnose minnows, and Johnny darters were found during the shoreline seine hauls. Creek chubs and common shiners were collected in the 1992 sampling but not in 1994. Rusty crayfish were observed both years.

Conclusions

The Pike Lake fisheries has evolved from the 1930's from a high quality walleye-perch fishery to a more diversified but poor quality fishery. This shift has come about through the slow appearing accumulative results of manmade changes in the lake that have occurred over the years, especially the accumulation of nutrients (organic matter). Except for the presence of walleye the present day species composition of the fisheries now resembles that of the upstream Rice Lake that is shallow with a bottom composed mainly of organic matter. **SEE TABLE 17.**

A lake's fish population in terms of number and growth patterns are never static as it changes with seasonal and annual fluctuations of food availability, water temperature, and environmental stress. But long term shifts in fish specie composition reflect complex changes in habitat (such as cover and spawning substrate), or introduction or prevention of native fish species migration(e.g. stocking or placement of barriers that limit fish movement).

The natural reproducing walleye fishery has been replaced by a population maintained through stocking. Poor survival of stocked fish have reduced the competition between walleye and growth of the walleye has increased. Without competition of abundant walleyes and with more nutrients providing more food both northern pike and largemouth bass predators have established good populations in Pike Lake. The largemouth bass and northern pike population are dominated by larger fish better able to capitalize the bluegill and pumpkinseed forage than the walleye.

In comparison of the fisheries data collected in 1969,1992 and 1994 the decreasing quality of the panfish was not only documented over the short time period of two years but over the longer period from 1969 to 1992 time period. The "quality" is the decline in size structure or overall growth to a certain age. This is reflective in the mean or average size of the fish captured. The only panfish that appeared to decline in number based on catch from 1992-94 was the black crappie. Therefore there was not only an increase competition between panfish species but within species with the increased number.

The outlook for the panfish is a perpetuation of abundant, small, and slow growing population. The abundant aquatic vegetation in Pike Lake at this time limits the effectiveness of predator fish to reduce panfish numbers now or in the future. The panfish species shift to include large population of pumpkinseed and bluegill from an early history dominated by yellow perch is further evidence of that habitat has changed. Yellow perch do better in a lake with sparse vegetation and more open and deep water areas. Bluegills and pumpkinseed do well in a lake with more vegetation and more shallow water areas. The more shallow water available the more pumpkinseed can dominate the bluegill. These habitat shifts relate to cover, food organisms available, and spawning habitat of each of the panfish species.

TABLE 17. Fishery Assessment History of Rice Lake, Marathon County, WI

RICE LAKE						
Sept 12,1960 Electroshocker Survey						
SPECIE	Northern Pike	LM Bass				
Number	2	13				
Size Range	7.8-13.3"	2.8-17.1"				
SPECIE	Black Crappie	Bluegill	Pumpkinseed	Yellow Perch		
Number	4	3	32	1		
Size Range	7.0-9.6"	3.5"-6.7"	2.8"-6.0"	4.6"		
May 20, 1975 Electroshocker Survey						
SPECIE	Northern Pike	LM Bass	Bl Bullhead			
Number	4	16	11			
Size Range	14.5-25.4"	5.5-13.4"	4.0-10.9"			
SPECIE	Black Crappie	Bluegill	Pumpkinseed	Yellow Perch	Golden Shiners	
Number	30	72	12		4	
Size Range	5.0-9.3"	2.7-7.9"	3.2"-7.5"		4.0-6.5"	
Stocking History						
1962 -300 Thousand Northern Pike Fingerlings						
1967 -275 Northern Pike Adults						

The study of forage minnows and their relationship to a fisheries, the food chain, and the ecology of the lake is not well understood on any lake. Minnow populations are important in the cycling of nutrients that accumulate in lakes and reservoirs from the insects, snails, and clams and plants into food for fish. Mud minnows were common in the fish captured in the fall electroshocking in 1994. During shoreline seining that year the minnow Johnny darter was most abundant. Bluntnose minnows, Iowa Darters, and fathead minnows followed in decreasing order of abundance.

Mudminnows is associated with moderate to densely vegetated waters. Mudminnows are bottom feeders and can survive oxygen conditions less than 1 ppm at both low and high temperatures where other species will perish.Newly hatched snails is one of the preferred foods of the mudminnow. This species is able to capitalize on newly flooded areas of a lake or stream better than any other minnow. Pike Lake and it's tributaries offer ideal spring habitat with these characteristics.

The Johnny darter inhabits most lakes and streams in Wisconsin but prefers small streams with sand and gravel substrates. There breeding area is usually in pools, slow moving raceways, and protected shallow waters of lakes that contain large rocks, logs, or mussel shells on which the eggs can be deposited on their bottom sides. This darter is tolerant of many organic & inorganic pollutants, and is able to inhabit siltier waters than tolerated by many other fish species. The Johnny darter is sensitive to low oxygen and will move towards moving water when this condition occurs. This darter host an immature stage of two clams on it's gills. In many waters it is a major food item for the walleye.

The bluntnose and fathead minnows are the most successful minnows in Wisconsin. This is mostly due to their lack of preference of undersurface material that they lay their eggs on and the fact that they lay their eggs throughout the spring and summer creating a large number of offspring over a long period of time. The bluntnose is primarily a bottom feeder that supplements its diet with surface insects and plankton. The fathead is a more opportunistic feeder feeding on insect larva on the bottom, fragments of higher plants, or algae in water column. The fathead is more tolerant of low dissolved oxygen and high temperatures than the bluntnose minnow.

The Iowa darter in Wisconsin is encountered most frequently in clear to slightly turbid light brown water in small lakes, bog ponds and slow moving brooks draining these waters. They are often associated with submergent vegetation especially filamentous algae covering stones and plants. This habitat is abundant in the Pike Lake ecosystem. This darter migrates upstream or into shallow waters of a lake and spawn in roots or filamentous algae. This darter is able to survive low oxygen conditions.

It appears that the minnows of Pike Lake are those species that has adapted to high organic conditions of Pike Lake. What is unknown? Are they maintaining population levels to support a good growing fish predator population?

PIKE LAKE, MARATHON COUNTY
RECOMMENDATIONS FOR LONG TERM PROTECTION & MANAGEMENT

Introduction

The future health of Pike Lake is dependent on area residents understanding the problems described in this study and how well and how sincerely we apply the solutions suggested in this plan. Maintaining oxygen and water flow are two key components of the Pike Lake Management that must be addressed for the future welfare of the lake ecosystem.

There are plenty of nutrients available for fish and aquatic plant growth so the future of Pike Lake is dependent on providing a suitable oxygenated environment so the nutrients can be utilized by fish, wildlife, a diversity of plants, and by man. At the same time, every effort must be made so new new nutrients enter the lake that would add to those already found in abundance.

The lake community will be the one that benefits from there own actions if they follow the recommendations below. Recreational benefits include: a sustainable restored fishery, a diverse and manageable aquatic plant community for increased wildlife viewing and boating, and increased beach areas for swimming. The monetary value of your lake property is reflected in the quality of your lake.

Pike Lake management options and recommendations are discussed under the following headings:

A. Water Level Control
B. Aeration System Operation & Evaluation
C. Aquatic Plant Management Plan
D. Watershed Protection Plan
D. Lake Use Plan
E. Fish Management Plan

WATER LEVEL CONTROL

Background

Pike Lake's geological history,watershed, and soils were evaluated as part of this grant's inventory appraisal. Since Pike Lake is drainage lake with added spring seepage the soils of the watershed and the shoreline have had a large part in the water quality problems of Pike Lake that we have today.

The damming of Pike Lake occurred sometime before 1937 and was not legally addressed as a permanent dam structure until 1949. The presence of the dam for over 60 years has contributed to a series of biological events that have accumulated in the problems of aquatic plant abundance, fishery changes, and water quality problems you have today. Some of these changes have been recognized in recent years as Pike Lake was chosen as a long term monitoring lake by the Department of Natural Resources in 1986 and has been evaluated ever since. Other changes have been documented for a longer period through the fish management history. It is these histories added to the current ecological evaluation as part of this grant that has recognized the significant impacts that the low head dam has had on the Pike Lake.

The damming of Pike Lake with a 1.2' head has backed water through Rice Lake Creek and increased the water levels in Rice Lake. It also raised water in adjacent low areas southeast of Lake View Drive. Most of the flooded land consisted of either muck or peat soils. Muck soils developed where spring seepage from the upland hills provide oxygen for decomposition of organic matter accumulated in wet areas. Peat soil accumulated where standing water accumulated organic matter without the presence of oxygen to break it down. Submerging of these soils slowly killed or altered the plants that held these soils in place.

Over the years spring runoff from melting snow, rain from storm events, and wind/ wave action eroded these soils releasing organic matter and dissolved nutrients to the waterways of the Pike Lake system. Rice Lake and Rice Lake Creek became shallower with the accumulation of released organic debris. Increased water flow from the above events continue to carry this material into the settling basin of Pike Lake.

The 1.2 foot increased head also decreased the flow from springs through increased water pressure. This spring seepage is important in providing oxygen and temperate water into deep and shallow water areas of the Pike Lake system. This seepage aids in decomposition and recirculation of the muck and other organic debris into the food chain during the growing period. This spring seepage also provides a refuge for organisms in an oxygen starved environment below the ice. It also provides oxygen to bottom sediments that can "tie up" phosphorus that would other wise enter the water column to grow aquatic plants.

Management Options

There are several options to the management of water levels but is important to realize that maintaining the dam will continue to accumulate organic matter in Pike Lake. This organic matter accumulation will in turn increased the nuisance levels of the aquatic plant community, continue to decrease the quality of the fishery, and increase problems associated with water quality. Thirteen member's in the property owners survey favored the water level and flow management as solution to Pike Lake's problems.

The FIRST OPTION is to do nothing. The problems of Pike Lake associated with nuisance levels of plants, low winter oxygen, and the maintenance of a fisheries can be addressed by more costly techniques. The success of these techniques will be dampened or hindered by the water quality problems that will still exist.

The SECOND OPTION is to conduct a hydrological survey that includes ground water flow measuring and modeling to quantify the effects on ground water flow of the dam. The dam could be lowered gradually to monitor the effects on the ecosystem but changes in rainfall and climate over the short term of a survey could cloud the results.

The THIRD OPTION is to work with the Town of Reid and the Town of Elderon in petitioning the Department of Natural Resources for the removal of the dam. The cost of the removal could be tied to Lake Protection Grant funding decreasing the cost. Monitoring the effects of the dam removal could be a part of future management.

The third option is recommended. Over time the Pike Lake ecosystem will stabilize and conditions in the lake will improve. Removal of the dam may not drop the head a full 1.2 feet during high water table and wet years of the hydrological cycle. Most of the Pike Lake shoreline drops off quickly and the hydraulics of shoreline wave action will scour organic matter from these areas. Organic soils that support the nuisance levels of plants and shallow water in areas of the lake will be moved to deeper water exposing sand in many places. In time these sediments stabilize in other shallow water areas or will work their way downstream.

Beaver dams will continue to be problem in the system and an increased effort will be needed to remove them and their dams.

AERATION SYSTEM OPERATION AND EVALUATION

Background

The evaluation of the oxygen- temperature regimes and the present aeration system of Pike Lake under the ice the past two winters (1995-96 & 1997-98) offers a picture of the oxygen conditions under the two extremes of winter - severe and mild. The twisted air supply line during the severe winter of 1995-96 hampered the monitoring effort to find out the ability of the system to provide an oxygen refuge for the fishery. The aeration system during the mild winter of 1997-98 provided little positive changes in the water quality that other areas of the lake ecosystem without aeration were providing.

Pike Lake Sportsmen Club, Ltd. has the equipment to continue the evaluation of the system when the next severe winter occurs or if the dam is removed to monitoring the changes in oxygen levels in the Pike Lake system.

Pike Lake at the present appears to recover from very poor winter oxygen conditions quickly when Rice Lake Creek opens up or when clear ice allows light penetration for phytoplankton to produce oxygen. The removal of the dam and restoration of spring seepage in Rice Lake may keep Rice Lake Creek open throughout the winter or at least extend the period of open water in both spring and fall

Management Options

There are several options in providing oxygen under the ice. The role that the aeration system plays depends on if it can supply more oxygen at critical times than the natural system. Can it be used to keep oxygen levels above the 5.0 mg/l level to avoid any oxygen stress to aquatic organisms or can it be used to maintain low amount of oxygen that will be enough for survival? Will an increasing organic load on to Pike Lake have an oxygen demand that any aeration system will be large enough to provide a refuge?

The FIRST OPTION is to continue operation of the system every winter as it is presently operated. On some winters it appears this is unnecessary and would be an expense without a benefit. On severe winter's it may not be adequate. Maintenance problems could be just as costly with non use as with use.

The SECOND OPTION would to operate the system when needed
Drought periods decrease spring seepage and natural aeration. In return wet periods increase spring seepage and natural aeration. When to begin and end aeration in a season could be keyed to further winter sampling. Summer aeration is not suggested.

The THIRD OPTION is to remove dam and monitor system for oxygen refuges and what conditions change under the ice. It may be found that when spring seepage increases and the organic load is reduced that aeration is unnecessary.

AQUATIC PLANT MANAGEMENT PLAN

Background

The long term monitoring program on Pike Lake the last 10 year's has recognized drastic changes in the plant community. Nuisance levels of aquatic plants have become a problem especially on the east and south side of Pike Lake. "Too many weeds" was the #1 complaint in the property owner's survey as part of this grant. The biggest changes in the plant community have occurred in the shallow water areas adjacent to shoreline properties in 1 to 5 feet of water. This restricts access and recreational use of these waters.

The plants that caused these nuisance levels have been identified in the recent aquatic plant surveys. The main plants causing the problems are the floating lily pads, floating duckweed, and the submergent coontail. Lily pads need an organic substrate to grow on. Both duckweed and coontail have no root system that get their nutrients from dissolved organic matter in the water. The shifts in the aquatic plant community from more rooted submergent plants that pose a less of a nuisance to these plants have has been documented in less than 10 years.

The cause of this shift is the accumulation of organic matter on the bottom substrate and dissolved in the water that favor these plants. The origin of this accumulated organic matter has been the flooded organic soils adjacent to the lake and in the flooded organic soils in the Rice Lake portion of the watershed. Wind and wave action has carried this organic matter to shallow areas of the lake. Aquatic plants are changing and becoming more dense in an attempt to absorb as much nutrients as possible.

Management Options

There are several options and levels of effort to deal with the over abundance of aquatic plants. Some will show results immediately such as cutting or spraying but are only a temporary solution. Other management strategies will take more time to see the results but will be more lasting and permanent. Plants will always be abundant in Pike Lake but which type they are, how abundant they appear, and where they will grow will depend on the management options you choose. These options are discussed below in detail by category.

The FIRST OPTION is to do nothing and tolerate the changes in the aquatic plant community of Pike Lake. Accepting this accelerated aging process will see a continued accumulation of organic matter and denser aquatic plant communities throughout the lake but especially in the shallowest of waters. The more plants that grow the more of a buffer of the shoreline areas to wind/ wave action. Muck and organic plant build up will build up in shoreline areas without this wind and wave action. Plankton and algae blooms will become more severe as this aging process proceeds.

The SECOND OPTION is to continue the aquatic plant spraying for algae and macrophytes (vascular plants). This option has fairly immediate results but the results are only temporary. In the property owner's survey this option received sixteen 1st through 3rd place votes as a solution to the priority problems of too many weeds. The long term environment effects of spraying are now just being realized. Accumulation of arsenic compounds in the sediment from past chemical spraying as already prohibited the use of "weed roller" technology on Pike Lake. The accumulation of copper compounds and other inorganic compounds in the sediment from past spraying may prohibit dredging of the bed material - another management tool that could eliminate some of the aquatic plant problem.

The THIRD OPTION is the removal of soft sediment or dredging. This option received only five 1st through 3rd place votes as a solution to the priority problems of too many weeds or too much muck or silt. This can be a lengthy process and would require a sediment profile, sediment testing, habitat evaluations, and an extensive dredging plan. A spoil deposition area would have to be identified and purchased or secured. This is an expensive option that has no government aid unless it important in maintaining navigational channels. A taxing Lake District is normally formed to cover the cost of the dredging.

Small area dredging is usually short lived as wind/ wave and boat action can carry silt from adjacent areas back into these areas. A 4" trash pump can be used to clear areas next to docks and swimming beaches and the organic matter pumped to adjacent gardens or woods for settling. A permit is required from the department of natural resources just as a larger dredging project.

The FOURTH OPTION is machine harvesting of aquatic plants. This option only received four 2nd and 3rd place votes in the property owner's survey.

Purchase, operation, and maintenance of an aquatic plant harvester is very expensive and not a practical alternative for the Sportsmen's Club. The cost could be occurred if a lake district was formed to secure funds for the purchase, operation, and maintenance. Joint purchase and operation with a nearby lake that needs a harvester could reduce the expenses. Cost sharing for purchase is also available through the state waterway commission but an aquatic plant management plan would have to be developed. These machines cost from $39,000 to $60,000 and more for complete harvesting and removal equipment. Operation and maintenance is additional.

There are several portable machine aquatic plant harvesters available that can be mounted on a boat and could be operated by lake volunteers or used by by individual lake residents to cut channels near their own shorelines. It is the law any weeds cut must be removed from the lake: therefore plants cut by these portable machines must be pulled out of the water, placed on the shoreline, and transported for disposal or composting. The cost of these harvesters start at $3,000 and can exceed $10,000 with additional equipment to aid in removal from the lake.

There are water weed cutters and rakes available for hand harvesting. These tools could be purchased by the club and loaned to lake shore residents to use. Plants that are cut can be put on the shoreline to dry, and used as mulch or compost. The light sandy soils around Pike Lake would benefit from these added nutrients. Cost of a cutter and rake is around $200.00.

The hiring of a plant harvester maybe a more practical alternative to deal with shallow area weed cutting. A six foot cutter can cut approximately a half an acre in one/half hour and haul 300 cubic feet of plants before having to unload at the landing. This cutting=g time can vary depending on the density of the weeds and the distance to the landing for unloading. Cutting of lily pads is one plant that would slow down this process time. This small harvester can cut down to a maximum depth of 5 feet but cutting in water less of than two feet deep in nearly impossible or very hard on the cutting bar. The price to hire a plant harvest contractor is approximately $140/hr for 20 to 40 hours of work and $120/hr if over 40 acres are harvested.

The FIFTH OPTION is to remove the dam and allow the ecosystem to restore itself. Overtime the removal will improve water quality conditions that will favor plants that existed in the past and disfavor the nuisance plants that are causing the problems today. Dissolved and suspended nutrients will be reduced in the system that will favor these plants. When the lake is lowered organic matter that had settled and accumulating in some shallow areas will now be moved by the wind and wave action. Plants that have large root systems will replace the nuisance plants that do not have root systems storing nutrients in the sediment, not in the water column.

Areas in the Rice Lake basin and east tributary area that were flooded by the dam and contributed organic matter to Pike Lake will now become nutrient sinks, again. The soils that were released to Pike Lake during spring thaw and rains overtime will stabilize in these areas and not be carried into Pike Lake. This will prevent further decreases in Pike Lake water quality in the future.

Lake level may not drop 1.2 feet after the removal of the dam. The removal of the dam would decrease the hydrostatic pressure in flooded spring seepage areas. This change in pressure would increase spring seepage into Rice Lake, Pike Lake, Rice Lake Creek, and their tributaries. This increased flow may mitigate all or part of any drop in water level. Spring seepage also varies with the water table changes and drought cycles.

Shoreline property owner's of Pike Lake would be most effected if the water level is dropped. On the west and south shorelines shallow water extends several hundred feet from shore. In these areas a limited aquatic plant harvest or dredging project could alleviate navigation and access problems. On the sand and gravel shoreline areas where the water drops off quickly wind and wave action will scour build up detritus and provide better substrates for fish spawn and habitat for other aquatic organisms.

WATERSHED PROTECTION PLAN

Background

A total of 4,092 acres of land drain through Pike Lake. Much of the upland of the watershed has very well drained to excessively drained sandy and stony soils therefore water enters the water table very quickly.

Only 33% of the watershed is used in agriculture. In 1996 only 13% of this 33% was tilled or had crops. The remaining 20% was old pasture or had a cover crop. Larger blocks of crop land are irrigated because of the highly porous sand and gravel beneath. Irrigation intercepts ground water that would normally flow through Pike Lake. Wind erosion on these bare and flat sandy crop land would be more of a problem than water erosion. Ground water contamination with pesticides could be a problem on these irrigated lands if careful cautions are not followed in application.

Thirty-eight percent of the watershed is forested. Most of these forested lands are on the hill tops in rocky terrain. These characteristics limits land use changes from there current use that could effect the water quality of adjacent waterways. Light residential construction will probably be the land use change that will effect the forested land. Roads if not properly build could erode these steep upland sites and fill in adjacent wetlands or alter wetland drainage to Pike Lake watershed drainage ways. Well development would intercept ground water that would normally flow to Pike Lake.

Sixteen percent of the watershed is open or forested wetland much of which is currently flooded by the Pike Lake Dam. The problems of flooding of these soils have been discussed in other parts of the recommendations. Areas adjacent to these wetlands need to be protected from development or erosion.

The steep embankments of highly porous soil surround most of Pike Lake. These soils are susceptible to erosion, drought conditions, and are not good for wastewater treatment. Over 75 dwellings surround Pike Lake and the property owner's survey indicates a move towards permanent dwellings and more use. With this use comes more development of each property. Access and parking on the steep slopes means replacement of trees and ground cover with pavement. The increase in pressure on sanitary services increases nutrients entering the ground water and Pike Lake. Increased shoreline activity will decrease habitat and esthetics of the lake. All of these increased pressures ultimately will effect the lake uses and recreational values we cherish in owning lake front property.

The upgrade of STH 29 will decrease the travel time from the Wausau area to the Pike Lake watershed. Development pressures will increase and land use planning will be needed to minimize the effects on the Pike Lake community.

Management Options

Their are several options to protect the Pike Lake watershed. Some options can be acted upon by individuals on their own property some will require becoming active in county and township activities. These options were developed from understanding the land, soil, and water and the needs expressed by the lake community through the property owner's survey.

The FIRST OPTION is to do nothing and tolerate changes in the landscape that uncontrolled development and land use creates. The deteriation in water quality from the changes in land use will be slower and harder to recognize. The changes in the watershed of the immediate shoreline will come quicker and effect not only water quality but the esthetics of viewing the lake from the shore or the open water.

The SECOND OPTION addresses the larger watershed of Pike Lake. Buffer strips along all wetlands and waterways are important in the functioning of the aquatic systems of the Pike Lake system. These areas must be protected through the passage and enforcement of current zoning laws or development of new land use plans and laws.

These buffers protect the waterways from eroded soils that enter from tilled land and light residential development. These buffer strips provide habitat for native plants and animals. The waterways provide habitat for reproduction and cover for minnows, amphibians, and some game fish. All of these living things consume nutrients and if they are destroyed these nutrients can enter the waters of Pike Lake and negatively effect water quality.

The THIRD OPTION is to develop shoreline buffer strips on all developed lots. The steeper the slope the wider the shoreline buffer should be. There are many reasons for this shoreline buffer strip.

The buffer strips prevent surface water runoff form entering Pike Lake from short grass areas, walkways, and roadways. It acts as a filter of sediments, salts, and fertilizers that would come from these drainage areas.

When planted with native flowering forbes and grasses (because they have extensive root systems) they can intercept ground water and absorb nutrients that may be entering Pike Lake from upland wastewater seepage beds.

The esthetic value of the buffer strip is also important. Using a variety of plant species of different heights will not restrict the view from the dwelling or from the open water, but provide a natural landscape frame (as a frame and matting would enhance a picture).

Design of these buffer strips can be tailored to your personal needs and wants. An abundance of colors, shapes, and sizes of native vegetation from flowers to shrubs to trees are available for planting. They are adaptive to shady or sunny areas. Walkway approaches to the lake can be angled and / or hidden to lesson the effects but still give access to docks and swimming areas. Plants can be selected to draw birds, butterflies, and other wildlife to your shoreline.

A FOURTH OPTION is maintaining a tree canopy in the shoreline areas of Pike Lake. This practice is particularly important on steep slopes and short grass areas to slow the erosion effects of heavy rains. The sandy soils on steep slopes need shade to maintain soil moisture for ground cover. Back lot areas adjacent to access roads especially need a canopy to maintaining ground cover to prevent erosion from water leaving the roadways during storm events. Selective cutting of trees and good road building techniques go along way in protecting the wetlands and open waters of Pike Lake.

A FIFTH OPTION is maintaining the sanitary systems around Pike Lake. The property owner's survey recognized an increase in year-round dwellings occupancy and increase property use that would correspond to more the use of the sanitary systems. Many systems have been replaced and holding tanks are replacing septic systems. Septic tanks should be cleaned when settled matter fills only 1/3 of the volume of the tank. If not done at this time, settling time of solid waste is reduced and solid waste can enter the drain field. Paying close attention to cottage or home use and maintaining a pumping record will help in understanding when to pump.