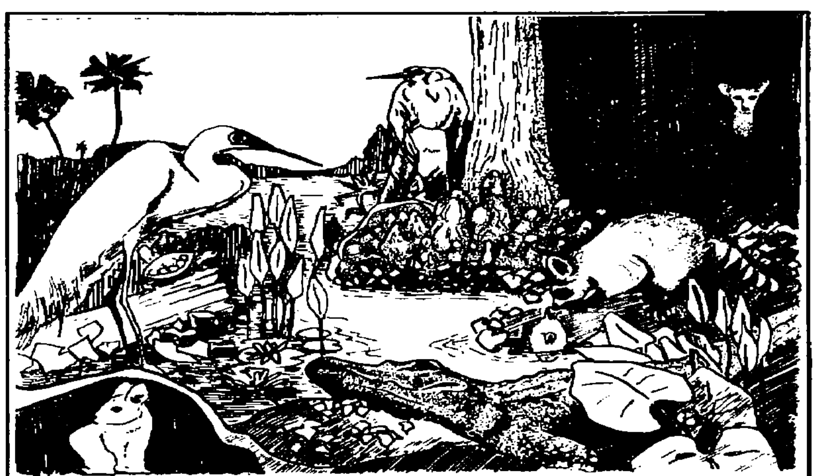
Winter Haven Chain of Lakes
Surface Water Improvement and Management (S.W.I.M.) Plan



Southwest Florida Water Management District
Approved Plan - April 17, 1998

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SURFACE WATER IMPROVEMENT AND MANAGEMENT (SWIM) PLAN FOR THE WINTER HAVEN CHAIN OF LAKES - 1998

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EXECUTIVE SUMMARY

The Winter Haven Chain of Lakes is composed of 19 interconnected lakes located within and around the City of Winter Haven in north-central Polk County. An investigation of lake sediment cores from five lakes on the Chain was conducted to evaluate historical changes in water quality. Sediments dated to about 1860 indicated that the lakes were historically in the mesotrophic to eutrophic range (moderately to slightly nutrient enriched) with a lack of bluegreen algae blooms during the summer. It is postulated that the Trophic State Index (TSI) for the lakes was probably around 50; however, due to extreme hydrologic changes to the lakes and the high degree of urbanization of the watershed, TSI's in the slightly eutrophic range are the best that can be reasonably expected (i.e., TSI's from 50 to 60). A target TSI of 60 is proposed for the Chain as a whole.

A twenty-five percent reduction in non-point loading of phosphorus will be required to lower the TSI ten units; this is consistent with a target TSI of 60 for most Chain lakes. Further, it has been estimated that a 25% reduction in non-point source loading will require a 50% reduction in stormwater phosphorus loading. In the case of the Southern Chain of Lakes this equates to an annual load reduction of 4,000 pounds of phosphorus, and for the Northern Chain, approximately 1,000 pounds. Using typical wet detention systems, this will require the equivalent of 20-25 retrofit projects on the highest loading subbasins.

The plan proposes to continue to implement stormwater treatment projects as funding becomes available. It is anticipated that stormwater treatment projects will include a mix of typical (e.g., wet detention) and innovative technologies (e.g., alum injection, periphyton filter system, etc.). In addition, the plan proposes to develop detailed nutrient budgets for at least two lakes on the Chain. The large number of lakes involved precludes an in-depth investigation of each; however, it is felt that accurate budgets for at least two lakes will increase confidence in model predictions, allow refinement of pollutant reduction goals, and help to develop the most cost effective nutrient reduction strategies.

The original SWIM plan for the Winter Haven Chain of Lakes identified stormwater treatment as a high priority. This plan essentially reaffirms that position. The degree and speed of implementation of future stormwater treatment projects will be dependent on available funding from the State (SWIM funding), District, and local governments.

CHAPTER ONE: INTRODUCTION

Florida is a state of exceptional aquatic resources. It is especially well known for its sunny, subtropical marine waters and white sandy beaches that attract tourists by the tens of millions annually. Equally impressive, however, are the state's vast expanses of wetlands and over 7,700 freshwater lakes (Edminston and Meyers 1983). Considering their obvious environmental, recreational and economic value, it is important that Florida protect these water bodies from the consequences of explosive developmental pressures and constantly increasing growth.

SWIM Act Sections 373.451-.459, Florida Statutes

The Florida Legislature, through the Surface Water Improvement and Management (SWIM) Act of 1987, directed the state's water management districts to "design and implement plans and programs for the improvement and management of surface waters" (Section 373.451, Florida Statutes). The SWIM legislation expresses concern for the ecological, aesthetic, recreational, and economic value of the state's surface water bodies, noting that degradation of surface waters is typically caused by a combination of point and nonpoint sources of pollution and by the alteration or destruction of natural systems that provide enhanced water quality as well as important wildlife habitat.

Priority Water Bodies

An initial phase in the development of SWIM plans and programs is the prioritization of water bodies within each water management district (WMD) based on their need for protection and/or restoration. The prioritization is done by the WMDs in cooperation with the Department of Environmental Protection (DEP). This process also includes review by the public, local governments, and other state agencies. The prioritization is subject to periodic review and changes are made as needed.

Criteria

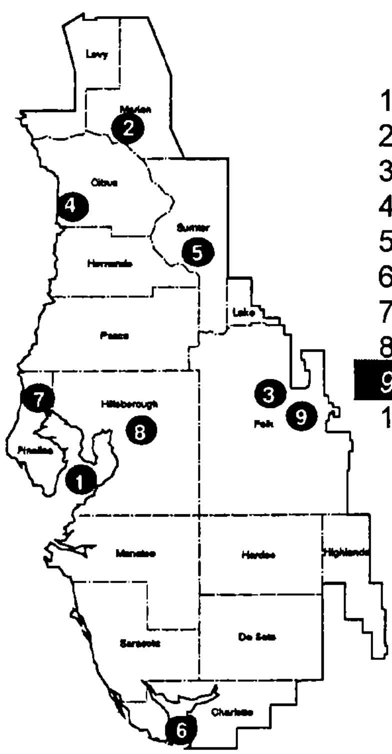
The SWIM Act establishes criteria by which water bodies are evaluated for prioritization. These criteria are further defined in Section 17-43 of the Florida Administrative Code. Districts were required to develop a list of priority water bodies of regional or statewide significance by March 1, 1988. **Specific criteria to be considered include:**

- **The degree to which state and water quality standards were violated;**
- **An evaluation of the nature and extent of conditions adversely affecting the water body;**

- o Threats to water supplies and recreational opportunities;
- o The extent to which local government plans policies, and ordinances are consistent with efforts to restore or preserve a water body;
- o The feasibility of monitoring success; and
- o The economic and environmental feasibility of accomplishing restoration or conservation goals.

The relative weight and means of assessing the above criteria is at the discretion of each WMD. The SWFWMD employed a semi-quantitative approach involving a specially formed ad hoc committee composed of representatives from the district and various state agencies. This committee developed a priority list from a master list of 67 water bodies nominated by representatives of county and local governments, state agencies, and the public at large. A list of 28 water bodies (lakes, streams, rivers and estuaries) that met DEP criteria was developed; eight were ranked in priority order. This list is periodically reviewed under the provisions of the SWIM Act. A ninth was added to the priority list in 1989 and a tenth in 1995 (Figure 1-1). More specific details regarding the evaluation process can be found in the report submitted to DEP (SWFWMD 1988). Final evaluation relied heavily on the expertise and experience of the ad hoc committee and upon public input received at numerous workshops.

Figure 1-1. SWIM Priority Waterbodies



1. Tampa Bay
2. Rainbow River
3. Banana Lake
4. Crystal River/ Kings Bay
5. Lake Panasoffkee
6. Charlotte / Placida Harbor
7. Lake Tarpon
8. Lake Thonotosassa
9. *Winter Haven Chain of Lakes*
10. Sarasota Bay

Development of SWIM Plan

SWIM legislation was specific; before funds could be drawn from the Ecosystem Management and Restoration Trust Fund's SWIM appropriation, an approved SWIM plan must first be developed. The process involves several steps. Development of SWIM management plans involves the collection and interpretation of relevant facts, identification of goals and management issues, selection of feasible implementation strategies, and provision for adequate funding support. Implementation strategies must undergo intensive review and result in meaningful and measurable improvements to the system. In addition, all projects must be part of an integrated approach, inextricably linked to the basic management goals. The purpose of each plan is to provide a logical and cohesive framework relevant to the waterbody under consideration for addressing central concerns raised in the SWIM legislation: point and nonpoint pollution sources, destruction of natural systems, and correcting and preventing surface water problems.

SWIM Advisory Committee

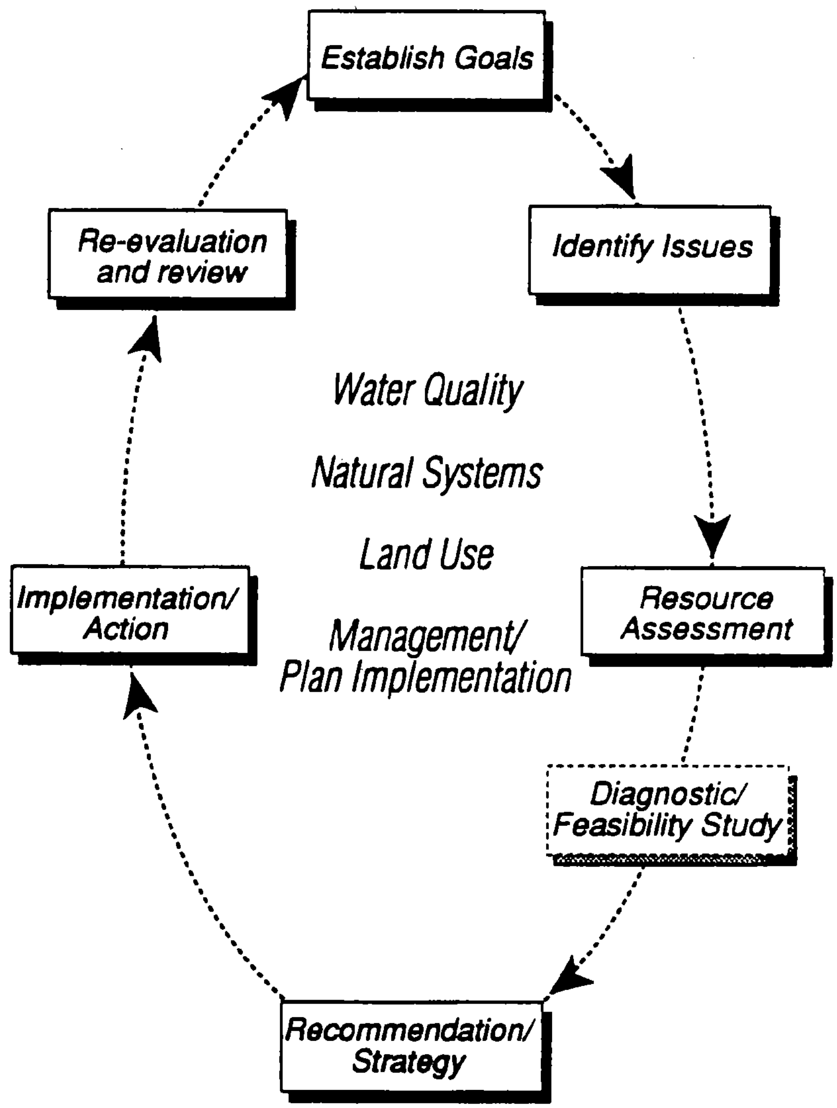
The Act is fairly comprehensive in outlining the necessary procedure for developing a workable management plan, suggesting a format similar to that advocated by Rast and Holland (1988). Both emphasized the importance of public input during the planning process and included the public in an advisory role. Initially the use of advisory committees was suggested; it is now mandated due to an amendment to the Act in 1988. The SWFWMD developed a management plan format based on what we have labeled the "GIPPs" protocol - Goals, Initiatives, Programs and Projects. Goals are broad based and global yet provide direction for formulating the balance of the plan. Four specific "initiatives" were identified: water quality, natural systems, land use, and water body management. Within each initiative, programs are developed to categorically address an issue within the initiative. Programs are more specific than initiatives yet allow for flexibility as projects are developed.

It is at the project level that the substance of the plan is put in place. A project is a specific activity with a specified end point. Projects have a defined timeline and an associated itemized budget. The planning process is presented graphically in Figure 1-2. The WMDs were given no additional or new regulatory or enforcement authority. Adoption of management plans at the local level will be voluntary; however, "the extent to which plans, ordinances, and policies of local governmental units with jurisdiction over a water body are consistent with a WMD's efforts to restore or conserve a water body" (Florida Administrative Code 17-43) is a consideration when prioritizing funding projects under SWIM.

SWIM Funding

Only water bodies identified in the Act in 1987 received funds from the SWIM Trust Fund in Fiscal Year 1988. The legislature appropriated $15 million in 1989 and again in 1990. Funding has decreased in recent years, and no new funds were appropriated for SWIM in Fiscal Year (FY) 1993; however, the legislature designated that interest compiled on unspent funds in the SWIM Trust Fund would remain in the fund. Therefore, $3 million was made available by the State for SWIM purposes in FY 1993. Ten million dollars was budgeted in FY 1994, and $10.5 million in FY 1995. No new funds were made available in FY 1996, and funds budgeted in FY 1997 were tied to DOT mitigation. While $3 million in funds was budgeted in FY 1998 only $400,000 was made available to the SWFWMD. Lack of a sustained,

Figure 1-2. SWFWMD SWIM Planning Process



dedicated source of funding hampers long range planning.

Only until a management plan is approved can monies be drawn from the Ecosystem Restoration and Management Trust Fund for implementation; exceptions are those waterbodies specifically named in the legislation.

Initially the Trust Fund provided up to 80 percent match on approved projects; changes to the Act now require at least a 40% match by the WMDs. Monies for the SWIM Program continue to be dependent on a yearly appropriation by the legislature. Of each yearly appropriation, 50% is divided evenly among the five water management districts; the allocation of the remaining 50% is determined by DEP.

Supportive Legislation

Florida has in recent years passed several important pieces of legislation and implemented certain programs that augment and further the goals and intent of SWIM. Three significant land acquisition programs, the Conservation and Recreational Lands (CARL) Program administered by DEP, the Save Our Rivers Program administered by the WMDs, and most recently Preservation 2000, take land into public ownership, preserving valuable wetland and upland resources.

Florida's Local Government Comprehensive Planning and Land Development Regulation Act of 1985 (Chapter 163, Florida Statutes) requires all counties and municipalities within the state to develop and adopt comprehensive plans. In these plans, local governments are required by rule (Rule 9J-5, Florida Administrative Code) to develop one or more policies to protect and conserve the natural functions of existing water bodies (Renner 1988).

Plan Format

A uniform format for all SWIM Plans was established by DEP as required by the SWIM Act and has been adhered to in this document.

The Plan Outline is as follows:

A. Introductory Text
B. Identification of Priority Issues and Analysis
C. Strategies
D. Specific Projects

SWIM Act - Intent and Focus

A number of central concerns as expressed in the SWIM Act must be addressed in the management plan; specific strategies and programs must be set forth for addressing these concerns. Point and nonpoint source pollution are inclusive terms; however, it is necessary that all significant causes of pollution to the water body be examined, and, at a minimum, the relative contribution of various point and nonpoint sources assessed. Once their relative contribution has been determined, it may be necessary to better quantify the proportional contributions of various sources so that a strategy for dealing with these sources can be addressed. If, for example, a nutrient budget shows that the atmosphere is contributing a significant amount of a critical nutrient, it may be necessary to determine the source of the atmospheric loading so a control strategy can be developed; however, if the amount contributed by the atmosphere is so small that it would have no impact on the overall budget even if eliminated completely, it would not be cost effective to determine the source of atmospheric loading.

Since many water body problems are related to nutrient loading (increasing eutrophication), an initial step in addressing this problem is to determine the extent of point and nonpoint sources (note: these same sources are also the source of other pollutants such as heavy metals and organic compounds). This step was an initial requirement, and supported one of the required elements of all SWIM Plans - a list of the owners of point and nonpoint sources of pollution that discharge into the water body or its tributaries.

Natural Systems

Natural systems associated with a water body are critical items of interest in all SWIM Plans. Unlike many past management plans which emphasize only water quality aspects, SWIM Plans must address natural systems. There should not be the presumption that if water quality concerns are adequately addressed further concern for natural systems is not warranted. Improvements in water quality alone will not necessarily lead to requisite and equivalent improvements in the natural systems associated with a water body. It should not be taken for granted that if a desired water quality is attained the wildlife value of the water body will increase correspondingly; likewise, attainment of a high quality sport fishery does not necessarily lead to desired water quality improvements or improvements necessary for other non-game wildlife species. It is incumbent that SWIM plans evaluate the natural systems associated with a water body and develop the appropriate strategies for maintaining and where necessary for improving or enhancing these systems.

SWIM Plans should focus on both the correction and prevention of surface water problems. It would be expected then that SWIM plans should contain a mix of reactive (i.e., restorative) and proactive (i.e., preventative) management strategies; the mix dependent upon the unique circumstances of each body.

The SWIM Act also focuses on the need for research relating to water body management. Studies or research related activities are often viewed much less favorably than action oriented ("dirt moving") projects; however, it should be appreciated that the information gained on a project specific to a particular water body could be extrapolated to many other water bodies. Also the potential effectiveness of restoration and other resource management strategies cannot at present be determined without diagnostic and monitoring studies. Any proposed SWIM project should be viewed from a perspective of increasing the body of knowledge relating to water body management. Given limited funding, it can even be argued that some preference should be given to those projects that at least contain an element of research that would improve our ability to manage water bodies more effectively. The SWIM Act clearly states its intent to foster research related to water body management.

Minimal Requirements

All plans must at a minimum include the following:

1. A description of the water body including its historical and current uses, hydrogeology, and watershed characteristics. This description should include as applicable the history of conditions which have caused the water body to be in need of restoration or the conditions which threaten the water body;

2. A discussion of all governmental entities with jurisdiction over the water body outlining their respective responsibilities and authorities relative to the water body [see Appendix A];

3. A description of land uses, pollution sources and permitted discharges within the area or watershed addressed by the plan;

4. A list of the owners of point and non-point sources of pollution that discharge to the water body or its tributaries which adversely affect the water body;

5. A description of strategies recommended for restoring or protecting a water body; these strategies should be sufficient to insure that the water body meets Class III standards (as defined in Section 17-3.121 Florida Administrative Code);

6. A list of studies that are being or have been prepared on the water body;

7. A list and the current status of active restoration and/or protection projects for the water body;

8. A description of the research and feasibility studies needed to determine what strategies will be used to restore and/or protect the water body;

9. A description of the measures needed to manage and maintain a water body once it has been restored and/or to prevent future degradation;

10. A schedule (timeline) for the restoration and/or protection of the water body; and

11. An estimate of the funds needed to implement specific restoration and/or protection strategies.

DEP SWIM Plan Review

Prior to Governing Board action, the DEP is required to review proposed SWIM Plans. They are required to make three specific determinations:

1) whether costs described in the plan are reasonable,

2) whether programs described in the plan are likely to result in significant improvements to the subject water body, and

3) what combination of programs can be funded based on monies available in the SWIM Trust Fund.

After Governing Board approval, the Plan is again submitted to DEP for final review (s. 373.456, F.S.). This review requires DEP to evaluate the plan for consistency with state water policy and the State Comprehensive Plan. Prior issues will be reviewed again to insure concerns of all commenting agencies have been addressed.

Review Requirements of Other Agencies

A number of state agencies in addition to DEP have some review responsibilities related to SWIM plans. The FGFWFC is required to review SWIM Plans to determine if plan implementation adversely affects fish or wildlife and/or their habitats. Likewise the Department of Community Affairs (DCA) must review SWIM Plans for consistency with the State Comprehensive Plan. The DEP examines the plan for potential impacts on state owned lands and the marine and estuarine environments inclusive of impacts to associated aquatic life and habitats. The Department of Agriculture and Consumer Services (DACS) reviews for potential adverse impacts to agricultural resources. Plans are also reviewed by the affected local governments and by individual members of the SWIM advisory committee.

Summary

The SWIM Program was established to address concerns on specific water bodies, either named specifically in the enacting legislation or as priority water bodies established by the WMDs. SWIM monies cannot be spent on a water body without a SWIM Plan approved by WMD governing board for each respective water body and the DEP. Legislation and rule require a periodic update of priority lists and approved plans. There is no dedicated source of state funding for the SWIM Program.

References:

Edmiston, H.L. and V.B. Meyers. 1983. Florida Lakes; A description of lakes, their processes and means of protection. Department of Environmental Regulation. Tallahassee, FL.

Rast, W. and M. Holland. 1988. Eutrophication of lakes and reservoirs: a framework for making management decisions. Ambio 17(1):2-12.

Renner, M. 1988. Lake Management for Local Governments. Technical Information Planning Series 88-2. Southwest Florida Water Management District. Brooksville, FL.

Southwest Florida Water Management District. 1988. Surface Water Improvement and Management (SWIM) Priority List. Brooksville, FL.

CHAPTER TWO: IDENTIFICATION OF PRIORITY ISSUES AND ANALYSIS

Introduction

The Winter Haven Chain of Lakes (WHCL) as discussed in the previous SWIM Plan is composed of 19 interconnected lakes located within and around the City of Winter Haven in north-central Polk County (see Figure 2-1). The WHCL is made up of two major groups of lakes.

The Northern Chain is composed of five lakes: Haines, Rochelle, Conine, Smart, and Fannie. Lakes Haines, Rochelle, Conine, and Smart fluctuate at the same level since they are inter-connected by canals, and lake stage is controlled by a single control structure (P-6) operated by the SWFWMD. Lake Fannie is downstream of P-6, and its elevation is controlled by Structure P-7. This structure is located on the eastern shore of Lake Fannie and empties into the Peace Creek Canal.

As originally defined (SWFWMD 1990), the Southern Chain of Lakes is made up of 14 interconnected lakes. The lakes composing this chain are Jessie, Idylwild, Hartridge, Cannon, Mirror, Spring, Howard, May, Shipp, Lulu, Roy, Eloise, Summit and Winterset. A recently completed modeling evaluation by Dames and Moore, Inc. (1994) included Lakes Mariana and Blue in the Southern Chain as well (refer to Figure 2-1). Surface outflows from this group of lakes are controlled by structures on Lakes Hartridge and Lulu. Lake Hartridge can discharge to the Northern Chain via Lake Conine when levels are high; however, the primary discharge from this group of lakes has typically been through a structure on Lake Lulu which discharges to the Wahneta Farms Drainage Canal and eventually to the Peace River. Both structures on the Southern Chain are operated and maintained by the Lake Region Lakes Management District (LRLMD).

Definition of the Management Boundaries and Land Use

The watershed of the WHCL is approximately 32 square miles and includes portions of the cities of Winter Haven, Lake Alfred and Auburndale (Figure 2-1; Dames and Moore, Inc. 1994). Land use as determined by Dames and Moore (1994) is depicted in Figure 2-2.

Climate and Geography

(originally taken from Spence and Hammer 1983 and Sinclair and Reichenbaugh 1981)

Lakes composing the Northern and Southern Chains and others in the vicinity lie on the Trail Ridge - Lakes Wales Ridge system which runs north-south through Polk County. This system is the oldest and highest of a series of sand ridges (relic beaches of ancient sea levels) which parallel the present coastlines. Ridge soils are for the most part composed of various sands and sandy clay which are typically well drained with a water table at least six feet below the surface. Because

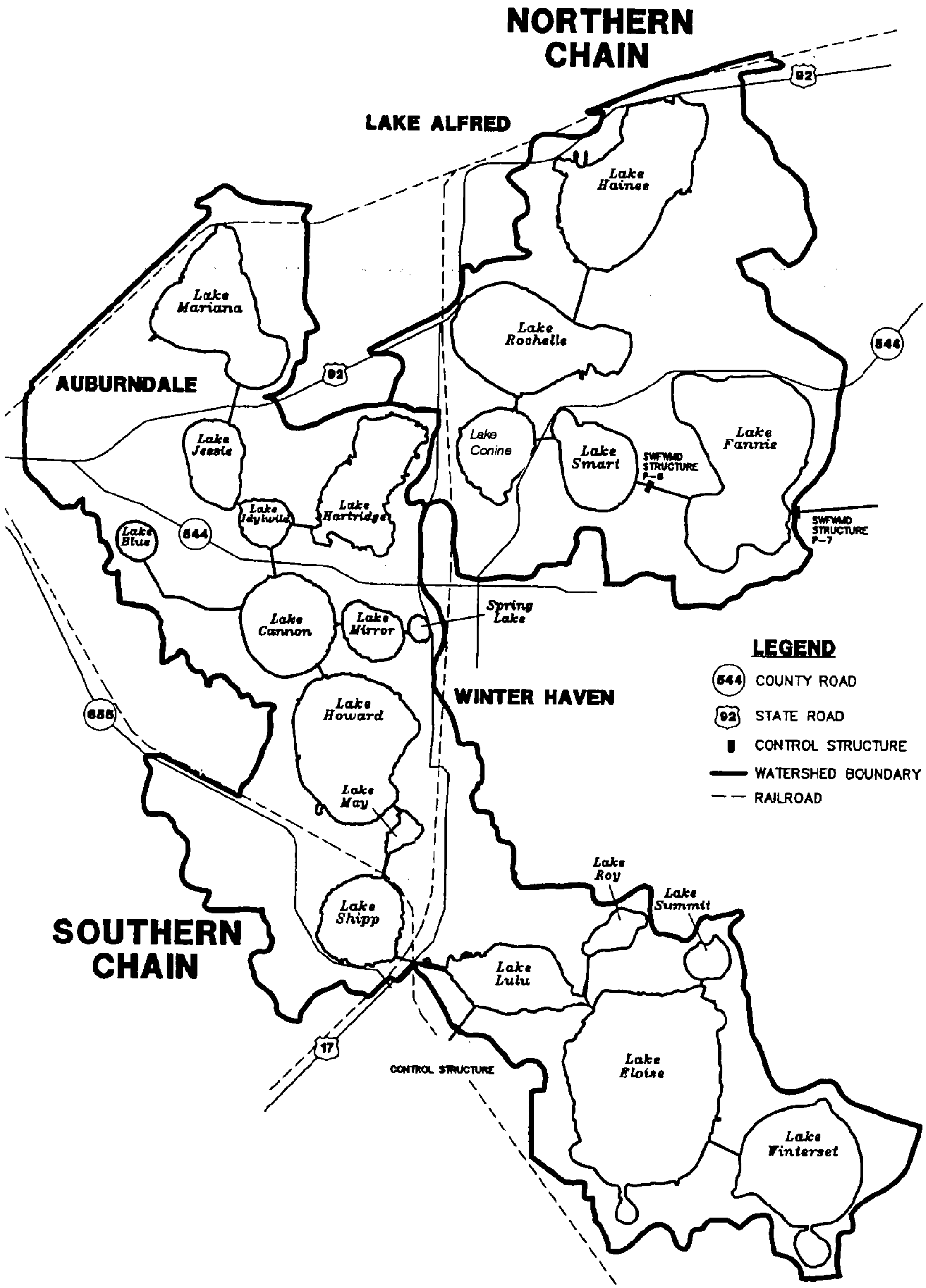


Figure 2-1. Winter Haven Chain of Lakes and watershed

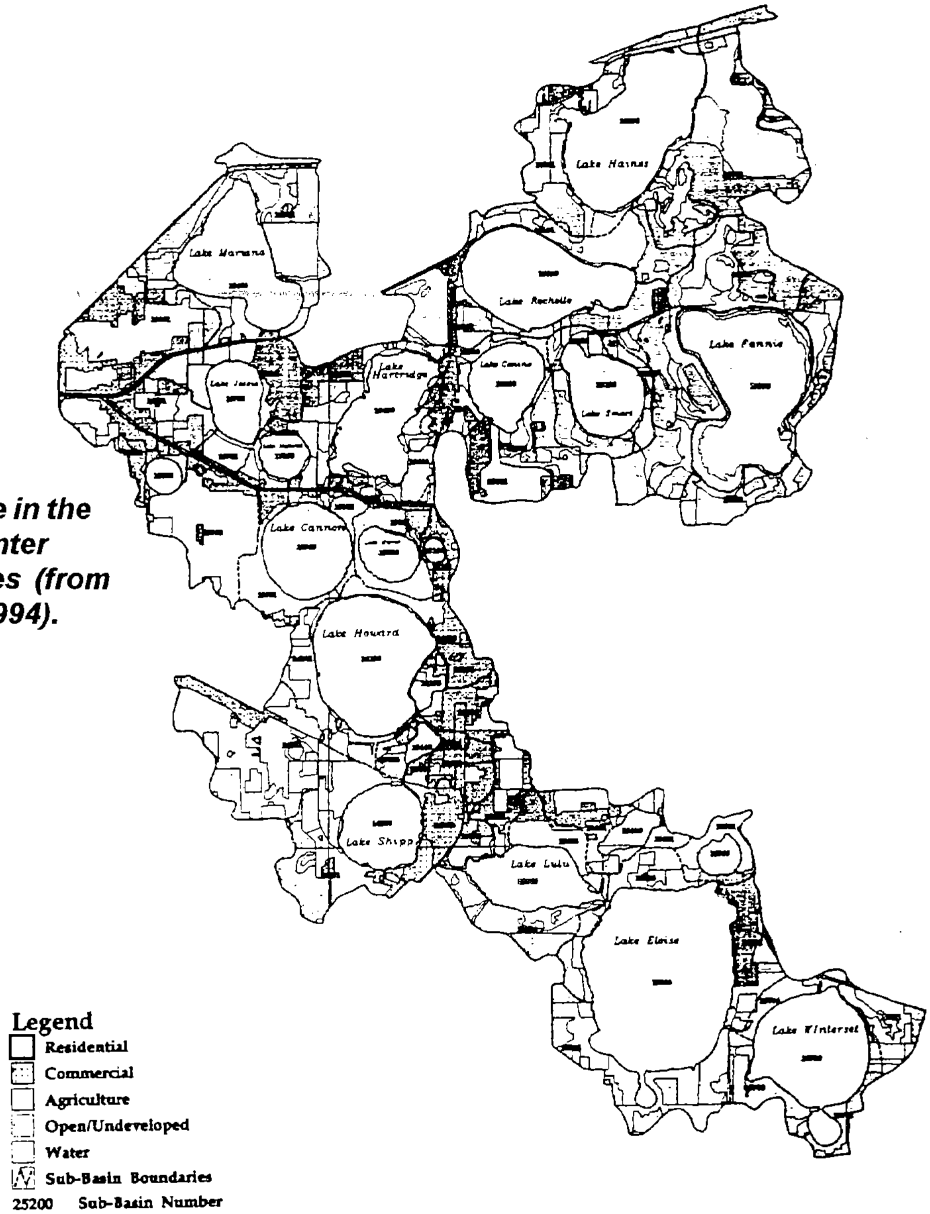


Figure 2-2. Land use in the watershed of the Winter Haven Chain of Lakes (from Dames and Moore 1994).

they are well drained, the general area is suited for urbanization; however, some lower lying areas consist of poorly drained top soils and muck. These areas, some adjacent to lakes, are unsuitable for development and are especially ill suited for septic tank drain fields. These unconsolidated deposits (sand and sandy clay) are as much as 150 feet thick and overlie a mantle of limestone (Sinclair and Reichenbaugh 1981). "Solution cavities developed in the limestone are reflected at land surface because of subsidence and collapse of the unconsolidated deposits, forming the many sinkhole basins characteristic of the area" (Sinclair and Reichenbaugh 1981).

The climate of the area is wet with humid summers and relatively dry cool winters. Mean annual temperature is 73F with an annual rainfall averaging 51.52 inches for the period 1946-77 (Sinclair and Reichenbaugh 1981) and 50.0 inches through 1991 (Dames and Moore 1994). The rainy season is typically from May through September, with 64% of the yearly average falling in this time period. The area has experienced a deficit of rainfall in the past several decades. Sinclair and Reichenbaugh (1981) noted that for the period 1960 to 1977 the deficit was 72.34 inches. Evaporation from the lakes averages approximately 49 inches per year.

Hydrology

Most studies cited in this document have dealt with the Southern Chain of Lakes; however, significant changes in hydrology have occurred in both the Southern and Northern Chains due to construction of canals which interconnect the lakes in the Chain. "Most of the lakes occupied individual basins before construction of the canals, and their hydrologic regimes were controlled by rainfall within their drainage areas, by rates of evaporation and transpiration, by subsurface inflow from the surficial aquifer, and by downward leakage to the underlying limestone, the Floridan aquifer" (Sinclair and Reichenbaugh 1981).

Data regarding lake stages prior to canal construction does not exist; under present conditions lakes within each major chain segment are maintained at a common stage, "even though lakes with large drainage areas contribute most of the lake water, and local geologic conditions may result in greater loss of water by downward leakage from some basins than from others" (Sinclair and Reichenbaugh 1981).

Water Level Control Structures on the Winter Haven Chain of Lakes

As reported by SWFWMD (1996), "The Lake Hamilton chain of lakes is located northeast of Winter Haven and consists of seven interconnected lake systems - Lake Alfred, Lake Rochelle, Lake Conine, Lake Smart, Lake Fannie, Lake Henry and Lake Hamilton. . . . Lake Alfred although not affected by the downstream lake levels in this system, is hydraulically connected to the system. The small size and high control elevation of a box culvert immediately downstream severely limits discharge from Lake Alfred. Four control structures regulate flows between the lakes within the system. These structures are on Lake Henry (P-5), Lake Smart (P-6), Lake Fannie (P-7), and Lake Hamilton (P-8). The P-8 structure controls flows from Lake Hamilton into the Peace Creek Canal.... The other major chain of lakes is the Winter Haven system consisting of 13 interconnected lakes ... An outlet structure on Lake Lulu regulates the water levels in the chain of lakes and discharges into the Wahneta Farms Canal that in turn discharges into the Peace Creek Canal. Outflow from Lake Lulu is regulated by the Lake Region Lakes Management District, which has jurisdiction over the maintenance and operation of this lake system. ... The two major chain of lakes ... are interconnected by a control structure between Lake Hartridge . . . and Lake Conine. . . The structure, in a small connecting canal that crosses under U.S. 17, consists of a fixed weir 10.00 feet wide with a crest elevation at 131.80 feet above NGVD." Please note: The Lake Hamilton Chain of Lakes as described in the SWFWMD 1996 report includes what is for SWIM purposes the Northern Winter Haven Chain of Lakes plus Lakes Henry, Alfred, and Hamilton. As originally submitted to the SWIM program the Northern Chain of lakes includes those lakes which are interconnected by the canal system managed by the Lake Region Lakes Management District. The Southern Chain of lakes also includes a series of 14 lakes interconnected by navigable canals maintained by the Lake Region Lakes Management District.

As reported by SWFWMD (1996) the watershed composing the Hamilton chain has an average elevation of 140 NGVD while the average elevation in the Winter Haven chain is 125 feet. Topography in the drainage basin below Lake Hamilton varies from a low of 100 feet near Bartow to 125 feet just downstream of Lake Hamilton; this drop of 25 feet over 34 miles equates to a channel slope of 0.02 percent. The drop in elevation in the Wahneta Farms basin is from 130 feet downstream of Lake Lulu to 100 feet at the Wahneta Farms Canal confluence with Peace Creek Canal. This is a drop of 30 feet over 5.5 miles and equates to a channel slope of 0.10 percent.

"The Lake Lulu outlet structure consists of two fifteen-foot-weirs with a crest elevation at 131.30 feet above NGVD, and two four-foot diameter discharge pipes located at the southeast end of the weir. The inlet of the pipes consists of a ten-foot long horizontal concrete platform with the top elevation about one-half-foot higher than the main weir. To increase storage in the upstream lakes, the main weir is equipped with a flash board one-foot high, which can be cranked down to sit on the weir crest to raise its elevation one foot. The flash board can also be cranked up to form a long rectangular orifice to control discharge into the Wahneta Farms Canal."

In order to implement water management responsibilities delegated to it by Chapter 373, Florida Statutes, the Southwest Florida Water Management District developed rules in May 1978 for setting lake levels. Lake levels have been adopted for all lakes in the Winter Haven Chain of Lakes. Adopted levels for all lakes on the Southern Chain of Lakes are the same and are as follows: 10-year flood warning level, 132.60 feet; minimum flood, 132.00 feet; minimum low management, 129.50 feet; and minimum extreme low management, 127.00 feet. The adopted levels for all lakes on the Northern Chain with the exception of Lake Fannie are as follows: 10-year flood warning level, 129.70 feet; minimum flood, 128.75 feet; minimum low management, 126.50 feet; and minimum extreme low management, 124.50 feet. Adopted levels for Lake Fannie are as follows: 10-year flood warning level, 127.00 feet; minimum flood, 125.75 feet; minimum low management, 123.50 feet; and minimum extreme low management, 120.00 feet. The establishment of management levels takes into account biological indicators, existing hydrologic modifications, and locations of structures such as foundation slabs, docks, septic tank drain fields, etc. Additional information on the District's lake levels program can be found in the report, *Lake Levels Program* (Gant 1994).

Causes of Degradation of Water Quality and Natural Systems

Water quality in the Chain varies from lake to lake. There are also distinct differences in water quality between the Northern and Southern Chains. These differences will be considered in following sections. While there are differences between lakes attributable to natural causes, this management plan is most concerned with those directly attributable to man's influence or indirectly attributable to man as a result of past impacts or interventions.

Any encroachment of man into a watershed will likely impact a waterbody, although it may be imperceptible; the objective is to minimize as much as practical deleterious impacts. Ultimately this involves a consideration of costs versus benefits whether implicit or not. The purpose of this section is to identify in broad terms the principle causes of degradation so that strategies can be developed to address these causes. Typically, one would anticipate that costs are minimized by dealing with causes as close to the source as possible. In a similar vein, prohibition of a particular activity may be the most cost effective control. Conversely, some solutions may not be considered cost effective, and the degrading activity must be tolerated, although all cost effective steps should be taken to minimize such impacts.

One of the most readily apparent changes attributable to man has been the interconnecting of various waterbodies in the Chain by constructing canals. The rationale for constructing canals is obvious. "The first group to envision the Winter Haven chain of lakes from the boater's eye view organized as the Twenty Lakes Boat Club in 1915.

At the time, some of the lakes had small runs or swampy places between them. These did not allow for general boat traffic. The club wanted canals there" (Recker and Ford 1986). While one intention of the canal system may have been for the transport of citrus, the primary objective was to improve and foster recreational usage of the lakes. From today's environmental perspective the construction of canals would probably not be permitted; the canals obviously affect water quality by distributing impacts throughout the Chain. However, from a historical perspective, their construction fostered the economic and recreational development of the area.

"Historically, the chain has been used as a place to dump waste materials" (FDAWPC 1970). Pollution sources present by 1949 included wastes from chemical fertilizer plants, citrus packing, citrus and vegetable canning, soft drink wash spillage and waste, milk bottling waste, laundry waste, and untreated municipal waste. Considerable improvement had occurred in the management of all these by 1970. Other more recent improvements have been the elimination of Winter Haven sewage discharges to Lake Lulu in 1977 and the elimination of overflows from the Jan-Phyl Village Sewage Treatment Plant into Lake Howard.

Much of this improvement has been offset by increases in urban stormwater pollution, runoff, and septic tank seepage (Spence and Hammer 1983). Local governments have enacted ordinances addressing stormwater management and restricting removal of lake shore vegetation, and a recent county ordinance increased septic tank setbacks from waterbodies. These regulations will help to control new pollution sources, but existing sources remain to be addressed. As an example, septic tanks located in soils rated as having severe limitations with respect to drainfields are common. One area, in the watershed of Lake Cannon, Census Tract 134, has a septic tank density of 1.63 per acre. Inspection of data presented by Spence and Hammer (1983), reveals of 18,801 homes in census tracts bordering the Southern Chain, almost one third (i.e., 6,153 homes) were on septic tanks, many in soils poorly rated for such a use."

At the time that the original SWIM plan was drafted, The City of Lake Alfred was discharging treated wastewater into Lake Haines (permitted at 0.3 MGD), and the City of Winter Haven was discharging treated effluent into Lake Conine (permitted capacity of 1.7 MGD). The City of Winter Haven and the City of Lake Alfred both ceased their discharges in 1992.

Water Quality Recent Trends (1981-1996)

Two data sets are available on the Winter Haven Chain of Lakes; one set maintained by Polk County Division of Drainage and Natural Resources and the other by LakeWatch. The LakeWatch program is administered by the Institute of Food and Agricultural Sciences (IFAS) of the University of Florida and is under the direction of Dr. Dan Canfield. The program is structured around a volunteer network of lake observers and water sample collectors. Volunteers collect samples on their lake of interest for analysis of total nitrogen (TN), total phosphorus (TP) and chlorophyll-a; actual analyses are done at IFAS's laboratory in Gainesville. In addition to collecting water samples, volunteers are trained to make field observations and measurements, including Secchi disk transparency. Volunteers typically take samples on a monthly basis so on those lakes with volunteers, a rather complete picture of seasonal variation can be obtained. Unfortunately, while LakeWatch participation was high in the early 1990's; volunteer interest has waned and few of the lakes in the Chain are presently being sampled by volunteers.

The Polk County data set includes a more complete chemical analysis of water samples; however, the sampling frequency is quarterly, not monthly. Samples are collected by Polk County staff and staff of the Lakes Management District (formerly the Canal Commission). The data sets are generally complimentary. Polk County water quality data have been summarized in tabular form for each of the lakes in the Chain and is presented in Appendix B. Also included for each lake is a plot of chlorophyll-a concentration over time.

Lake Trophic State and Trophic State Index (TSI)

More often than not, water quality and related biotic problems in lakes are the direct result of increased nutrient enrichment (i.e., cultural eutrophication). A convenient way of expressing the degree of enrichment is by means of a Trophic State Index (TSI). Comparison of present trophic state with historic values helps to determine if the rate of eutrophication has increased, and can provide with other information a means for determining the degree of nutrient reduction(s) necessary to achieve improved water quality. The trophic state or degree of nutrient enrichment of a lake is typically summarized in the form of a Trophic State Index value. Inspection of TSI equations developed by Huber et al. (1982) is helpful to obtaining a basic understanding of nutrient impacts on lake water quality.

$$TSI(Chl\text{-}a) = 16.8 + 14.4 \ln Chl\text{-}a$$

with Chl-a expressed in ug/l or mg/m3

This equation was based on two criteria: 1) a 10 unit increase in TSI is equivalent to a doubling of chlorophyll-a concentration (and presumably phytoplankton biomass) and 2) the midpoint of the scale (i.e., TSI=50) is set equivalent to a Chl-a concentration of 10 ug/l.
Using a relationship developed between Secchi disk transparency (SD) and chlorophyll-a, Huber et al. developed the following equation for expressing TSI from SD data.

Since SD = 4.33 Chl a $^{-0.484}$, the TSI equation using SD becomes

TSI(SD) = 10[6 - 3 ln SD]
with SD expressed in meters

Huber et al. developed three equations relating nutrient concentrations to Chl-a and hence TSI. Separate equations were developed depending on whether a lake is nitrogen (N) limited, phosphorus (P) limited, or nutrient balanced. Phosphorus limited lakes by definition are lakes with a total nitrogen (TN) to total phosphorus (TP) ratio (TN/TP) greater than 30. Nitrogen lakes are defined as lakes with a TN/TP less than 10; and balanced lakes, therefore, have TN/TP equal to or less than 30 but greater than or equal to 10.

Huber et al. (1982) found that:

ln Chl-a = 1.64 ln TP - 2.12

TSI(TP) = 10(2.36 ln TP - 2.38)

For TN they found that:

ln Chl-a = 2.97 + 1.49 ln TN

TSI(TN) = 10(5.96 + 2.15 ln TN)

The equation for nutrient balanced lakes is a little more complex and involves calculation of two subindices:

TSI(TNB) = 10(5.6 + 1.98 ln TN)
TSI(TPB) = 10(1.86 ln TP - 1.84)

with TSI(NUTR) = 0.5 [TSI(TNB) + TSI(TPB)]

The TSI as originally conceived by Robert Carlson (1977) was developed with the intent of replacing the somewhat subjective designations of oligotrophic, mesotrophic and eutrophic (and hypereutrophic) with a more objective measure of trophic state. This is particularly useful for comparing lakes from different studies and developing statistical relationships between the degree of eutrophy (TSI) and other variables. Unfortunately, the old descriptors are too hard to put away, and people still find themselves interpreting TSI values as good, fair or poor or as oligotrophic, mesotrophic or eutrophic. Unlike researchers that have followed (including Huber et al.), Carlson did not intend that an Average TSI be computed using all three variations of the TSI equation. Carlson intended to make it possible for parties with varying information to compute a common variable (i.e., TSI) from one of a number of variables (SD, chlorophyll-a, or TP). For phytoplankton dominated lakes (as compared to those dominated by macrophytes) either raw Chl-a concentration data or the TSI computed from Chl-a concentrations is probably the single best indicator of a lake's trophic state. If Chl-a data are not available, a TSI calculated from nutrient or Secchi transparency data is a good surrogate provided there is a good relationship between the surrogate variable and the Chl-a concentration (the goodness of fit for a number of Florida lakes was demonstrated by Huber et al. 1982).

Figure 2-3. Relationship between Secchi transparency and chlorophyll-a.

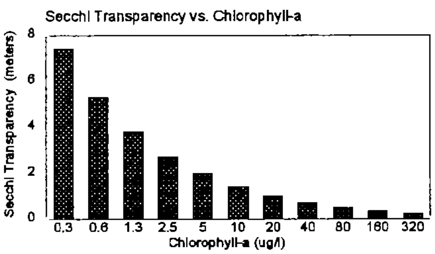


Figure 2-3 demonstrates an important relationship for phytoplankton dominated lakes. Although absolute values vary for different groups of lakes or individual lakes, the shape of the relationship is fairly typical. These relationships basically predict that there is no appreciable decrease in water clarity once Chl-a begins to exceed 40 ug/l. If, for example, one is able to reduce nutrients sufficiently to cut the amount of phytoplankton biomass in half in a lake with an initial Chl-a concentration of 80 ug/l (i.e., change from 80 to 40 ug/l), the Secchi transparency of the lake would only increase by about 0.2 meters (8 inches). To go from 40 to 20 ug/l would increase Secchi transparency by 11 inches or 19 inches if you go from 80 to 20 ug/l. If the goal for a lake is to reduce the incidence of blue green algae blooms, to go from 80 to 40 ug/l would probably be a substantial improvement; however, the transparency would not improve greatly. If, however, one were to go from 80 to 20 ug/l, one should see a reduction in algae blooms and probably a visual improvement in Secchi disk transparency. In this example, one might feel that a reduction in in-lake phosphorus concentration of 35% (from 80 to 52 ug/l) would reduce algae blooms; but a 58% reduction in P (from 80 to 34 ug/l) would be needed to reduce algae blooms and increase transparency. It should also be appreciated that a 35% reduction in TP concentration in-lake is not simply accomplished by reducing stormwater TP by 35%, since stormwater does not represent 100% of the nutrient load. It should also be appreciated that actual in-lake concentration is not a simple function of all the loading sources (e.g., atmosphere, stormwater, sediment release, baseflow, etc.), but is also a function of competing biological uptakes, outflows, and sinks (burial in sediment).

Pollutant Load Reduction Goals (PLRGs), Target Water Quality and Paleolimnology

The DEP Water Resource Implementation Rule now requires the development of Pollutant Load Reduction Goals (PLRGs) for SWIM priority waterbodies. To develop PLRGs it is first necessary to develop a goal or target for the waterbody. This goal can be stated in terms of a desired water quality (Secchi transparency, Chl-a concentration, TP concentration, etc.) and related to a desired biological state (such as re-establishment of seagrass beds as proposed for Tampa Bay). Once the target is set then the necessary load reduction of a pollutant needed to reach the target can be determined. This is not necessarily an easy determination, since the relationship between the target and the pollutant must be determined. If there is no controlling cause-effect relationship, then it is not appropriate to set a goal for a "supposed" pollutant.

The following sections discuss the various steps taken in developing a PLRG for the Winter Haven Chain of Lakes. Historic water quality was assessed using paleolimnology, and considering both historic water quality and current hydrologic conditions, a target water quality is expressed in terms of a desired trophic state. The water and nutrient budget for Lake Howard is evaluated and a simple empirical model applied to determine the nutrient load consistent with current observed water quality. Using the same modeling approach, the load necessary to maintain a desired (target) water quality is determined. The difference between the observed and target load is the pollutant load reduction necessary to achieve the desired water quality. Following establishment of a PLRG, a strategy for achieving the desired reduction in phosphorus is presented.

With respect to water quality, one means of helping to set a target is to refer to historic water quality and frame the goal in terms of returning to a more pristine or undisturbed prior condition. A problem frequently encountered with this approach is that reliable pre-disturbance water quality data are often lacking. Given a lack of data, a goal could be set with the hope that it is realistic; the problem with this approach is that the goal may not be attainable because the waterbody has historically never been at the target. While for economic, social and political reasons, it may not be possible to achieve a desirable historic level, knowing the historic level does help to establish a more accurate estimate of desirable water quality conditions for a particular lake. For example, suppose that a lake presently has a Trophic State Index of 75; since the DEP currently defines a TSI of greater than 70 as "poor" and a TSI of 59 or less as "good", one might be tempted to conclude that the goal for a lake should be a TSI of 59 or less (TSI of 60-69 is defined as "fair"). What if the lake in pre-disturbance time never had a TSI below 60?

It is possible, however, to evaluate certain historic changes in water quality through the use of paleolimnological techniques. Using sediment cores from a lake, an assessment of 210Pb (a naturally occurring radionuclide of lead) to recognize pre-disturbance horizons that correspond to ca. 1860 (a date prior to significant European settlement in much of Florida), and an examination of diatoms frustules (remains of a certain group of microscopic algae), pre-disturbance water quality can be reconstructed.

With SWIM funding, Drs. T.J. Whitmore and M. Brenner (1995) conducted a paleolimnological investigation of sediment cores from five lakes (Lakes Conine, Haines, Hartridge, Howard, and May) in the Winter Haven Chain of Lakes. The objective of their study was "to use paleolimnological methods to evaluate historical changes in water quality of Lakes Conine, Haines, Hartridge, Howard, and May caused by accelerated nutrient loading and watershed disturbances during the past century... These lakes may have been historically eutrophic because of edaphic factors (Canfield 1981), but preliminary evidence for Lake Howard (Whitmore 1993) suggests that limnetic nutrient concentrations in the chain may have increased in recent decades" (Whitmore and Brenner 1995).

Whitmore and Brenner (1995) concluded that "Qualitative interpretations .... clearly show similar patterns of historical change in all five study lakes. Deepest, pre-disturbance (Nominally 1860) samples in all study lakes showed dominance of the planktonic species *Aulacoseira granulata* and *A. granulata var. angustissima*, which are distinctive indicators of mesotrophic to eutrophic conditions (Whitmore 1989). These species occur in long chains of cells that require frequent wind mixing of the water column to maintain buoyancy, and their peak production usually occurs during summer months (Bradbury 1975). Dominance by these planktonic forms indicates a lack of cyanobacterial proliferation during warm months, which would normally inhibit populations of large planktonic diatoms. We conclude that pre-disturbance water quality in the study lakes, therefore, was in the mesotrophic to eutrophic range, and summertime blooms of cyanobacteria were absent. Modern diatom assemblages reflect eutrophic conditions. . . . In all five study lakes, pre-disturbance samples show that the study lakes previously had substantially greater input from adjacent swamps or marshes. While the study lakes formerly sustained areas of open water, they may have been subject to periods of low-water level, or received input from adjacent wetlands that were subject to water-level fluctuation. It does not appear entirely feasible to restore these lakes to pre-disturbance water quality conditions, therefore, because the lakes are qualitatively different today than in the past because of extensive hydrologic changes that have occurred. Given predisturbance conditions in the five study lakes, however, we conclude that the maximum improvement in current water quality that is feasible would result in mesotrophic to eutrophic conditions, elimination of cyanobacterial blooms, and re-establishment of summer populations of planktonic diatoms including *Aulacoseira*."

The cutoff between mesotrophic and eutrophic equates to a TSI of about 50. This probably represents the TSI of most WHCL lakes over 100 years ago; however, as noted above, many factors affecting water quality have changed. It is unlikely that any of these changes has led to improved water quality. Many of these changes are likely irreversible for a number of reasons, and although improvements are possible, TSI's in the slightly eutrophic range (i.e, TSI's from 50 to 60) are probably the best that can be reasonably expected.

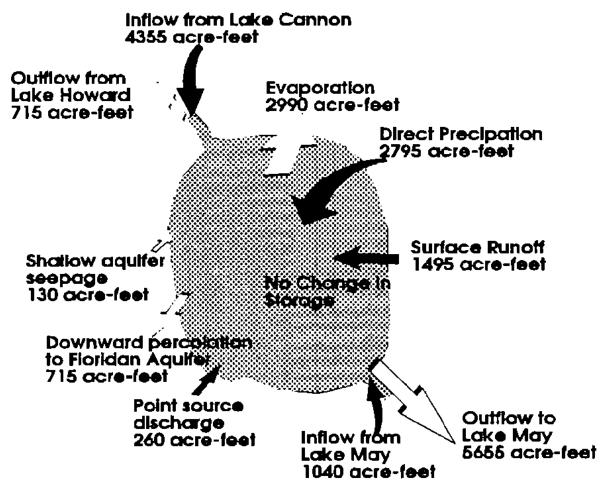
There has been considerable hydrologic modification in the watershed including the interconnection of chain lakes by a canal system. As Whitmore and Brenner also noted, at least one chain lake, Conine, was acidic historically as indicated by its historic diatom flora. The acidity was probably attributable to swamp drainage and/or high humic input; neither of which occurs today. This lake is now noticeably alkaline; in part due to high algal productivity. Lakes in the Chain are considered a fishery resource especially the Northern Chain, and from a fish production perspective, slight eutrophy is desirable. Given the above considerations, a TSI target of 60 for the WHCL appears reasonable. Further, assuming a P limited condition can be achieved, a desirable in-lake TP target would be 34 ug/l. If reached, this would result in Secchi transparencies of approximately one meter with a mean annual chlorophyll-a concentration of 20 ug/l.

Assuming that the above targets are reasonable, some calculations of needed load reductions can be made using the following logic. Based on known empirical relationships, in-lake TP concentration is a function of TP load and detention time; therefore, we can calculate the total load that a lake can accept and maintain a certain in-lake concentration. Realizing that certain loading sources may not be amenable to control, once the total load of TP is known, one can examine the nutrient budget and develop a control strategy based on the amount of reduction needed in the controllable loads to achieve the desired in-lake concentration.

Water and Nutrient Budgets

An important source of information for identifying opportunities to improve water quality in the Winter Haven Chain of Lakes is a study performed in 1980 by Water and Air Research, Inc. (WAR) for the Central Florida Regional Planning Council. Their report, "Lake

Figure 2-4. Generalized water budget for Lake Howard as developed by WAR 1980.



Annual water budget for Lake Howard assumming average annual rainfall of 52 inches. (Note: there is no longer a point source discharge)

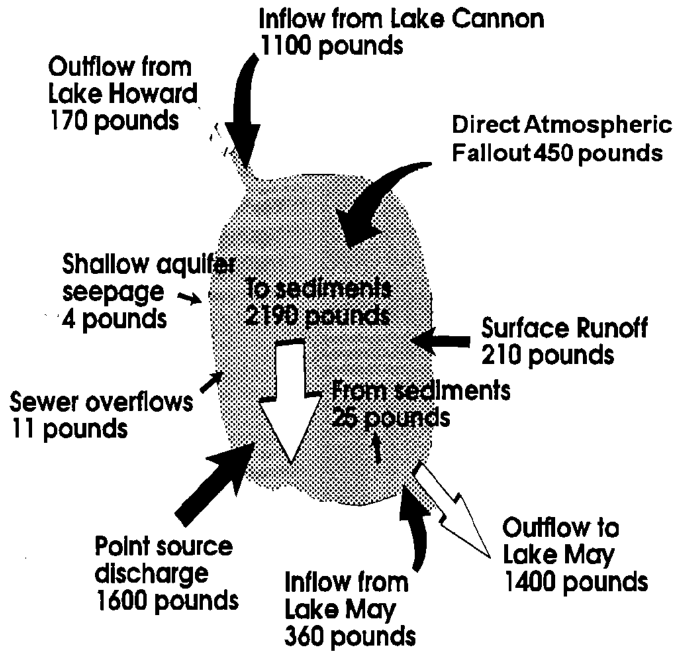
Howard Restoration Study", outlines the most complete water and nutrient budget developed for any lake on the WHCL. The report noted seven potential sources of nutrient input to the lake: stormwater runoff, precipitation, point sources, surface water inflow, groundwater inflow, nitrogen fixation and internal recycling.

A generalized water budget for Lake Howard was developed for an average water year (52 inches; see Fig. 2-4). Although a number of simplifying assumptions were used in the development of this budget (WAR 1980), it is useful for discussion purposes especially in assessing the relative importance of the various sources. Because the contributing watershed to the WHCL is small in comparison to the total lake surface area, direct rainfall onto the lakes' surfaces represents a large volume proportionally. For many temperate lakes and most reservoirs, for example, it is not uncommon for a watershed to be 10 to 20 times larger than the receiving waterbody; for these waterbodies direct rainfall represents a relatively small proportion of the water budget. This distinction is important since this also means that precipitation contributes a proportionally greater nutrient load in the former case.

As a simple example, assume that the watershed is twice as large as the lake area and the only water that enters a lake is direct precipitation and runoff from the watershed. Further, assume that the runoff coefficient (the percentage of water running off the watershed into the lake or streams feeding the lake) is 0.25. This means that 25% of the precipitation landing on the watershed potentially finds its way into the lake. Under this simplified scenario, 67% of the water entering the lake comes from direct precipitation (since the runoff coefficient for rain directly on the lake's surface is 100%), and 33% comes from the watershed. Using the same simple assumptions, in a lake with a watershed to lake surface area ratio of 20 to 1, 83% of the water entering the lake would be from runoff and only 17% from direct precipitation. All things being equal (and they are not), a lake with a smaller watershed should be in better condition water quality wise than a lake with a larger watershed if the quality of the precipitation (wet and dry fall) is good. The advantage to a larger watershed, is that the larger the watershed the higher the flushing rate. The water budget for the Southern WHCL developed by WAR (1980) estimated that rainfall accounted for 65% and runoff 32% (surface inflow and groundwater inflow accounted for the remaining 3 to 4%) of the water budget.

To balance the water budget, outflows must equal inflows unless there is a change in the volume of water stored within the lake. Over time lake volume remains relatively constant so that inflow on average equals outflow. There are three significant outflows for the Southern WHCL, evapotranspiration, surface outflow (through the structure on Lake Lulu) and percolation (through the bottom of the lake). During

Figure 2-5. Projected total phosphorus nutrient budget as proposed by WAR (1980).



Annual phosphorus budget for Lake Howard
(Note: there is no longer a point source discharge)

normal water years, WAR (1980) concluded that evaporation accounted for 70% of the outflow while surface outflow via Lake Lulu accounted for 13%, and percolation accounted for 17%. In dry years, surface outflow could cease altogether while in wet years surface outflow could account for approximately 35% of the total water loss, but evaporative loss would still exceed 50%.

The projected nutrient (TP) budget for Lake Howard as proposed by WAR (1980) is shown in Figure 2-5. While there is increasing concern that atmospheric concentrations of nutrients have been increasing, state average deposition rates were used in lieu of site specific data. Florida average values are 0.75 gm/m2/yr for TN and 0.051 gm/m2/yr for TP according to Huber et al. (1982). It is interesting to note that Hendry et al. (1979) reported a value of 0.100 gm/m2/yr for TP at the Citrus Experiment Station in Lake Alfred. For other assumptions used to calculate these TP loads, the reader is referred to WAR (1980).

Modeling the Effect of P Load Reduction on Lake Howard Water Quality - Using the Dillon-Rigler Model

Using data presented by WAR (1980) and following the approach of Baker et al. (1981) and Phelps and German (1995), the Dillon-Rigler model was applied to Lake Howard. The main purpose was to develop a feel for the amount of stormwater load reduction necessary to lead to demonstrable improvement in Lake Howard water quality. This could then be used as an indication of amount of treatment needed on the WHCL in general.

The response of lakes to changes in nutrient loading can be predicted with the use of rather simple empirical models if flow and nutrient budgets are developed for a lake. Baker et al. (1981) found that the best model for predicting nitrogen and phosphorus concentrations in Florida lakes was a modified Dillon-Rigler model.

The Dillon-Rigler equation used for predicting in-lake nutrient concentrations is (Baker et al. 1981; USGS 1995):

$$C=A^1[L(1-R)/Qs]A^2$$

where C is predicted constituent concentration in mg/l;

L is constituent input load in gm/m2 of lake surface/yr;

R is retention coefficient (dimensionless);

Qs is hydraulic loading rate (the sum of all input water volumes in cubic meters per year divided by lake surface area in meters squared, the resultant value is expressed in meters/year);

A^1 and A^2 are empirical coefficients used to optimize (calibrate) agreement between predicted and measured in-lake nutrient concentrations.

The retention coefficient, Rp for phosphorus, is defined as

$$R = 1 - (Pout/Pin).$$

Projected In-lake P Concentration in Lake Howard

The projected in-lake P concentration in Lake Howard using the nutrient and water budgets developed by WAR (1980) was computed using the Dillion-Rigler Equation.

$$C = A1[L(1-R)/Qs]A^2 \quad \text{Dillon-Rigler Equation}$$

Following the lead of Phelps and German (1995) "no attempt was made to find the values for A^1 and A^2 that give the best agreement between simulated and actual concentration. Rather the equation was used in its basic form (A^1 and A^2 equal to 1) to simulate ... total phosphorus concentrations ... as a function of input loading."

The equation then becomes: $C = L(1-Rp)/Qs$

Referring to the P loading budget developed by WAR (1980), the P load for Lake Howard is 3,760 pounds over the 650 acre lake. This is equivalent to 0.645 gm/m2 of lake surface area/year (i.e., L = 0.650 gm/m2/yr). The retention coefficient (Rp) for P is 1 - (1570 lbs/3760 lbs) which reduces to 0.58. Qs, the hydraulic loading rate, is the sum of all input volumes divided by the total lake area. Using volumes developed by WAR (1980), inputs to Lake Howard were 10,075 acre-feet per year. Dividing by a lake surface area of 650 acres yields a Qs of 15.5 ft/year which is equivalent to 4.72 meters per year. Substituting all these values into the above equation yields a C (in-lake nutrient concentration) of 0.058 mg/l.

Removing the presumed load from the Jan-Phyl Wastewater Treatment Plant (and assuming all other factors remained unchanged) yields a C of 0.034 mg/l. Further, removal of direct stormwater loads into Lake Howard would yield to a mean in-lake TP concentration (i.e., C) of 0.030 mg/l or about an 12% reduction in in-lake P concentration. This relatively small decrease in in-lake TP concentration is attributable to the fact that the bulk of P entering Lake Howard after removal of the point source comes from Lake Cannon to the north and from Lake May to the south. As a result a large part of the P entering Lake Howard is attributable to stormwater drainage basins which drain to other lakes in the chain.

There is a marked disparity in the annual projected stormwater loads between the WAR (1980) study and those predicted by Dames and Moore (1990). WAR (1980) projected a stormwater P load of 210 pounds from the basin contributing directly to Lake Howard while Dames and Moore (1990) estimated a P load of 1102 lbs from the 1077 acres which drain to Lake Howard. Substituting the Dames and Moore estimated load in place of the 210 pounds yields a projected TP concentration of 0.071 mg/l with the Jan-Phyl WWTP, a concentration of 0.048 mg/l TP without the WTTP input, and a concentration of 0.030 mg/l with all direct stormwater inputs removed. Dames and Moore (1990) projected stormwater inputs play a greater role in determining in-lake TP concentrations than stormwater loads estimated by WAR (1980). Using the WAR scenario but loads as projected by Dames and Moore (1990), removal of direct stormwater loads into Lake Howard would have a greater restorative effect (i.e., about a 38% reduction in in-lake TP) than that predicted using WAR (1980) estimates. Mike Britt, the Lakes Manager for the City of Winter Haven (personal communication), has compared predicted nutrient loading from the Dames and Moore study with estimates generated using actual stormwater samples from selected subbasins (numbers 24105 and 24103) in the Lake Howard watershed. Although there was a considerable range in the predicted and estimated values for total nitrogen and BOD, the total phosphorus results were in fairly close agreement. In subbasin 24105 Dames and Moore predicted an annual mean loading of 216 pounds while Britt calculated a loading of 210 pounds (97% of the predicted), and for subbasin 24103 Dames and Moore predicted a loading of 331 pounds to Britt's estimate of 235 (71%). This limited comparison would seem to validate the use of Dames and Moore predicted values over those suggested by WAR.

In summary, the largest improvement in in-lake water quality for Lake Howard should have been realized with the removal of the Jan-Phyl WWTP. Incremental improvements in water quality can be achieved by treatment of stormwater runoff, but because Chain lakes are interconnected, a considerable part of the non-point source load of nutrients is attributable to stormwater runoff from basins draining to other lakes. The predicted in-lake decrease in TP is highly dependent on a number of basic assumptions as demonstrated by comparison of two estimates of stormwater loading (i.e., WAR 1980 and Dames and Moore 1990).

Urban Runoff

Historically much of the poor water quality found in the Winter Haven Chain of Lakes can be ascribed to untreated or inadequately treated point sources (Spence and Hammer 1983). The last two of these point sources were removed by the diversion and reuse of treated effluent from City of Winter Haven's Wastewater Treatment Plant and the City of Lake Alfred's WWTP. Although these point sources have been removed, lake water quality may still be indirectly affected due to the accumulation of organic rich sediments caused by historic nutrient enrichment and organic loading. These potential sources are considered elsewhere; however, given that direct point sources have now been eliminated, continued allochthonous inputs must be attributable to non-point sources. Given the land use of the watershed, it can be argued that urban runoff is the single greatest contributor to non-point nutrient loading.

"Urban runoff carries pollutants from many sources and activities – automobiles, oil and salt on roads, atmospheric deposition, processing and salvage facilities, chemical spills, pets wastes, industrial plants, construction site erosion, and the disposal of chemicals used in homes and offices. In fact, pollution levels in urban waterbodies are generally much greater than in forested watersheds.

Runoff water quality worsens as urbanization increases:

- Trees that once intercepted rainfall are gone.

- Natural dips or depressions that had formed temporary ponds for rainwater storage are lost by grading and filling for development.

- Thick, absorbent layers of natural vegetation and soils are replaced by paved (impervious) surfaces such as roads and roofs.

- Eroded paths such as streambanks become channels, increasing the amount of sediment carried by runoff.

As asphalt and concrete replace vegetation, runoff increases and reaches waterbodies faster and with greater force. And when the land loses its capacity to absorb and store rainwater, the ground-water table drops and stream flows decrease during dry weather" (Terrene Institute 1994).

In the report, "Stormwater loading rate parameters for Central and South Florida", Dr. Harvey Harper (1994) evaluated the existing scientific literature dealing with pollutant concentrations and loading rates for selected parameters and land use types in Central and South Florida. He concluded that "virtually no comprehensive information is available on pollutant loading rates for total coliform and pesticides, as well as oil and grease"; however, he was able to evaluate nutrient loading (total nitrogen, total phosphorus, and orthophosphorus), biochemical oxygen demand, suspended solids and two heavy metals(total lead and total zinc). Harper's results are presented in summary form in Table 2-1. Although the concentration of a given constituent running off a particular piece of land is important, the

TABLE 2-1. Calculated areal pollutant loading rates (kg/ac-yr) for Central and South Florida. Values in parenthesis are runoff concentrations (mg/l). *Data taken from Harper (1994).*

LAND USE CATEGORY	Total Nitrogen kg/ac-yr (mg/l)	Ortho-Phosphate kg/ac-yr (mg/l)	Total Phosphorus kg/ac-yr (mg/l)	BOD kg/ac-yr (mg/l)	TSS kg/ac-yr (mg/l)	Total Zinc kg/ac-yr (mg/l)	Total Lead kg/ac-yr (mg/l)
Low-Density Residential	2.88 (1.77)	0.169 (0.077)	0.320 (0.177)	7.63 (4.4)	31.9 (19.1)	0.064 (0.032)	0.052 (0.037)
Single-Family	4.68 (2.29)	0.335 (0.15)	0.594 (0.30)	14.3 (7.4)	56.1 (27.0)	0.122 0.057)	0.083 (0.048)
Multi-Family	8.51 (2.42)	0.924 (9.27)	1.72 (0.49)	38.4 (11.0)	256 (71.7)	0.188 (0.055)	0.299 (0.087)
Low-Intensity Commercial	5.18 (1.18)	0.157 (0.03)	0.650 (0.15)	36.1 (8.2)	343 (81.0)	0.511 (0.111)	0.635 (0.138)
High- Intensity Commercial	13.0 (2.83)	1.52 (0.33)	1.96 (0.43)	79.3 (17.2)	435 (94.3)	0.782 (0.170)	0.985 (0.214)
Industrial	7.3 (1.79)	0.519 (0.13)	1.24 (0.31)	39.5 (9.6)	383 (93.9)	0.543 (0.122)	0.872 (0.202)
Highway	6.69 (2.08)	0.361 (0.14)	1.32 (0.34)	21.9 (5.6)	182 (50.3)	0.508 (0.134)	0.727 (0.189)
Ag - Pasture	4.54 (2.48)	0.732 (0.349)	0.876 (0.476)	7.99 (5.1)	126 (94.3)	—	—
Ag - Citrus	2.91 (2.05)	0.123 (0.088)	0.197 (0.088)	3.60 (2.55)	21.9 (16.3)	—	—
Ag - Row Crops	2.84 (2.68)	0.421 (0.398)	0.595 ((0.562)	—	—	—	—
Ag - General	3.62 (2.32)	0.380 (0.227)	0.551 (0.344)	5.80 (3.8)	74.0 (55.3)	—	—
Recreational / Open Space	1.07 (1.25)	0.003 (0.004)	0.046 (0.053)	0.956 (1.45)	7.6 (11.1)	0.05 (0.006)	0.021 (0.025)
Mining	2.21 (1.18)	0.131 (0.07)	0.281 (0.15)	18.0 (9.6)	176 (93.9)	0.229 (0.122)	0.378 (0.202)
Wetland	1.81 (1.60)	0.204 (0.13)	0.222 (0.19)	4.96 (4.63)	11.2 (10.2)	0.009 (0.006)	0.039 (0.025)
Open Water / Land	3.23 (1.25)	0.130 (0.05)	0.273 (0.11)	4.02 (1.6)	8.05 (3.1)	0.073 (0.028)	0.065 (0.025)

actual loading (i.e., mass of material) delivered to a waterbody is perhaps a better measure of the impact of a given land use on a waterbody. The loading is generally expressed as mass (kilograms or pounds) of material per unit area per year. This makes the amount of impervious acreage particularly important, since it will to a large extent determine the volume of water delivered. Since load is the product of volume times concentration, it is possible that a source having high concentrations of a given parameter may not be a significant source of that parameter if the volume of runoff generated is low. The converse is also true, what may appear to be only slightly elevated concentrations of a parameter may be a significant load if the volume of water involved is relatively large.

A stormwater pollutant transport study cooperatively funded by the City of Winter Haven, Polk County and the SWFWMD performed by Dames & Moore was completed in 1990. This study looked specifically at the potential of subbasins within the WHCL's watershed to contribute pollutants via stormwater runoff on the basis of actual and future basin specific land use. The implied premise behind this study was that stormwater was an important source of pollutant loading, and that attempts at controlling pollutants contributed by stormwater should be directed to those areas contributing the highest load. It is important to recognize that the subject of this study was nonpoint stormwater pollution and did "not include a consideration of loadings resulting from atmospheric, groundwater and lake interchanges"; in-lake sediments were not included either. It was not the purpose of this study to compare point source loading to nonpoint source loading nor to develop a strategy for dealing with all pollutant sources.

A number of assumptions must be made to develop and carry out such a study. Implicit from the beginning was the assumption that stormwater is a major contributor of pollutants. Also implicit was the assumption that pollutant loads in stormwater can be effectively reduced. Since nonpoint source pollutants are by definition diffuse, it is also assumed that a rational approach to treating stormwater involves the prioritization of the contributing subbasins. Simply stated the most desirable stormwater pollutant load reduction plan involves getting the most pollutant load reduction for available dollars, since this should result in the greatest improvement in lake water quality. The modeling approach yielded predicted pollutant loads for a number of parameters for each specific subbasin in the study area. The study area included all but one of the lakes (i.e., Haines) in the SWIM designated WHCL and twenty lakes not in the WHCL (e.g., Lake Hamilton, Silver, Ina, etc.).

The Dames & Moore report used a composite ranking system based on loadings of a number of constituents and their perceived importance to lake eutrophication, turbidity, oxygen depletion and toxicity. Each constituent was assigned a specific weighting factor based on this perceived importance. Total nitrogen and total phosphorus were given weights of 30% each, suspended solids was weighted 20%, biochemical oxygen demand was weighted 10% and lead and zinc were each weighted 5%.

However, since SWIM is concerned with a subset of the lakes considered in the Dames & Moore report; and since eutrophication seems to be of chief concern in the Chain, a subbasin prioritization is presented below based only on WHCL contributing sub-basins (Table 2-2). This prioritization considers only total phosphorus, and ranks subbasins on a composite of areal loading rates (pounds/acre/year) and total annual loading by subbasin (pounds/year).

Even given this approach, further considerations must be made when evaluating the desirability of implementing some form of stormwater pollution control in one subbasin versus another. A number of practical considerations arise concerning the size, locationand availability of project sites. Differences in land prices can greatly affect the cost effectiveness of a project. With respect to nutrient loading the objective is to minimize the cost per pound of nutrient removed/controlled. Although most technologies in use today control both of the major nutrients, some techniques may be better suited than another dependent on the nutrient of concern. For example, the addition of alum (AlSO4) is particularly effective for binding phosphorus but is not nearly as effective in controlling nitrogen availability. An alum injection system would not be a particularly good solution in a nitrogen limited situation; however, it may work well on the WHCL, especially on the Southern Chain of Lakes, since the majority of Chain lakes appear to be nutrient balanced or phosphorus limited.

Strategy for Managing Urban Stormwater

To effect changes in in-lake water quality, controls must be directed at major nutrient sources. For example, in eutrophic lakes it is unlikely that measurable changes will result from removal of 10 or possibly even 20% of a nutrient load. Unfortunately, it will not be possible to remove even 10% of the non-point source load with a single project. It will be necessary to implement a number of projects before any appreciable change in overall lake water quality will occur. Without detailed nutrient budgets for the lakes in the Chain, it is not possible to give an accurate estimate of the number of projects that will be required to yield demonstrable results. For this reason, it will be necessary to develop better nutrient budgets for Chain lakes. Until such budgets are developed, past modeling efforts and professional judgement will be relied upon to implement stormwater pollution reduction projects in the most cost effective manner.

The following strategy is proposed for pursuing future stormwater treatment projects concurrent with the development of better nutrient budgets and associated modeling. It consists of two initiatives. The first initiative is the continued development and construction of typical

Table 2-2. A ranking of Winter Haven Chain of Lakes sub-basins according to phosphorus loading potential. The lower the rank, the higher the loading potential.

Rank	Lake	Basin	Acres	Load	% of Total Load
Northern WHCL					
8	Conine	28002	228	331	18.6
12	Conine	28003	155	198	11.2
30	Rochelle	26101	203	193	10.8
33	Fannie	26202	440	268	15.1
36	Fannie	26207	180	142	8.0
37	Smart	28101	140	125	7.0
39	Fannie	26201	338	169	9.5
40	Rochelle	26102	366	157	8.9
46	Conine	28001	120	85	4.8
48	Fannie	26203	162	87	4.9
48	Smart	28102	107	75	4.2
50	Rochelle	26103	271	95	5.3
53	Rochelle	26104	111	50	2.8
Southern WHCL					
1	May	25602	188	348	4.2
2	Hartridge	20402	327	520	6.2
2	May	25601	155	321	3.8
4	Lulu	25302	164	321	3.8
5	Jessie	23702	247	385	4.6
6	Howard	24104	128	259	3.1
7	Shipp	24203	164	274	3.3
9	Jessie	23701	374	488	5.8
10	Spring	25101	76	158	1.9
11	Roy	25402	157	232	2.8
13	Hartridge	20401	195	244	2.9
14	Cannon	23901	220	264	3.2
15	Mirror	25002	104	136	1.6
15	Lulu	25305	95	128	1.5
17	Cannon	23902	281	329	3.9
18	Howard	24107	75	110	1.3
19	Eloise	25201	1503	1413	1.7
20	Shipp	24202	259	277	3.3
20	Howard	24102	185	218	2.6
22	Howard	24106	23	51	0.6
23	Lulu	25303	55	83	1.0
24	Howard	24105	21	48	0.6
25	Cannon	23903	91	114	1.4
26	Cannon	23904	42	63	0.8
27	Howard	24101	69	88	1.1
28	Shipp	24201	200	196	2.3
29	Mirror	25003	51	68	0.8
30	Mirror	25001	26	41	0.5
32	Howard	24103	576	328	3.9
34	Idylwild	23802	58	71	0.8
35	Summit	25501	74	88	1.1
38	Summit	25504	51	61	0.7
41	Roy	25401	35	42	0.5
42	Lulu	25304	188	115	1.4
42	May	25603	66	69	0.8
44	Summit	25503	35	42	0.4
45	Summit	25502	17	20	0.2
47	Lulu	25306	48	47	0.6
51	Roy	25403	53	49	0.6
52	Idylwild	23801	43	38	0.5
54	Lulu	25301	49	15	0.2
55	Idylwild	23803	25	8	0.1

stormwater treatment systems targeted at areas where demonstrable improvement is most likely to occur. The second initiative is the development and implementation of newer technologies that offer increased pollutant removal efficiencies.

Because typical stormwater treatment systems are better at removing phosphorus than nitrogen and because lakes in the Southern Chain appear to be phosphorus limited to nutrient balanced (Northern Chain lakes presently appear to be nitrogen limited), improvement in water quality as measured by decreases in total nutrients or chlorophyll a should more quickly be seen in Southern Chain lakes. It should be anticipated that reductions in nutrient loading should lead to reductions in in-lake nutrient concentrations (total nitrogen and total phosphorus) and Chl-a (phytoplankton). [Since Lake Hartridge is a macrophyte dominated lake, reductions in nutrient loading will probably not be manifested as reductions in Chl-a concentrations.] One should expect that reductions in chlorophyll a should also lead to improved water clarity; however, at the higher trophic levels typical of Chain lakes a substantial reduction in chlorophyll is required before a noticeable improvement in clarity occurs.

Decreases in the limiting nutrient of a lake should also reduce the occurrence and severity of algae blooms, and reductions in phytoplankton biomass should, likewise, lead to reductions in the lake's sedimentation rate. This in turn should decrease the amount of decomposition in the bottom waters and sediment thus lessening the rate at which oxygen is removed from the water column. As a consequence, the probability of fish kills related to oxygen depletion should decrease.

In summary, this plan proposes to continue implementing projects to remove pollutants from stormwater; however, this plan also recommends that priority be given to phosphorus reduction rather than a combination of parameters (phosphorus, nitrogen and total suspended solids). In practicality this does not differ greatly from the priorities as determined in the Dames and Moore (1990) study; however, we have re-ranked the basins only on the basis of phosphorus load and concentration. A prioritization of the basins is given in Table 2-2.

***Linked Watershed/Watebody Model Application to the WHCL** (Dames and Moore, Inc. 1994a)*

A mechanistic modeling approach was used to produce runoff flows and non-point source loadings to the lakes in the WHCL. The modeling approach uses a combination of two USEPA supported models, SWMM and WASP5 which were combined into a Linked Watershed/Waterbody Model (LWWM). The model used was one specifically developed for the SWIM Department by Dames and Moore, Inc, and their subconsultant, AScI. The WHCL was used as a test application of the modeling approach (Dames and Moore, Inc.

1994a). Dames and Moore, Inc. was relied upon to develop data files which could be used by the District and others to model the WHCL. With the use of LWWM, the District will be able to evaluate the effectiveness of various restoration strategies. The model is flexible and adaptable to changes in land use and any desired combination of restoration strategies.

In running a test of the model's capabilities, several deficiencies in the data available for the WHCL were noted. "There were a paucity of data for stormwater inflow to the lakes. Data were inadequate for calibrating the water quality routine in the SWMM model. These data limitations while affecting the model results, do not have an impact on the purpose of this project (i.e., testing the linkages in the LWWM). The model has been set up and functions, but can be revised as more data become available and management decisions are required" (Dames and Moore, Inc. 1994a). Since the completion of model testing, both the City of Winter Haven and Polk County have acquired some stormwater data specific to the WHCL as part of their NPDES (National Pollutant Discharge Elimination System) permitting requirements. These data should be useful in further applications of the model. The accuracy of any model predictions for management decision making would be improved by good stormwater loading data.

Water budgets are the foundation for building nutrient budgets. Although Dames and Moore, Inc. (1994a) were able to simulate lake levels fairly accurately on the WHCL, accuracy could be improved by keeping better records on structure operations on both the North and South Chains and by gaging the outflows so that direct discharge can be obtained. Due to the large number of interconnected lakes in the WHCL, accurately simulating the movement of water through the Chain is difficult but important. Lack of water flow data between lakes necessitated a number of simplifying assumptions; the validity of these assumptions could be tested and refined by accurate measurements on a subset of lakes. This would involve gaging both ends of an interconnecting canal so that differences in direction of flow could be determined based on differences in elevation from one end of the canal to the other.

Realizing that the objective of the report by Dames and Moore, Inc. was to validate the functioning of the model and not to develop management objectives (they were restricted using best available data), their modeling results do suggest some interesting possibilities. Modeling results on the Northern Chain suggested that marked improvement in water quality should have been seen in water quality on Lakes Haines, Smart and Conine after removal of the last two point sources on the Chain (i.e., the City of Lake Alfred's discharge to Lake Haines and the City of Winter Haven's discharge to Lake Conine). [Please note that modeling was done using primarily LakeWatch data collected on the Chain in 1991-92.] The model essentially predicted similar water quality. It was suspected, however, that improvement would not take place immediately since lake sediments were expected to be a reservoir of nutrients (please refer to discussion of Lake Conine whole lake alum treatment elsewhere in this document). The model can be made to adjust to changes in flux rates by entering the appropriate values as constants, but the model is not capable of adjusting these automatically. No adjustments were made simply because no flux rates have been determined for any lakes in the Chain. In practice, accurate rates are difficult to obtain and are not routinely obtained in most lake studies. Given present lake water quality in the Northern Chain, the model results do suggest, however, that sediments are now a potentially significant source of nutrients. There are two readily apparent management options: 1) wait for sediments nutrients to flush from the system over time, or 2) attempt to control sediment release rates.

Lake Conine water quality improved rather dramatically after diversion of the effluent from the Winter Haven WWTP, and an attempt was made to hasten improvement with a whole lake alum application. Similar improvement was not observed in Lake Haines, however. In fact, it appears that water quality in Lake Haines may have continued to decline even after removal of the point source (Lake Alfred's WWTP). The decline is puzzling. Although Lake Haines is considerably larger than Lake Conine and the volume of discharge and load contributed to Lake Haines by the Lake Alfred WWTP was not great in comparison to that received by Conine, some improvement in Lake Haines water quality was anticipated. Because water quality does not appear to be improving in Lake Haines, some other factor must be contributing to the poor water quality and needs to be investigated.

One of the most interesting results relative to the Southern Chain was that as a group these lakes did not respond to simulated reductions in nitrogen loading; however, there was a noticeable response to simulated phosphorus reductions. In other words, the lakes in the Southern Chain appear to be phosphorus limited. Results also indicated a noticeable improvement in water quality in most lakes in the Southern Chain with a 25% reduction in non-point source loading of phosphorus. In most cases a 25% reduction would lead to approximately at 50% reduction in chlorophyll-a concentration, or a halving of the amount of phytoplankton in the water column. Certain sources of non-point phosphorus are less amenable to treatment/removal than others (e.g., atmospheric); therefore, a 25% reduction in non-point source loading may require a substantial reduction in stormwater phosphorus loading.

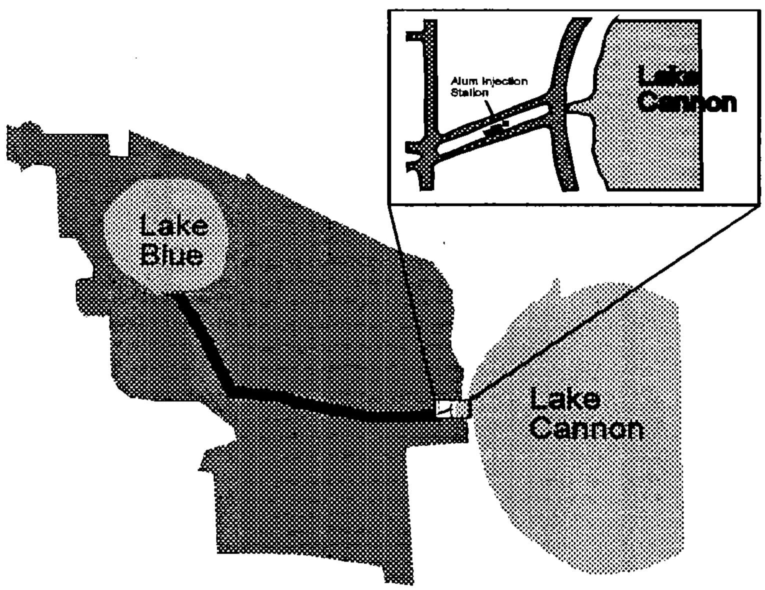
It is possible using models to estimate the effect of nutrient reduction on in-lake water quality and primary productivity. It is anticipated that the modeling approach developed by Dames and Moore, Inc. and their sub-consultant, AScI, will be used to develop an overall management strategy for reducing non-point source loading (especially phosphorus) to the Chain of Lakes. To make accurate predictions on the effectiveness of various management strategies to control nutrient loading (especially phosphorus), we propose to reapply the model as better monitoring data becomes available. The District is developing in-house expertise on the model and will be applying the model for that purpose, and it is anticipated that the LWWM will be used to develop Pollutant Load Reduction Goals (PLRGs) for the WHCL and other surface waterbodies in the District as required by State statute.

Inwood Ditch Alum Injection Stormwater Treatment System *(from PCWRD 1991)*

The District with SWIM and Peace River Basin Board funds entered into a cooperative agreement with Polk County for the construction of a Stormwater/Alum Injection System on Inwood Ditch which discharges into Lake Cannon. The cooperative agreement was for a 50/50 cost share between the District and Polk County for a total amount not to exceed $180,000 (i.e., $90,000 each). Prior to SWIM involvement, Polk County had already completed a feasibility study for the proposed project with funds provided by the United States Environmental Protection Agency and the Florida Department of Environmental Protection under Section 205(J) of the Clean Water Act.

"The Inwood Ditch, which discharges to Lake Cannon, has long been considered to be among the worst stormwater sources on the Winter Haven Chain of Lakes" (PCWRD1991). "The Inwood area has a drainage watershed of approximately 650 acres ... This watershed includes approximately 490 acres of high density residential land use which discharges directly into the Inwood Ditch ... The up gradient drainage basin contributing to Lake Blue, consists of commercial and

Figure 2-6. Schematic of Inwood Ditch Alum Injection System.



light industrial land uses... The remainder of the drainage watershed consists primarily of medium density residential land use with a population of 2612 and an equivalent density of 3412 per square mile. These areas have minimal drainage pipe systems; and no sewage collection system. Individual sewage treatment systems or septic tanks are widely used within the area... The watershed area drains to the Inwood Ditch. This ditch, between Lake Blue and Lake Cannon, is a manmade earth ditch approximately 5,860 feet in length and runs southeasterly from Lake Blue to Lake Cannon. The southern most 1,600 feet of the ditch, which outfall to Lake Cannon, has been replaced with a seven feet wide four feet high concrete box culvert" (PCWRD 1991) (see Figure 2-6).

Construction of the alum injection system was completed and put into operation on January 28, 1994. The system was turned off and on for calibration of instrumentation in the early stages of operation; however, the system has been operating continuously for more than a year. While it is known that removal of nitrogen and phosphorus through formation of an alum floc and subsequent settling is approximately 50 and 95% effective, respectively, for water entering Lake Cannon from Inwood Ditch, nutrient concentrations at the center lake site have not declined substantially (see Appendix B). Total phosphorus concentrations in 1995 actually appear higher than normal, while total nitrogen and chlorophyll-a concentrations appear to have declined somewhat with the peak chlorophyll concentration in 1995 considerably less than in the preceding three years. It is not possible to judge if these changes are attributable to nutrient inactivation via alum injection; it is equally possible that they may be attributable to flushing from above normal rainfall. Dramatic in-lake reductions are not necessarily expected, since the Inwood Ditch represents only one of many sources of nutrient input. Further nutrient reduction may be necessary before measurable improvement is seen.

Derby Ditch Project *(taken from Envisors 1995; Dames and Moore 1990)*

Derby Ditch drains a sub-basin of 407 acres in size directly into Lake Jessie (see Figure 2.7). Envisors (1991) was not able to determine what public entity constructed the ditch; there are no public easements on this man-made ditch. Most of the ditch's drainage basin has been urbanized. The dominant land-use is residential with most housing located on small lots typically less than 1/4 acre in size. There are several high density residential mobile home parks in the basin and there are areas of commercial development, particularly along Havendale Boulevard, which experiences heavy vehicular use. There is a commercial nursery located in the lower portion of the ditch near Lake Jessie, however, it is below the area that will be treated by the stormwater treatment pond system (i.e., the Derby Ditch Project).

Major conclusions by Envisors (1991) were :

1. The Derby Avenue Ditch is a man-made ditch which drains stormwater from a heavily urbanized area into Lake Jessie.

2. The ditch is major source of pollution to the Winter Haven Chain of Lakes. Pollutants include; (1) sediment; (2) trash and litter; and (3) non-point source pollutants such as phosphorus, nitrogen, and BOD, as indicated by modeling studies.

3. The stream cross section is very large at the start of the ditch and progressively decreases in size. The stream profile originates as very flat and greatly steepens at the downstream end.

4. Steep, unstable stream banks at the upstream end of the ditch appear to be the major source of sediment loading.

Envisors (1991) suggested a number of conceptual solutions for mitigating the impacts of Derby Ditch on Lake Jessie; one was the construction of an off-line sedimentation/wet detention pond with an in-line diversion weir to direct flow from the ditch into the pond. "The purposes of the pond are to: (1) treat the quality of the ditch's stormwater through a wet detention pond; and (2) trap sediment and trash."

The Southwest Florida Water Management using SWIM Funds (80% State and 20% Peace Basin Board) agreed to fund 50% of construction costs up to a total amount not exceeding $200,000. Land acquisition was the sole responsibility of Polk County. Although the original agreement between the County and District was entered into in October, 1991, the Derby Ditch Project experienced delays due to land acquisition, design and permitting. All these delays were attributable directly or indirectly to funding; however, as a result of in-

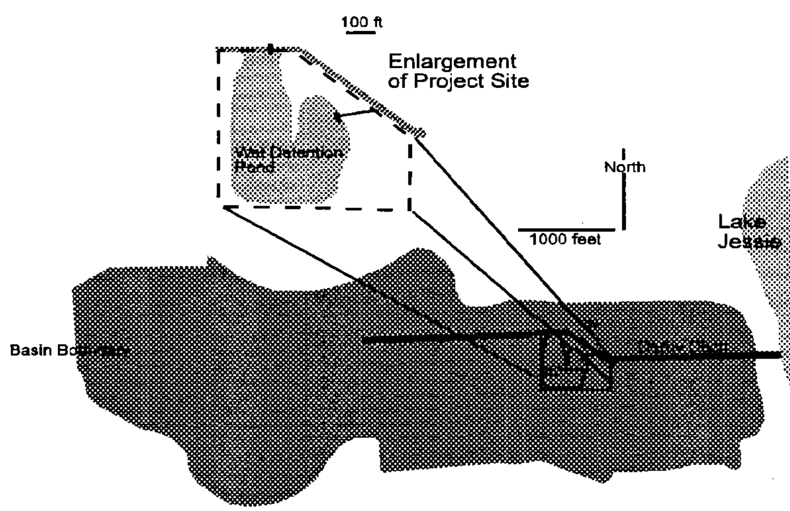


Figure 2-7. Schematic of Derby Ditch Stormwater Retrofit Project.

house design and permitting by Polk County considerable costs were saved (approximately $50,000).

Polk County purchased an 8 acre parcel specifically for the project. Construction on this project was completed by April 1996. As designed and constructed, the project includes a 4.3 acres wet detention treatment pond, a structural weir to divert the stormwater flow from Derby Ditch into the pond, and an outfall structure to detain stormwater flows within the detention pond. The pond was constructed with a sump area and littoral zones for improved stormwater quality treatment. The majority of the project's 5 acres was historically an open area; a 3 acre forested area was not utilized for the project but set aside as potential park space.

The wet detention facility was designed to detain base flow and runoff from about 1.0 inch of rainfall over the watershed (i.e., runoff volume is equivalent to 0.115 inch from the contributing 285 acres). Excess flow will bypass or overflow from the pond into Derby Ditch. It is anticipated that as part or an ongoing SWIM funded monitoring program being implemented by Polk County that water quality upstream and downstream of the project will be monitored to evaluate treatment (pollutant removal) efficiency.

Lake Conine - Whole Lake Alum Application

Although not a SWIM funded project, Polk County and the Peace River Basin Board entered into a cooperatively funded project in 1994 for a whole lake alum treatment of Lake Conine. In addition to funding from the SWFWMD, the County also executed cooperative agreements with the City of Winter Haven and the Lake Region Lakes Management District for partial project funding. The County contracted with Environmental Research and Design to design and implement an alum application plan. After some preliminary testing, a whole lake alum application of 130,000 gallons was begun on March 18, 1995. Although the purpose of the alum application was to inactivate sediment nutrients, the alum was applied at the surface of the water rather than immediately above the sediment. As expected there was an immediate improvement in transparency and a substantial reduction in Chl-a after application of the alum (see Figure 2-8). Although it appears that Lake Conine water quality is now similar to that seen immediately before the application, it should be noted that water quality in other Chain lakes appears to have worsened presumably due to increased loading from higher than normal rainfall over the past two rainy seasons. In addition, water quality in Lake Smart immediately downstream from Lake Conine appears to have improved (see Figure 2-9) presumably due to movement of some of the alum from Lake Conine into Lake Smart. This project needs to be evaluated further before other whole lake alum applications are made on the Chain.

Figure 2-8. Plot of total phosphorus versus time for Lake Conine.

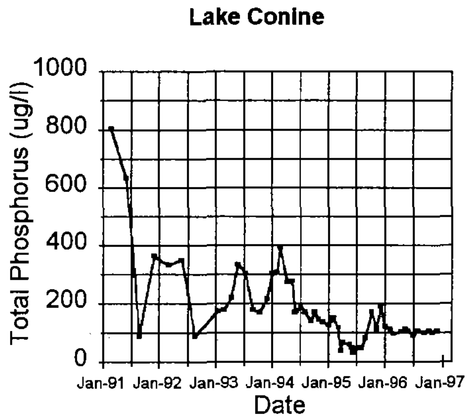
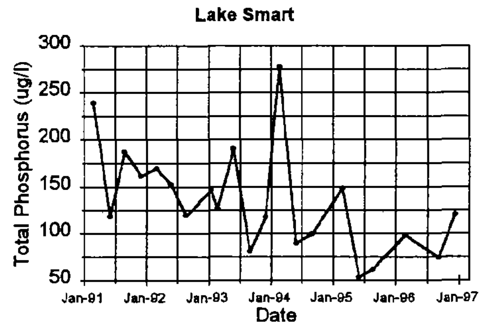


Figure 2-9. Plot of total phosphorus versus time for Lake Smart.



Jan-Phyl Stormwater Retrofit Project *(cited material taken from BCI 1997)*

"The Jan-Phyl Secondary Wastewater Treatment Plant was taken off-line and abandoned in the late 1980's upon start-up of the Central Regional wastewater treatment facility. Part of the Jan-Phyl plant site was dedicated to a stormwater conveyance ditch monitored by the City of Winter Haven as part of ongoing studies of the Lake Howard watershed and the City verified that the pollutant loadings from this basin were appreciable. . . The 7 acre project site is located west of Winter Haven, approximately ½ mile due west of the Coleman Road and Recker Highway intersection... Three percolation ponds were constructed at the site by excavation and berming up the pond edges with spoil material... The project catchment area contributes runoff to the City of Winter's Haven 21st Street outfall to Lake Howard

Lake Howard Stormwater Retrofit Project

In 1993, the City of Winter Haven and the Peace River Basin Board of SWFWMD cooperatively funded a $53,000 project to examine the feasibility of using property on the south-western shoreline to treat stormwater for a large sub-basin (576 acres) that discharges to Lake Howard. The project consultant was responsible for recommending specific stormwater management strategies and designs to improve water quality in Lake Howard. As a result of the feasibility study, the Peace River Basin Board entered into another cooperative funding agreement with the City of Winter Haven in 1994 for the construction of a 9.5 acre wet detention and wetland treatment system. The Basin Board has agreed to fund an amount not to exceed $240,000 for the design, permitting and construction of the project; in addition to the District and City a number of entities are involved in the funding for this project including the Lake Region Lakes Management District, Polk County, the Florida Department of Environmental Protection and the Florida Game and Fresh Water Fish Commission. The City of Winter Haven acquired the property in December, 1996, and the City has retained the services of Boyle Engineering for the design and permitting of the project.

Lake Howard Alum Injection Project

Using funds budgeted in fiscal year 1997, the District just recently entered into another cooperative agreement with the City of Winter Haven for construction of an alum injection system designed to treat stormwater from three of the highest loading sub-basins in the watershed. The proposed system will be housed entirely underground on available right-of-way and treat a combined area of 170 acres which drains a significant amount of downtown Winter Haven. The agreement between the City and District is for a total of $332,000, with 50% of the funds coming from the Peace River Basin Board and the SWIM funds.

Recreational Use and Angler Creel Survey
(taken from Rossegger 1995a, 1995b)

With funding from the Peace River Basin Board and the SWIM Trust Fund, the Florida Game and Fresh Water Fish Commission (FGFWFC) began a year-long recreational use and angler creel survey of the WHCL in April 1994. The original project design called for one full year survey to be followed by a peak recreational usage survey in 1995-96. The timing of the shortened twelve week survey would be determined after reviewing the first year of data. Sampling was begun on the Southern Chain in April and on the Northern Chain in June 1994. The survey provides multiple data needs. The angler creel survey (interviews with fishermen) documents total fishing pressure and species-directed effort and success, and serves to "provide an important measure of the biological health of a waterbody" (Rossegger 1995a). The recreational use portion of the survey identifies dominant recreational uses and determines proportion of use by various activities, and thereby demonstrates the relative importance of various water based activities and identifies potential user conflicts. The data can also be used to determine the economic value of the resource, which could then be used in making cost/benefit determinations with regard to particular management strategies.

Although much of the data gathered generated statistics with respect to the fishery on the Chain, fishing was not the dominant recreational use on the Southern Chain. Picnicking accounted for 33% of the use, waterskiing 20-25%, pleasure boating 22-25%, fishing 13-14% and jet skiing 7%. Of those fishing on the Southern Chain, 57-69% (depending on sampling quarter) targeted largemouth bass and 18-42% targeted bream (bluegill, redear and warmouth). Only marginal effort was directed at crappie, catfish and shiners. Based on preliminary data analysis, the Southern Chain appears to support a good fishery with harvest rates for bass and bream substantially above the state norm. In a comparison with Lake Parker (2,273 acres) in Lakeland, Rossegger (1995) noted that peak season effort (hours spent fishing) totaled 7,742 hours on Lake Parker contrasted with 32,741 hours for a similar time period on the Southern Chain (total of 4,361 acres). Proportionally, the Southern Chain supports a much larger recreational fishery.

Since the survey began later on the Northern Chain, the following observations are based on fewer observations and over a shorter time period than for results for the Southern Chain; however, there are some apparent differences between dominant recreational uses and the fishery. Fishing is the dominant recreational activity on the Northern Chain 68-69%; picnicking accounted for 17-18% of the recreational users. In the first quarter sampled, fishermen directed their effort toward bass 37% of the time and toward bream 62% of the time. In the second quarter, more effort was placed on bass (68% of the time) than on bream (35% of the time). Bass fishermen were almost twice as successful on the Northern Chain as on the Southern Chain (i.e., 0.5-0.6 bass per hour on the Southern Chain versus 0.93-0.96 bass per hour on the Northern Chain). Bream fishermen were about equally successful on the Northern and Southern Chains, averaging from 2.0-2.5 bream per hour. Black crappie were caught with some regularity on the Southern Chain but were not on the Northern Chain.

Wildlife Habitat Utilization Study

In mid-1991 the University of Florida began a wildlife habitat utilization study on the Winter Haven Chain of Lakes. As originally conceived the study was to last three years. The initial year of study was to document wildlife usage of aquatic macrophytes, and it was anticipated that in following years habitat would be manipulated by exotics removal and revegetation with "more desirable" aquatic plants. Wildlife usage of revegetated plots would be monitored in the hopes of developing a database that would aid in the development of aquatic plant management strategies on the Winter Haven Chain of Lakes. This study was to proceed concurrently with a cattail harvesting and revegetation projects planned for the Chain.

Only one year of the Wildlife Habitat Utilization Project was completed. Essentially, except for avifauna data, little definitive data were obtained for most wildlife groups (e.g., small mammals, herptiles). "Additional data are needed to better understand the habitat relationships of small mammals and herptiles in the emergent vegetation of lakes. The data collected to date, suggest that the emergent plant communities are not important habitat for most species. Small mammals likely are not rare around these lakes, however, they were not captured within the emergent plants. A number of amphibians were recorded in the vicinity of the study lakes, but only 2 species occurred within the emergent plants...."(Huegel 1993).

While data for most wildlife were insufficient to evaluate habitat preferences, "Bird-use data are extensive, however, and give a good picture of both the diversity and habitat preferences of the various species. One clear result is that the standard palette used in most littoral shelf plantings will have few positive impacts on the wildlife expected to use these lakes, and that they may have some negative ones. Although pickerel weed, duck potato and bulrush may provide some benefits that were not easily measured by this study, the resulting habitat produced by a mix of these species can be expected to provide few real benefits to wildlife that would not have been present otherwise" (Huegel 1993).

List of Permitted Point and Non-point Sources

Table 2-3. Permitted point and non-point sources in the watersheds of lakes composing the Winter Haven Chain of Lakes.

Facility Name	Facility ID	Type	Status	Issued	Expires	Rec. Water Body
Firestone Auto Services Center	FL0060950	Industrial	Inactive			Lake Howard
Winter Haven - Lake Lulu WTP	FL0021831	Municipal	Inactive	7/1/77	6/30/82	Lake Lulu
Orange Manor MHP - Winter Haven	FL0022420	Industrial	Inactive	6/30/75	8/15/80	Lake Eloise
Florida Cypress Garderns Ind.	FL0042463	Industrial	Active	3/30/95	3/31/97	Lake Eloise
Northagate Citgo Station	FL0041688	Industrial	Inactive			Lake Spring
FL Cypress Gardens Inc. - CY	FL0026433	Industrial	Inactive	12/16/74	9/30/75	Lake Summit
Lake Alfred WWTP	FL0021784	Municipal	Inactive	9/27/88	9/30/93	Lake Haines
Fl Distillers Co., Lake Alfred	FL0029017	Industrial	Active	1/20/95	1/31/00	Lake Haines
Plam Shores Mobile Home Park	FL0041572	Industrial	Active	7/8/94	7/31/99	Lake Haines
Lucerne Park Mobile Court - WI	FL0023388	Industrial	Inactive	12/16/74	3/31/76	Lake Smart
Flamingo Shores MHP	FL0028908	Industrial	Inactive	1/25/84	1/31/89	Lake Jessie
Ullrich Enterprises	FL0038032	Industrial	Inactive	4/9/84	4/30/89	Lake Jessie

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CHAPTER THREE:

GOALS, INITIATIVES, PROGRAMS, AND PROJECTS

GOAL

The Goal of the Surface Water Improvement and Management Plan for the Winter Haven Chain of Lakes is in a broad sense that as outlined in the intent of the SWIM Act; namely, the improvement and/or maintenance of water quality and natural ecological systems associated with the waterbody. This Goal is to be achieved through implementation of specific projects developed under the four inter-related initiatives - Water Quality, Natural Systems, Land Use and Waterbody Management.

TSI Target and Pollutant Load Reduction Goal

Assuming that the historic TSI for Chain lakes averaged 50 (based on paleolimnological evidence) and considering the hydrologic modifications that have been made to the Chain, a target TSI of 60 is proposed for the Chain of Lakes. The mean TSI of lakes in the Southern Chain over the last six years (1991-1996) was 63; however, if weighted by surface area the mean TSI was 64. Since it can be argued that Lake Hartridge is a macrophyte dominated lake and that a TSI calculated based on chlorophyll-a is not appropriate for this lake, a weighted mean TSI using lake areas but not including Lake Hartridge was calculated. When this is done, the area weighted mean TSI for the Southern Chain of Lakes was 65.7. To achieve a target TSI for the Southern Chain exclusive of Lake Hartridge would require lowering the weighted mean TSI by six units from 66 to 60. On the Northern Chain of Lakes the area weighted mean TSI for the period 1991-1996 was 69. To achieve a target TSI of 60 for the Northern Chain would require a lowering of nine TSI units.

It is believed that a 25% reduction in non-point loading of phosphorus will be required to lower the TSI ten units. Further, it has been estimated that a 25% reduction in non-point source loading of phosphorus will require a 50% reduction in stormwater phosphorus loading. In the case of the Southern Chain of Lakes this equates to an annual load reduction of 4,000 pounds of phosphorus; and for the Northern Chain this is equal to approximately 1,000 pounds of phosphorus. Using typical wet detention systems, this will require the equivalent of approximately 20-25 retrofit projects on the highest loading subbasins. Until further refined as proposed in this SWIM plan, the proposed Pollutant Load Reduction Goal for the Winter Haven Chain of Lakes is a 25% reduction in non-point source loading of phosphorus, or a reduction in annual loading of 4,000 pounds on the Southern Chain and 1,000 pounds on the Northern Chain.

The goal of 25 % reduction in non-point source loading of phosphorus is considered a long term, non-regulatory goal. It is recognized that no funding mechanism necessary to reach the goal is now in place or anticipated to be in place in the near future. Furthermore, the ability to meet this goal is dependent on the funding and cooperation of several local municipalities, Polk County, the Florida Game and Fresh Water Fish Commission, the Department of Transportation and the Southwest Florida Water Management District.

A. Water Quality Initiative

SWIM legislation was careful to acknowledge that the ecological, aesthetic, recreational and economic value of the state's surface wasters is dependent on the maintenance and/or achievement of desirable water quality. Poor water quality is often visually perceived as a decline in water clarity or a decline in associated natural systems (e.g., decreased fishing success, fishkills, or the occurrence of frequent algae blooms). Water quality and natural systems are inextricably linked, and often times water quality enhancement is prerequisite to natural systems improvement. The water quality sub-initiatives below propose strategies and projects for maintaining, improving or restoring water quality.

Initiative A.1. *Reduce point and non-point source pollutant loadings to attain water quality necessary to restore and maintain healthy and productive natural systems, protect human health, and to attain the highest possible water use classification.*

Because concern for stormwater pollutant loading was identified as the number one priority issue on the Chain of Lakes when the original SWIM plan was drafted, the position was taken that work should begin on the highest priority stormwater projects using a combination of modeling results and past studies as well as professional judgement. This strategy was and continues to be implemented as funds become available.

Review of existing data indicates, that while considerable information exists on individual lakes within the Winter Haven Chain of Lakes, little real data is available to quantify inputs (water and nutrients) into the Chain. Although a stormwater loading modeling effort has been conducted on the Chain (Dames and Moore 1990) much of the effort relied on assumptions with regard to pollutant loadings by land use. This is acceptable for strategies to be directed towards those non-point sources being modeled and for which reasonable loading factors exist, and this was the objective of that study. This type of modeling, however, may not consider point sources and can not consider unknown and/or illegal point and non-point source loading.

The question remains, however, is it cost effective to deal with modeled non-point sources when the effects of non-modeled sources (e.g., atmospheric loading, groundwater and sediment fluxes) on the loading and subsequent trophic state of the receiving water remains unknown? Because of this uncertainty, development of more refined water and nutrient budgets should become a greater priority (and is in this SWIM plan). The relative impact of sources other than direct stormwater runoff needs to be further refined so that specific strategies and recommendations for dealing with these inputs can be evaluated on a cost/benefit basis.

As proposed in the previous SWIM plan a linked watershed/waterbody model was developed (Dames and Moore 1994) for use in assessing the relative impacts of various nutrient sources on lake trophic state. Model function was tested using available data on the Winter Haven Chain of Lakes; however, this plan proposes to use the model and more site specific information to help optimize the implementation of various restoration strategies.

Concern for point source pollutant loading was a high priority in the original SWIM plan. The two major point sources at that time (City of Winter Haven Wastewater Treatment Plant and the Lake Alfred WWTP) have discontinued their direct discharges into Chain lakes (i.e., Lakes Conine and Haines).

Programs:

A.1.a. Municipal and industrial pollutant discharge reduction

- Achieve a thorough understanding of the quantity and composition of domestic and industrial effluent being discharged into the Chain.

Project: Nutrient Budget - Although it is deemed fiscally impractical to develop detailed nutrient budgets on each lake in the Winter Haven Chain unless other sources of funding become available, it is the consensus of the SWIM Advisory Committee that confidence in modeling outputs would be substantially improved if detailed nutrient budgets could be developed for at least two lakes in the Chain.

This plan proposes that nutrient budgets be developed for one lake in the Northern Chain (e.g., Lake Haines) and one lake in the Southern Chain (e.g., Lake Howard) to gain an understanding of the extent to which various sources control lake water quality (trophic state). These other sources include atmospheric deposition, groundwater seepage and sediment fluxes.

Project: Watershed and Waterbody Modeling of the Winter Haven Chain of Lakes - The proposed modeling effort will be conducted in-house by SWIM staff. The objective of this project will be to better define pollution load reduction goals and to evaluate the effectiveness of various strategies to accomplish water quality goals. The modeling effort consists of two parts. A waterbody model will predict in-lake water quality as a result of nutrient loads, and a watershed model which will develop nutrient loads based on landuse.

Project: Model Water Quality Impacts Resulting from Exchange of Water from Southern Chain of Lakes to Northern Chain of Lakes - Although the Northern and Southern Chain of Lakes are connected by a culvert between Lakes Hartridge (on the Southern Chain of Lakes) and Conine (on the Northern Chain of Lakes), there is only flow between the Chains when water levels are high on the Southern Chain. Typically water leaves the Southern Chain via a structure on Lake Lulu, although it is possible to route flows north under certain circumstances since lake elevations on the Southern Chain of Lakes are higher than on the Northern Chain. Because of the possibility that the connection between the Chains may be improved by an extension of the canal system and thus allow for navigation between the Southern and Northern Chains (using some sort of lock structure), concerns have been raised regarding water quality impacts to lakes on both sides of the connection. For example, Lake Hartridge is a macrophyte dominated lake with generally high water clarity, and any water moved from Hartridge to Conine will be replaced with poorer quality (i.e., more nutrient rich) water from Lake Idylwild. Lake Conine's water quality, although improved considerably in recent years, should improve with the inflow of lower nutrient laden water from Lake Hartridge. It should be possible with the proposed Watershed and Waterbody Modeling Project mentioned above to address some of these water quality questions, although the model will not be able to adequately simulate water quality changes in Lake Hartridge, since it is a macrophyte dominated lake (lake models are designed for phytoplankton dominated lakes). Modeling the impacts resulting from exchange of water from the Southern Chain to the Northern Chain would only necessitate a slight modification to the proposed Watershed and Waterbody Modeling Project. The project is mentioned here, however, so that it is explicitly acknowledged that SWIM will address the issue of water exchange between the Southern and Northern Chains.

- Minimize and/or eliminate pollutant loadings from domestic and industrial wastewater discharged into the Chain through alternative reuse and disposal options.

Project: Pollutant Characterization and Grab Sampling Program (ongoing through existing agreement with Polk County Department of Drainage and Natural Resources) - a laboratory budget has been established for analysis of suspect grab water samples on an as needed basis. The primary object of the program is to identify suspect pollutant sources and non-permitted discharges

- Assist in the development of new local, state, and federal legislation and rules necessary to reduce domestic and industrial pollutant discharges to acceptable levels.

A.1.b. Enforcement of Effluent Discharge Limitations

SWIM will work In cooperation with DEP and local governments to identify any dischargers not in compliance with their permits and, if found, will work with the permitting agency to develop time frames for compliance. It should be noted that the two last remaining domestic discharges to the Winter Haven Chain were removed in 1992.

A.1.c. Urban Stormwater Management

- Assist local governments in the development of policies or rules that will demonstrably reduce levels of nutrients and other contaminants in urban stormwater runoff.

- Minimize the quantities of non-point source pollutants entering the Winter Haven Chain of Lakes

Project: Stormwater Management and Retrofit (ongoing and continuing) - stormwater is still perceived as the number one issue requiring action in Winter Haven Chain of Lakes watershed.

To date the District has participated (using a combination of SWIM and Cooperative Funding dollars) with local governments and other agencies in five major stormwater retrofit projects on the Winter Haven Chain of Lakes. Since much of the Winter Haven Chain of Lakes' watershed was developed prior to the implementation of stormwater management rules, there is very little stormwater treatment in the entire watershed. The District should continue to participate with local government in funding stormwater retrofit projects in the most cost-effective means possible. It is SWIM and Basin Board policy to cooperatively fund such projects on a 50/50 cost share basis, so funding of future projects is dependent not only on District funds but on funding sources available to local governments as well.

A.1.d. Agricultural Stormwater Management

-Specific strategies for dealing with agricultural stormwater management will be considered when and if it is demonstrated that agricultural stormwater runoff is a significant contributor to pollutant loading. The Modeling Project will be used to evaluate the potential effects of this loading source.

A.1.e. Management and Disposal of Toxic and Hazardous Pollutants

-To date no toxics or hazardous pollutants requiring treatment have been identified, although the SWIM program has not specifically identified or funded a project designed to detect such pollutants.

A.1.f. Sediment Nutrient Release

- One of the unknowns with regard to lakes in the WHCL is the extent to which lake sediments contribute to nutrient enrichment of overlying water; however, it is possible that they contribute an important load, particularly in those lakes that received point source discharges (e.g., Lakes Conine and Haines). It is envisioned that sediment flux rates will be determined for some lakes on the WHCL as part of the project proposed below. These flux rates can be used in the waterbody portion of the modeling effort to evaluate the possible effects of sediment loading on overlying water quality.

Project: Evaluate the Feasibility of Whole Lake Alum Treatment as a Restoration Tool on Selected Chain Lakes - A whole lake alum treatment was performed on Lake Conine in early 1994 which resulted in dramatic short-term improvement in water quality. Lake Conine water quality remains improved; however, the success of the project has not been fully evaluated. For example, a couple of factors may make productive Florida lakes uniquely different from more temperate systems where whole-lake alum treatments are more often used. Very productive lakes exhibit high pHs which can affect floc formation. In addition, under conditions of high standing stocks of planktonic bluegreens, it was noted on Lake Conine that floc may not necessarily settle out since gas vacuoles in bluegreens will make the floc buoyant. It is possible that some of the systems to which we would like to add alum may be too productive. This project would evaluate the success of the Lake Conine treatment and determine the feasibility/effectiveness of a similar treatment on other Chain lakes, specifically Lake Haines on the North Chain and one lake on the Southern Chain.

B. Natural Systems Initiative

The concept of "natural systems" was specifically addressed in the SWIM legislation. The Legislature found that the water quality of many surface water of the state had been degraded or was in danger in degradation. Explicit in their finding was that "the natural systems associated with many surface waters have been altered so that they no longer perform the important functions that they once performed." Further the ecological, aesthetic, recreational, and economic decline of the state's surface waters was in large part attributable to the destruction of associated natural systems which provide wildlife habitat and contribute greatly to the natural purification processes of aquatic systems. Implicit in the Legislature's mandate to the state's water management districts was the charge to protect and enhance these natural systems, and where necessary, restore altered or damaged natural systems.

Initiative B.1. *Preserve, enhance, restore, and/or create new upland and aquatic habitats for 1) biological communities, 2) pollution abatement, and 3) aesthetic purposes.*

B.1.a. Preservation of existing habitats: promote the preservation of relatively pristine or functional habitats already in existence.

-Assist in the development of adequate local, state, and federal legislation protecting freshwater and upland habitat

-Assist in the development of environmentally sound local, regional, and state comprehensive plans, inclusive of preservation categories

-Conduct, promote and fund public programs designed to educate people on the importance and attributes of leaving habitats intact

-Assist in existing acquisition programs at the state (e.g., Save Our River, Conservation and Recreation Lands, Preservation 2000) and local level

B.1.b .Augmentation and Restoration of Habitats: expand, restore, and/or create new habitats as replacement for habitat losses throughout the Winter Haven Chain of Lakes

-Planting of upland and aquatic vegetation

-Management or eradication of non-native or ecologically undesirable vegetation from lacustrine and nearby upland areas (where such eradication has been demonstrated through a habitat utilization criteria to be beneficial to wildlife populations) and replacement with appropriate native plant species

B.1.c. Monitoring and Research: establish monitoring / research studies associated with projects outlined above

Initiative B.2. Preserve, enhance, and / or restore plant and animal populations that use the Chain of Lakes, its tributaries, and / or associated uplands for part or all of their life cycles.

B.2.a. Optimize habitats as suggested in Initiative B.1. above.

B.2.b. Monitoring and research: promote and/or fund monitoring and research which provides information important to the development and implementation of ecologically sound wildlife management programs and maintenance of viable wildlife populations.

Project: Assessment of Fisheries and Food Web Value of Specific Aquatic Emergent Vegetation. This project will cooperatively fund a proposed project by the Department of Environmental Protection designed to evaluate the fishery and wildlife value of selected aquatic macrophyte species (specifically cattail and bulrush).

B.2.c. Wildlife management programs: promote and/or draft wildlife management programs to protect populations and communities associated with the Chain of Lakes inclusive of all threatened or endangered species as well as species important for commercial and sport/public harvests.

Promote adoption of ordinances designed to protect wildlife populations associated with Chain of Lakes (e.g., ordinances establishing upland buffers and/or wildlife corridors).

C. Land and Public Use Initiative

The goals of improved water quality and natural systems or the maintenance and continuance of already desirable water quality and natural systems can only be achieved by implementing environmentally and ecologically sound land use practices. Land use initiatives are outlined below with these objectives in mind. SWIM legislation was also concerned with the aesthetic, recreational, and economic values of the state's waterbodies. These can also be addressed in part by appropriate rules, regulations, ordinances or policies.

Initiative C.1. Provide sound environmental policies governing land use that minimize the adverse impacts of development on the natural resources of the Chain of Lakes.

C.1.a. Appropriate Land Use: encourage appropriate development and agricultural use of lands bordering the Winter Haven Chain of Lakes

Assist local governments in the designations of increased buffer zones, setback requirements, wildlife corridors, and conservation easements.

Assist local governments in the development of environmentally sound local and state comprehensive plans for consistency with this SWIM Plan.

C.1.b. Laws and Permitting Review: as needed and as resources allow, evaluate adequacy of existing zoning laws, environmental laws and permitting processes as related to land use and environmental resources.

C.1.c. Developmental Designs and Practices: promote environmentally sound projects and practices.

Initiative C.2. Assist local governments in the development of policies and ordinances encouraging the use of existing natural features and native plant species for landscaping and habitat.

Assist local governments in the development of policies and ordinances aimed at reductions in densities, percent impervious surfaces, use of chemical fertilizers and pesticides, and use of non-native plant species.

Develop programs or promote requirements for management of non-native plant species and replacement with appropriate native plant species.

Provide opportunities for the public to utilize the Chain of Lakes for recreational activities consistent with minimizing environmental impacts.

D. Waterbody Management Initiative

The SWIM Act, aside from requiring the development of management plans for particular waterbodies, provides funds for the implementation of plan recommendations (projects). The Act also provides for the periodic review and update of approved plans.

Initiative D.1. Implement the plan of work presented in this document.

D.1.a. Plan implementation: Develop detailed work scopes, staffing needs, work schedules, and budgets as required to efficiently implement the plan of work.

D.1.b. Interlocal Agreements: Develop interagency coordination / liaison programs including interlocal agreements which will work to carry out the work plan.

D.1.c. Public Awareness / Education: Participate in public awareness and education programs as requested.

D.1.d. Effectiveness of Plan Implementation: monitor the effectiveness of and make improvements to the SWIM plan as needed.

Project: Winter Haven Chain of Lakes SWIM Advisory Committee - maintain and continue to meet periodically with the SWIM Advisory Committee. The Committee will advise on and monitor the implementation of the SWIM plan.

Initiative D.2. Promote the adoption and enforcement of laws and regulations necessary to implement the Water Quality, Natural Systems, and Land Use Initiatives of the Plan.

D.2.a. Work to insure a permanent source for SWIM funding.

D.2.b. Work to insure that the necessary state legislation and agency rules are in place to carry out the Plan.

Initiative D.3. Work with local governments to develop and implement an effective long-term management process for the comprehensive management of the Winter Haven Chain of Lakes.

CHAPTER FOUR:

PRIORITY PROJECTS

Projects have been identified to address priority issues. The following pages contain more specific information regarding each proposed project. Each project is identified by title, and projects are presented in the order in which they first appeared in the preceding chapter. Each project requiring specific funding has been assigned a priority number; the lower the number the higher the priority. Presumably higher priority projects will be funded first. Actual implementation, however, will partly depend on available funds and how well proposed projects integrate with ongoing projects and overall plan goals.

Initiative categories and program categories identify which initiatives, subinitiatives and programs are at least partially fulfilled by a given project. Overall project objectives are stated, and the justification / rationale in support of a particular project is given. The Scope of Work is briefly outlined and an estimated total budget presented. Unlike previous SWIM plans, no attempt is made to project a firm timeline for particular projects since much is dependent on available funding.

Projected 5-year Budget - see following discussion for greater detail

	1998	*1999*	*2000*	*2001*	*2002*
Stormwater Management and Retrofit Program				$ 250,000	$ 250,000
Lake Howard Alum Injection System	$ 166,250				
Lake May Stormwater Treatment System		$ 112,500	$112,500		
Nutrient Budget Development		$ 60,000	$ 60,000		
Whole Lake Alum Treatment					
Phase I. Feasibility		$ 45,000			
Phase II. Implementation			$125,000		
Periphyton Filter Nutrient Removal Project	$ 120,000				
Habitat Management Project			$ 35,000	$ 35,000	
Total	$ 286,250	$ 217,500	$ 332,500	$ 285,000	$ 250,000

NUTRIENT BUDGET

Initiative Categories Supported:
Water Quality, Natural Systems

Priority 1

Program Categories Supported:
A.1.a., A.1.c., A.1.f., B.1.a., B.2.a.

Project Objective(s):
To develop a detailed nutrient budget for one lake (i.e., Lake Haines) in the Northern Chain and one lake (i.e., Lake Howard) in the Southern Chain of Lakes.

Justification / Rationale:
Due to the number of lakes in the chain (i.e., 19) the initial SWIM plan took the position that it would be fiscally impractical to develop detailed nutrient budgets for each lake in the Chain of Lakes. Modeling based on available data was proposed for making management decisions. A model has been prepared and tested on the Chain of Lakes; however, it is felt that its reliability/accuracy could be considerably enhanced by actual field measurements on Chain lakes. To date we have relied on literature values and professional judgement in assessing such variables as sediment flux rates, groundwater input/output, atmospheric deposition, and nutrient loadings based on landuse.

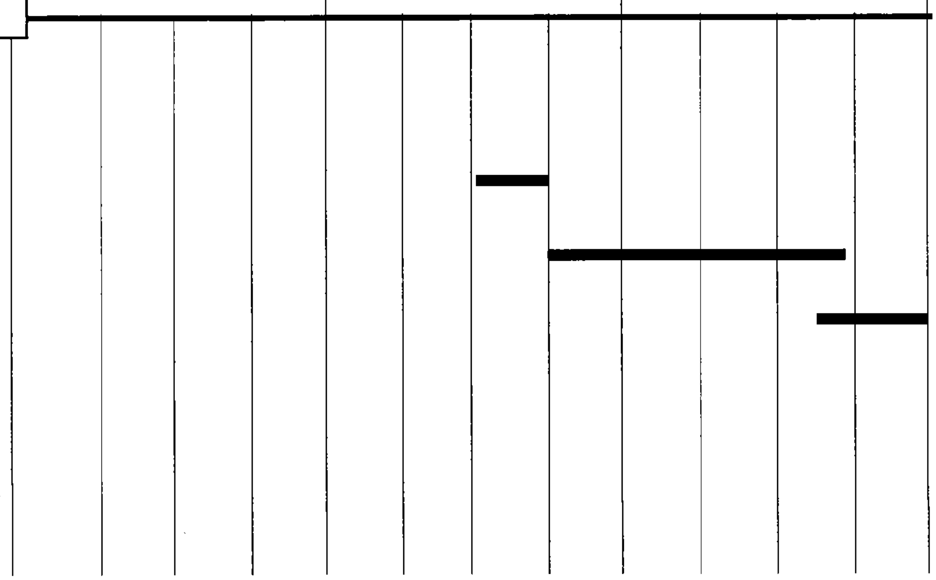
Budget Estimate	FY98	FY99	FY00
Salary and benefits			
Expenses			
Travel			
Supplies			
Data Processing			
Miscellaneous			
Contracted Services		$ 60,000	$ 60,000
Equipment			
Other:			
TOTAL		$ 60,000	$ 60,000

Timeline

Consultant Seclection

Collection of Field Data

Report



WATERSHED / WATERBODY MODELING PROJECT

Initiative Categories Supported: ***Priority*** 1

Water Quality, Natural Systems, Land and Public Use, Waterbody Management

Program Categories Supported:

A.1.a., A.1.c., A.1.d., A.1.f., B.1.a., B.2.b., C.1.a., C.1.c., D.1.d.

Project Objective(s):

To apply the linked watershed/waterbody model to the Winter Haven Chain of Lakes as a tool for evaluating pollutant load reduction strategies. The model system would include two components: a model that would predict changes in in-lake water quality as a result of nutrient loading, and a watershed model that would be used to generate pollutant loads based on landuse. The model would also be used to assess potential water quality impacts on Chain lakes as a result of a proposed improved connection between the Northern and Southern Chain of Lakes (between Lakes Hartridge and Conine).

Justification / Rationale:

A watershed/waterbody model would be used to evaluate the effectiveness of individual projects in reducing nutrient loads. The model would allow for the development of the most cost effective pollutant load reduction strategy. It is also anticipated that the model will be used to refine the Pollutant Load Reduction Goal(s) for the Winter Haven Chain of Lakes.

Budget Estimate	FY98	FY99	FY00
Salary and benefits			
Expenses			
Travel			
Supplies			
Data Processing			
Miscellaneous			
Contracted Services		$ 50,000	
Equipment			
Other:			
TOTAL		$ 50,000	

Timeline

NOTE: It is anticipated that this project will be accomplished by SWIM staff; however, a budget is proposed so that a consultant can be contracted if District priorities warrant.

STORMWATER MANAGEMENT AND RETROFIT PROGRAM

Initiative Categories Supported: ***Priority*** 1
Water Quality, Natural Systems, Waterbody Management

Program Categories Supported:
A.1.c., B.1.a., D.1.b., D.1.d

Project Objective(s):
As presented in this SWIM plan, a major initiative is to reduce stormwater nutrient loading throughout the watershed by constructing stormwater treatment systems in the most cost effective manner possible. The highest loading areas will be targeted; phosphorus is the targeted nutrient.

Justification / Rationale:
A list of the highest loading sub-basins based on modeled projections is discussed in Chapter Two. There is very little stormwater treatment throughout the watershed of the Chain of Lakes, although it is believed that stormwater is the source most amenable to nutrient management. It is anticipated that a minimum of 15 (possibly 30) retrofit projects will be needed to result in measurable improvement (25% non-point source load reduction which equates to a 50% reduction in stormwater loading) in in-lake water quality. We propose to cooperatively implement on a 50/50 cost share basis stormwater retrofit projects throughout the watershed on a priority basis. It is anticipated that 1 or 2 new stormwater retrofit projects will be started annually at an average cost of $250,000 per project.

It is the intent of retrofit efforts to address the highest loadings areas; however, land availability and other factors (e.g., priorities of cooperating agencies) will determine to some extent which projects are implemented. Assuming funds will become available opportunities exist to implement projects on some of the highest ranked loading sources including:

Basin 25602 which drains to Lake May
Basin 20402 which drains to Lake Hartridge
Basin 25601 which drains to Lake May
Basin 25302 which drains to Lake Lulu
Basin 28002 which drains to Lake Conine

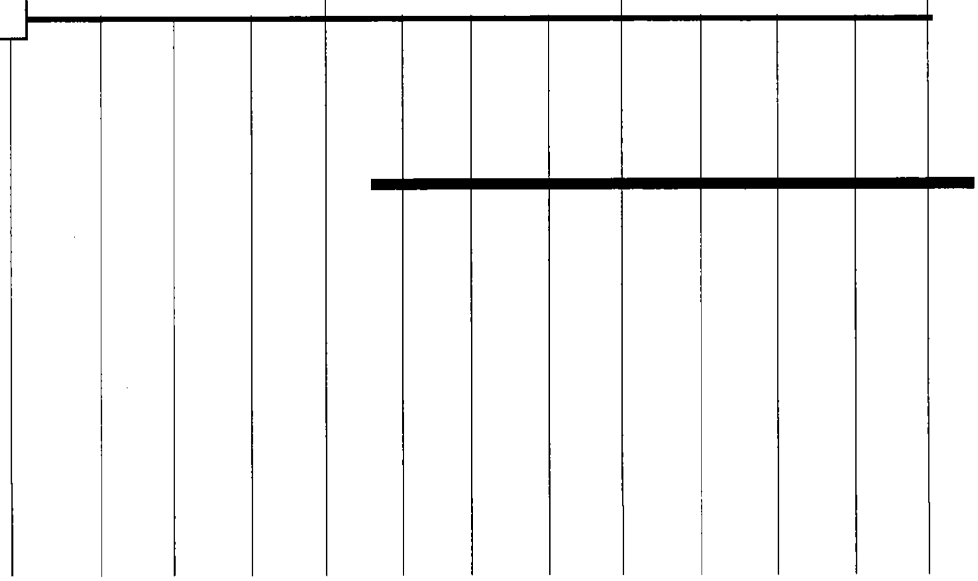
Basin numbers are those assigned by Dames and Moore (1990).

Budget Estimate

	FY98	FY99	FY00
Salary and benefits			
Expenses			
Travel			
Supplies			
Data Processing			
Miscellaneous			
Contracted Services			
Equipment		$ 125,000	$ 250,000
Other:			
TOTAL			

Timeline

Scope and time table for projects to be developed in consultation with SWIM Advisory Committee and cooperatively funding agencies (Polk County, City of Winter Haven, Lake Region Lakes Management District, DEP, etc.)



STROMWATER MANAGEMENT AND RETROFIT PROGRAM - LAKE HOWARD ALUM INJECTION SYSTEM

Initiative Categories Supported: ***Priority*** 1

Water Quality, Natural Systems, Waterbody Management

Program Categories Supported:

A.1.c., B.1.a., D.1.b., D.1.d

Project Objective(s):

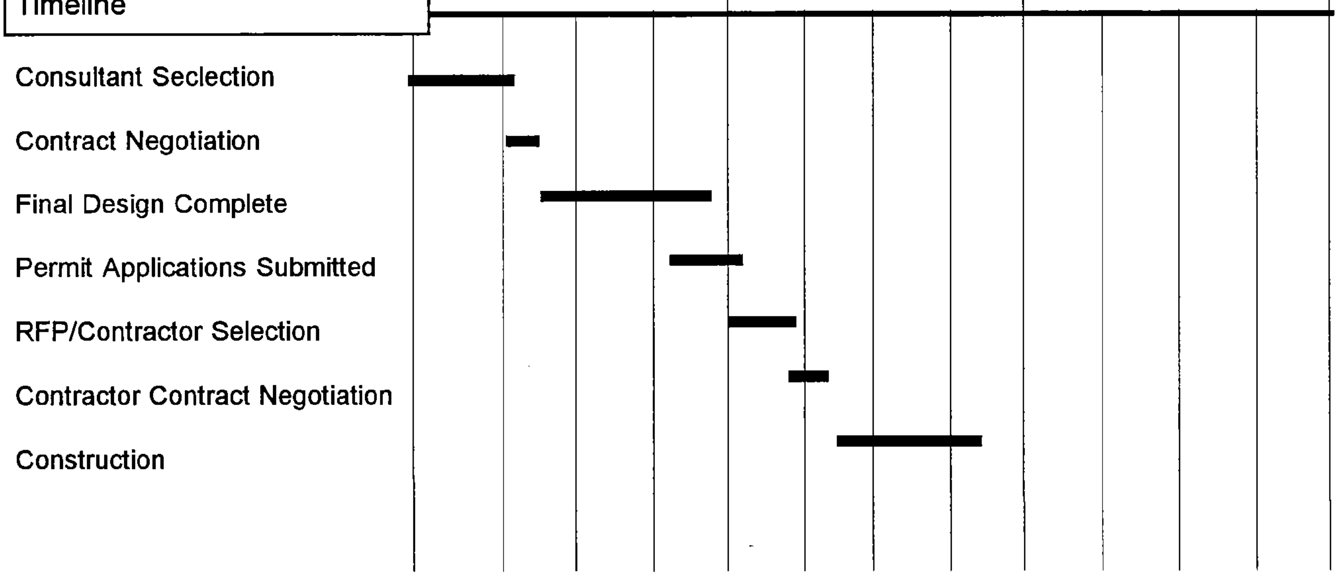
Construction of an alum stormwater treatment system which would inject alum into two major stormwater outfalls and one minor outfall that drain directly to Lake Howard.

Justification / Rationale:

Much of the continuing poor water quality in Chain lakes is believed attributable to nonpoint sources since all known domestic point sources have been removed. As a group the Southern Chain of Lakes has historically and continues to be either phosphorus limited or nutrient balanced, indicating that reduction in phosphorus will reduce chlorophyll concentrations and improve water quality. The total nitrogen to total phosphorus ratio for Lake Howard in particular indicates phosphorus limitation. Alum is known to be especially effective in inactivating phosphorus (i.e., making it unavailable for plant uptake) particularly in the pH range of 5 to 8. The area of the watershed proposed for treatment is highly urbanized (the downtown Winter Haven area), and sufficient lands for conventional stormwater treatment are not available.

Budget Estimate	FY98	FY99	FY00
Salary and benefits			
Expenses			
Travel			
Supplies			
Data Processing			
Miscellaneous			
Contracted Services	$166,250		
Equipment			
Other:			
TOTAL			

Timeline



WHOLE LAKE ALUM TREATMENT

PHASE I. FEASIBILITY

PHASE II. IMPLEMENTATION

Initiative Categories Supported: Water Quality, Natural Sytems

Priority 2

Program Categories Supported:
A.1.f., B.1.a.

Project Objective(s):
Phase I: Feasibility Study: Evaluate the potential effectiveness of whole-lake alum treatment on Chain lakes.

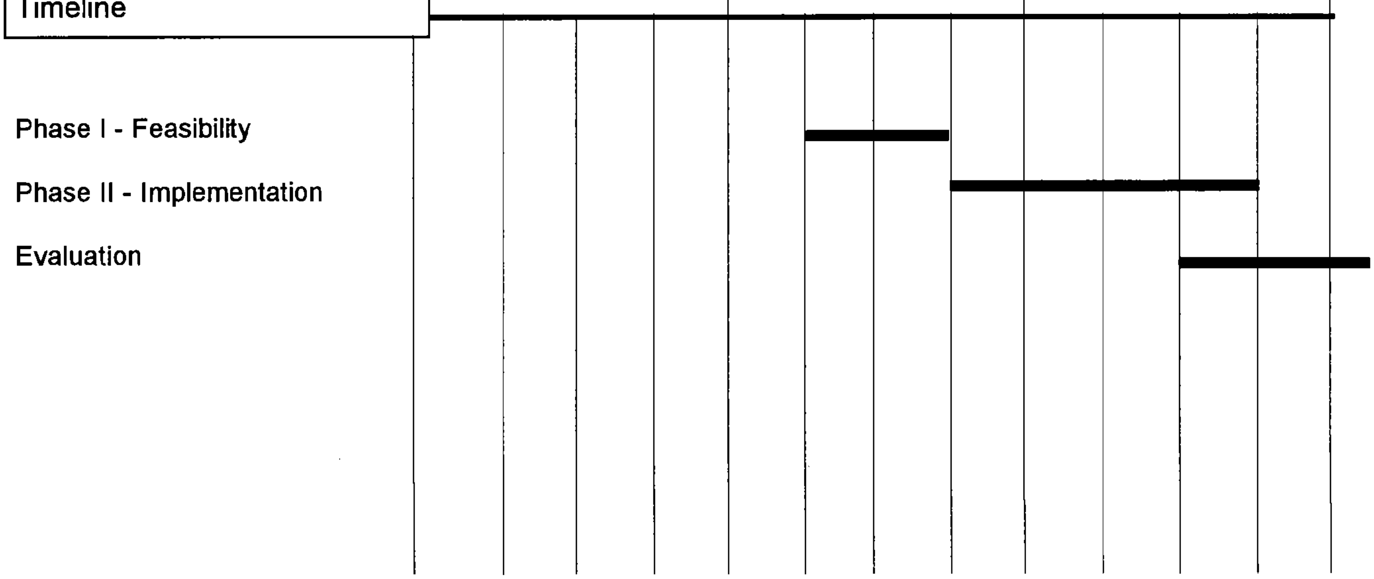
Phase II: Implementation: To apply aluminum sulfate (Alum) lakewide and on a one time basis. Alum will be applied over a period of several weeks on the surface of the lake and allowed to flocculate and settle to the lake's bottom. The primary objective will be to bind (inactivate) sediment phosphorus and prevent recycling to the overlying water column.

Justification / Rationale:
Much of the continuing poor water quality in Chain lakes is believed attributable to nonpoint sources since all known domestic point sources have been removed. As a group the Southern Chain of Lakes has historically and continues to be either phosphorus limited or nutrient balanced, indicating that reduction in phosphorus will reduce chlorophyll concentrations and improve water quality. Alum is known to be especially effective in inactivating phosphorus (i.e., making it unavailable for plant uptake) particularly in the pH range of 5 to 8.

The two remaining domestic point sources to the Winter Haven Chain of Lakes were removed in 1992. One discharged directly to Lake Conine and the other to Lake Haines. Lake Conine was the subject of a whole lake alum treatment in early 1994, and a whole lake alum treatment of Lake Haines has been contemplated. There was a dramatic improvement in water clarity and trophic state in Lake Conine immediately after treatment; however, the present trophic condition of the lake as determined by chlorophyll-a is not greatly improved over pre-treatment conditions. The effectiveness of this treatment needs to be evaluated before other whole lake treatments are attempted. The majority of Chain lakes are surrounded by urban development and dredging would be a costly method for controlling sediment nutrient release; however, alum application may offer an attractive alternative.

Budget Estimate	FY98	FY99	FY00
Salary and benefits			
Expenses			
Travel			
Supplies			
Data Processing			
Miscellaneous			
Contracted Services		$45,000	$125,000
Equipment			
Other:			
TOTAL		$45,000	$125,000

Timeline



PERIPHYTON FILTER FOR NUTRIENT CONTROL

Initiative Categories Supported: ***Priority*** 1
Water Quality, Natural Systems, Waterbody Management

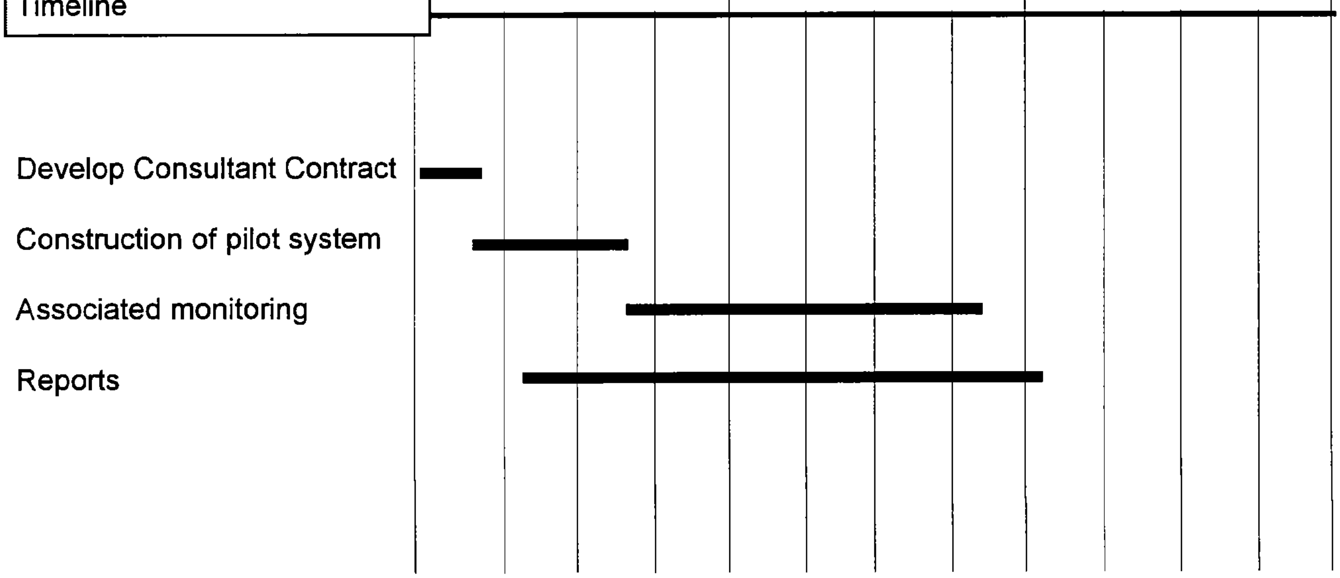
Program Categories Supported:
A.1.c., B.1.a., D.1.b., D.1.d

Project Objective(s):
Demonstrate the utility of a Periphyton Filter system as a sustainable means of controlling lake water phosphorus and nitrogen concentrations. This will be accomplished by documenting phosphorus and possibly nitrogen removal rates for a pilot-scale Periphyton Filter System over a 20 month period.

Justification / Rationale:
Much of the Winter Haven Chain of Lakes' watershed was developed prior to stormwater quality treatment regulations; as a consequence much of the watershed will need to be retrofitted in some respect in order to reduce nutrient loading to the lake system. Typical stormwater treatment systems are land intensive and removal efficiencies are relatively low; therefore, costs per pound of nutrient removed are high. It is believed that a Periphyton Filter system may offer higher cost efficiencies and would remove nutrients presently in the system for recycling elsewhere.

Budget Estimate	FY98	FY99	FY00
Salary and benefits			
Expenses			
Travel			
Supplies			
Data Processing			
Miscellaneous			
Contracted Services	$180,000		
Equipment			
Other:			
TOTAL	$180,000		

Timeline



HABITAT MANAGEMENT - ASSESSMENT OF FISHERIES AND FOOD WED VALUE OF EMERGENT VEGETATION

Initiative Categories Supported: Natural Systems

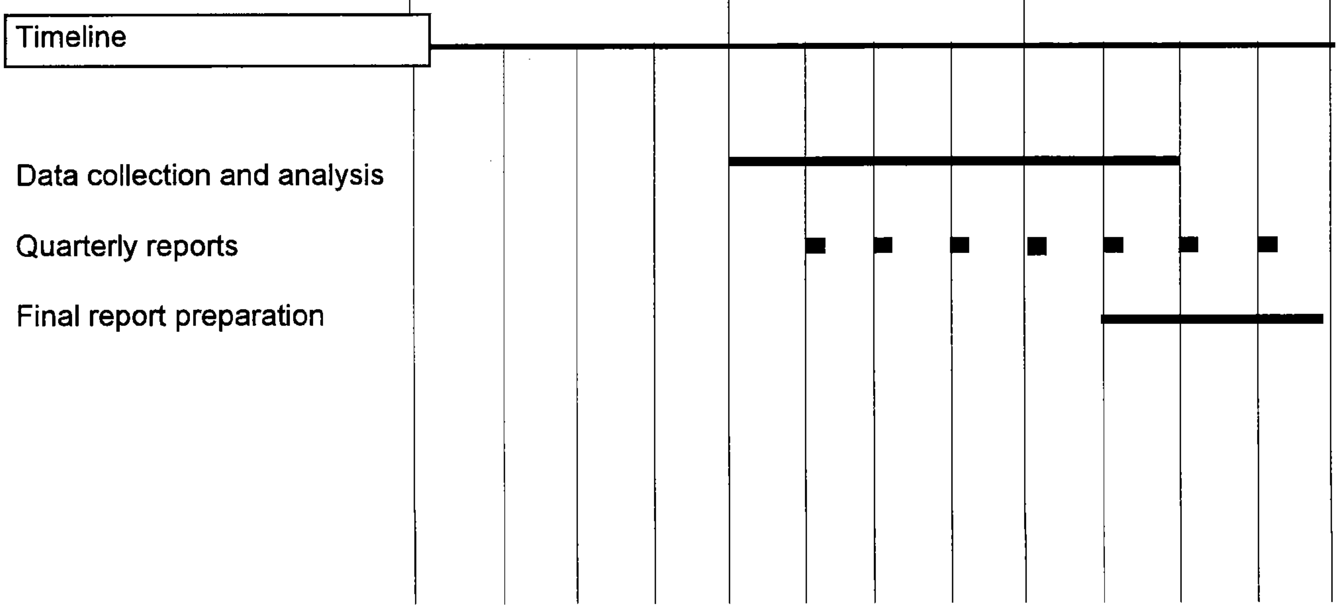
Priority 3

Program Categories Supported:
B.1.b.

Project Objective(s):
The primary objective of this project is to measure over time the diversity macroinvertebrates (food organisms) and fish found in emergent stands dominated by cattails or bulrush. Other wildlife usage will be documented during field work.

Justification / Rationale:
Aquatic plants provide cover and habitat for fish and other wildlife and protect areas from erosion. Project results are intended to provide some regionally specific baseline information on the comparative role of cattail and bulrush habitat in fishery and wildlife food webs. Such information will be used by aquatic plant managers in reviewing management actions on cattails an bulrush. This project is being proposed by the Bureau of Aquatic Plant Management (FDEP) for joint funding.

Budget Estimate	FY98	FY99	FY00
Salary and benefits		$30,000	$30,000
Expenses			
Travel		5,000	5,000
Supplies			
Data Processing			
Miscellaneous			
Contracted Services			
Equipment			
Other:			
TOTAL		$35,000	$35,000



Regulatory Jurisdictions Over the Water Body

Federal

United States Army Corps of Engineers

"Projects constructed by the U.S. Army Crops of Engineers for local flood protection are subject to regulations prescribed to cover operation and maintenance. These regulations are contained in Sections 208.10 and 208.11, Title 33 of the Code of Federal Regulations" (US Corps of Engineers 1987).

"The U.S. Army Corps of Engineers received jurisdiction over Inland Waters of the United States, for navigation purposes, in Section 9 and 10 of the Rivers and Harbors Act of 1899" (Barile et. al. 1987). A revision of the Rivers and Harbors Act in 1968 extended Corps jurisdiction allowing them to consider the fish and wildlife, conservation, pollution, aesthetics, ecology and other relevant factors of a project. The Corps regulatory program was further expanded in 1972 with the passage of the Federal Water Pollution Control Act Amendments, also known as the Clean Water Act (CWA). The discharge of dredge and fill into United States waters is regulated by the Corps under Section 404 of this act. The Corps jurisdiction was extended to wetlands due to a Supreme Court order in 1975 and Amendments to the CWA in 1977 (Barile et. al. 1987). The Corps also contributes 50% of the funds reimbursed to SWFWMD by DNR for exotic aquatic plant control on Rainbow River.

United States Environmental Protection Agency

The Environmental Protction Agency (Southeast Regional Office, Area IV, Alanta, Georgia) has jurisdiction over surface waters in the state. The agency was created in 1970 as an amalgamation of functions previously divided between the Interior Department, Department of Agriculture, Department of Health Education and Welfare and other federal departments. Enforcement authority was given under the Clean Water Act of 1972 and broadened under its revision in 1977. Key activities include the issuance of National Pollution Discharge Elimination System (NPDES) permits and the review of permits issued by the Florida Department of Environmental Protection for the treatment, disposal and storage of hazardous wastes. Authority regarding the discharge of oil or hazardous substances into surface water is divided between the EPA and the US Coast Guard (Barile et al. 1987).

United States Coast Guard

In inland waters the Coast Guard Auxiliary performs boating safety inspections and search and rescue missions. The Auxiliary is a volunteer group reimbursed expenses when asigned a mission by the Coast Guard (Barile et al. 1987).

United States Fish and Wildlife Service

The US Fish and Wildlife Service is responsible for oversight of the federal program for fish and wildlife as authorized in the Coast Resources Barrier Act, National Environmental Protection Act, Migratory Bird Act, Endangered Species Act, and Fish and Wildlife Coordination Act. "Under provisions of the Fish and Wildlife Coordination Act, the Fish and Wildlife Service must be consulted before the Corps of Engineers can submit a plan for Congressional approval. The Fish and Wildlife Service comments on the impacts of proposed projects on endangered species, migratory birds and other fish and wildlife and their habitats" (Barile et al. 1987). The Fish and Wildlife Service is directed to prepare environmental impacts assessments or statements for proposed Corps projects under provisions of the National Environmental Protection Act, and the Fish and Wildlife Service is authorized under the Endangered Species Act to issue "Jeopardy Opinion" aganist any proposed project which will negatively effect an endangered species (Barile et al. 1987).

State

Department of Environmental Protection

The Florida Department of Environmental Protection (DEP) receives its authority partly from Florida state law, and partly from programs which have been delegated by the US Environmental Protection Agency. DEP generally has responsibilities in the following areas:

Water quality protection
Water management
Drinking water quality protection
Hazardous and solid waste management
Wetland protection
Power plant sitting

Only a few of the areas of DEP's responsibility are applicable in this waterbody's watershed. They are discussed more fully as follows:

Water Quality: There are are domestic wastewater (sewage) treatment plants in the watershed. None of them are approved to discharge directly to surface waters: they are all required as a condition of their permit to dispose of their treated wastewater on-site, either via percolation / evaporation ponds, or land-spreading (also referred to as spray irrigation). All are required to treat their effluent to at least secondary treatment levels (i.e., either 90% removal of biochemical oxygen demand and total suspended solids, or 20 mg per liter of each, whichever is least).

Since percolation ponds and land application could potentially contaminate groundwater, all such sources of 100,000 gal per day or more are required to monitor groundwater around the perimeter of their treatment site. Depending upon the specific situation, the department occasionally requires groundwater monitoring from sources exempted by the rule.

Industrial: Industrial waste facilities cover a wide range of types and sizes from large factories and power plants to small shops, and produce a wide variety of pollutants. Treatment requirements likewise are varied, depending upon the type of pollutants involved.

Sludge: Since sludge essentially consists of pollutants which were removed from a wastewater in the treatment process, DEP is concerned about the use or disposal of sludges. Sludges are categorized according to their origin (domestic or industrial) and their content. Some industrial sludges may be categorized as hazardous wastes, and would have to be disposed of in a place and manner approved for hazardous waste treatment or disposal. Other industrial sludges may be able to be adequately handled by disposal in a landfill, or by incineration.

Domestic sludge is usually spread on land and allowed to dry. Thereafter, it may be used as a soil supplement for certain agricultural uses. Sometimes it is used directly in its wet state. Sludge disposal sites must be approved by DEP.

Solid Waste: Solid waste must be disposed of either in an approved landfill or by an accepted means such as incineration. Solid waste is only being mentioned to point out that some waste materials are exempt from DEP solid waste regulations (specifically brush and yard trash, and wastes of other types generated and disposed of entirely on one property). Wastes which are exempt from DEP regulations might be disposed of in the WHCL watershed. Such wastes can contain putrescible matter (i.e., material which decays and might contribute nutrients to ground and surface waters).

Dredge and Fill: Most construction, digging, filling, etc., in the waters of the state, or in wetlands contiguous to waters of the state are regulated by DEP. The intent is to ensure that the act of construction and the long-term use of the property will not adversely impact water quality or result in loss of wetlands.

Stormwater: Most new land-use activities are subject to regulations which require retention or treatment of stormwater prior to its discharge. DEP has delegated most stormwater regulation to the Southwest Florida Water Management District, but has retained responsibility connected to an activity which requires another type of DEP permit (e.g., dredge-and-fill, certain industrial facilities, etc.). Stormwater regulations generally presume that treatment or detention are adequate to meet standards, and monitoring is not ordinarily required, except in unusual cases (such as runoff from an industrial site).

Through responsibilities delegated the former Department of Natural

Resources, the DEP has the following responsibilities / jurisdictions:

Under Chapter 16C-20, "Aquatic Plant Control Permits", the DEP regulates through permits the mechanical, biological (except grass carp) and chemical control of aquatic plants in the WHCL and may take herbicide samples from spray tanks to determine if herbicides being used are permitted / legal.

Under Chapter 16C-50, "State Funding for Aquatic Plant Control", DEP reimburses Polk County on a 50/50 cost share for exotic plant control.

Under Chapter 16C-54, "Cooperative Aquatic Plant Control Program", DEP reimburses Polk County 100% for hydrilla, water lettuce and water hyacinth control in the WHCL. Fifty percent of such funds are received by DEP from the U.S. Army Corps of Engineers.

Persons cultivating / revegetating / collecting aquatic plans in the WHCL are required under Chapter 16C-52, "Aquatic Plant Importation, Transportation, Cultivation and Possession", to obtain a permit from DEP; therefore, persons transporting aquatic plants which are attached / adhering to boat trailers are in violation of this rule.

By authority of Chapters 18-20 and 18-21, "Sovereignty Submerged Land Management", before commercial docks can be placed in water body a submersed land lease is required from DEP. Also residential docks (over 250 square feet) must meet certain DEP requirements. Any other activity on submerged lands shall require consent from DEP.

DEP also performs annual aquatic plant flora surveys, performs routine inspections of permit sites, investigates fish kills and algae blooms, and performs extension work such as the formulation of management plans.

Department of Health and Rehabilitative Services

"The Department of Health and Rehabilitative Services' responsibilities include the public health functions of water supplies (primarily small to medium supplies), onsite sewage disposal, septic tank cleaning and waste disposal (in conjunction with DEP), solid waste control (secondary role)" (Barile et. al. 1987).

The primary statutes providing DHRS authority are to be found in Chapter 154, 381 and 386 of the Florida Statutes and the 10D Series of the Florida Administrative Code, known as the "Sanitary Code". Each county has a DHRS Office responsible for jurisdiction within the county (Barile et. al. 1987).

Game and Fresh Water Fish Commission

It is the mission of the Florida Game and Fresh Water Commission to manage fresh water aquatic life and wild animal life and their habitats to perpetuate a diversity of species with densities and distributions that provide sustained ecological, recreational, scientific, educational, aesthetic and economic benefits.

The Florida Game and Fresh Water Fish Commission was established under authority of Article 4, Section 9 of the State Constitution; its rules and regulations were defined in Chapters 39.101 and 39.102 of the Florida Administrative Code. The FG&FWFC coordinates enforcement of all freshwater fishing and hunting regulations and oversees habitat restoration and monitoring, and the stocking of freshwater rivers and lakes. Implementing regulations regarding the utilization of fish and wildlife in Winter Haven Chain of Lakes is under the jurisdiction of the Commission.

Department of Agriculture and Consumer Services (DACS)

The DACS Division of Agriculture Environmental Services (AES) regulates the registration and use of pesticides, including the purchase of restricted pesticides, maintains registration and quality of fertilizers, regulates pest control operations, mosquito control, and evaluates and manges environmental impacts associated with agrichemicals.

The DACS Division of Forestry (DOF) is responsible for developing Best Management Practices (BMPs) to control forestry-related nonpoint source pollution. The DOF is also responsible for statewide implementation of BMPs, and for monitoring public and private forestry operations to determine BMP compliance and effectiveness. Florida's 34 State Forests and several other parcels of public land are managed by DOF.

The Division of Plant Industry is responsible for, among other duties, regulating the movement of noxious weeds, and, with input form the Endangered Plant Advisory Council, protecting endangered, threatened or commercially exploited plant species.

The DACS Office of Water Policy Coordination (or Agricultural Water Policy, OAWP) is responsible for participating in water policy issues to ensure the availability of an adequate supply and quality of water for the production of food and fiber. OAWP cooperates with agencies and agricultural producers to make available streamlined agricultural regulatory processes and voluntary, incentive-based, acceptable alternatives and agricultural best management practices consistent with the sustainability of agriculture and resource conservation. OAWP provides assistance to Soil and Water Conservation Districts, including the Polk Soil and Water Conservation District, in carrying out conservation activities at the local and watershed level, and providing improved local delivery of resource management services to agricultural producers. OAWP facilitates the participation of Soil and Water Conservation Districts in water-related issues at the district (county) or watershed level.

District

Southwest Florida Water Management District

"The Southwest Florida Water Management District was created by Chapter 61-691, Laws of Florida, as a public corporation for carrying out and effectuating the provisions of Chapter 378, Florida Statutes. Other than as provided in Chapter 61-691, Laws of Florida, the District operates under and is governed by provisions of Chapter 373, Florida Statutes" (Chapter 40D-0, page 0-1, Rules of Southwest Florida Water Management District, October, 1986).

The following permitted activities fall under the jurisdiction of the SWFWMD, and unless expressly exempted by law or District rule, the following permits must be obtained prior to commencement of activity:

"(1) A water use permit under Chapter 40D-2 must be obtained prior to use or withdrawal of water;

(2) A well construction permit under Chapter 40D-3 must be obtained prior to the construction, repair or abandonment of a well.

(3) A surface water management permit under Chapter 40D-4 must be obtained prior to construction, alteration, abandonment or removal of any dam, impoundment, reservoir, appurtenant work or works;

(4) An artificial recharge permit under Chapter 40D-5 must be obtained prior to construction of any project involving artificial recharge or the intentional introduction of water into any underground formation;

(5) A works of the District permit under Chapter 40D-6 must be obtained prior to connecting with, placing construction in or across, discharging into or otherwise making use of works of the district.

(6) A Storm Water Discharge permit under Chapter 17-25 must be obtained prior to construction or modification of a storm water discharge facility." (Chapter 40D-1.602)

Chapters 40D-4 and 40D-40 were adopted to ensure continued protection of the water resources of the District including wetlands and other natural resources. The rules in these chapters are to implement the Surface water management permit system mandated in part IV of Chapter 373, Florida Statutes; the statutes resulted from passage of Chapter 84-79, Laws of Florida, The Warren G. Henderson Wetland Protection Act of 1984.

Permitting under Chapter 40D-6 is required to protect existing works and works for which planning is underway (e.g., canals, water control structures, rights-of-way, lakes and streams) form actions which would impair their ability to function as intended. The District has declared the natural floodway, tributaries, connecting channels, canals and lakes of the following waterbodies to be "Works of the District": the Hillsborough River, Oklawaha River, Withlacoochee River, Peace River, authorized Green Swamp Basin, Anclote River, Lake Tarpon, Old Tampa Bay (north of Courtney Campbell Causeway), Alafia River, Little Manatee River, Palm River and Six Mile Creek, Pithlachascotee River, Waccasassa River, McKay Bay (north of 22nd Street Causeway), Weeki Wachee River, Lake Sloan, Crystal River, Homosassa River, Chassahowitzka River, Bullfrog Creek, and Delany Creek.

Chapter 40D-8 provides that for those lakes meeting specified criteria SWFWMD will establish regulatory levels for lakes in the District. Under this Lake Levels Program, SWFWMD will: provide guidelines (primarily in the floodplain) for development bordering lakes; conserve water storage and recharge capabilities of lakes; provide levels for operation of lake control structures; and provide information for District consumptive use permitting (CUP) activities.

Pursuant to Chapter 87-97 of the Laws of Florida, the District has been given the responsibility for prioritizing water bodies within the District in need of preservation or restoration. The Act also provides for the development of surface water improvement and management (SWIM) plans for priority water bodies and funding for the implementation of these plans.

The District provides for the control of noxious species of aquatic weeds (primarily Hydrilla and water hyacinths) in waters designated by the Florida DEP (Chapter 16C-52).

County

Polk County

The County provides for the control of noxious species of aquatic weeds (primarily Hydrilla and water hyacinths) in waters designated by DEP (Chapter 16C-54).

The following ordinances apply to aquatic systems in Polk County:

Ordinance No. 84-18 relates to aquatic vegetation, and essentially limits removal of aquatic vegetation by riparian owners to a corridor not to exceed 25 feet in width and of sufficient length to reach open water. No other removal is allowed unless permitted by DEP. The ordinance also calls for revegetation when plants are removed by herbicide and/or physical means without an aquatic weed control permit.

Ordinance No. 88-04 implements the National Flood Insurance Program. Some elements covered under this ordinance are:

- A development permit is required for any development within 100 feet of watercourse (other than phosphate mining),

- Prior to issuance of a development permit, an applicant must submit a Storm Water Management Plan,

- All new and replacement on-site waste disposal systems within 100 feet of a watercourse shall be designed so as not to allow infiltration of flood waters into the system and discharge from the system into flood waters,

- Stormwater runoff shall be subject to best management practices prior to discharge into natural or artificial drainage systems,

- Any altered site shall be revegetated, with such revegetation to be substantially completed within 180 days following completion of a development.

Ordinance No. 89-47 "relating to the protection and preservation of the water quality, recreation potential, and wildlife values of Polk County's lakes and streams; establishing surface water setbacks for new structures and on-site sewage disposal systems; providing the authority to conduct water quality investigations." Specific elements addressed by this ordinance are:

- Onsite disposal systems (OSDS) shall not be located closer that 150 feet from the ordinary high water line of surface waters. OSDS located on lands with soils with a rating of severe must be at least 200 feet from the ordinary high water line.

- All new structures shall be located a minimum of 50 feet landward of the ten year flood plain or landward of the 100 year flood plain whichever is less restrictive.

- The Polk County Department of Natural Resources and Drainage is authorized to investigate and report possible violations of State laws and rules related to the protection of surface waterbodies and to assist State and Federal agencies with enforcement of such laws and rules.

Local

City of Winter Haven

Ordinance Chapter 10: Marine activities, structures and waterways. Section 10-1 restricts the use of nets, seines and traps in lakes within the city's jurisdiction. Section 10-2 prohibits filling or unloading of herbicide spraying tanks, machines, etc., on any lakeshore in the city.

Article II of Chapter 10 regulates and restricts boats within canals connecting lakes, provides for 15 mph speed limit within 150 of any shoreline, authorizes the city manager to permit public boat races, and addresses other boating and swimming safety issues. Article III regulates docks, piers and boathouses; and Article IV restricts the amount of clearing and removal of shoreline vegetation by requiring a permit to remove more than 25 feet of shoreline vegetation.

Ordinance Chapter 7 addresses flood protection and prevention. Article II is concerned with flood hazard reduction while Article III is concerned with stormwater management. With regard to stormwater management, quantity is addressed; quality is not.

Lake Region Lakes Management District

(taken from Recker and Ford 1986) is directed by commissioners elected by taxpayers within its district. The Commission holds the right to eminent domain and is responsible for the construction and maintenance of canals, locks, and other improvements within its District which includes both the Northern and Southern Chain of Lakes. A 1945 amendment to the Commission's charter, fist adopted by the Florida Legislature in 1919, gave the Commission the authority to "beautify the right-of-way, canal bank and other property of the District ... and ... to take such legal steps and to initiate such proceedings as may be conducive to the conservation of water and to the maintenance of water levels in said lakes within or adjacent to said District." The 1945 amendment also allowed for the levy of a property tax of up to 1 mil for present and future expenses.

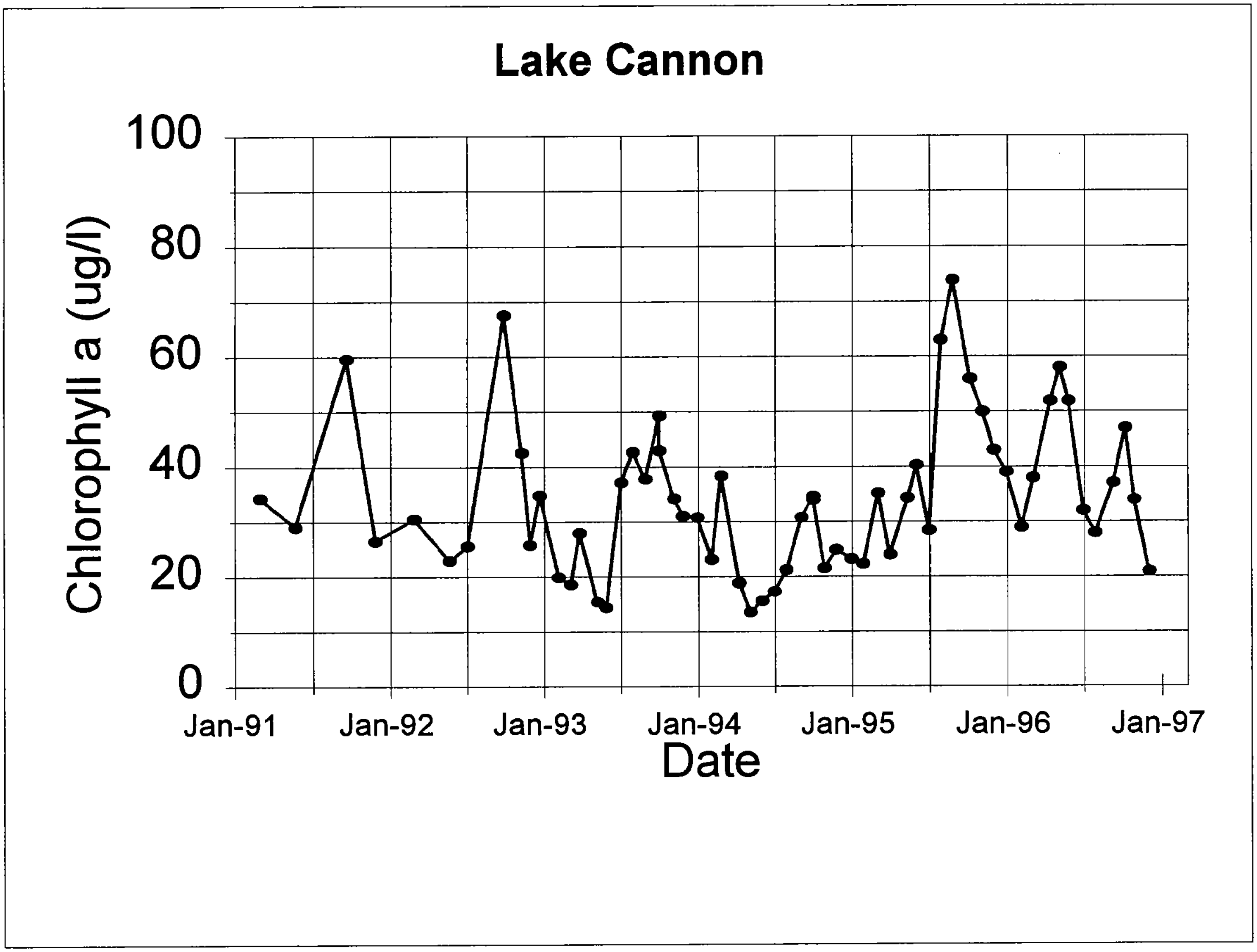
Amendment in 1955 added the authority to build and maintain boat ramps and to control water weeds. In 1984 amendments allow the Commission to take action against polluters in lakes as well as canals and made it a second degree misdemeanor to damage any structures of the Commission, to fill or obstruct flow of water in the canals, and to pollute lakes and lower lake water quality or damage plant life.

Appendix B - water quality summaries for lakes in the Winter Haven Chain of Lakes

The following appendix contains a summary of annual mean water quality for lakes in the Winter Haven Chain of Lakes. Data are arranged alphabetically by lake. In most cases, data are presented as a summary table of data followed by a figure showing variation in chlorophyll-a concentration over time (1991-1996). For a few lakes, additional plots are also provided to supplement comments made in the text.

Table B-1. Lake Cannon - Annual averages of selected water quality parameters.

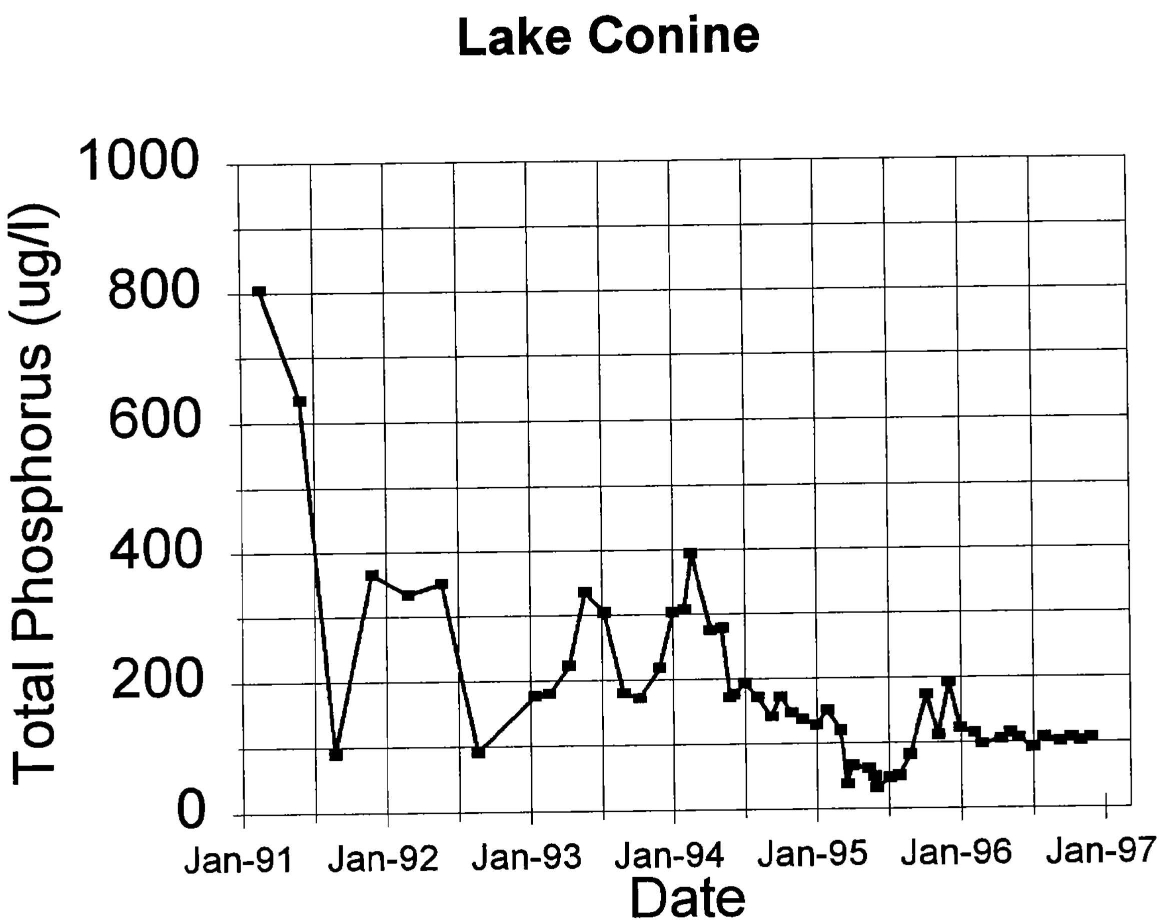
Year	TP (ug/l)	TN (ug/l)	Chl-a (ug/l)	Secchi (feet)	TN/TP	TSI (Chl-a)
1991	75	1235	37	0.7	17	69
1992	55	1253	36	0.8	24	68
1993	58	1320	31	0.8	24	66
1994	62	1102	25	0.7	20	63
1995	87	1494	41	0.5	20	70
1996	77	1331	40	0.6	19	70
Mean	69	1289	35	0.7	21	68

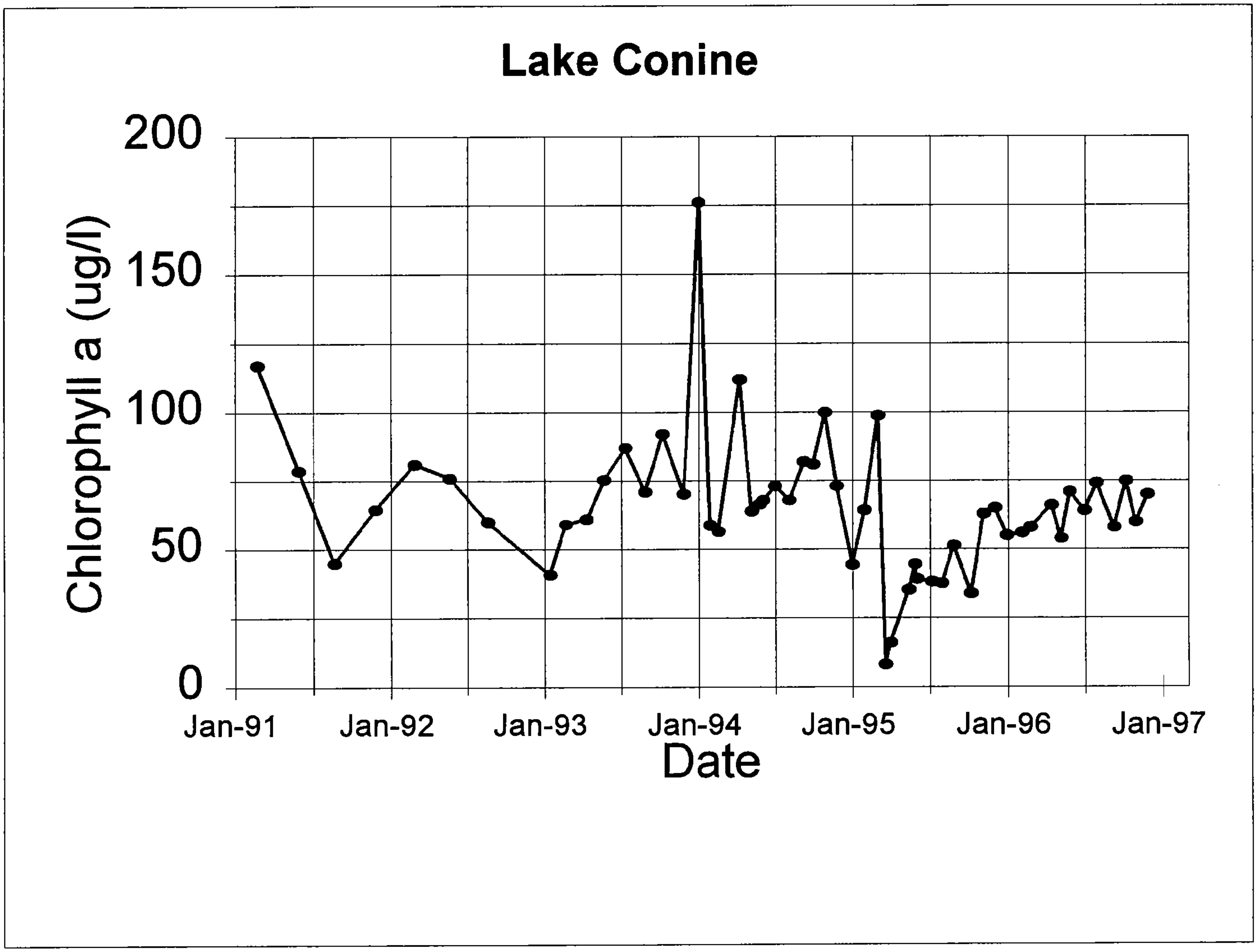


Lake Cannon
100
80
60
40
20
0
Chlorophyll a (ug/l)
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Date

Table B-2. Lake Conine - Annual averages of selected water quality parameters.

Year	TP (ug/l)	TN (ug/l)	Chl-a (ug/l)	Secchi (meters)	TN/TP	TSI (Chl-a)
1991	474	2062	76	0.5	18	89
1992	259	1937	72	0.5	10	78
1993	224	1958	70	0.6	9	78
1994	221	2168	83	0.3	10	80
1995	93	1446	46	0.6	20	72
1996	107	1469	63	0.4	14	77
Mean	229	1840	68	0.5	12	77


Lake Conine
Total Phosphorus (ug/l)
1000
800
600
400
200
0
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Date



Lake Conine
Chlorophyll a (ug/l)
200
150
100
50
0
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Date

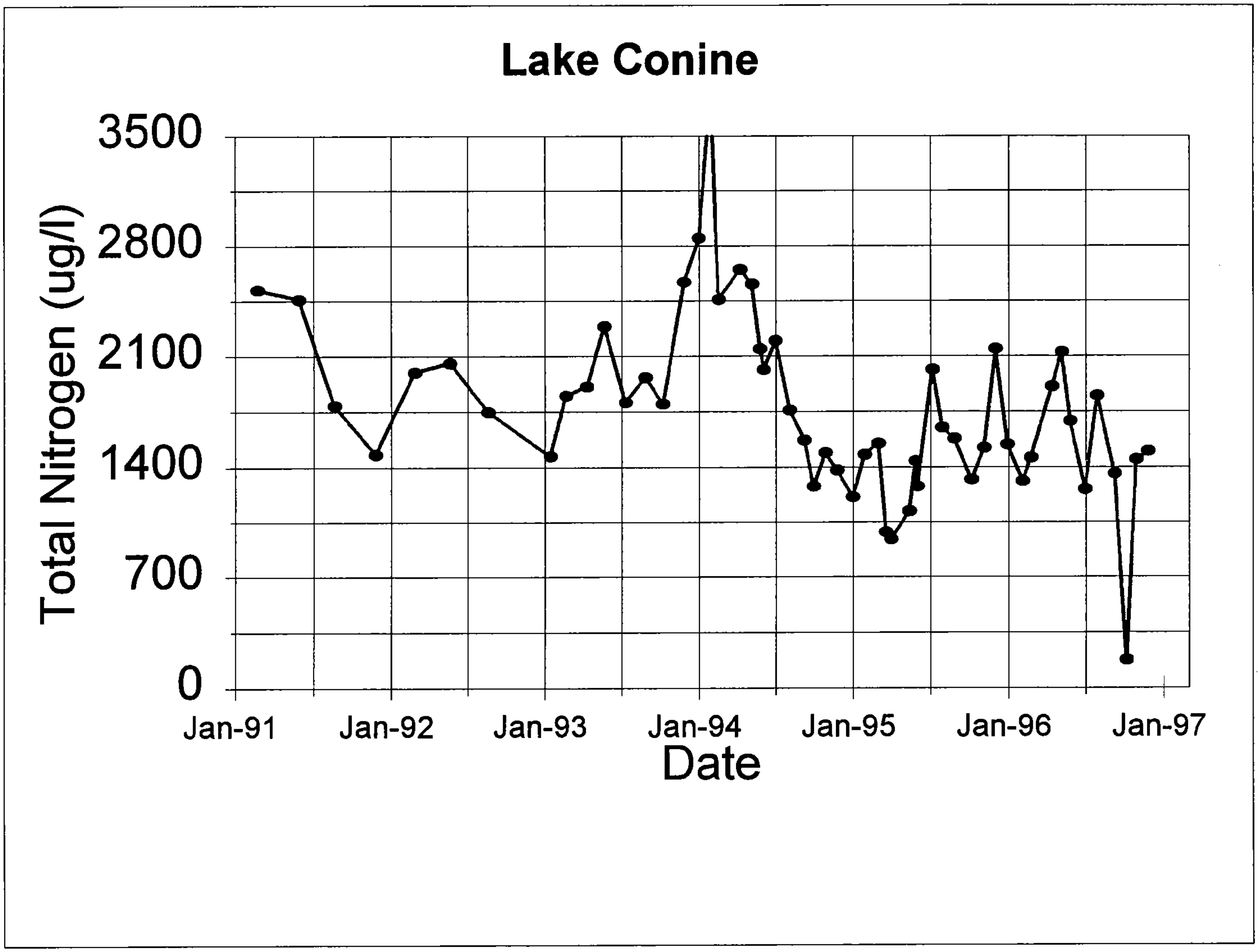

Lake Conine
Total Nitrogen (ug/l)
3500
2800
2100
1400
700
0
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Date

Table B-3. Lake Eloise - Annual averages of selected water quality parameters.

Year	TP (ug/l)	TN (ug/l)	Chl-a (ug/l)	Secchi (meters)	TN/TP	TSI (Chl-a)
1991	56	1595	37	0.7	29	69
1992	51	1530	38	0.7	30	69
1993	31	1613	36	0.7	52	68
1994	46	940	18	0.8	21	58
1995	58	1293	28	0.6	24	65
1996	66	1363	29	1.1	29	65
Mean	51	1389	31	0.8	31	66

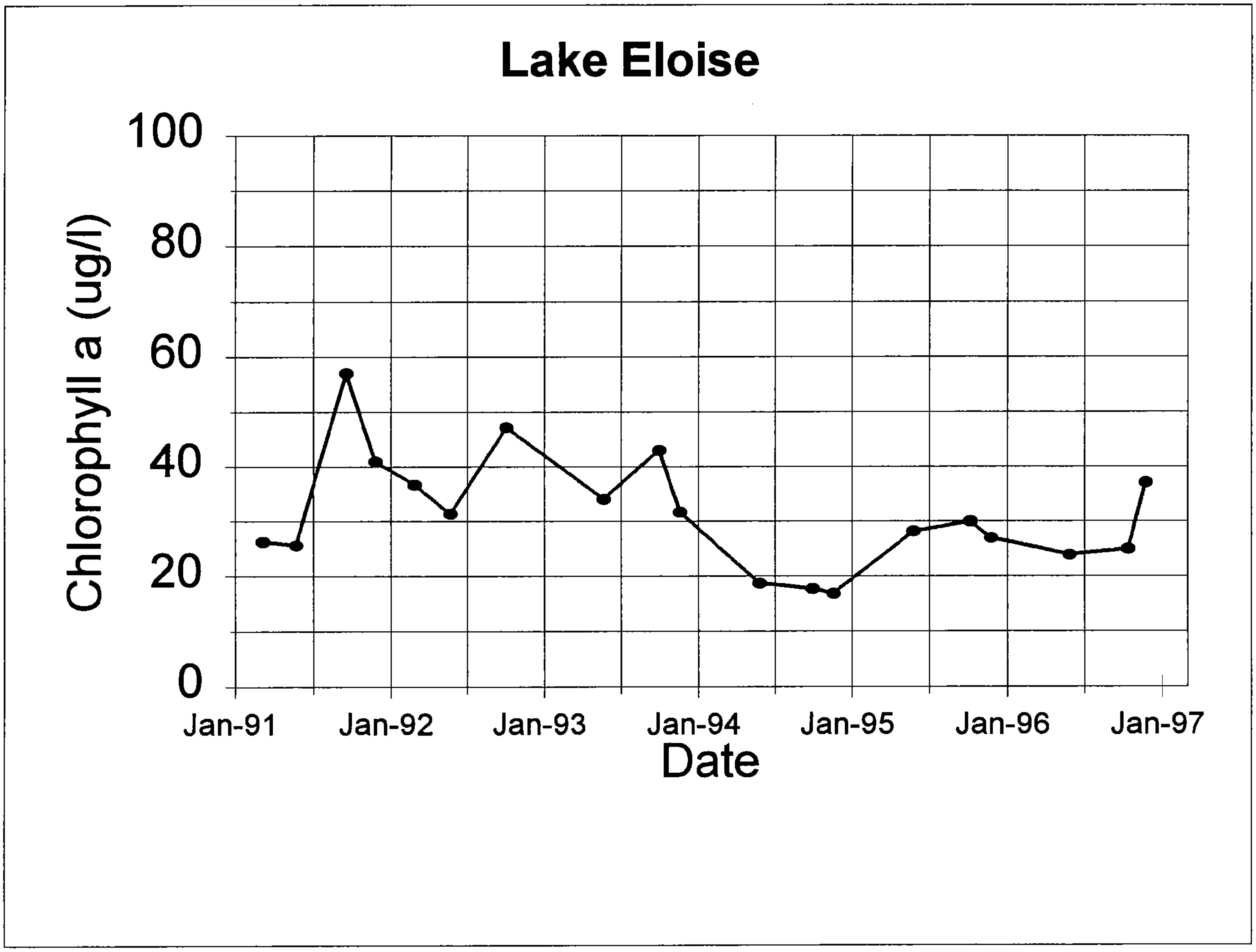
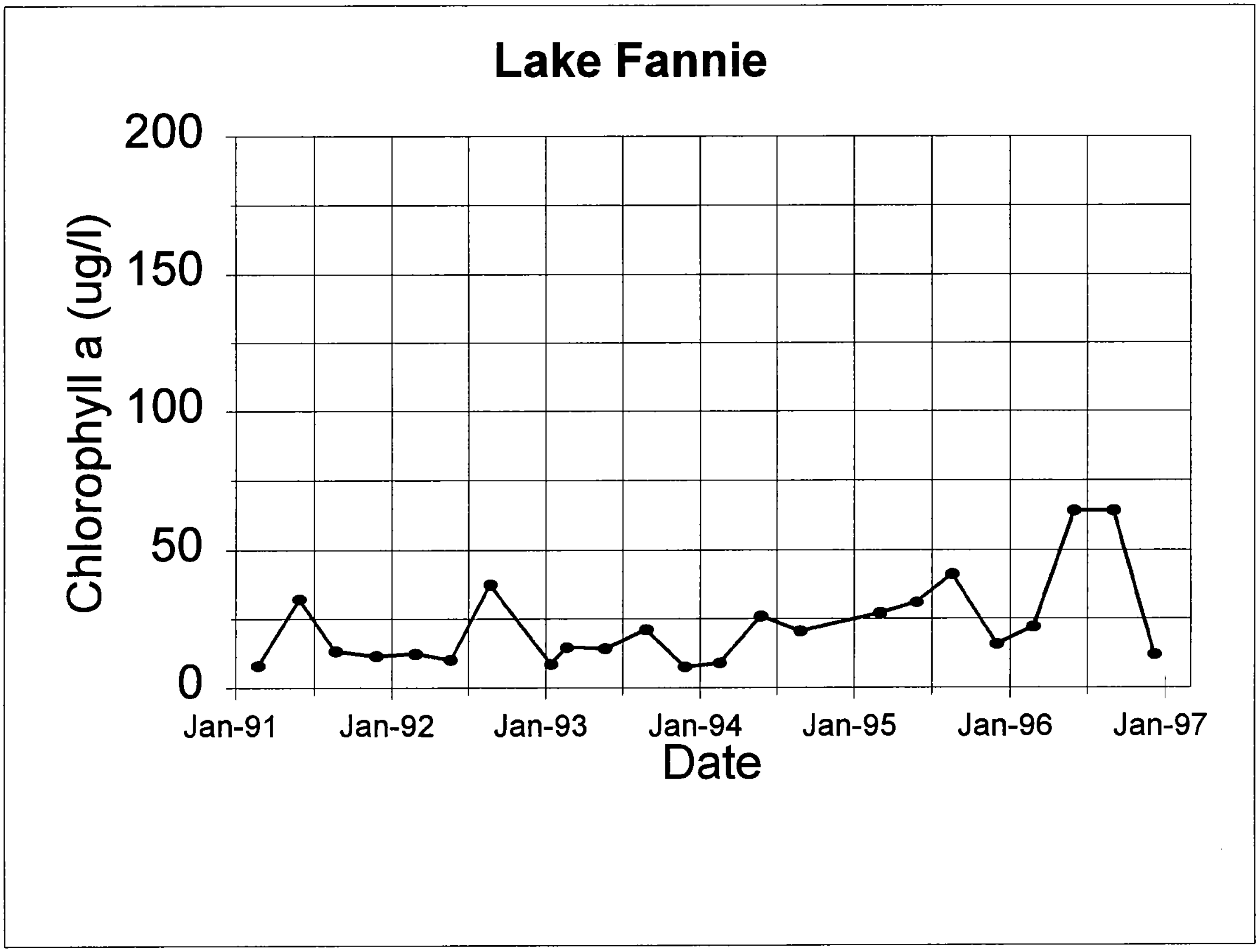

Lake Eloise
Chlorophyll a (ug/l)
100
80
60
40
20
0
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Date

Table B-4. Lake Fannie - Annual averages of selected water quality parameters.

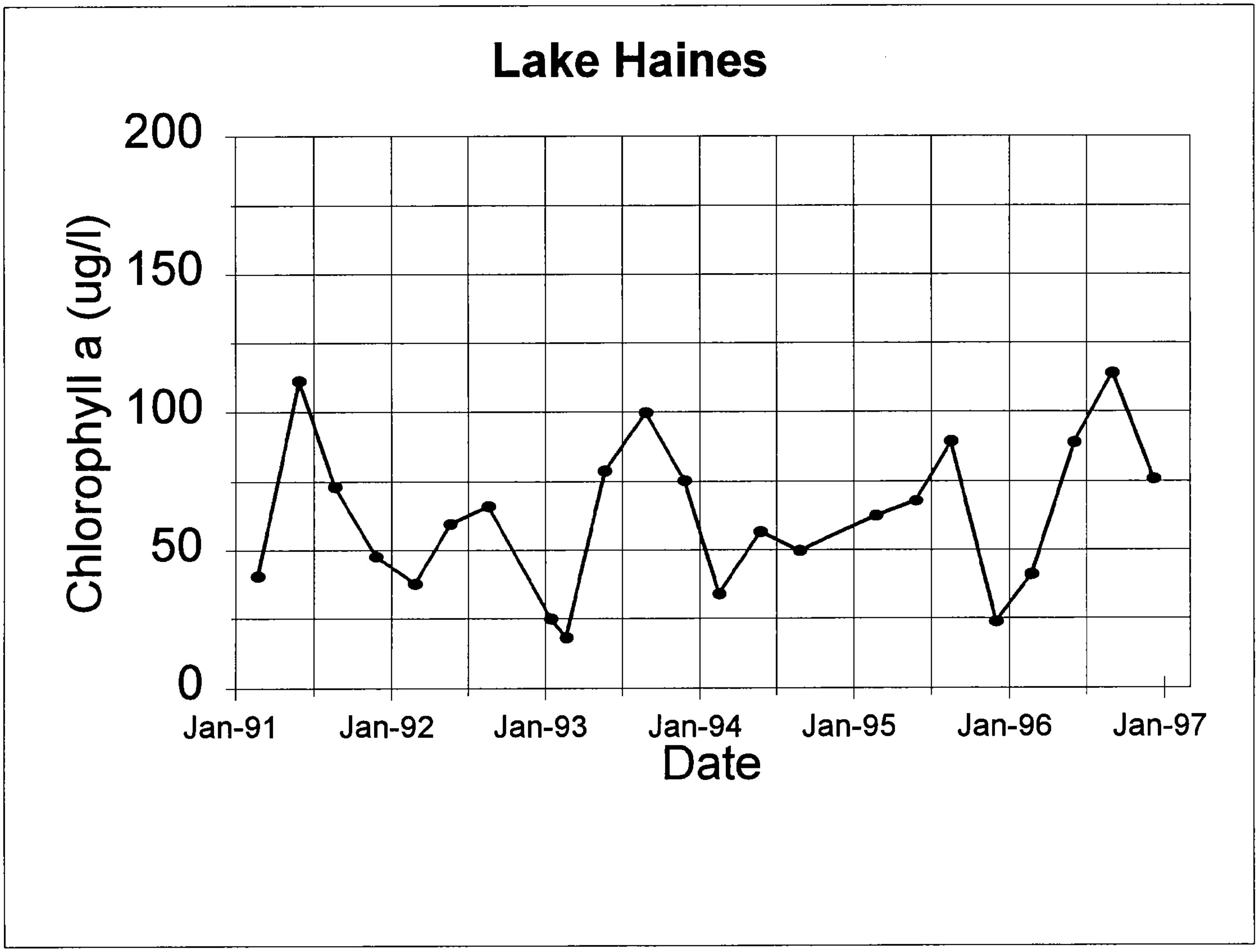
Year	TP (ug/l)	TN (ug/l)	Chl-a (ug/l)	Secchi (meters)	TN/TP	TSI (Chl-a)
1991	83	1333	16	0.8	19	57
1992	66	1127	20	0.8	18	60
1993	60	1200	13	0.7	25	54
1994	69	1243	19	0.5	18	59
1995	75	1093	29	0.6	17	65
1996	84	1288	40	0.7	15	70
Mean	73	1214	23	0.7	19	61



Lake Fannie
200
150
100
50
0
Chlorophyll a (ug/l)
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Date

Table B-5. Lake Haines - Annual averages of selected water quality parameters.

Year	TP (ug/l)	TN (ug/l)	Chl-a (ug/l)	Secchi (meters)	TN/TP	TSI (Chl-a)
1991	178	2203	68	0.5	13	78
1992	108	1663	54	0.7	16	74
1993	155	1744	59	0.7	12	76
1994	163	2107	47	0.5	13	72
1995	102	1280	61	0.5	13	76
1996	157	1900	80	0.5	13	80
Mean	144	1816	62	0.6	13	76



Lake Haines
200
150
100
50
0
Chlorophyll a (ug/l)
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Date

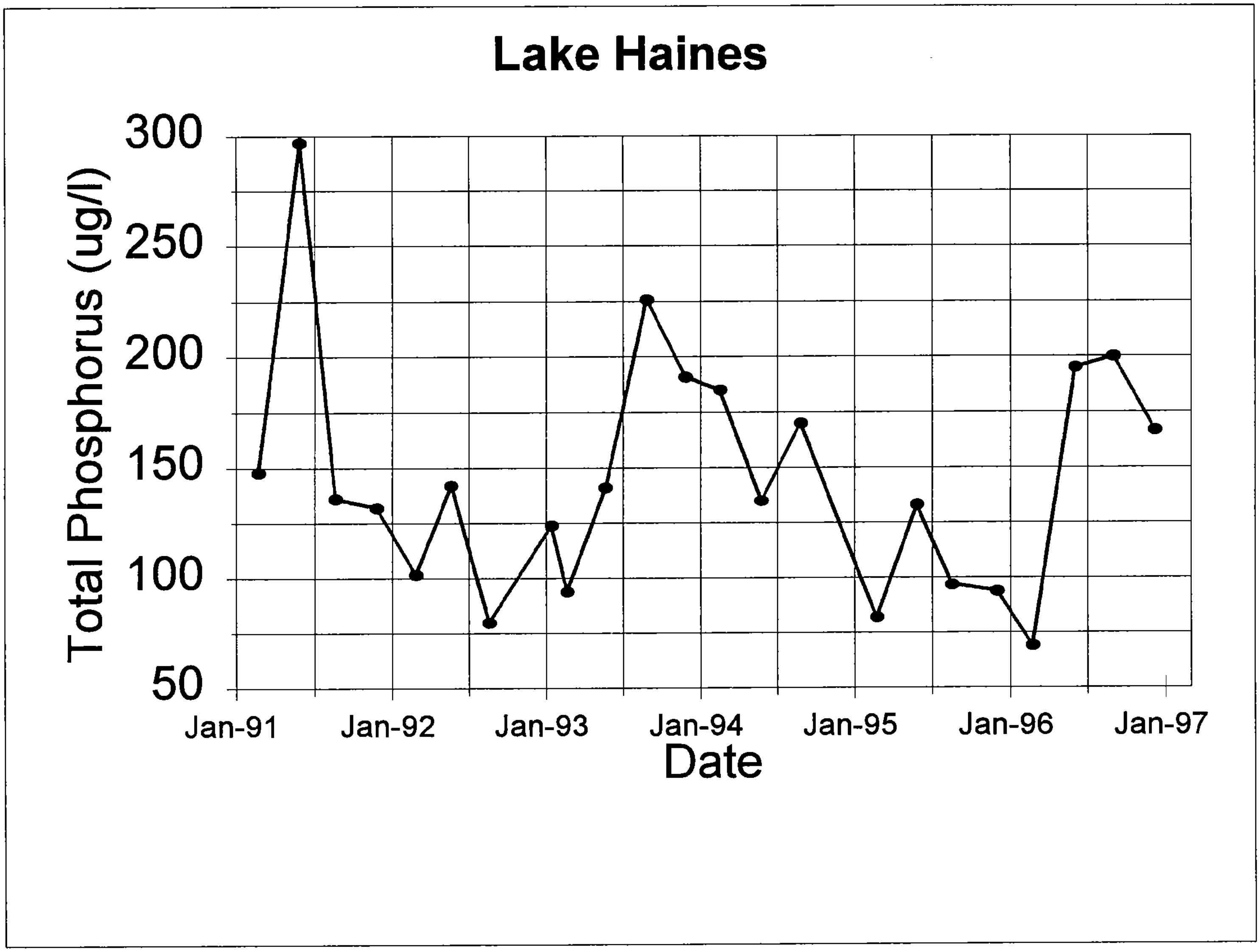
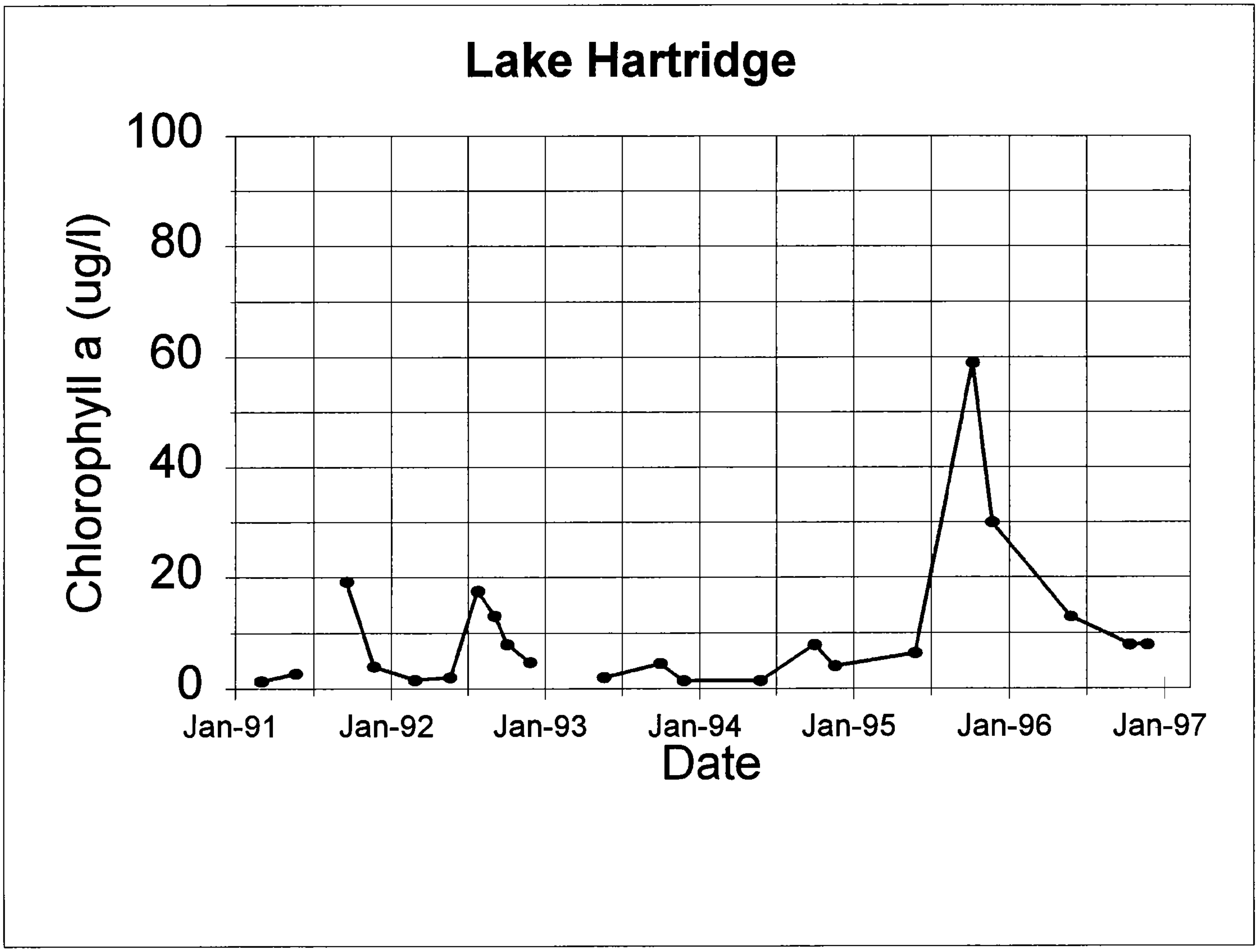

Lake Haines
Total Phosphorus (ug/l)
300
250
200
150
100
50
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Date

Table B-6. Lake Hartridge - Annual averages of selected water quality parameters.

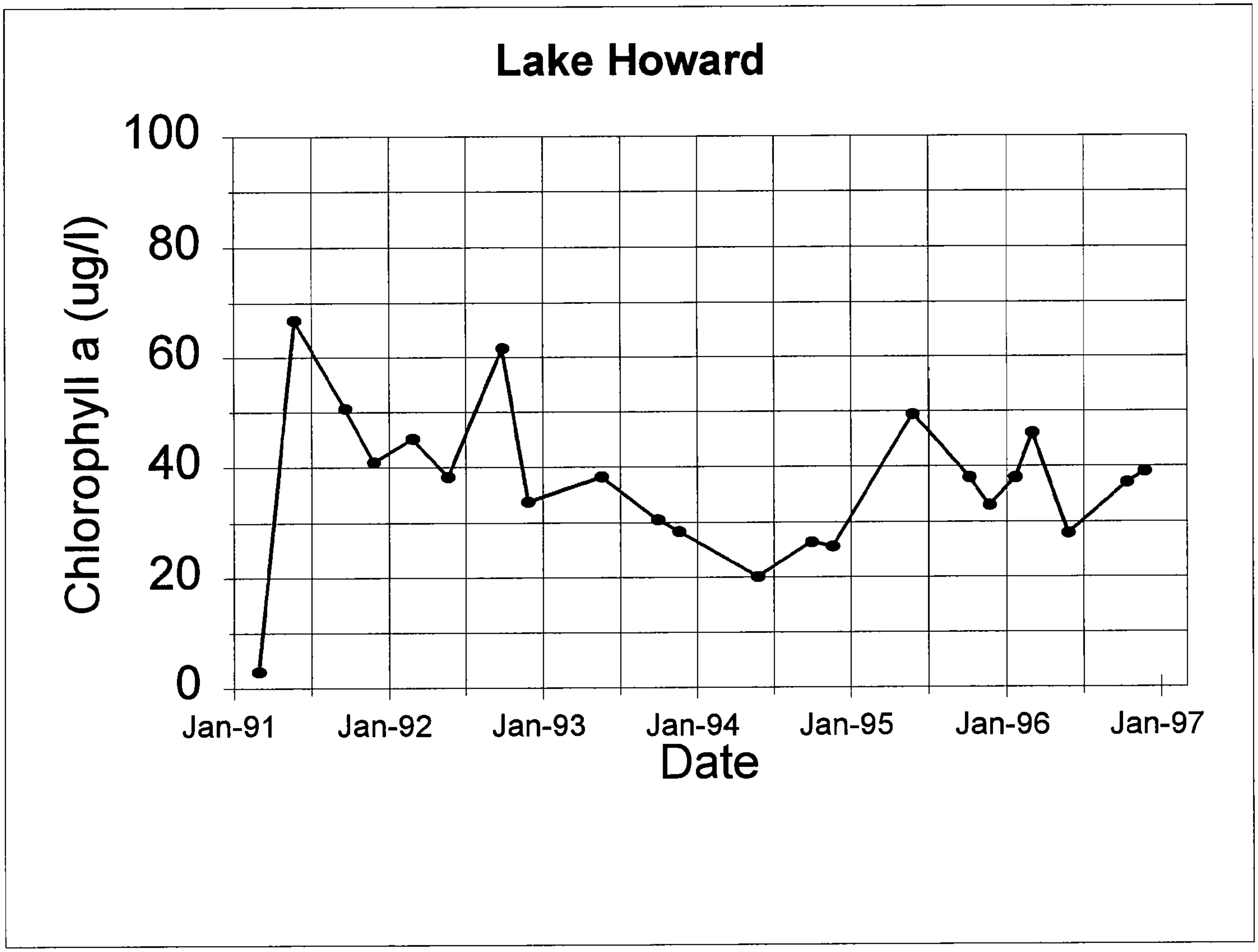
Year	TP (ug/l)	TN (ug/l)	Chl-a (ug/l)	Secchi (meters)	TN/TP	TSI (Chl-a)
1991	29	708	7	2.1	26	44
1992	21	704	8	2.3	40	47
1993	22	567	3	3.5	36	31
1994	37	633	4	1.9	19	38
1995	67	1193	32	2.4	21	67
1996	52	683	10	1.3	14	49
Mean	38	748	11	1.4	26	46



Lake Hartridge
Chlorophyll a (ug/l)
100
80
60
40
20
0
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Date

Table B-7. Lake Howard - Annual averages of selected water quality parameters.

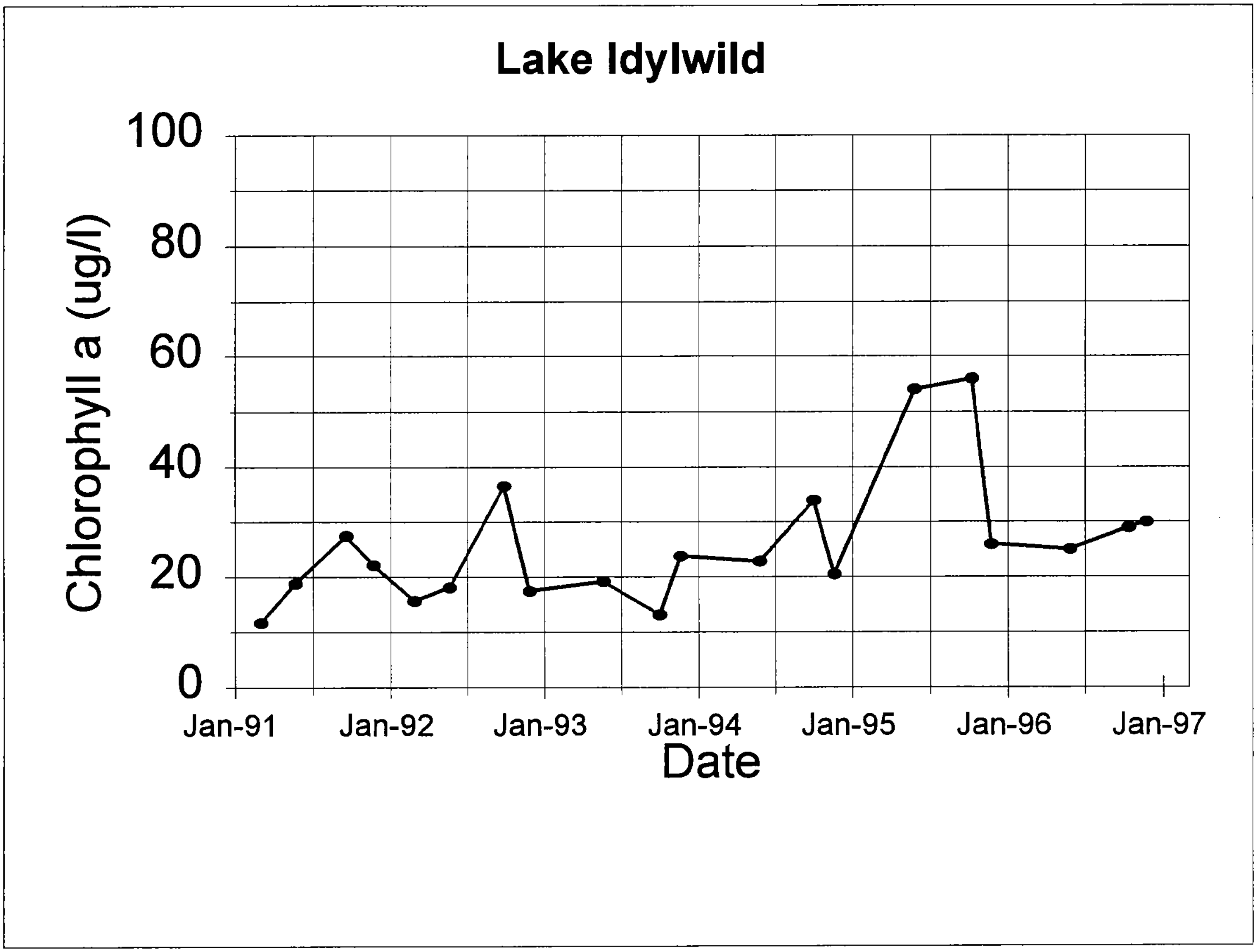
Year	TP (ug/l)	TN (ug/l)	Chl-a (ug/l)	Secchi (meters)	TN/TP	TSI (Chl-a)
1991	59	2278	40	0.6	39	70
1992	43	1823	45	0.6	44	71
1993	31	1633	32	0.6	54	67
1994	66	1187	24	0.6	20	63
1995	64	1637	40	0.5	28	70
1996	67	1474	38	0.8	36	69
Mean	55	1672	37	0.6	37	68



Lake Howard
Chlorophyll a (ug/l)
100
80
60
40
20
0
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Date

Table B-8. Lake Idylwild - Annual averages of selected water quality parameters.

Year	TP (ug/l)	TN (ug/l)	Chl-a (ug/l)	Secchi (meters)	TN/TP	TSI (Chl-a)
1991	59	1085	20	1.1	19	60
1992	37	1003	22	1.1	29	61
1993	30	927	49	1.0	32	59
1994	68	1223	26	0.7	18	64
1995	104	1330	45	0.7	15	72
1996	67	1073	28	0.8	16	65
Mean	61	1107	27	0.9	21	63



Lake Idylwild
100
80
60
40
20
0
Chlorophyll a (ug/l)
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Date

Table B-9. Lake Jessie - Annual averages of selected water quality parameters.

Year	TP (ug/l)	TN (ug/l)	Chl-a (ug/l)	Secchi (meters)	TN/TP	TSI (Chl-a)
1991	77	1115	32	0.9	15	66
1992	64	1200	40	0.8	20	70
1993	54	1100	32	0.8	21	66
1994	66	1023	29	0.7	16	65
1995	122	1290	54	0.7	11	74
1996	95	1113	41	0.8	12	70
Mean	80	1140	38	0.8	16	69

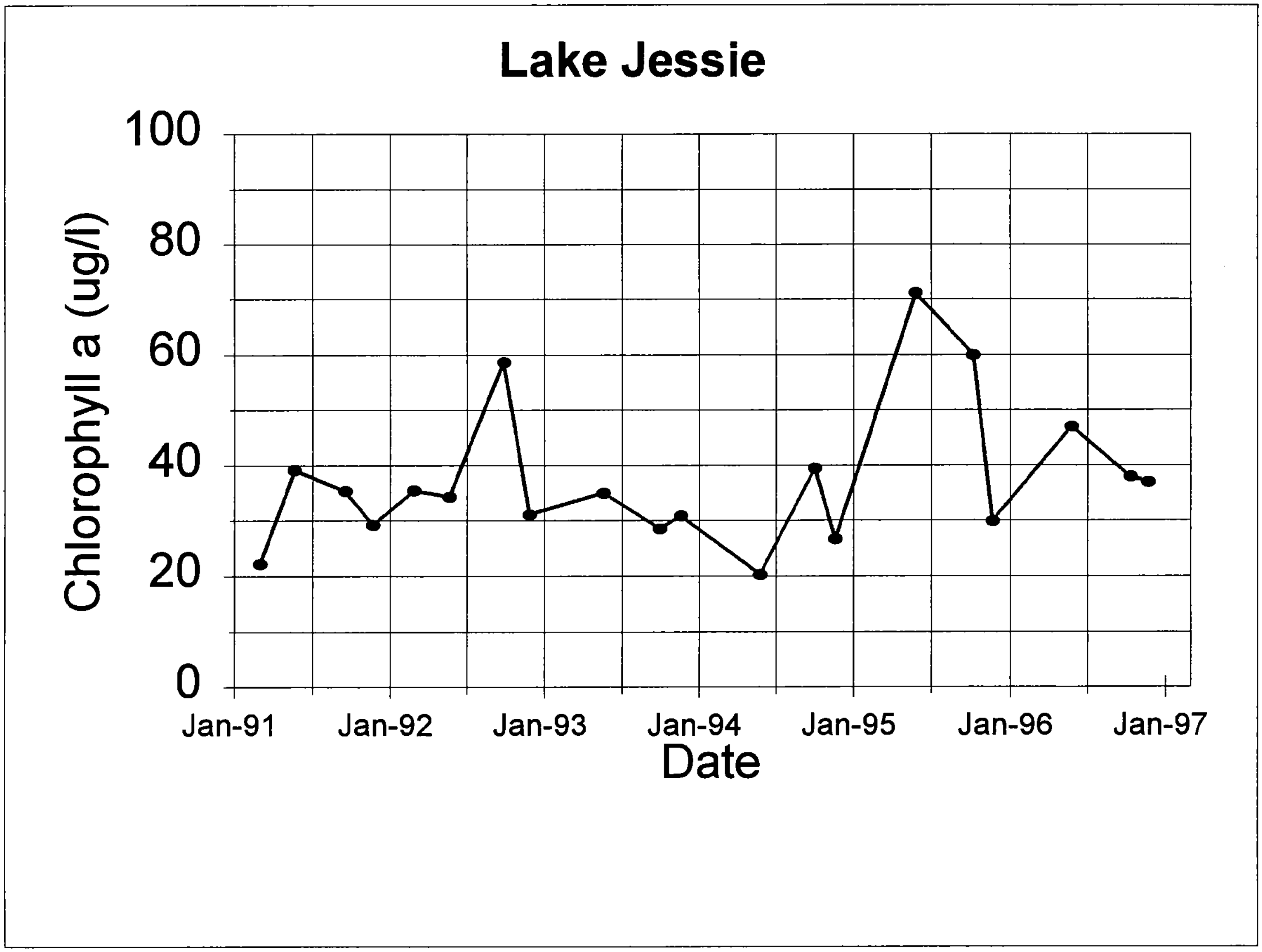

Lake Jessie
Chlorophyll a (ug/l)
100
80
60
40
20
0
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Date

Table B-10. Lake Lulu - Annual averages of selected water quality parameters.

Year	TP (ug/l)	TN (ug/l)	Chl-a (ug/l)	Secchi (meters)	TN/TP	TSI (Chl-a)
1991	88	1457	31	0.7	17	66
1992	67	1450	34	0.7	23	67
1993	57	1590	33	0.7	28	67
1994	59	1077	23	0.4	18	62
1995	79	1206	33	0.6	17	67
1996	71	1143	34	0.8	16	67
Mean	70	1321	31	0.6	20	66

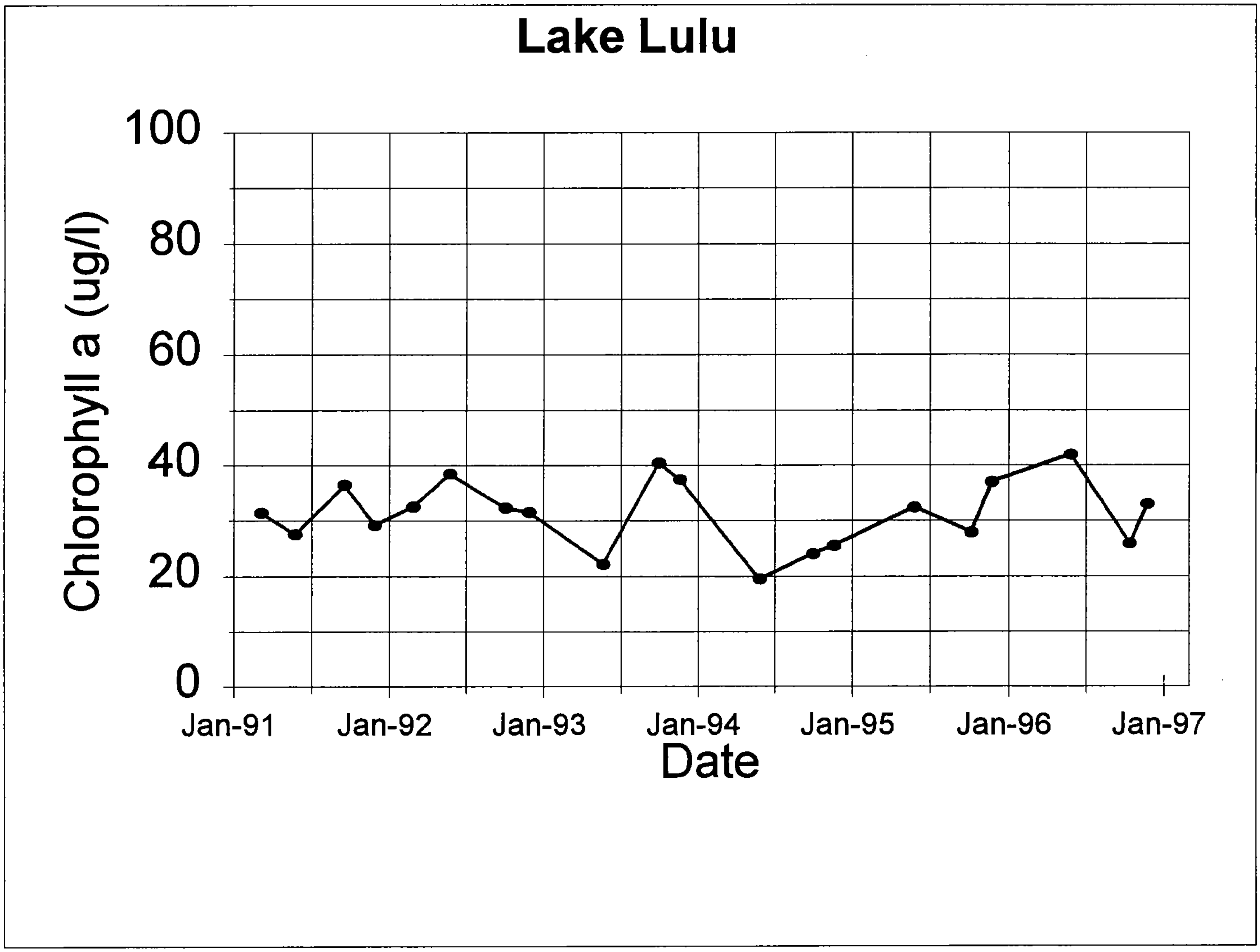
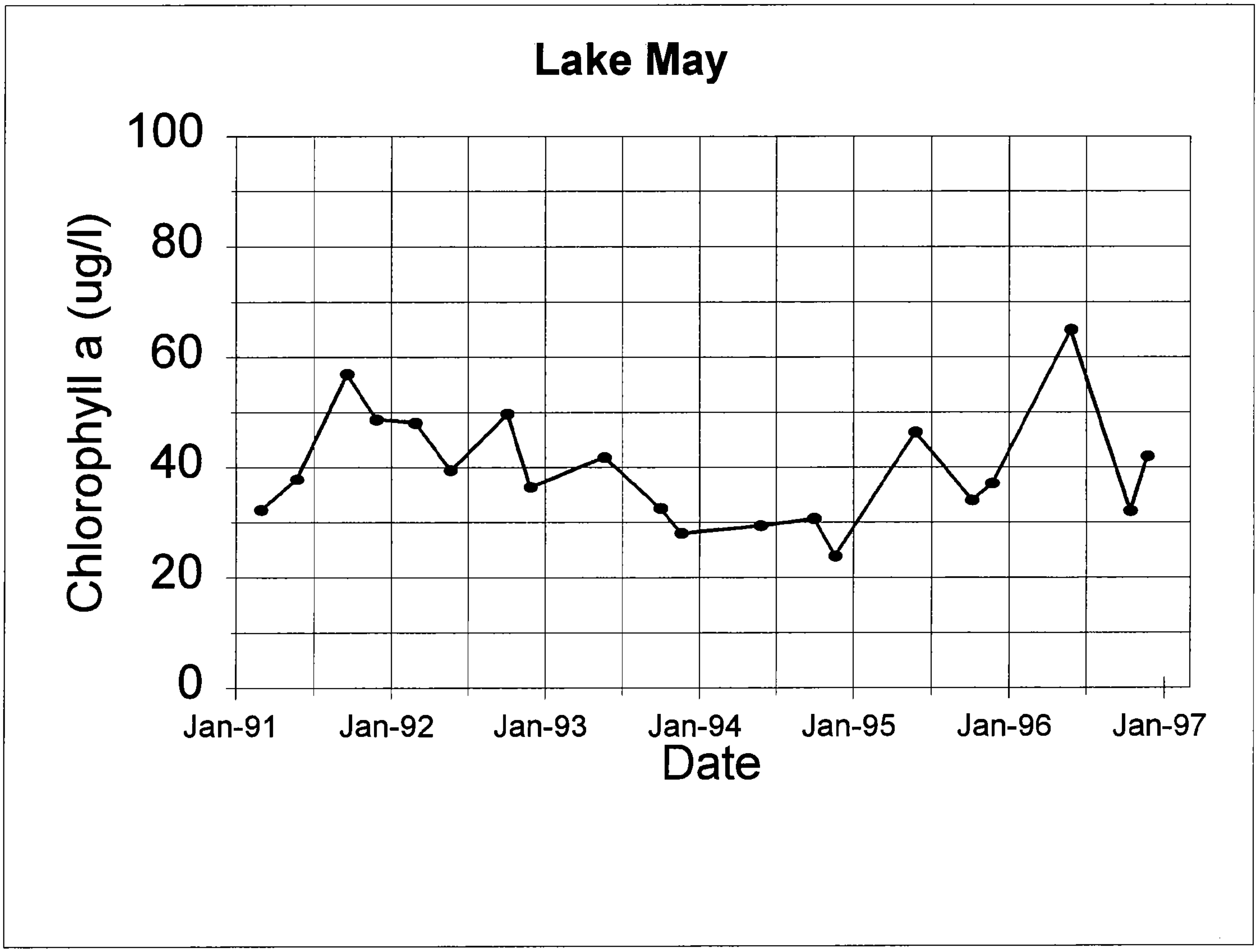

Lake Lulu
100
80
60
40
20
0
Chlorophyll a (ug/l)
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Date

Table B-11. Lake May - Annual averages of selected water quality parameters.

Year	TP (ug/l)	TN (ug/l)	Chl-a (ug/l)	Secchi (meters)	TN/TP	TSI (Chl-a)
1991	104	2040	44	0.5	20	71
1992	79	1813	43	0.6	24	71
1993	76	1610	34	0.6	22	68
1994	102	1210	28	0.6	12	65
1995	86	1813	39	0.6	21	70
1996	74	1336	46	0.7	21	72
Mean	87	1620	39	0.6	20	69



Lake May
Chlorophyll a (ug/l)
100
80
60
40
20
0
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Date

Table B-12. Lake Mirror - Annual averages of selected water quality parameters.

Year	TP (ug/l)	TN (ug/l)	Chl-a (ug/l)	Secchi (meters)	TN/TP	TSI (Chl-a)
1991	57	1707	39	0.6	32	69
1992	41	1535	34	0.7	38	68
1993	48	1667	43	0.6	37	71
1994	50	1273	29	0.8	27	65
1995	62	1587	44	0.6	27	71
1996	51	1350	41	0.9	28	70
Mean	51	1457	38	0.7	30	69

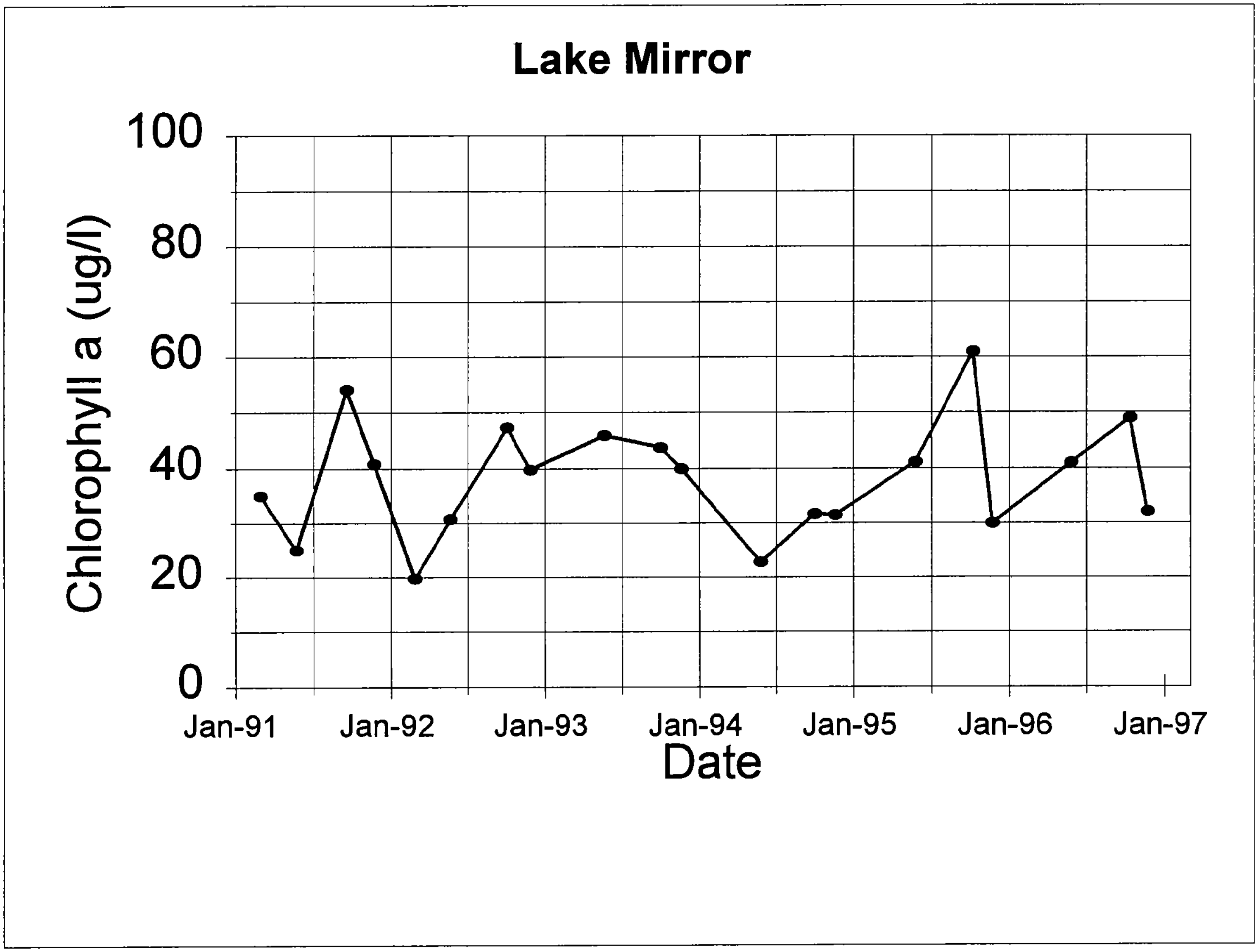

Lake Mirror
Chlorophyll a (ug/l)
100
80
60
40
20
0
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Date

Table B-13. Lake Rochelle - Annual averages of selected water quality parameters.

Year	TP (ug/l)	TN (ug/l)	Chl-a (ug/l)	Secchi (meters)	TN/TP	TSI (Chl-a)
1991	199	1272	21	0.7	7	60
1992	95	1353	42	0.7	16	71
1993	95	1344	23	0.8	14	62
1994	116	1487	29	0.6	14	66
1995	74	1160	38	0.7	16	69
1996	93	1295	30	0.8	14	66
Mean	112	1319	31	0.7	14	66

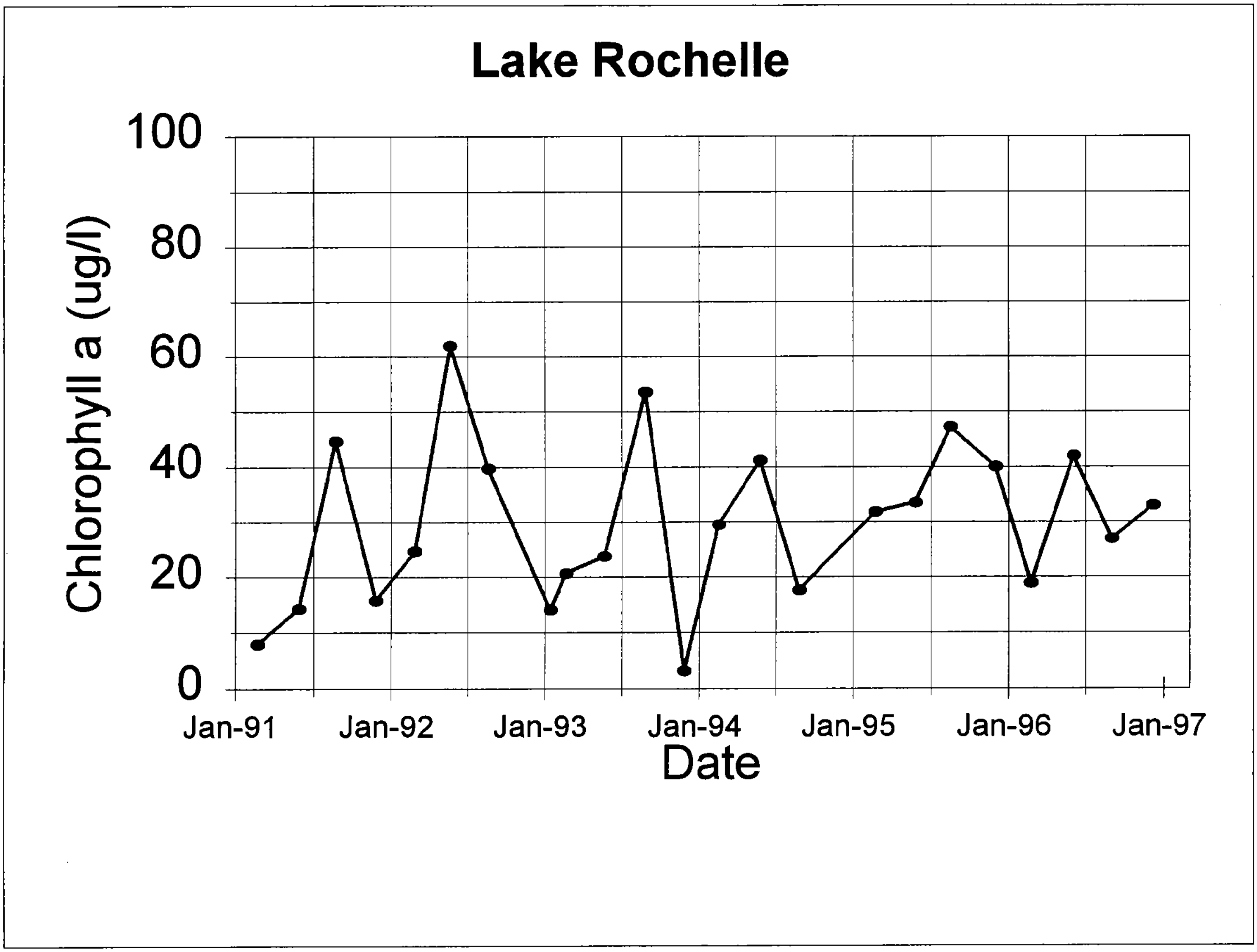

Lake Rochelle
Chlorophyll a (ug/l)
100
80
60
40
20
0
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Date

Table B-14. Lake Roy - Annual averages of selected water quality parameters.

Year	TP (ug/l)	TN (ug/l)	Chl-a (ug/l)	Secchi (meters)	TN/TP	TSI (Chl-a)
1991	47	1015	17	1.2	22	57
1992	35	1108	20	1.2	32	60
1993	17	880	9	1.7	23	49
1994	45	783	8	1.2	18	48
1995	43	820	10	1.6	22	50
1996	73	1023	17	1.4	14	58
Mean	43	938	14	1.4	22	54

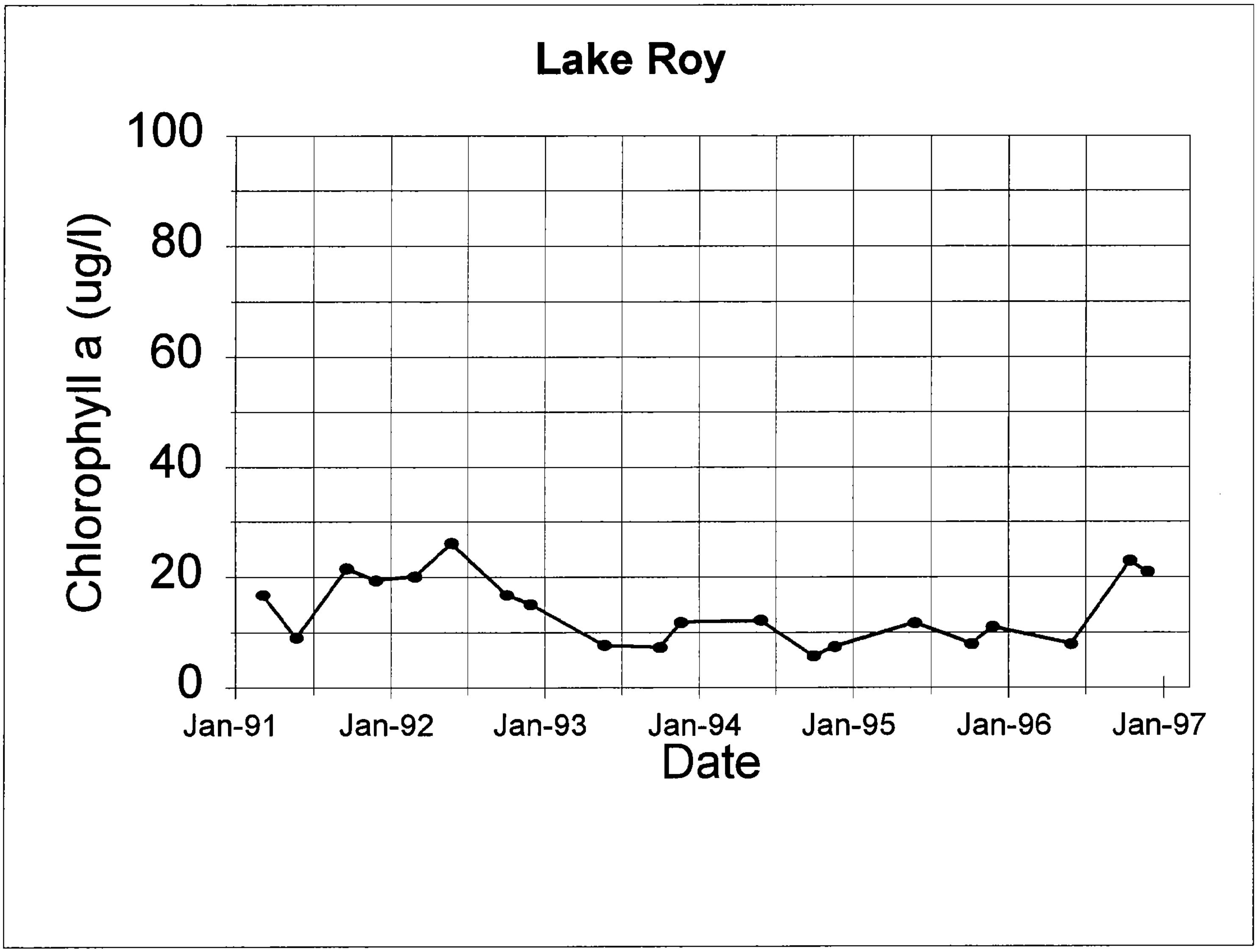
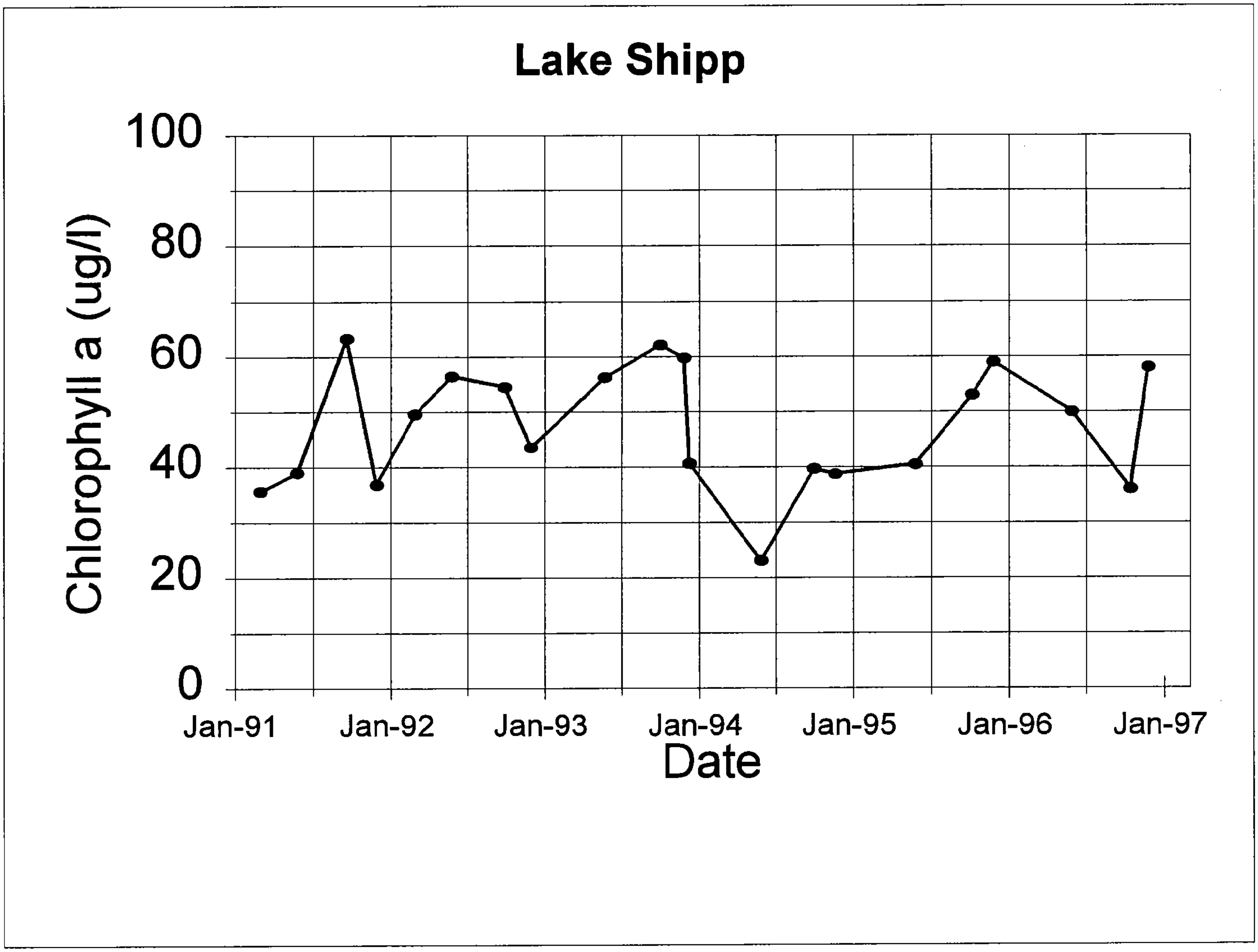

Lake Roy
Chlorophyll a (ug/l)
100
80
60
40
20
0
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Date

Table B-15. Lake Shipp - Annual averages of selected water quality parameters.

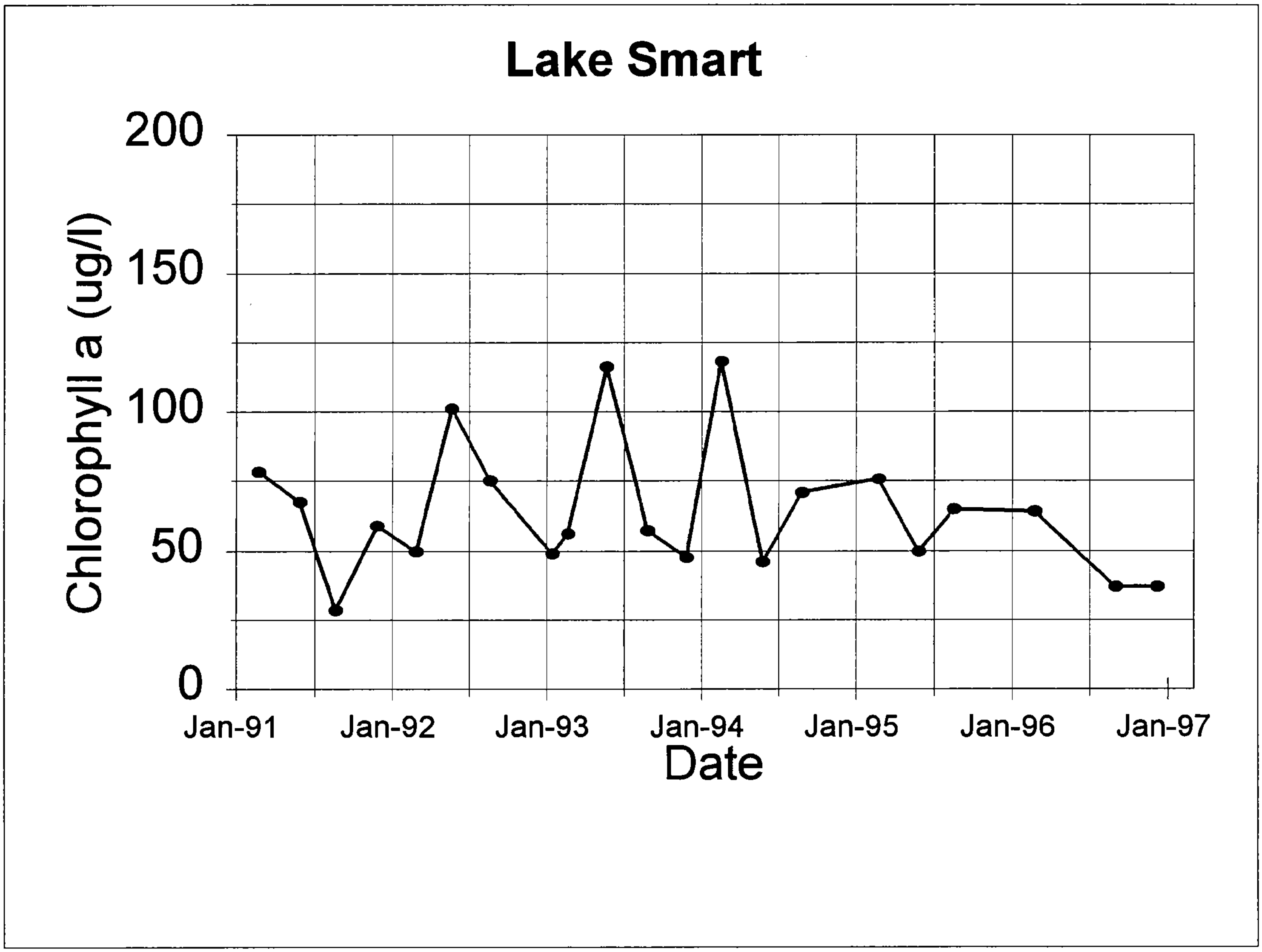
Year	TP (ug/l)	TN (ug/l)	Chl-a (ug/l)	Secchi (meters)	TN/TP	TSI (Chl-a)
1991	90	1905	44	0.6	22	71
1992	70	1970	51	0.5	29	73
1993	63	1978	55	0.5	32	74
1994	71	1333	34	0.5	20	67
1995	65	.1853	51	0.5	29	73
1996	71	1767	48	0.5	26	73
Mean	72	1801	47	0.5	26	72



Lake Shipp
Chlorophyll a (ug/l)
100
80
60
40
20
0
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Date

Table B-16. Lake Smart - Annual averages of selected water quality parameters.

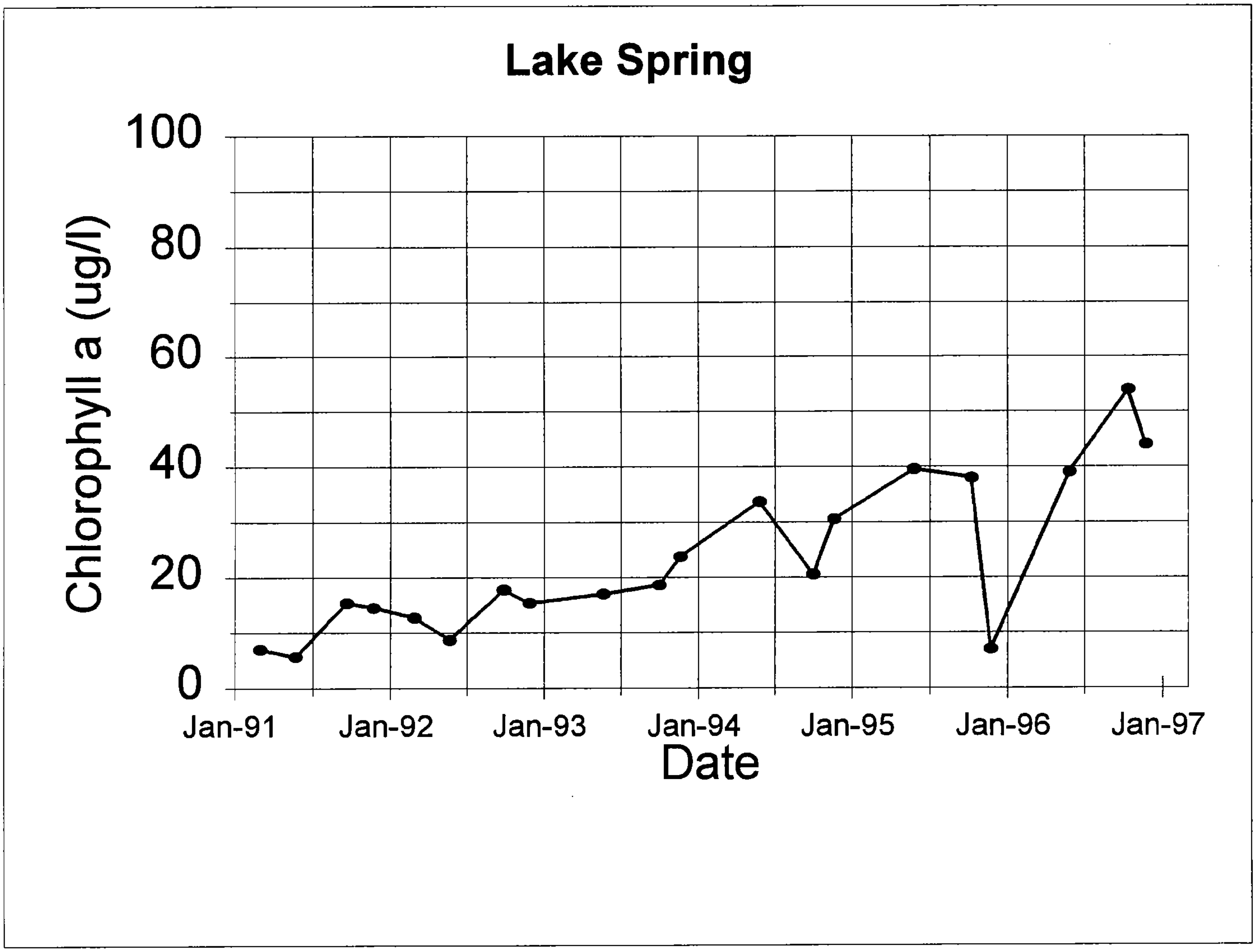
Year	TP (ug/l)	TN (ug/l)	Chl-a (ug/l)	Secchi (meters)	TN/TP	TSI (Chl-a)
1991	177	2183	58	0.6	13	75
1992	148	2217	75	0.6	15	79
1993	133	2144	65	0.6	17	77
1994	156	2473	78	0.4	18	80
1995	88	1777	63	0.4	23	77
1996	98	1740	46	0.7	18	72
Mean	133	2089	65	0.5	17	76



Lake Smart
Chlorophyll a (ug/l)
200
150
100
50
0
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Date

Table B-17. Lake Spring - Annual averages of selected water quality parameters.

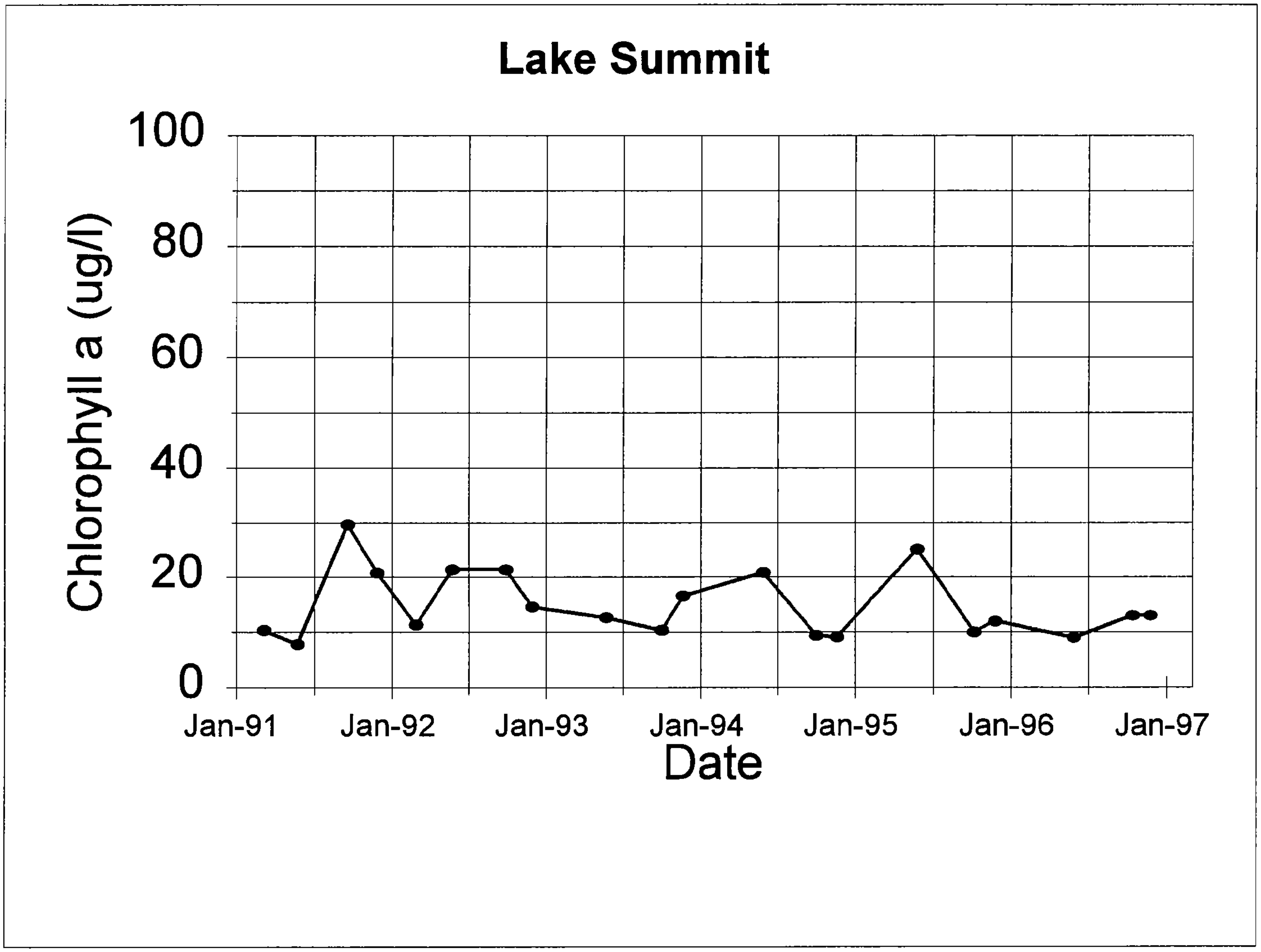
Year	TP (ug/l)	TN (ug/l)	Chl-a (ug/l)	Secchi (meters)	TN/TP	TSI (Chl-a)
1991	45	865	11	2.2	20	51
1992	33	873	13	2.0	30	54
1993	37	797	20	1.3	22	60
1994	49	1063	28	0.8	22	65
1995	52	930	28	2.1	21	65
1996	69	1270	46	0.8	23	72
Mean	47	966	24	1.5	23	61



Lake Spring
Chlorophyll a (ug/l)
100
80
60
40
20
0
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Date

Table B-18. Lake Summitt - Annual averages of selected water quality parameters.

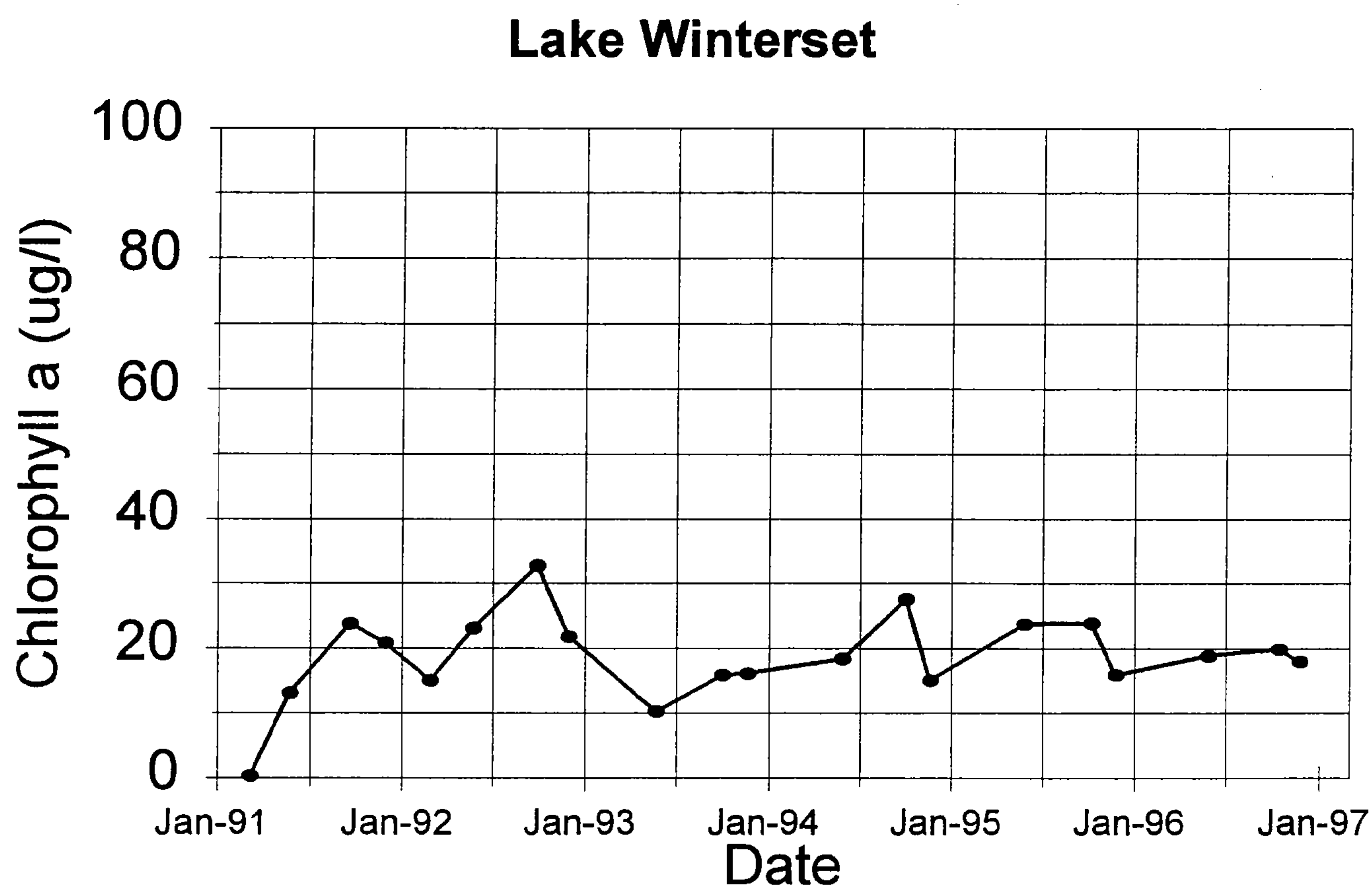
Year	TP (ug/l)	TN (ug/l)	Chl-a (ug/l)	Secchi (meters)	TN/TP	TSI (Chl-a)
1991	47	965	17	1.3	21	58
1992	35	1098	17	1.2	33	58
1993	22	983	13	1.2	48	54
1994	39	913	13	1.1	25	54
1995	47	917	16	1.4	22	56
1996	57	883	12	1.5	16	52
Mean	41	960	15	1.3	28	55



Lake Summit
Chlorophyll a (ug/l)
100
80
60
40
20
0
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Date

Table B-19. Lake Winterset - Annual averages of selected water quality parameters.

Year	TP (ug/l)	TN (ug/l)	Chl-a (ug/l)	Secchi (meters)	TN/TP	TSI (Chl-a)
1991	37	958	15	1.3	27	55
1992	25	1213	23	1.0	51	62
1993	22	1083	14	1.1	73	55
1994	44	1033	20	0.8	26	60
1995	44	1240	22	0.9	.36	61
1996	54	1017	19	0.9	19	59
Mean	38	1090	19	1.0	39	59


Lake Winterset
Chlorophyll a (ug/l)
100
80
60
40
20
0
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Date