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For the sake ... of the Lake! JAN 27 1998

Columbia Lake
Watershed Management Plan

Prepared By: The Columbia Lake Watershed Protection Task Force

January 1998

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Columbia Lake Watershed Management Plan

Executive Summary

I. About Columbia Lake

Columbia Lake is a very high quality water resource. It supports a variety of active and passive recreational uses. It supports a healthy biological community. It is a critical resource to the Town of Columbia.

The reputation and quality of Columbia Lake's waters has a tremendous effect on property values and tax revenues. About $21 million of the Town's tax base is related to Columbia Lake and its high quality. At the current tax rate of 22 mill, Columbia Lake results in approximately $323,400 in annual tax revenues. The high quality of Columbia Lake is also reflected in residential property values town-wide.

Many Connecticut Lakes have experienced "eutrophication" (a process caused by additional nutrients entering the lake from land draining to it). Eutrophication results in blooms of algae (turning waters turbid-green in summer) and increased weed growth. Ultimately, eutrophication can cause the loss of important habitat for many desirable species. It can interfere with recreational uses of the lake. It can decrease the value of the lake resource. If water quality were to deteriorate in the future, the results could include expensive in-lake treatments, state/federal mandates for sewers, and declining property values and tax revenue base.

Fortunately, Columbia Lake currently exhibits very good resource quality. This Watershed Management Plan is intended to preserve the quality of Columbia Lake, to avoid water quality decline, and to maintain the value of the lake to the Town.

In the spring of 1995, after review of many years of monitoring data, and based on recommendations of numerous experts in lake resource management, the Lake Management Advisory Committee recommended to the Board of Selectmen that a Task Force be assembled to develop and implement an effective watershed management plan for Columbia. Specific lake quality goals were adopted as policy, and a set of management strategies were to be formulated to meet those goals. The Board of Selectmen concurred with the recommendation to assemble a Task Force to develop a specific plan for Columbia, and authorized the institution of such a Task Force. *The resulting Task Force recommendations comprise a specific plan, developed by Columbia, for the protection of Columbia Lake.*

II. Long-Term Lake Quality Goals

A. Transparency (Clarity)

- ***GOAL: Maintain a mean summer Secchi disk transparency of 4 m (13.1 ft) or greater, and a minimum of 3 m (9.8 ft) at any time between Memorial Day and Labor Day.***

B. Oxygen Content at Depth

- ***GOAL: Maintain at least 1 mg/L dissolved oxygen at a depth of 6m (19.7 ft) at all times.***

C. Other Pollutants

- ***GOAL: Prevent contamination by pathogens (e.g. fecal bacteria), toxic materials, or other substances which are damaging to the lake ecosystem and/or lake users.***

III. Basis of Watershed Planning

The task force examined the sources of nutrients that flow to the lake and reviewed several lake management strategies to evaluate the applicability of the strategies to the management of Columbia Lake. Topics specifically studied were the identification of phosphorous as the primary nutrient concern for lake quality, the effect of septic systems, the management of the Erdoni Brook wetland, and the seasonal release of phosphorus to lake water from sediments.

IV. Total Phosphorous Budget

The *Task Force* examined sources of phosphorus loading to Columbia Lake and considered a variety of alternative control methods for each source. The task force determined that a strategy of allocating the phosphorous load from different properties would provide a quantitative basis for managing nutrient flows to Columbia Lake.

V. Recommendations

(Note: Order of recommendation presentation is not intended to imply a priority ranking)

- **The *Task Force* recommends the designation of a Lake Protection Area with three SubAreas A, B, and C.**

- **The *Task Force* recommends that the Town of Columbia implement a Septic System Pump-Out Reporting Ordinance, and that pump-out frequencies be in accordance with recommended frequency tables.**

> NOTE: A model Septic System Licensing Ordinance was also developed by the *Task Force* (Appendix B). However, the *Task Force* recommends other measures first, including the reporting ordinance. The Licensing Ordinance is recommended if, in several years, it becomes apparent that pump-out frequencies and the incidence of failing systems warrant more stringent regulations.

- **The *Task Force* recommends that effluent filters *be considered for use* in all new installations and when servicing existing systems.**

- **The *Task Force* recommends that the sand fill used for the construction or re-construction of septic systems have a specified P-attenuation capacity (for example, greater than 0.01 kg P / ft^3).**

- **The *Task Force* recommends that the design of new and re-constructed septic systems consider leaching field geometry which maximizes the soil contact volume which is available to treat wastewater.**

- **The *Task Force* recommends that no septic system additives be permitted for use in the Columbia Lake Watershed.**

- **The *Task Force* recommends that innovative septic system design concepts, specifically to increase phosphorus removal, be encouraged within the Lake Protection Areas (especially SubArea A). Innovative designs incorporating such features as iron-enriched filter media, alum-enriched sand, up-flow sand filters, and other phosphorus removal techniques should be considered in addition to other Health Code requirements.**

- **The *Task Force* recommends that a voluntary "ban" on the use of high phosphorus content fertilizers be advertised and implemented annually.**

- The *Task Force* suggests a number of policies and standard permit conditions (Inland Wetland and Zoning Permits), including erosion and sedimentation control performance standards, with emphasis on "source controls", monitoring and reporting conditions, "Contractor's Compliance Statement", "Notice of Intent to Begin site work", and construction season for near-lake or lake-bed work.

- The *Task Force* recommends that the nutrient allocation assessment approach be used for all new and existing development in the watershed, anytime a permit is sought or site work is planned.

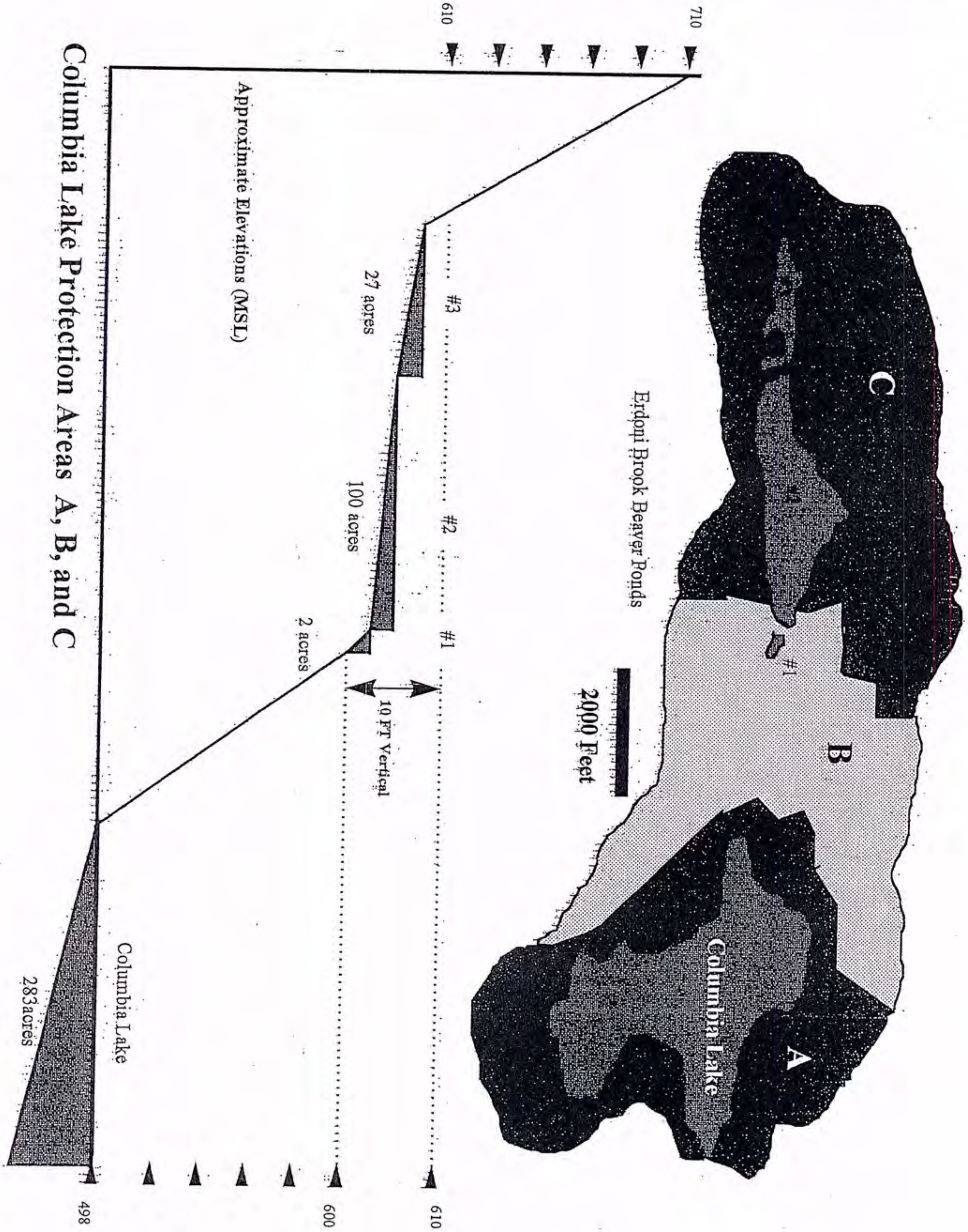
- The *Task Force* recommends that the current policy of early spring road sweeping and drainage catch basin cleaning be continued.

- The Task Force recommends that the Erdoni Brook wetlands which have been flooded by beaver dams be restored to a live deciduous wooded swamp structure by installation of an outlet control device. This recommendation should be implemented in collaboration with the CTDEP and adjacent land owners to address all wildlife, storm water detention, water quality, and other functional values of the wetland system.

No management option is recommended for implementation at this time to control atmospheric deposition, livestock, or in-lake phosphorus loading sources (sediments).

Recommended Implementation Schedule

Recommended Method	Implementation by:	When Implemented	Review of Effectiveness
1. Designation of Lake Protection Areas A, B, C	Board of Selectmen; PZC, Inland Wetlands Commission	1997, Continually	Upon Computerized Assessor's Maps - CAD/GIS
2. Septic Reporting Ordinance	Town/ BOS; Town Health Department	1998, Continually	2000; and every 4 Years
2a. Septic Licensing Ordinance	BOS, Town, Town Health Department	To Be Determined	To Be Determined
3. Effluent Filter Program	Town Health Department	1998, Continually	2000; and every 4 Years
4. Septic Fill P-Attenuation Performance Standard	PZC; Town Health Department	1998, Continually	2000; and every 4 Years
5. Septic Geometry	Town Health Department	1998, Continually	2000; and every 4 Years
6. Septic Additive Ban	BOS; Town Health Department	1997, Continually	2000; and every 4 Years
7. Innovative Septic Designs	Town Health Department	1998, Pilot Test Phase	2000; and every 4 Years
8. P Fertilizer Ban	BOS, Lake Association-SubArea A	Annually in February	2000; and every 4 Years
9. Standard Permit Conditions	PZC, Inland Wetlands Commission	1997, Continually	2000; and every 4 Years
10. Allocation Plan	PZC, IWA, advisory from Conservation Commission	1997, Continually	2000; and every 4 Years
11. Road Maintenance	BOS, Public Works	1997, Annually March-May	2000; and every 4 Years
12. Beaver Dam Outlet(s)	BOS, PZC, IWA	When Approved	Monitoring Following Implementation
13. In-Lake Treatment	BOS, IWA	Only if other measures are not adequate	To Be Determined



Columbia Lake Protection Areas A, B, and C

For the sake ... of the Lake!

Columbia Lake Watershed Management Plan

Introduction

A. About Columbia Lake

Columbia Lake is a very high quality water resource. It supports a variety of active and passive recreational uses. It supports a healthy biological community. It is a critical resource to the Town of Columbia. Indeed, the lake provides an "identity" to the Town of Columbia.

The Town of Columbia has a variety of important assets. Next to its residents, Columbia Lake is the Town's most important resource. The lake's aesthetic, recreational, and economic qualities make it the centerpiece of our community. Many years of research and testing, numerous reports, and observations of those who enjoy the lake indicate that implementation of watershed management is critical to preserving the high quality of Columbia Lake, and the many benefits it confers on the Town. Columbia Lake needs to be protected, preserved for the future. If it were to become more overgrown with weeds and algae (more "eutrophic"), restoration would be much more costly. *"An ounce of prevention will avoid pounds of cure."*

The reputation and quality of Columbia Lake's waters has a tremendous effect on property values and tax revenues.

The minimum market value of a residential lot in Columbia (not near the lake) is approximately $35,000. Waterfront lots and those with a lake view have a minimum market value of about $70,000. Waterfront lots have an additional value of approximately $700 per water frontage foot. Hence, the value of property which is directly attributable to Columbia Lake is approximately:

plus $35,000 per min lot x150 lakefront and 75 lake view =	$ 7,875,000
$700 x 19,000 ft lake perimeter =	$13,300,000
Total Estimated Market Value due to Lake =	$21,175,000

About $21 million of the Town's tax base is directly due to Columbia Lake (the grand list tax base would be about $21 million lower for existing properties if the lake were woodlands). The assessed value of Columbia property is 70% of estimated market value. At the current tax rate of 22 mil, Columbia Lake results in approximately $323,400 in annual tax revenues.

The high quality of Columbia Lake is also reflected in residential property values town-wide. Columbia is a very desirable place to live for many reasons, including a high-quality Columbia Lake. The availability of the lake and beach to all Columbia citizens tends to enhance the value of all properties in town, although the "dollar value" is more difficult to quantify. Clearly a decline in the quality of Columbia Lake would have social and economic impacts to the Town of Columbia.

Many Connecticut Lakes have experienced "eutrophication" (a process caused by additional nutrients entering the lake from land draining to it). Eutrophication results in blooms of algae (turning waters turbid-green in summer) and increased weed growth. Ultimately, eutrophication can cause the loss of important habitat for many desirable species. It can interfere with recreational uses of the lake. It can decrease the value of the lake resource. What once was a valuable "lake amenity" can become a liability. Restoration of a highly eutrophic lake is a very difficult and costly endeavor. If water quality were to deteriorate in the future, the results could include expensive in-lake treatments, state/federal mandates for sewering, and declining property values and tax revenue base.

Fortunately, Columbia Lake exhibits very good resource quality. It has experienced "episodes" when algae blooms reduced clarity and oxygen loss intensified, but these have not become a regular occurrence. This Watershed Management Plan is intended to preserve the quality of Columbia Lake, to avoid water quality decline, and to maintain the value of the lake to the Town. If a management plan is not successfully implemented and followed it is likely that the quality of Columbia Lake will decline.

Columbia Lake covers 284 acres to mean and maximum depths of 17 ft and 26 ft, respectively. Its watershed covers 1,959 acres. Columbia Lake is a high quality water resource which generally exhibits good transparency, infrequent algae blooms, and viable habitat for a variety of aquatic plants and animals. However, during some summers algae blooms are more intense and approach "nuisance conditions".

The lake is a very important natural resource to the Town of Columbia, providing a variety of water-based recreation opportunities as well as other functions. It has an influence on property values, and hence the tax base of the Town. There is substantial concern about the present and future quality of Columbia Lake, and dedication to protecting the lake is genuinely shared by the townspeople. Fortunately, a significant information/database has been developed over the past 20 years, largely by volunteer efforts.

B. Watershed Management Plan: Background

In the spring of 1995, after review of many years of monitoring data and based on recommendations of numerous experts in lake resource management, the Lake Management Advisory Committee recommended to the Board of Selectmen that a Task Force be assembled to develop and implement an effective watershed management plan for Columbia. Many initiatives through Town Boards and Commissions had already been implemented for protecting the lake. The purpose of a Task Force was to integrate watershed management efforts into an overall plan based on the actual resource protection needs of the lake in order to ensure its continued high quality. Specific lake quality goals were adopted as policy, and a set of management strategies were to be formulated to meet those goals. The Board of Selectmen concurred with the recommendation to assemble a Task Force to develop a specific plan for Columbia, and authorized the institution of such a Task Force.

A "Columbia Lake Watershed Management Task Force" (hereinafter called *Task Force*) was assembled in 1995 to develop and implement a long-term plan for protecting the quality of Columbia Lake. Since its first meeting on October 24, 1995, the *Task Force* has spent many hours to develop a plan that will work for Columbia. The *Task Force* has had involvement and representation from various organizations, Town Boards and Commissions, and community groups. It has examined a variety of potential causes of resource degradation, compared alternative management methods, and received advice from experts in lake and watershed management, on-site wastewater disposal, turf management, and related aspects. *The resulting Task Force recommendations comprise a specific plan, developed by Columbia, for the protection of Columbia Lake.*

A variety of studies and reports have been prepared over the past 20 years which identify the need for long-term watershed management, including:

- 1973 E.A. Wells; Thesis; University of Connecticut
- 1973 Conservation Commission, Town of Columbia
- 1974 Institute of Water Resources; University of Connecticut
- 1975 Institute of Water Resources; University of Connecticut
- 1977 The New England Council of Water Center Directors
- 1977 Windham Regional Planning Agency
- 1977 Peter H. Rich, Ph.D.; Biological Sciences Group, University of Connecticut
- 1978 Institute of Water Resources; University of Connecticut
- 1981 Eastern Connecticut RC&D; Environmental Review Team
- 1982 Windham Regional Planning Agency
- 1985 D. Eustis, Thesis; University of Connecticut
- 1987, 1991, 1995 Ecosystem Consulting Service, Inc.

The following individuals have served the *Task Force*:
Task Force members:

Bob Baldwin, BOS
Dr. David Chase, LMAC
Martha Fraenkel, Town Planner
Mary Hocevar, Town Planner
Chuck Phillips, CC
Richard Shea, LMAC
John Valente, Sanitarian
Ron Wikholm, IWC
Henry Beck, LMAC
Diane Duva, CC
Tip Garritt, IWC
Ed Johnston, PZC
Clark Robinson, IWC
Chick Shifrin, LMAC
Greg Vickers, LMAC

BOS=Board of Selectmen; LMAC= Lake Management Advisory Committee;
CC= Conservation Commission; IWC= Inland Wetland Commision;
PZC= Planning and Zoning

Lake Management Advisory Committee members:

Henry Beck
John Burrell
Mark Coleman
Jim Santos
Chick Shifrin
Mark Vining
Neal Burgess
David Chase
Marshall Nuhfer
Dick Shea
Greg Vickers

The following have contributed to the development of the management plan as a guest expert, consultant, or in an advisory capacity:

Guest Speaker: Mr. Randy May, Chief Sanitary Engineer - State of Connecticut DEP

Site Walks (esp. regarding management options for watershed wetlands which have been flooded by beaver dams):

Dan Donahue, Joshua's Tract and Land Trust
Robert Kortmann, Ph.D., Ecosystem Consulting Service, Inc.
Donald Les, Ph.D., University of Connecticut
Harvey Luce, Ph.D., University of Connecticut
Peter Rich, Ph.D., University of Connecticut
Skip Hilliker, State of Connecticut DEP
Paul Rothbart, Supervising Wildlife Biologist State of Connecticut DEP
John Valente, Inland Wetland Agent, Town of Columbia
Members of:

Joshua's Tract and Land Trust
Columbia Board of Selectmen
Columbia Inland Wetland Agency
Columbia Planning and Zoning Commission

Conservation Commission
Lake Management Advisory Committee
Columbia Lake Watershed Management Task Force

C. Watershed Management Plan: Principles

The Town of Columbia Plan of Development identifies a number of strategies already in place for the protection of Columbia Lake (1988 Plan of Development, pg 22). The Watershed Management Task Force (*Task Force*) has developed specific additional lake protection recommendations. During initial meetings of the *Task Force*, several basic "principles" were established to guide the decision making process regarding how to protect the Lake.

Principle 1

The Watershed Management Plan is to be *based on sound technical information* about the lake and anticipated impacts of land-use and water-use activities. The Plan is to be specific to the nature and needs of Columbia Lake and the Town of Columbia. *Unnecessary "regulation", or other forms of restricting use of the lake and watershed properties are to be avoided.* Additionally, the Watershed Management Plan is based on specific water quality goals for Columbia Lake:

- Mean Summer Transparency > 13 ft
- Minimum Summer Transparency > 10 ft
- Minimum Oxygen Content of 1 mg/L at 6 m deep (higher oxygen content above 6m deep)

In order to accomplish these goals, the amount of total phosphorus (the plant nutrient which stimulates weed and algae growth in Columbia Lake) which enters the lake must be kept below 726 lb/year. Methods to keep nutrient inputs below that level include education/public awareness programs, voluntary actions, and several necessary regulations/ordinances.

Principle 2

Implementation and the "Degree of Management" should "radiate out from the shorefront properties". Restrictions, regulations, policies, and other management approaches should begin near the lake and expand outward throughout the watershed. The *Task Force* has defined three Watershed Protection Areas *A*, *B*, and *C*. Watershed management actions will begin, and be most vigorously pursued, in Area A, the immediate lake area. However, all land areas which ultimately drain to Columbia Lake are important to its future, and must be managed. Those areas which are closest, and which drain directly to the lake, require the most immediate action. These near-lake areas include a high intensity usage on generally small lots.

Principle 3

When possible, voluntary approaches and educational/public awareness approaches, should be attempted first--before Regulations and Ordinances. Ultimately, some Regulations and Ordinances may be needed, but implementation should begin with the assumption that "the Citizens of Columbia want to protect a high quality Columbia Lake- and are willing to do their fair share". The *Task Force* has developed several voluntary programs (a fertilizer ban, model landscaping plan to reduce nutrient runoff, etc.). It has also developed several programs which may need to become regulations/ ordinances in the future, but which will be implemented on a voluntary basis first (Septic Management Ordinance, Nutrient Allocation Regulations). If voluntary efforts are not adequately successful, several Regulations and Ordinances may be needed.

Principle 4

No "Undue" or "Unnecessary" burden should be placed on the Community or Individuals. The Plan needs to be specific to actual needs for protecting the lake. Any "Regulatory Approaches" that are implemented must be well defined, very specific -not "arbitrary or ambiguous" or "subject to too much interpretation." Ordinances or Regulations which may become necessary will be specific, quantitative, and will have defined performance standards.

Principle 5

Management measures which are recommended, promoted, or required should be simple, low-maintenance, effective at controlling phosphorus (and other pollutants), and relatively low cost.

Principle 6

The Watershed Management Plan will be "dynamic" and amendments should be based on continued annual water quality monitoring and effectiveness of various Plan components. Regular progress reviews shall be performed (e.g. every 4-5 years).

II. Long-Term Lake Quality Goals

A. Transparency (Clarity)

- ***GOAL: Maintain a mean summer Secchi disk transparency of 4 m (13.1 ft) or greater, and a minimum of 3 m (9.8 ft) at any time between Memorial Day and Labor Day.***

The recommended basis for long-term management at Columbia Lake is to preserve water clarity. There are several reasons to use clarity. First, it is easy to measure frequently. An eight-inch diameter black and white disk (Secchi disk) is lowered into the lake until it disappears from view. Then it is raised until it reappears. The average of these two depths is the Secchi disk depth (SD), a simple measure of transparency or clarity. The SD also indicates to what depth sunlight penetrates and photosynthesis occurs. It reveals much about the nature of the lake. Finally, the clarity or transparency is what people notice about Columbia Lake. It is "clear," except during an occasional algae bloom.

Aside: The "Summer" was selected because lower transparency can be expected at other times during the year, and those intervals of lower transparency are "natural" and do not indicate a decline in resource quality. For example, after ice leaves a lake in early spring the waters are typically less clear due to an early growth of diatoms (a type of algae). This is typical in lakes, as is a subsequent increase in clarity. Also in October, at the end of the growing season a decline in transparency is typical. For the long-term health of Columbia Lake, and for it's recreational users, the summer stratification period was used to define a transparency goal.

B. Oxygen Content at Depth

- ***GOAL: Maintain at least 1 mg/L dissolved oxygen at a depth of 6m (19.7 ft) at all times.***

Related to Secchi disk transparency, a secondary goal recommended for Columbia Lake management is the most shallow depth at which dissolved oxygen drops below 1.0 mg/L. This affects release of phosphorus from bottom mud as well as habitat for fish, small animals that eat algae, and bottom-dwelling organisms.

C. Other Pollutants

- ***GOAL: Prevent contamination by pathogens (e.g. fecal bacteria), toxic materials, or other substances which are damaging to the lake ecosystem and/or lake users.***

Although transparency and oxygen content are the two primary goals to be established by "policy," other substances also need to be considered. This goal is intended to include contaminants which do not cause algae blooms or decrease transparency; yet are damaging to lake ecosystems. For example, some of the clearest lakes in the United States are acidic due to atmospheric deposition. Fortunately, Columbia Lake exhibits adequate buffering capacity and a pH of 6-7. It is not in immediate jeopardy of acidification impacts. Some lakes become unsuitable for swimming at times due to bacteria levels from animal waste and/or failed septic systems. "Prevention of contamination by other pollutants" includes maintaining bacteria levels (coliform bacteria) below water quality limits for swimming, and maintaining water quality that meets all State standards.

III. Basis of Watershed Planning

A. Overview

The Columbia Lake Watershed Management Plan Task Force ("task force") looked at the watershed for Columbia Lake and examined sources of nutrients that flow over the land and through the ground to Columbia Lake due to activities in the watershed. The task force then considered a variety of alternative control methods for each source, meeting each month for over two years to fully examine sources and alternative controls in order to reach informed decisions about what would be best for Columbia. Scientific literature was searched and reviewed, and experts in the fields of lake management and wastewater disposal systems met with the task force to discuss alternatives. Discussions of nutrient sources, controls, and specific recommendations of the task force follow.

B. Sources and Quantities of Nutrient Loading

Although other substances are important, total phosphorus (TP) availability is what limits algae from further growth in Columbia Lake. Additional phosphorus would stimulate further algae and weed growth ("eutrophication"). Hence, watershed management to minimize phosphorus input is recommended for Columbia Lake. There exists a direct, predictable, relationship between the spring total phosphorus concentration, annual phosphorus inputs from the watershed, summer algae growth (transparency and chlorophyll-a), and oxygen consumption in lakes (see Appendix A).

Based on a review of data collected over the past 20 years, the amount of total phosphorus (TP) that can enter the lake each year without causing algae bloom problems (called the "Bloom Threshold") is approximately 330 kg TP per year (727 lb TP/year). That annual load would result in a spring TP concentration of about 18 mg m^{-3}, above which the recommended summer transparency (4 m) and oxygen loss depth (6 m) could not be met.

1. Septic Systems

During fall and spring 1994-95, Ecosystem Consulting Service, Inc. conducted several lake perimeter surveys while the lake level was low. Small holes were dug where groundwater was seeping out of the ground and the seepage water was sampled. No evidence of "contamination" by bacteria, viruses, or other particulate components was observed. No odors were observed. The occurrence of "septic system failures" is believed to be low. However, total phosphorus and nitrate concentrations were higher in groundwater seepage than would be expected for "background" levels. Furthermore, the highest levels of these nutrients were found in areas with significant shoreline development, while the lowest levels coincided with areas without significant development. Using field results, estimated groundwater input volumes, and septic system water loading, the estimated annual phosphorus input was 91 kg $year^{-1}$. Although it is difficult to quantify accurately, the task force believes 100 kg $year^{-1}$ is a reasonable estimate of septic system TP loading under existing conditions. Dissolved nutrient inputs occur because the capacity of soils to remove phosphorus, and dilute nitrate, is exceeded after a certain age-of-use for septic systems. Dissolved nutrients such as nitrate and phosphorus are not a threat to public health but can stimulate growth of weeds and algae.

2. Wetland Management: Erdoni Brook Basin

The extent of anaerobic respiration in the beaver pond impoundments of Erdoni Brook, and resulting seasonal release of phosphorus from these impoundments has been identified as a significant contribution to seasonal TP loading of Columbia Lake. It was originally estimated that during years when oxygen loss becomes intense in the beaver ponds that an *additional 27 kg of P* loading occurs during the summer (over that which is "normal"). Since the initial estimates, monitoring has revealed a much more extensive flooded area (nearly 100 acres), more severe anaerobiosis than expected (oxygen loss within 1 ft of the water surface at times), and high downstream phosphorus concentrations during summer (typically exceeding 100 mg/m^3), and (at times) during winter. The original estimate of +27 kg P loading related to wetland inundation and anaerobic processes may have been underestimated. Many experts have been consulted, and most agree that controlling the water level in the beaver ponds (hence controlling the degree of anaerobic processes) is a prudent management step to take (eg, DEP wildlife, DEP lakes, UCONN Limnology, UCONN soils, etc). The principle of the approach is to restore the existing "dead wooded swamp" to its former "live deciduous wooded swamp" character. However, agreement is not unanimous, and to date no solution to this nutrient load source has been mutually acceptable to everyone.

3. Lake Sediments

The seasonal release of phosphorus to lake water from sediments has been described in numerous reports. During "typical years" most sediment-released P remains below the thermocline (about 38 kg P yr^{-1} affects algal productivity). During years when the thermocline is weak and mixing is more intense (especially in June), about 76 kg P yr^{-1} affect algal productivity. This was the probable cause of blooms in 1992.

IV. Total Phosphorus Budget

A. Existing Development

Several nutrient load budgets have been estimated for Columbia Lake. Some were estimates based entirely on land-use relationships (Windham Regional Planning Agency; WRPA) with no field verification data. Others were based on field measurements for major tributaries and estimates of other sources (Rich and Pallotti, 1977). Others used field data and in-lake incubation experiments to quantify specific sources (Eustis 1985; Kortmann et al, 1987, 1995). All of these previous studies provide valuable information about Columbia Lake and its watershed. However, some estimates need to be "adjusted" to "fit" the actual observed field conditions. For example, the WRPA budget estimated annual loading at 557 kg/year and the Rich and Pallotti budget was 660 kg/year. Both are overestimates based on observed field data (spring TP concentrations would be higher if these input estimates were accurate). However, the *relative proportions* of TP loading from different sources provides very useful information for management. All previous work was used to construct an estimated TP load budget for Columbia Lake.

The following is an estimated TP load budget based on all available information "adjusted" to "fit" field data, especially spring Total Phosphorus concentrations (TP).

Existing Condition: Estimated TP Loads ("Bloom Threshold" = 330 Kg P/year)

	"Normal Year"	Anoxic Wetland	Weak Stratification	Weak Strat. and Anoxic Wetland
Septic Systems	100	100	100	100
Direct Runoff	50	50	50	50
Atmospheric	84	84	84	84
Livestock	4	4	4	4
Erosion	40	40	40	40
Internal Load	38	38	76	76
Anoxic Wetland	0	27	0	27
TOTAL	**316**	**343**	**354**	**381**

Note: The internal cycling of sediment-released TP accounts for approximately 38 kg in "typical" years, and more during "weak stratification years". The additional TP input from the Erdoni Brook basin (over what is expected from a woodland of its size) is approximately 27 kg/year. Either a "weak stratification year", or seasonal TP inputs from the Erdoni Brook Basin can cause TP inputs to exceed the "bloom threshold" during some years.

The following illustrates the effect of *existing development* as the septic systems "age" and soil phosphorus attenuation capacity is used up. Note that without any change in land-use in the watershed, Columbia Lake can be expected to receive more phosphorus (above the amount predicted to cause increased algae blooms).

Future Condition: Estimated TP Loads ("Bloom Threshold" = 330 Kg P/year)
Considers only the AGING OF EXISTING SEPTIC SYSTEMS

	"Normal Year"	Anoxic Wetland	Weak Stratification	Weak Strat. and Anoxic Wetland
Septic Systems	125	125	125	125
Direct Runoff	50	50	50	50
Atmospheric	84	84	84	84
Livestock	4	4	4	4
Erosion	40	40	40	40
Internal Load	38	38	76	76
Anoxic Wetland	0	27	0	27
TOTAL	**341**	**368**	**379**	**406**

B. Future Development ("Built-Out" Condition)

Although the previously described phosphorus loads appear to be "reasonably accurate" for depicting existing conditions, they do not account for any future growth (new development and seasonal home conversions). Hence, we attempted to estimate what the "totally developed watershed" might be like. The "Built-Out Condition" is an estimate of all watershed land being developed according to existing zoning, inland wetlands, and other constraints. Based on a review of the watershed, existing development, and other factors, we believe a reasonable estimate for a future "built-out" condition would add an additional 200 Kg TP $year^{-1}$ (perhaps more). The following table presents an estimated future TP Load Budget for a "Built-Out Condition" with and without incorporation of adequate Best Management Practices (BMPs) to keep phosphorus loading below the "bloom threshold." Best management practices (BMPs) are methods which can reduce the impacts of land use. We suggest that this table be used as the basis for managing the watershed.

Built-Out Condition *Without Best Management Practices*
Estimated TP Loads ("Bloom Threshold" = 330 Kg P/year)

	"Normal Year"	Anoxic Wetland	Weak Stratification	Weak Strat. and Anoxic Wetland
Septic Systems	239	239	239	239
Direct Runoff	75	75	75	75
Atmospheric	84	84	84	84
Livestock	4	4	4	4
Erosion	78	78	78	78
Internal Load	38	38	76	76
Anoxic Wetland	0	27	0	27
TOTAL	**518**	**545**	**556**	**583**

Clearly management practices are needed to protect Columbia Lake.

Built-Out Condition ***With Best Management Practices***

Existing Condition: Estimated TP Loads ("Bloom Threshold" = 330 Kg P/year)

	"Normal Year"	Anoxic Wetland	Weak Stratification	Weak Strat. and Anoxic Wetland
Septic Systems	120	120	120	120
Direct Runoff	35	35	35	35
Atmospheric	84	84	84	84
Livestock	4	4	4	4
Erosion	48	48	48	48
Internal Load	38	38	40	40
Anoxic Wetland	0	0	0	0
TOTAL	**329**	**329**	**331**	**331**

This table illustrates a possible "built-out" watershed condition with BMPs employed to control phosphorus loading from internal sediment sources, wetland flooding in the Erdoni Brook basin, and other input sources.

The conclusions from these budget estimates (with and without BMPs) are cause for some concern:

- During years when "more than normal" TP loading occurs from either the Erdoni Wetland or Internal Sediment Release, the 330 Kg yr^{-1} bloom threshold is exceeded.

- Even without the Erdoni Wetland and Internal Loading Episodes, the "bloom threshold" will likely be exceeded due to aging of existing septic systems sometime in the future.

These budget categories appear to be reasonably accurate, considering the "occasional bloom years" which have occurred recently (e.g. 1992). The goal of the watershed management plan is to accomplish the "Built-Out With BMPs" nutrient load, (maintaining <330 Kg P / Year) without unreasonable restrictions on use of private property.

V. Recommendations

A. Allocation of Phosphorus Loading

The "threshold" amount of phosphorus loading has been estimated at approximately 330 Kg TP $year^{-1}$ (726 lb $year^{-1}$) at Columbia Lake. Perhaps the most equitable approach to watershed and lake management is to establish an "allocation" of the threshold load. This would provide a quantitative basis for managing Columbia Lake. It establishes the "management need" for resource protection, and minimizes the potential for "arbitrary decisions" about land-use practices.

B. Septic System Management Goals

A discussion of septic systems, how they work, what causes problems, and maintenance requirements is contained in Appendix B. The *Task Force* has identified two critical goals for septic system management. It is important that watershed management 1.) prevents septic system failures and 2.) reduces nutrient loading from functioning systems.

Signs of Septic System Problems:

- Wet or "soggy" ground over the leaching field,
- Occasional odors,
- Very "lush" vegetation over or near the leaching field,
- "sluggish draining" of plumbing fixtures,
- water backing up into the house…

If you experience any of these signs contact the Town Sanitarian who will help you solve the problem.

1. Prevent System Failures— Septic system failure occurs when the ground is unable to accept the volume of wastewater generated by a household. Failure results in a breakout of wastewater on the ground surface or a backup into the building. Failure can be caused by poorly drained soils, high groundwater, or clogging of the pipes, leaching field, or soils (often the result of not pumping the septic tank often enough). Septic system failure poses a health risk and causes resource degradation; it must be corrected immediately. Also, if the incidence of septic system failure becomes high, a community could be forced to install sewers to prevent pollution.

2. Reduce Nutrient Loading from Functioning Septic Systems—The most important component of a septic system for phosphorous removal is the soil. Phosphorous adsorbs ("sticks to") soil particles as wastewater passes through the soil. The amount of soil which treats water is limited, hence phosphorus removal is limited. As a home and its septic system age phosphorus removal capacity of the soil is consumed. Eventually dissolved phosphorus can reach the lake through the ground, even when bacteria and viruses continue to be removed. Hence, although particles in wastewater continue to be removed, eventually dissolved phosphorous will pass through soils to the lake. The length of time that phosphorous is removed depends on soil type (its attenuation capacity), wastewater loading, and soil contact volume (system geometry—see Appendix B). Even septic systems that do not "fail" can become a nutrient source to lake waters.

Phosphorus Removal by Septic Systems:

The soil through which wastewater passes is where most dissolved phosphorus is removed. *You can extend phosphorus removal of your septic system by:*

- *Using low phosphorus or phosphate-free detergents,*
- *Not using Septic System Additives,*
- *Designing reconstructed systems for maximum phosphorus removal.*
- *Adequate Pump-out Frequency*
- *Water Conservation*

C. Management Options to Prevent Septic System Failure

1. Community Wastewater Systems and Sewering

- **Recommendation: The task force recommends that methods to ensure the proper operation and maintenance of individual "conventional" septic systems (as discussed above) be the focus of management.**

Individual on-site wastewater treatment systems (septic systems) can be very effective treatment systems, producing very high quality effluent water. The soils around Columbia Lake are generally favorable for septic system installation. *However, septic system maintenance, reconstruction of failing systems, and design features which go beyond conventional Health Code requirements are needed.* If these methods are unsuccessful, a variety of wastewater collection and disposal alternatives may need to be evaluated further.

2. Education Approach

The task force has developed several educational flyers to raise public awareness regarding the proper use and maintenance of septic systems (Appendix B). The first step to effective septic system management will be distribution and use of educational materials (mailings, presentations, use in schools, etc.).

3. Recommended Septic Tank Pump-Out Frequencies

The following tables were prepared based on a review of scientific literature. The task force recommends pump-out intervals for properly functioning septic systems (systems which show signs of problems may need more frequent maintenance).

Note that if your home has a kitchen garbage grinder-disposal system that pump out is needed more frequently!

Recommended Septic Tank Pumping Frequency (Years)
Without Kitchen Garbage Disposal

Number of	SEPTIC TANK VOLUME (Gallons)					
Occupants	**500.0**	**1000**	**1500**	**2000**	**2500**	**3000**
1	5.0	10.0	10	10	10	10
2	2.5	5.0	7.5	10.0	10	10
3	1.7	3.3	5.0	6.7	8.3	10.0
4	1.3	2.5	3.8	5.0	6.3	7.5
5	1.0	2.0	3.0	4.0	5.0	6.0
6	0.8	1.7	2.5	3.3	4.2	5.0
7	0.7	1.4	2.1	2.9	3.6	4.3
8	0.6	1.3	1.9	2.5	3.1	3.8
9	0.6	1.1	1.7	2.2	2.8	3.3
10	0.5	1.0	1.5	2.0	2.5	3.0

Frequencies > 10 Years are not Recommended

Recommended Septic Tank Pumping Frequency (Years)
With Kitchen Garbage Disposal

Number of	SEPTIC TANK VOLUME (Gallons)					
Occupants	500.0	1000	1500	2000	2500	3000
1	3.3	6.7	10.0	10	10	10
2	1.7	3.3	5.0	6.7	8.3	10.0
3	1.1	2.2	3.3	4.4	5.6	6.7
4	0.8	1.7	2.5	3.3	4.2	5.0
5	0.7	1.3	2.0	2.7	3.3	4.0
6	0.6	1.1	1.7	2.2	2.8	3.3
7	0.5	1.0	1.4	1.9	2.4	2.9
8	0.4	0.8	1.3	1.7	2.1	2.5
9	0.4	0.7	1.1	1.5	1.9	2.2
10	0.3	0.7	1.0	1.3	1.7	2.0

Frequencies > 10 Years are not Recommended

4. Reporting Procedures/Ordinances

- **Recommendation: The task force recommends that the Town of Columbia implement a Septic System Pump-Out Reporting Ordinance.**

The Reporting Ordinance should apply to the entire lake watershed. It may be prudent to apply the Reporting Ordinance town-wide. Under the recommended Ordinance, septic-system pumpers would be required to submit a completed "Pump-Out/Inspection Report Form" (Appendix B) to the Town Sanitarian within one month of servicing a system.

The purpose of the Reporting Ordinance is to acquire data on pump-out frequencies and to identify further wastewater management needs (for example, whether a Septic System Licensing Ordinance is needed).

5. Septic System Licensing Ordinance

- **Recommendation: The task force recommends that a licensing ordinance be considered in the future if necessary.**

A model ordinance was developed by the *Task Force* (Appendix B). However, the *Task Force* recommends other measures first. This Licensing Ordinance is recommended if, in several years, it becomes apparent that pump-out frequencies and the incidence of failing systems warrant more stringent regulations.

6. Septic Tank Effluent Filters

- **Recommendation: The task force recommends that effluent filters *be considered for use* in all new installations and when servicing existing systems.**

During its study and discussion with experts in wastewater systems, the *task force* was made aware of filter screens which can be added to existing septic tanks and included in new installations. Costs are considered very reasonable. Tank effluent filters prevent solids from flowing out of the septic tank and into the leaching field where costly repairs would be needed. Applicability and cost will vary due to the specific design of a particular system (hence, and evaluation is needed on a case-by-case basis). The Town Sanitarian should be asked for advice regarding the installation of an effluent filter in a particular system. Effluent filters appear to be an effective, low cost approach to extend the life of septic systems.

D. Management Options Considered to Reduce Phosphorus Loads from Functioning (Non-Failing) Septic Systems

1. Performance Standard for Soil Phosphorous Attenuation

- **Recommendation:** The task force recommends that the sand fill used for the construction or re-construction of septic systems have a specified Phosphorous-attenuation capacity (for example, greater than 0.01 kg P / ft^3).

Most of the soil types found around Columbia Lake exhibit a phosphorous attenuation capacity of 0.003 - 0.005 kg P / ft^3. A performance standard for P-attenuation capacity of fill could increase the effective life of a septic system for phosphorous removal. Although "typically available septic sand fill" may not meet such a standard currently, the phosphorus attenuation capacity of available materials could be increased. Methods to enhance the attenuation capacity of sand fill include selecting material with a high natural capacity and/or adding iron oxide or other soil conditioning additive as a soil amendment. The Town Sanitarian shall approve the method of accomplishing the minimum P-attenuation capacity as well as material test results prior to the use of material in the construction of septic systems in the Lake Protection Areas A, B, and C.

2. Septic System Geometry

- **Recommendation: The task force recommends that the design of new and re-constructed septic systems consider leaching field geometry which maximizes the soil volume which is available to treat wastewater.**

This can be accomplished by maximizing setback from a potential groundwater exfiltration site (stream, wetland, lake), by selecting an area with maximum depth to groundwater, and by placing the long axis of a leaching field parallel to topographic contours (see Appendix B). Wherever it is prudent and feasible, a minimum of 16,000 ft^3 of soil contact volume, with a minimum P-attenuation capacity of 0.005 kg P/ ft^3, shall be provided.

3. Ban on Septic System Additives

- **Recommendation: The task force recommends that no septic system additives be permitted for use in the Columbia Lake Watershed.**

The task force identified no septic system additive that is suitable for use within the Lake Protection Areas A, B, and C. Although some products may reduce the rate of solids accumulation in septic tanks, "liquefied effluents" may create problems. The Connecticut

Department of Environmental Protection has not approved any septic system additives for use in Connecticut.

4. Up-Flow and Iron-Enriched Sand Filter Systems

- **The task force recommends that innovative design concepts, specifically to increase phosphorus removal, be encouraged within the Lake Protection Areas (especially SubArea A). Innovative designs incorporating such features as iron-enriched filter media, alum-enriched sand, up-flow sand filters, and other phosphorus removal techniques should be considered in addition to other Health Code requirements.**

Several septic system design approaches were reviewed which may be effective at phosphorous removal in newly constructed and reconstructed systems. Systems which use an "up-flow sand filter," "iron-enriched filter media," and principles of the Oregon sand filter systems, may be very useful in the watershed, especially in the immediate lake area (Lake Protection Area A). A "concept sketch" of possible design features is contained in Appendix B.

E. Management Options for Controlling Development Effects

Land disturbance activities in the watershed increase the amount of nutrients, sediments, and other contaminants which enter Columbia Lake. There are short-term (during disturbance) effects as well as long-term water quality and quantity changes.

1. Fertilizers

- **Recommendation: The task force recommends that a ban on the use of high phosphorus content fertilizers be implemented annually (see Appendix C).**

2. Control of Short-term Construction Phase Impacts

- **Recommendation: The *Task Force* suggests a number of policies and standard permit conditions (Inland Wetland and Zoning Permits):**

Erosion and sedimentation is a major concern during land clearing, grading, excavation, filling, and construction. It is critical that well planned and implemented controls are used during all watershed disturbances, and that control systems are maintained and effective throughout the period of disturbance.

- Erosion and sedimentation controls should be clearly defined on plans and specifications, with detailed installation, timing, maintenance, and monitoring requirements.

- "Erosion source controls," such as heavy mulch covering of exposed soils, should be emphasized. "Recovery methods," which are intended to remove sediment from flowing water after it has been mobilized by erosion, should also be used, but not as a sole method.

- Whenever it is feasible, erosion control systems should be fully and properly installed prior to disturbance of soils. When not feasible (e.g. for mulch coverage of soil stockpile), all materials should be on-site and ready for *immediate* installation prior to the first storm following disturbance.

- When a significantly large area is to be disturbed (e.g. > 0.5 acre total area) a detailed plan should be required, including monitoring and reporting conditions.

- A "Contractor's Compliance Statement" and "Notice of Intent to Begin Site Work" should be required as a standard condition for all permits involving land disturbance in the watershed. For large projects an Environmental Site Monitor should be required with a specified reporting frequency.

- Disturbance along the immediate shoreline, and in the "drawdown lakebed" should be avoided whenever possible. If such disturbance is *unavoidable*, disturbance should be *minimized in area extent and duration*. Disturbance through the winter in these areas should be avoided. All work which is permitted along the lake shoreline, and within the exposed lake bed during winter drawdown, should be completed and stabilized prior to March 15.

3. Control of Long-term Land-Use Impacts

- **Recommendation: The task force recommends that the nutrient allocation assessment approach (Appendix D) be used for all new and existing development in the watershed, anytime a permit is sought or site work is planned. The PZC and Inland Wetlands Commission should place immediate emphasis on reducing disturbance area, impervious area, and peak runoff increases of proposed activities in the watershed.**

By using a nutrient allocation assessment model a landowner can select a set of BMPs *appropriate for their property and use*, and thereby come into compliance with the allocation of his or her parcel. Initially it should be used for "assessment" and to identify "prudent and feasible" methods to reduce land-use related impacts. Eventually this may need to become a regulatory program, at least in Lake Protection Area A.

Even after a disturbed site has again been stabilized (e.g. several years after a new home is completed), water quality and quantity impacts continue. Impervious surfaces (roads, driveways, rooftops, etc.) and semi-pervious surfaces (e.g. lawns) result in higher runoff volumes and increased nutrient loading to Columbia Lake than do undeveloped (wooded, shrubby) surfaces. The "threshold" amount of phosphorous that can enter Columbia Lake is approximately 725 lb/year. Above that "threshold," algae blooms would become more frequent and the water quality goals established for Columbia Lake would not be met. The "threshold" load translates to about 0.32 lb/acre/year watershed-wide. Research conducted in Connecticut (Appendix D) indicates that developed, agricultural, and forested lands yield about 1.5, 1.0, and 0.1 lb/acre/year, respectively. These estimates are within the ranges estimated during the National Eutrophication Survey. It is clear that land development poses a threat to the quality of inland lake resources.

In order to address long-term nutrient loading due to developed land uses the *Task Force* has prepared a "Nutrient Allocation Plan" for the watershed. Each parcel of land is assigned an allowable amount of phosphorous export based on its acreage and which Lake Protection Area it lies in (with lower phosphorous export allowed nearer the lake). Phosphorous export amounts are assigned to each type of land use (for example, area of lawn, area of road, etc.). The total projected phosphorus export for the parcel is then compared to its allocation to determine compliance.

If a development is projected to export more phosphorus than its annual allocation, a set of "Best Management Practices" (BMPs) can be employed to ensure compliance. BMPs are relatively simple, inexpensive, low maintenance approaches, including:

- stormwater collection/infiltration
- creation of "simulated woodlands"
- runoff landscaping techniques

4. Road Maintenance

- **Recommendation: The task force recommends that the current policy of early spring road sweeping and drainage catch basin cleaning be continued.**

Although small, motor vehicles contribute approximately 0.22 kg of phosphorous per year. This phosphorous source was kept in the budget estimate to help account for potential increases in the future if axle-miles traveled on watershed roads increases significantly. It should be noted that other "contaminants" which are carried in road runoff can be very damaging to the lake, including hydrocarbons, ethylene glycol (antifreeze), heavy metals, sediment, road sand and deicing compounds, etc. Phosphorus is not the only consideration for road runoff and drainage system maintenance.

These maintenance actions should be scheduled to "radiate out from the lake area", (Lake Protection Area A first). The Town should request similar treatment of State roads and drainage structures by the Connecticut Department of Transportation.

Future Options Recommended

- **Recommendation: The Task Force recommends that the Erdoni Brook wetlands which have been flooded by beaver dams be restored to a live deciduous wooded swamp structure by installation of an outlet control device. This recommendation should be implemented in collaboration with the CTDEP and adjacent land owners to address all wildlife, storm water detention, water quality, and other functional values of the wetland system.**

1. Erdoni Brook Beaver Dams

Restoration of the previous "live deciduous wooded swamp" which has become dead wooded swamp with extensive flooding and oxygen loss, could be accomplished by a relatively simple outlet control at the beaver dams. Most experts attending the site walk agreed that this was a prudent management step for the lake, and for the wetland itself. Indeed, DEP offered to install a beaver dam outlet system, and to study effects so wildlife management would be optimized. However, a few disagree with the need to restore wetland structure and function which was lost due to beaver dam flooding. This aspect of the watershed management plan requires further work. Although the actual project is not difficult to implement, and wildlife issues have been addressed to the satisfaction of DEP, acquiring approval and consent by adjacent land owners has not been accomplished.

- **Recommendation: The task force recommends that management efforts not be implemented to control internal nutrient sources (sediment P release) at this time.**

2. In-Lake Loading

The seasonal release of phosphorus to lake water from sediments has been described in numerous reports. During "typical years" most sediment-released P remains below the thermocline (about 38 kg P yr^{-1} affects algal productivity). During years when the thermocline is weak and mixing is more intense (especially in June), about 76 kg P yr^{-1} affect algal productivity. This was the probable cause of blooms in 1992. . Several management options have been identified to control this internal nutrient loading source, including:

- Deep Flow-Routing Outflow
- Nutrient Inactivation Treatment
- Deep Layer Aeration (without mixing the entire lake)

Although these remain viable options, consultant recommendations placed higher priority on watershed management aspects, and the Town decided that watershed management implementation should be given higher priority. In-lake phosphorus enrichment due to sediment release will be limited if the transparency goals and dissolved oxygen goals are met by watershed management. If not, in lake treatment may become necessary.

3. Atmospheric Deposition

In 1977, Rich and Pallotti estimated that about 115 kg total phosphorous per year fell on the lake surface. We have adjusted that estimate to 84 kg total phosphorous per year based on subsequent precipitation testing, reduced lake area during winter drawdown, etc. There is little that can be done locally to reduce this direct load to Columbia Lake (ca. 26% of its annual total phosphorous load).

4. Livestock

Although a small fraction of nutrient loading currently, we have retained the contribution of livestock wastes (approximately 4 kg total phosphorous per year) to account for potential increases in livestock numbers in the watershed in the future.

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RITY

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APPENDICES

A. RELATIONSHIPS BETWEEN TOTAL PHOSPHORUS, ALGAE, AND LAKE WATER CLARITY

B. INFORMATION REGARDING SEPTIC SYSTEMS

C. FERTILIZER BAN

D. NUTRIENT ALLOCATION PLAN AND POLICY

E. ERDONI BROOK BEAVER DAMS

F. ADDITIONAL LAKE PERIMETER AND SEEPAGE DATA

G. EXCERPTS: 1988 WATERSHED MANAGEMENT REPORT

Relationships between Total Phosphorus, Algae, and Lake Water Clarity

The amount of plant nutrients (especially phosphorus), algae growth, and water clarity are related to each other in Columbia Lake. Total phosphorus tends to be the required nutrient that is in the "shortest supply" to algae. If more total phosphorus were to get into Columbia Lake, more algae would grow. If more algae were to grow, water clarity would decline and the lake would frequently look turbid and green during the summer. If waters became less clear, light would not penetrate as deep and oxygen would not be produced by plants in deep water. Oxygen loss in deep water would result. With more oxygen loss, more phosphorus would be released from bottom muds into lake waters. Still more algae growth would result. The increase in algae and turbidity would accelerate, and water quality would decline abruptly. This sequence of events occurs in several nearby lakes.

There are some relatively well documented (mathematically) relationships between total phosphorus inputs from the watershed, concentration in lake water, algae growth (chlorophyll concentration), water clarity (Secchi disk transparency), and oxygen consumption. It is clear that the amount of total phosphorus that gets into Columbia Lake each year from the watershed needs to be controlled. Lake eutrophication models and field data collections have been used to estimate the "allowable" about of annual phosphorus loading and that amount has been "allocated" to areas of the watershed to serve as the basis of management. Simply put:

More Phosphorus Inputs from the Watershed (Septic Systems, Runoff, Fertilizers, etc)

↓

Higher Lake Phosphorus Concentrations ↑

↓

More Algae Blooms

↓

More Oxygen Loss

↓

More Phosphorus Cycling Within the Lake

Water quality decline due to algae blooms would become an accelerating cycle if watershed phosphorus loading were to increase (above about 330 Kg TP per year).

Empirical Models for Prediction of Summer Chlorophyll and Summer Secchi

Range of Total Phosphorus mg/L =	0.01	0.02	0.03	0.04	0.05
Observed Retention Rate years =	0.99				

Empirical Chlorophyll a Model

Dillon Rigler (1974)

$$Chla = 0.0731 \quad P^{1.449}$$

Where: P is Spring Total Phosphorus mg m-3
Chla = Summer Chlorophyll a mg m-3

Potental or Observed Spring TP pp	5	10	15	20	25	30	35
Predicted Summer Chlorophyll a u	0.75	2.06	3.70	5.61	7.75	10.10	12.63

Empirical Secchi Depth Model

Reckhow (1989)

$$\log_{10}(SD) = .5 - .6\log_{10}\{\log_{10}[1000P]\} + .98\log_{10}\tau$$

TP mg/L =	0.01	0.02	0.03	0.04	0.05
Secchi (m) =	3.1	2.7	2.5	2.4	2.3

U.S. EPA (1974)

$$SD = \frac{\log(p) - 0.818}{-1.307}$$

= log SD in inches
Using TP entered in Rechow model

Secchi (m) =	3.6	2.1	1.6	1.3	1.1

Dillon Rigler (1975)

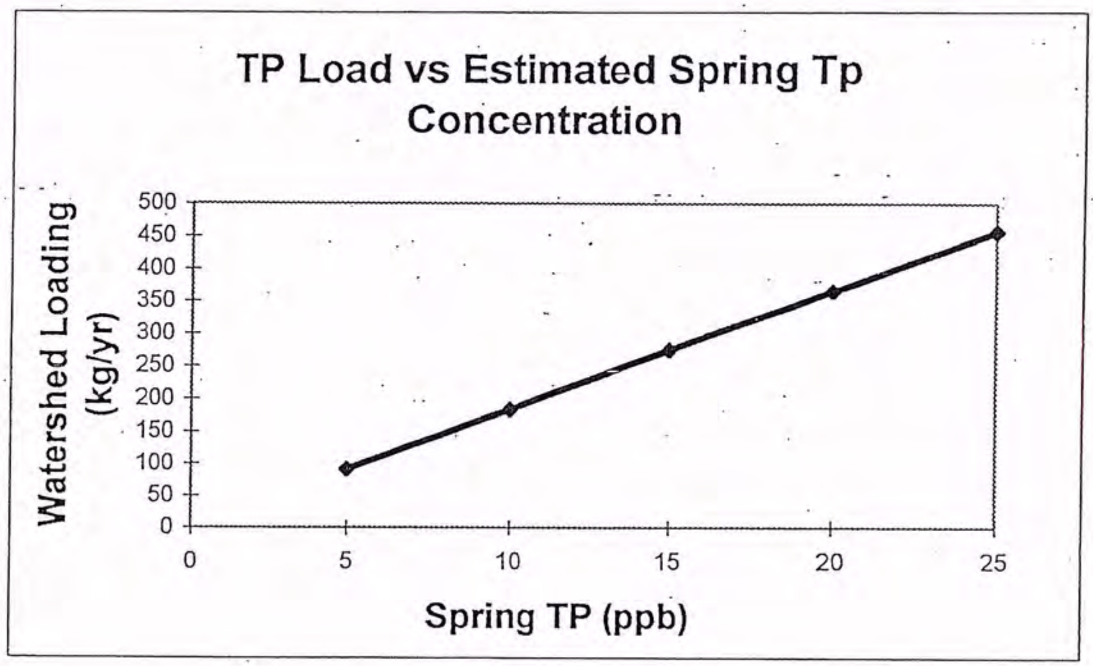
$$SD = 8.7(1/1 + .47\,Chla)$$

= uses Predicted Chlorophyll from model above

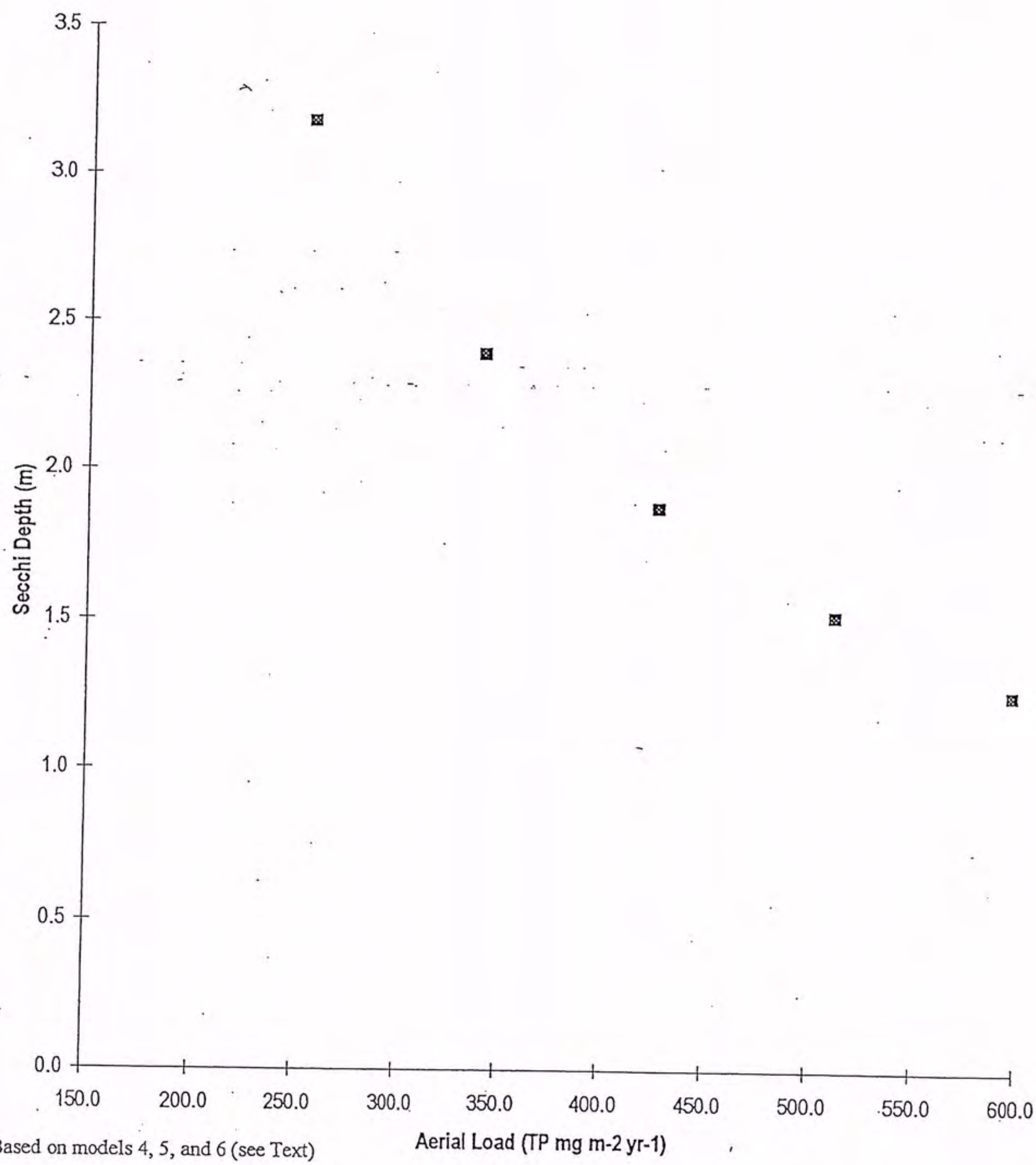
Secchi (m) =	6.4	4.4	3.2	2.4	1.9	1.5	1.3
TP ppb	5	10	15	20	25	30	35

Phosphorus Loading Estimates For Columbia Lake

	ppb				
Model	**5**	**10**	**15**	**20**	**25**
K&D 1975	100	199	299	398	498
V 1975	81	162	244	325	406
Chapra 1975	94	187	281	374	468
Mean	91	183	274	366	457

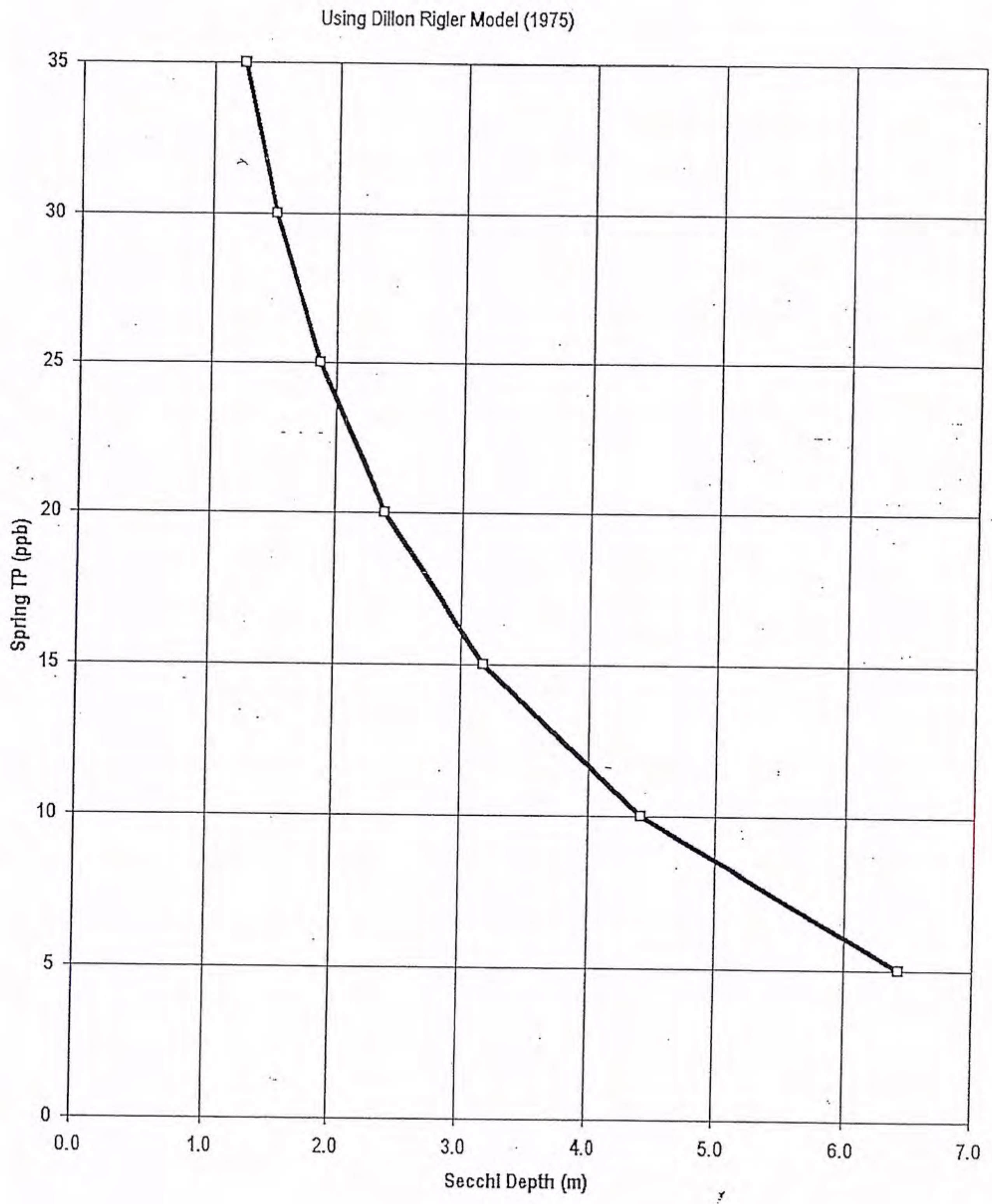


Prediction of Secchi Depth Based on Increased Aerial Load



Based on models 4, 5, and 6 (see Text)

Predicted Secchi Depth Based on Spring Phosphorus



APPENDIX B INFORMATION REGARDING SEPTIC SYSTEMS

Flyer

Model Ordinance

Tank Pump-Out Frequency Recommendations

Setback Model

Effluent Filters

Concept Designs for Sand Filter Beds

Septic System Management

"For the Sake . . . of Columbia Lake"

As an important part of long-term protection of Columbia Lake, *the Columbia Lake Watershed Management Task Force* has evaluated ways to reduce phosphorus inputs from the watershed. The largest contribution of phosphorus appears to come into the lake through the ground- from septic systems. Fortunately, the field studies which have been conducted indicate that septic systems appear to be operating properly, removing pathogens from wastewater. *No public health problems have been identified at Columbia Lake relative to septic system failures.* Unfortunately, even septic systems that are performing properly may eventually contribute phosphorus to the lake. ***You can help!***. Septic Systems are perhaps the best wastewater treatment systems available. However, they depend on site conditions and *your maintenance and operation of the treatment system.* Maintenance of septic systems is very important for protecting Columbia Lake (as well as your property and septic system investments).

How does a Septic System Work?

Three "functional components" of a Septic System:

1. **The Septic Tank** is designed to remove and accumulate solids from wastewater. Materials which either float or sink are collected in the tank. Only liquid passes through the septic tank to the drainage field, for further treatment and discharge to the ground.

2. **The Leaching Field** is designed to discharge the volume of wastewater generated by a household into the ground. It usually consists of dug trenches filled with stone, with perforated pipes on top to distribute wastewater evenly over the leaching field. Wastewater contains dissolved organic and inorganic materials which are "food" to many types of microorganisms. Hence, a biological crust grows on the stones in the trenches. This "Biocrust" helps to treat wastewater as it passes through the field, removing much of the dissolved organic and some of the dissolved inorganic material.

3. **The Soil** through which wastewater passes en route to a water body (lake or tributary stream) is the last "processing component" of a Septic System. It is here, in the soil, where dissolved materials (like Phosphorus) must be removed- mostly by adsorption to soil particles.

Septic Systems can treat wastewater very effectively. Indeed, they can be so effective that they are often considered "Advanced Wastewater Treatment Systems" which produce water of near-potable quality. However, they are only that effective when site features such as Soil Type, Depth to Groundwater, Soil Contact Volume, and Percolation Rate are favorable. When conditions are not so favorable, management practices are needed to avoid very serious water resource impacts such as eutrophication (e.g. algae blooms) and contamination (e.g. pathogenic bacteria, viruses, and other contaminants).

What Conditions Present Septic System Problems? ...What Management Methods can Help?

- **Poorly Drained Soils**

Soils with a high content of very small particles (silt and clay) often are not capable of accepting and holding the amount of water we need to dispose of. Hence, wastewater "backs-up" either into the home or breaks out on the ground surface. This is called "septic system failure" and it presents both a water resource problem and a direct public health problem. Septic system failure can also occur if soils become clogged because the tank wasn't pumped often enough. Septic system failure warrants immediate correction, either by reconstructing the system, enlarging the field, or in some cases by regional wastewater collection, treatment, and disposal. *Water conservation in the home can help prevent system failure by reducing the volume of wastewater we need to put into the ground.* Water saving devices are readily available. Altering our habits - *to use less water* - can also be very effective. Fortunately, most of the soils around Columbia Lake are adequately drained for effective use of septic systems.

- **Neglecting to Maintain a Septic System Properly**

Septic Systems require regular maintenance! Of paramount importance is periodic pumping of the septic tank. Recall that, by design, the tank is meant to collect and store solids that either float or sink. Accumulated solids must be removed on a regular basis by pumping. The pumping interval will vary by size of household (how much waste goes into the system), by seasonal or all year use, and by size of the tank (how much waste it can store). *The following tables identify recommended septic tank pump-out frequencies.* When the tank is not pumped out, the capacity of the tank to store floating and settled solids can be exceeded, and the pipes, trenches, and soil will become clogged. *The septic system will be destined to fail.* The cost of routinely pumping the system greatly prolongs the life span of the leach field and avoids costly reconstruction *"An ounce of prevention is worth pounds (and many dollars) of cure!"*

Recommended Septic Tank Pumping Frequency (Years)
Without Kitchen Garbage Disposal

Number of Occupants	SEPTIC TANK VOLUME (Gallons) 500.0	1000	1500	2000	2500	3000
1	5.0	10.0	15.0	20.0	25.0	30.0
2	2.5	5.0	7.5	10.0	12.5	15.0
3	1.7	3.3	5.0	6.7	8.3	10.0
4	1.3	2.5	3.8	5.0	6.3	7.5
5	1.0	2.0	3.0	4.0	5.0	6.0
6	0.8	1.7	2.5	3.3	4.2	5.0
7	0.7	1.4	2.1	2.9	3.6	4.3
8	0.6	1.3	1.9	2.5	3.1	3.8
9	0.6	1.1	1.7	2.2	2.8	3.3
10	0.5	1.0	1.5	2.0	2.5	3.0

Frequencies > 10 Years are not Recommended

Recommended Septic Tank Pumping Frequency (Years)

With Kitchen Garbage Disposal

Number of Occupants	SEPTIC TANK VOLUME (Gallons) 500.0	1000	1500	2000	2500	3000
1	3.3	6.7	10.0	13.3	16.7	20.0
2	1.7	3.3	5.0	6.7	8.3	10.0
3	1.1	2.2	3.3	4.4	5.6	6.7
4	0.8	1.7	2.5	3.3	4.2	5.0
5	0.7	1.3	2.0	2.7	3.3	4.0
6	0.6	1.1	1.7	2.2	2.8	3.3
7	0.5	1.0	1.4	1.9	2.4	2.9
8	0.4	0.8	1.3	1.7	2.1	2.5
9	0.4	0.7	1.1	1.5	1.9	2.2
10	0.3	0.7	1.0	1.3	1.7	2.0

Frequencies > 10 Years are not Recommended

I Don't Need to Pump My System Because I use a Septic System Additive ... Right?

Absolutely wrong! There are a variety of "Additives" on the market. Most of the additives are intended to perform one function- *to liquefy the solids in wastewater*. If the additive prevents solids from accumulating in the tank, where do they go? The "liquefied solids" flow into the Leaching Field, the Soil, and ultimately into Columbia Lake! Many can reduce treatment effectiveness. *Avoid using Septic System Additives.* Maintaining your Septic System can save Columbia Lake...as well as thousands of dollars in repair bills.

What about the Detergents used in the household?

Anyone living near the lake or a stream should be aware of what goes into their septic system. Phosphorus is very important because it is the substance that stimulates weed and algae growth. *It is not the only material to be concerned about!* In the 1960's, concern about the degraded quality of many lakes, including the Great Lakes, resulted in a National Eutrophication Survey, and the use of Phosphate Detergents became controversial. Industry responded by producing low and non-phosphate detergents. The phosphate content is printed on the label of detergents. The best ones to use are those with the lowest phosphate content. There are only a few non-phosphate dishwasher detergents on the market, so look closely. Also, remember that *the more solids put into the septic system, the more frequently it will need to be pumped.* Avoid using a kitchen garbage disposal grinder.

Other cleaning agents can also be damaging. The Task Force recommends minimal use of harsh cleansers, avoid phosphate detergents, and never dispose of paints, solvents, or other chemicals in your septic system.

Your septic system maintenance is a major step toward preserving a clean and healthy Columbia Lake Ecosystem. Thank you for helping to reduce nutrient runoff - *for the sake of Columbia Lake*!

Columbia Lake Watershed Management Task Force
Columbia Board of Selectmen

"For the sake... of Columbia Lake!"

YOUR SEPTIC SYSTEM

You depend on a septic system to treat and dispose of your household wastewater. The purpose of a septic system is to treat liquid wastes from your home in order to prevent contamination of your well, groundwater, streams, and Columbia Lake.

When a septic system is suitably located, properly designed, carefully installed and adequately maintained, you will have a waste disposal system that is effective, economical, and safe! *Proper maintenance is the key to a lasting septic system.*

HOW YOUR SYSTEM WORKS...

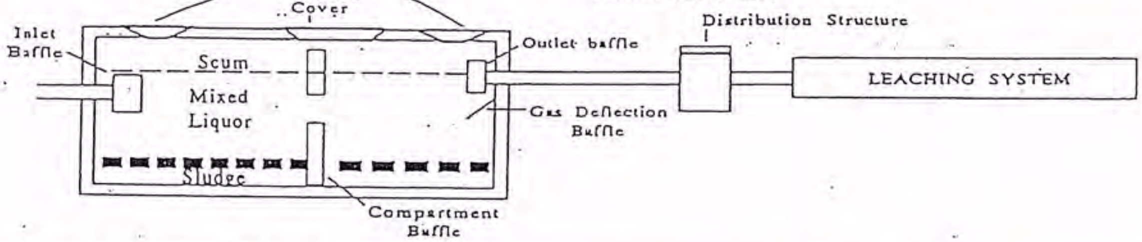
A septic system has several working parts:

Septic Tank

Wastewater flows from the house into the septic tank. Here heavy solids settle and are partially decomposed by bacteria in the tank to form sludge. Light solids and grease float to the top, forming a scum layer.

Leaching System and Soils

Partially treated wastewater is discharged from the septic tank into a leaching system. Here, the water is further purified by filtration and decomposition by microorganisms in the soil. The soil is the essential treatment mechanism to prevent polluted water from entering surface and groundwater, and ultimately Columbia Lake.



Common Causes of Failure

- leaking fixtures/overuse of water
- neglecting to regurlarly inspect and clean the septic tank
- lack of understanding on proper use of the system
- poor soil conditions and/or faulty design or installation
- Signs of failure include: high surface water in the leaching area, lush growth of grass, odor and wastewater draining slowly from the bathroom or kitchen fixture...or even backing up.
- Often the problem can be prevented by simple maintenance...but not all. (A regular cleaning costs relatively little and can help prevent system failures.) If this situation does occur, it is best to contact the sanitarian or health officer for instructions - as pumping and cleaning alone may not cure the problem.
- (Homeowner should verify cleaner/ installer is licensed, and comes well recommended.)

Do

- keep accurate records about location and cleaning of system in the permanent house file so this information can be passed on to the next owner.
- if tank is 3-4 feet below ground level, simplify inspection and cleaning by installing a 20-24 inch manhole about 12 inches below ground level...most recently installed tanks are just 6-12 inches below ground and this would make a manhole unnecessry.
- set-up and adhere to a sound system of inspection and cleaning.
- check for faucet leaks...it is estimated that one leaky faucet can waste as much as 700 gallons of water a year.
- educate your family to proper use of the system.

Don't

- allow excess amounts of fat or grease to enter the system - it can congeal and cause obstructions.
- use garbage grinders or Septic System additives.
- use chemical compounds, enzymes or septic tank "cleaners" - there is no such thing as a "quick fix."
- use large amounts of laundry soaps, detergents, bleaches, drain cleaners - recommended quantities should not adversely affect the system.
- flush down paper towels or other heavy matter.
- soak diapers in toilet bowl - a child may come along and try to flush the toilet.
- discharge salt brine solution from water softeners into subsurface sewage systems. Ct. Dept. of Health regulations prohibit this. The salt brine may also build up in the ground water and pollute wells and springs supplying drinking water.
- use matches or open flames to inspect septic tank; gases produced by decomposing sewage may explode and cause serious injury.
- allow trucks or heavy equipment to drive over the tank or leaching field.
- put a lot of water into the system all at once...use water sensibly and teach children to do the same.
- do all your laundry in one day...space it out.

TOWN OF COLUMBIA
SEPTIC SYSTEM MAINTENANCE ORDINANCE
(Draft-Modeled after an example by the CT DEP)
SECTION 1. Purpose

The purpose of this regulation is to ensure periodic inspection and pumping out of septic tanks, to prevent malfunctioning of septic systems which can create conditions causing the spread of disease, or environmental impacts to water resources. This regulation is promulgated under Section 19a-207 of the Connecticut General Statutes.

SECTION 2. Septic Tank Maintenance Certificate

2.1 Requirement of Certificate. Any person who owns a building, residence, or other structure, within the area designated as *Watershed Management District -Subdistrict A* which is served by an on-site sewage system and is occupied, either seasonally or permanently, must have a valid septic tank maintenance certificate issued in his or her name for that system.

2.2 Application for Certificate. To obtain a septic tank maintenance certificate, a person must file an application with the local Health Department on forms supplied by the Department. All applications shall state the applicant's name and address, and the address or location of the on-site sewage system. Each application shall also contain the following statement, which must be completed and signed by a septic tank pumper licensed with the State Department of Public Health.

I certify that on the __ day of ____________, 19__, I inspected the septic tank located at the address stated on this application, and I:

(Check One of Three)

☐ Found the tank to be 1000 gallons or more and I pumped all sludge and scum out of the septic tank.

☐ Found the tank to be 1000 gallons or more and found that the depth of sludge was less than 1/3 the depth of the liquid in the tank, and that the scum layer was more than 3" above the bottom of the outlet baffle; thus, I did not pump the septic tank.

☐ Found the tank to be less than 1000 gallons and I pumped all sludge and scum out of the septic tank.

IF THE TANK WAS PUMPED:

(Check One of Two)

☐ During pump-out I observed no backflow from the leaching field into the tank.

☐ During pump-out I did observe backflow from the leaching field into the tank.

(Check One of Two)

(Note: this section is for informational purposes)

☐ Recognizing the limitations of visual inspection during one pump-out time, it appeared that both inlet and outlet baffles were structurally sound and functioning properly.

☐ I replaced faulty baffle or baffles per Public Health Code requirements.

(Check One of Two)

☐ An Effluent Filter was present on the outflow side of the septic tank. Or

☐ I Installed a Septic Tank Effluent Filter

Signature_____________________________

License #:____________________________

2.3 System Map. An application for a septic tank maintenance certificate shall include a map of the system showing the location of the system and manholes or covers in relation to the building served. If such a map for the system is already on file with the local director of health from a previous application for that system, then subsequent applications need not include a map.

2.4 Issuance. The local Health Department shall issue a certificate to the applicant upon receipt of a completed application. The certificate shall include the applicant's name and address, the address or location of the on-site sewage system, the date of issuance, and renewal date.

2.5 Validity. A septic tank maintenance certificate shall be valid for two years from the date of issuance. The Local Health Department may extend validity of a certificate to three years based on submitted information.

2.6 Transfer of Certificate. When property served by a septic system is sold or given to a new owner, the certificate remains valid and may be transferred to the new property owner. However, the new property owner must record his name and address with the local Health Department within 30 days after obtaining possession.

SECTION 3. Enforcement

3.1 Responsibility for Enforcement. The local Health Department shall be responsible for enforcement of these regulations.

3.2 Inspections. The local Health Department, whenever there is probable cause to believe that a valid septic tank maintenance certificate is not held or that the application for a certificate contains significant misinformation, shall have the right, at reasonable time, to enter the property, question the owner, or dig up the ground and inspect the septic tank.

3.3 Orders. If the local Health Department determines that a valid septic tank maintenance certificate is not held, or if an inspection reveals that a septic tank has not been pumped, the local Health Department shall order the owner to file an application for a certificate and have the septic tank pumped out, if needed, within a time specified by the Department.

3.4 Issuance of Orders. Every order authorized by this ordinance shall be in writing. Orders issued under this ordinance shall be served on the property owner in a manner consistent with other health orders.

3.5 Hearing. Any owner receiving a written order shall be given an opportunity, within a reasonable length of time, for a hearing before the local director of health to object to the order. If the evidence indicates that, in fact, a violation has not occurred, the local Health Department shall revoke the written order.

3.6 Penalties. A person neglecting or refusing to comply with a written order issued under this ordinance shall be fined not more than $500 for each offense, in addition to pump-out costs. Failure to comply with each written order issued shall be considered as one offense. Written orders shall be issued, and penalty assessed, each calander quarter until compliance with the ordinance. In the event of repeated non-compliance, the Town of Columbia shall have the right to have the system pumped and inspected at the owner's expense.

SECTION 4. Definitions

4.1 Local director of health - means and includes town, city and borough and local district director of health, local superintendent and commissioner of health and any other officer or person having the powers and duties of a local director of health as defined in sections 19a-206 and 19a-207 of the Connecticut General Statutes.

4.2 On-site sewage system - any system which treats and/or disposes of sewage underground on the same property where the sewage is generated or on another property per use of a legal easement, and includes a tank for the collection of solids.

4.3 Property Owner or Person - any individual, partnership, public or private corporation, unincorporated organization, trust, or other entity.

4.4 Certificate - written certificate issued by the local Health Department.

4.5 Septic tank - any container used for the collection of solids in an on-site sewage system.

SECTION 5.0 Effective Date

This Ordinance shall become effective 2 years following adoption by the Town of Columbia.

SEPTIC SYSTEM MANAGEMENT

"For the Sake... of Columbia Lake"

As an important part of long-term protection of Columbia Lake, *the Columbia Lake Watershed Management Task Force* has evaluated ways to reduce phosphorus inputs from the watershed. The largest contribution of phosphorus appears to come into the lake through the ground- from septic systems. Fortunately, the field studies which have been conducted indicate that septic systems appear to be operating properly, removing pathogens from wastewater. *No public health problems have been identified at Columbia Lake relative to septic system failures.* Unfortunately, even septic systems that are performing properly may eventually contribute phosphorus to the lake. *You can help!*. Septic Systems are perhaps the best wastewater treatment systems available. However, they depend on site conditions and *your maintenance and operation of the treatment system.* Maintenance of septic systems is very important for protecting Columbia Lake (as well as your property and septic system investments).

How does a Septic System Work?

Three "functional components" of a Septic System:

1. **The Septic Tank** is designed to remove and accumulate solids from wastewater. Materials which either float or sink are collected in the tank. Only liquid passes through the septic tank to the drainage field, for further treatment and discharge to the ground.

2. **The Leaching Field** is designed to discharge the volume of wastewater generated by a household into the ground. It usually consists of dug trenches filled with stone, with perforated pipes on top to distribute wastewater evenly over the leaching field. Wastewater contains dissolved organic and inorganic materials which are "food" to many types of microorganisms. Hence, a biological crust grows on the stones in the trenches. This "Biocrust" helps to treat wastewater as it passes through the field, removing much of the dissolved organic and some of the dissolved inorganic material.

3. **The Soil** through which wastewater passes en route to a water body (lake or tributary stream) is the last "processing component" of a Septic System. It is here, in the soil, where dissolved materials (like Phosphorus) must be removed- mostly by adsorption to soil particles.

Septic Systems can treat wastewater very effectively. Indeed, they can be so effective that they are often considered "Advanced Wastewater Treatment Systems" which produce water of near-potable quality. However, they are only that effective when site features such as Soil Type, Depth to Groundwater, Soil Contact Volume, and Percolation Rate are favorable. When conditions are not so favorable, management practices are needed to avoid very serious water resource impacts such as eutrophication (e.g. algae blooms) and contamination (e.g. pathogenic bacteria, viruses, and other contaminants).

Zabel A1800 Residential Septic Tank Effluent Filter

The Zabel A1800 Residential Septic Filter is a true 1/16" effluent filter that will fit in any 4" sanitary tee providing a real Residential Septic Filter at a very low price.

Filter versus screens: Twenty-five years ago Zabel developed the first genuine Septic Tank Filter utilizing 1/16" and 1/32" filtration slots in a patented Disc Dam stack. Other manufacturers have utilized an 1/8" mesh screen and off the shelf components in an effort to produce a lower cost device. We believe that any device that provides some protection for the drain field is better than no protection at all, but we have refused to take this "screen" approach or to compromise in any way on our product quality in order to cut costs.

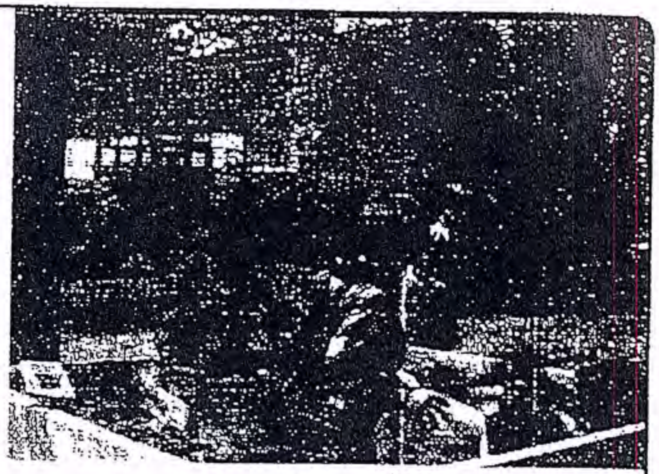
Now after years of development, Zabel brings you a true Residential Septic Tank Effluent Filter specifically engineered and manufactured with many of the same great features of our bigger A100 and A300 Zabel Filters at a cost below screens.

Compare these Features!

1. **Finest filtration:** The 1/16" filtration slots are finer than any other device and twice as fine as most codes require.
2. **Lowest cost:** No other filter or screen can be purchased and installed for less.
3. **Easier to install or retrofit:** One size fits all. The filter cartridge fits in any 4 inch sanitary tee.
4. **Easier to service:** Pull the cartridge out by grasping the handle and pulling upward. Tap the cartridge on the inside of the inspection port or hose off into the tank, if needed, and reinstall.
5. **Self cleaning:** Solids filtered out of the effluent stream attach to the inside of the vertical cylinder wall and drop to the bottom of the tank when the flow is in a resting state. Sloughs most solids back into the tank.
6. **Prevents siphoning:** Filter is 100% top vented and will not siphon into the pump chamber.
7. **Scum layer cannot plug:** Large vent opening keeps filter from plugging with tank scum.
8. **Prevents effluent bypass:** If scum and material surge over tee, it cannot exit without passing through the filter.
9. **Servicing frequency:** The filter should be cleaned when the tank is normally inspected and pumped. The filter does not increase the frequency of service in a normal installation.
10. **Lifetime warranty:** We are the only manufacturer of effluent filters that has enough confidence in the quality of their products to provide a lifetime warranty. At the end of installation fill out and return the enclosed warranty card. In the event the unit breaks due to faulty material or workmanship on the part of the manufacturer, clean and return the used unit for a new replacement.

U.S. Patent No. 5,382,357

Protect Your Home With An A1800 Zabel Filter!



This home is protected by a Zabel Filter.

A failing septic system can potentially expose your children and pets to untreated waste-a real health hazard.

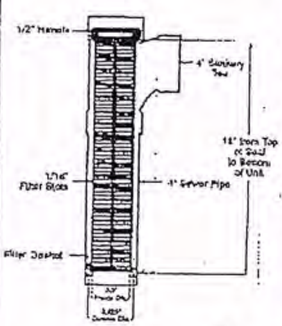
Your home is the single largest investment you make. If your septic system fails, your property value decreases.

Thousands of unprotected septic systems fail every year. A small investment in a Zabel Filter helps to protect your septic system from costly repair.

The most common reason for failure of septic systems is excessive solids leaving the septic tank which then causes clogging of lateral lines and drain fields. With a Zabel Filter installed in your tank, solids are kept in the tank so they can be further broken down and kept out of your lateral lines.

Zabel Environmental Technology guarantees every Zabel Filter to be free from defects in materials and manufacture for the lifetime of the homeowner-purchaser.

LOWER COST:	Lower cost than any other filter or screen.
FINER FILTRATION:	1/16" filtration is the finest on the market.
EASIER INSTALLATION:	Fits any 4" outlet T and pipe.
FLOW RATE:	800 GPD

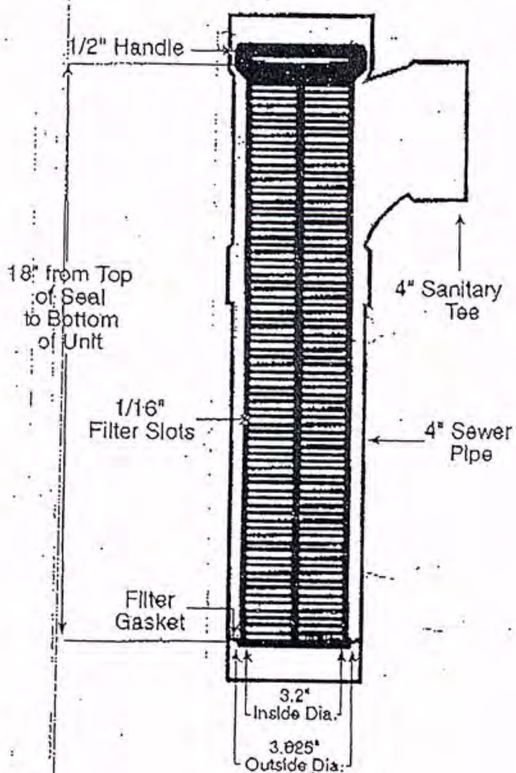


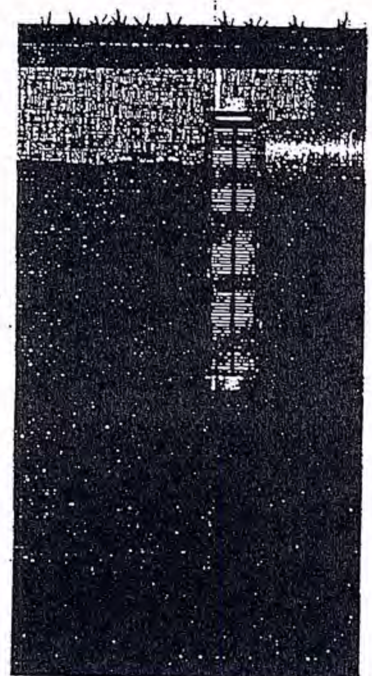
U.S. Patent 5,382,357

For More Information Contact:

Manufactured by Zabel Environmental Technology • 10409 Watterson Trail • Jeffersontown, KY 40299

Zabel A1800 Residential Septic Tank Effluent Filter Specifications





Typical A1800 Installation

Application: Single family homes.

Flow Rate: 800 gpd.

Installation: The A1800 Effluent Filter Cartridge will fit any 4" sanitary tee and sewage pipe used as a septic tank outlet baffle. Extend the sewage pipe at least one inch below the bottom of the filter cartridge gasket.

Service: Grasp filter handle and pull up to remove from Sanitary Tee. Lightly hose off taking care to wash the effluent back into the tank and not on the ground.

Service Frequency: Clean the filter cartridge when the tank is normally inspected and pumped.

Materials: Injection molded PVC.

Lifetime Warranty: Covers the filter cartridge–labor for removal and re-installation is not included.

U.S. Patent No. 5,382,357

Questions concerning The Zabel A1800 Effluent Filter please call 1-800-221-5742 or Fax (502) 267-8801 for further information.

Zabel A 1800 Septic Tank Filter Testing Independent Research

by Division of Water Resources Personnel, Dover, DE.

Abstract

During the period June 1994 through June 1995 a Zabel Model A1800 Tank Filter was tested in place in two separate septic systems. One system was subject to moderately heavy use and the other to light use. In both cases the tank's flow-through was unimpeded throughout testing. "Grab" sample analysis and "observation" were the methods used to evaluate the A1800's performance. Effluent from the moderately heavy use system with the A1800 in place exhibited a 76% reduction in Total Suspended Solids(TSS) over the test period while effluent from the light use system exhibited a 51% reduction in TSS. Small improvements in BOD (Biological Oxygen Demand) were observed at both sites.

Call Zabel at 502-267-1222 for further details.[1]

[1] Department of Natural Resources and Environmental Control, Division of Water Resources, Dover, DE. By Steve Rohm with active participation by Hollis Warren Jr. and Ken Darling from the Local Industry. June '94 through June '95.

Zabel A1800 Septic Tank Filter Testing
Independent Research*
"Moderate" Use Residential Site

TIME	TSS(MG/L)	REDUCTION IN TSS (%)
Before filter	289	----
After filter(days)		
45	112	61
75	139	52
99	100	65
159	85	71
358	70	76

*Department of Natural Resources and Environmental Control, Division of Water Resources, Dover, DE. By Steve Rohm with active participation by Hollis Warren Jr. and Ken Darling f the Local Industry. Period covered by this research was June '94 through June '95.

SEPTIC SYSTEM SETBACK REQUIREMENTS

To provide adequate soil contact volume for long-term phosphorus removal assuming:

5 % regeneration of attenuation sites

Required Total Contact Volume= >16,000 cubic feet

@.01 KgP/cu ft
Need > 8000 cu ft.

Total Soil Contact Volume= Field Volume + Setback Volume
Field Volume= W x L x D
Setback Volume= WV x L x X (WV assumed = 1/2 Davg)

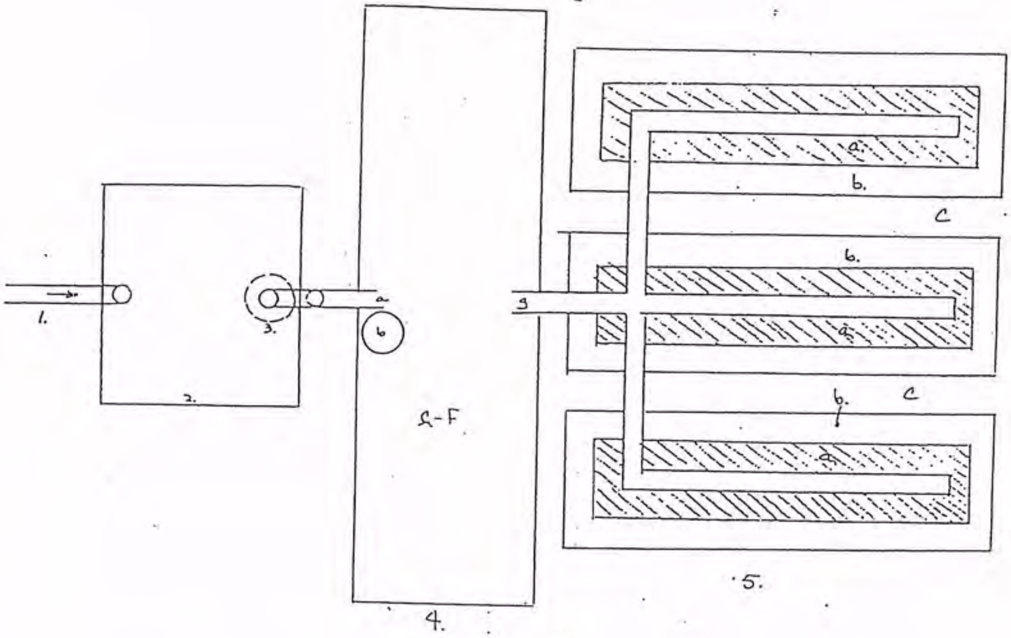
Davg (ft)	L (ft)	Field V	WV (ft)	Required Setback (ft)
1	50	1250	0.5	590
2	50	2500	1	270
3	50	3750	1.5	163
4	50	5000	2	110
1	75	1875	0.5	377
2	75	3750	1	163
3	75	5625	1.5	92
4	75	7500	2	57
1	100	2500	0.5	270
2	100	5000	1	110
3	100	7500	1.5	57
4	100	10000	2	30

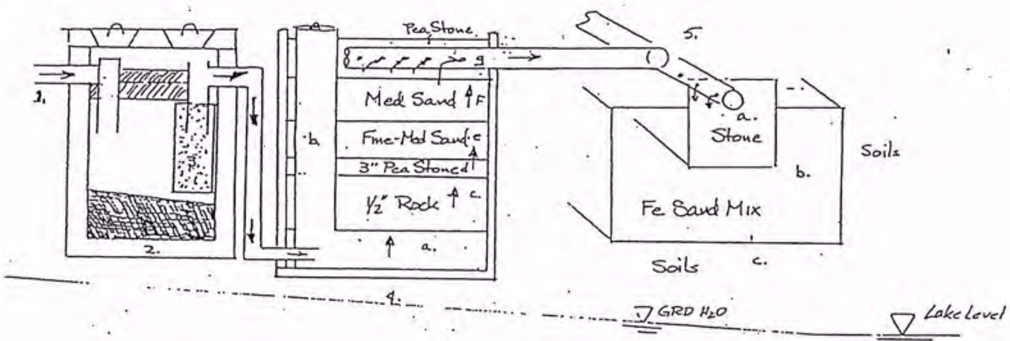
Assumptions Used:

* 5% of consumed soil attenuation sites are regenerated each year,
* Depth of leachate plume on top of the natural water table (soil contact depth) equals one half the average depth to groundwater between the leaching field and point of exfiltration (wetland, stream, or lake),
* Leaching field width equals 25 feet,
* Soil attenuation equals .005 kg P/cubic ft (average for soils found in the watershed),
* Input of P to a septic system equals 4 kg/year (single family res.)

Variables:

* L= Length of leaching field paralel to topographic contours,
* Davg= Average depth of watertable between the leaching field and point of exfiltration (wetland, stream, or lake).





Schematic - N & P Removal Septic System

Components: 1.) Septic Pipe from House
2.) Septic Tank (min. 1000 gal.) (Aerobic?)
3.) Tank Effluent Filter
4.) Upflow Sand Filter
a. distribution chamber
b. cleanout
c-F. layers of stone - sand
g. filter outlet
5.) Drain (Leaching) Field
a. Stone Trenches
b. Ferric Sand Mix
c. Natural Soil Profile

Notes: Tanks Must be Watertight

ECOSYSTEM CONSULTING SERVICE, INC.

LAKE COMMUNITY FERTILIZER

Although I enjoy landscaping and take pride in my green lawn, the fact that I too could be contributing to the proliferation of the weed scourge concerned me and I was looking for alternatives. In the past, I had used an organic fertilizer (15-3-7) which was lower in phosphorous than the traditional commercial brand, and due to its slow release capabilities, necessitated less frequent use. What I learned from Gerry was that there is available, through Aquatic Control, a lake-friendly fertilizer that is phosphorous free (15-0-5), 15% nitrogen, 0% phosphorous, and 5% potash.

One pound of phosphorous can result in over 10,000 lbs. wet weight of weeds and algae growth. Most lawn fertilizers contain 5 to 15% phosphorous or 2.5 to 7.5 lbs. per 50 lb. bag. It doesn't take too many pounds of phosphorous to encourage and support excessive weed and algae growth.

Of the total nitrogen in Lake Community Fertilizer, 50% is of the slow release formulation which will feed your lawn for 2-3 months. Two applications, one in early spring, and a second in the fall, will provide adequate "greening power" for nearly every lawn. A 50-lb. bag of Lake Community Fertilizer will cover approximately 7500 sq. ft. of lawn area. Most established lawns require little, if any, phosphorous if proper soil pH is maintained by the addition of lime. As Gerry noted, the only significant benefit of phosphorous is for root development in a new lawn. In summation, using Lake Community Fertilizer is a contribution that you can make that helps the lake and your lawn.
Aquatic Control Technology, Inc. is willing to provide LMPA members with Lake Community Fertilizer at a cost of $21.75 for a 50-lb. bag. However, Gerry needs an LMPA order of ten or more bags. Personally, I am committed to the use of Lake Community Fertilizer and will be ordering three bags. If anyone else is interested, I will be placing an order by the middle of March. Please call me at 478-9568 and join in the fight against weed infestation on our lake.

Dave Gibbs

Columbia Phosphorus Fertilizer Ban

Based on a recommendation of your Columbia Lake Watershed Management Task Force, the Board of Selectmen has endorsed a ban on the use of lawn fertilizers which contain more than 4% available phosphate. The ban is a part of a comprehensive plan being developed by the Task Force to reduce the nutrient loading to Columbia Lake. Several research studies have been conducted, which have identified phosphorus as the nutrient which stimulates algae growth in Columbia Lake. If phosphorus levels increase there will be more algae. The Task Force is examining all of the sources of phosphorus input to the lake, as well as practical methods to reduce those phosphorus amounts in order to preserve Columbia Lake. Columbia Lake continues to be one of the highest quality water resources in the area. One source of phosphorus that can be reduced is the application of lawn fertilizers, which contributes up to 15% of the phosphorus that gets into the lake. Restrictions on the use of high phosphorus content lawn fertilizers will be of benefit for protecting Columbia Lake.

Fortunately, lawns generally do not require very much phosphorus!
Low phosphorus fertilizer will keep the lawn green...and the lake clean!

The "Fertilizer Ban" includes the following guidelines:

- **The phosphorus content of lawn fertilizers should not exceed 4%.** Fertilizers have a three number system stated on packaging which indicates the fractions of available Nitrogen (N), Phosphorus (P), and Potassium(K). For example, 25-4-4 fertilizer contains 25% N, 4% P, and 4% K containing compounds. The ban restricts the content of Phosphorus compounds (the middle number) to 4% or less. This type of lawn fertilizer is readily available in local stores.

- **Reduce the total amount of fertilizer used in the spring.** We suggest application of the total dose in two parts, several weeks apart; and only apply the second half if the turf needs it (for example if it hasn't "greened up" adequately).

- **Apply lawn fertilizer only after significant rainstorms, when no further storms are forecast for the next several days.** "Water in" the fertilizer after application. These measures will help keep your fertilizer investment on your lawn where it is needed, and out of Columbia Lake (where it is not needed).

- **If necessary, apply higher phosphorus content lawn fertilizer only between Labor Day and Columbus Day.** This is when the phosphorus requirement of lawns is higher for root development and to help grasses "over-winter". Again be careful with amounts applied and timing of applications.

Thank you for participating in this voluntary **Phosphorus Lawn Fertilizer Ban.** Your efforts will help preserve a clean and healthy Columbia, and Columbia Lake Ecosystem. *Thank you for helping to reduce nutrient runoff - for the sake of Columbia Lake!*

Columbia Board of Selectmen

Nutrient Allocation Plan and Policy
NAPP: A Quantitative Watershed Planning Approach

Robert W. Kortmann, Ph.D., Ecosystem Consulting Service, Inc.
430 Talcott Hill Road Coventry, Conn. 06238 (203)742–0744

The sum of many, seemingly insignificant, land-use impacts can cause degradation of a water resource. Best Management Practices (BMPs) are available to control water quality of runoff from all aspects of land-use: Development, Agriculture, Stormwater Control, Wastewater Treatment, etc. However, implementation of an effective and appropriate combination of BMPs for a specific land-use remains rare for a variety of reasons. The 5th Amendment of the United States Constitution ensures that private property (and use thereof) shall not be "taken" without due compensation (the "Taking Issue"). The cumulative impacts of many users need to be accounted for to regulate an individual's use (and contribution to impact). Resource allocation planning (a.k.a. Nutrient Allocation Plan and Policy - NAPP) is an approach to quantifying cumulative impact as a basis for land-use regulation.

NAPP can provide an effective means for watershed management planning because:

1) NAPP is built on a sound scientific basis -- *a reason for regulation,*
2) NAPP "allocates" the tolerance of a water resource for watershed loads among all watershed areas and users -- *it is equitable; not discriminatory.*
3) NAPP does not prohibit any land-use. It requires adequate BMP implementation by a specific land-user to protect the resource -- *it avoids the "Taking Issue."*

Nutrient Allocation Planning is a quantitative approach to long-term protection of a lake-watershed system. The "Threshold Nutrient Load" of a water resource is identified and "Allocated" across the tributary watershed. Land-uses are assessed relative to the areal nutrient load from a specific property. If the "nutrient export allocation" for the property is exceeded, Best Management Practices (BMPs) are identified to help bring the use within the allocation. The development of a NAPP requires a field-based assessment of the water resource, upon which a spreadsheet land-use evaluation model is based.

Columbia Lake- Nutrient Allocation Approach

A Nutrient Allocation Approach has been developed for Columbia Lake. Phosphorus is a particularly important plant nutrient in many lakes. If more phosphorus entered Columbia Lake (total phosphorus = TP) it would stimulate more algae growth. If a "threshold amount" of TP entered Columbia Lake, too much algae growth would occur, the long-term water quality goals could not be achieved. The amount of TP which comes from three types of landscapes can be "estimated or predicted":

0.10 lb / acre / year from undisturbed woodlands,

1.0 lb / acre / year from semi-pervious areas,

1.1 lb / acre / year from impervious areas.

These "unit estimates" are consistent with data reported in the National Eutrophication Survey and research conducted in Connecticut (see: Norvell, et al., 1979; end of this Appendix). Hence, we can forecast or estimate how much TP is likely to enter Columbia Lake from an existing or proposed land-use.

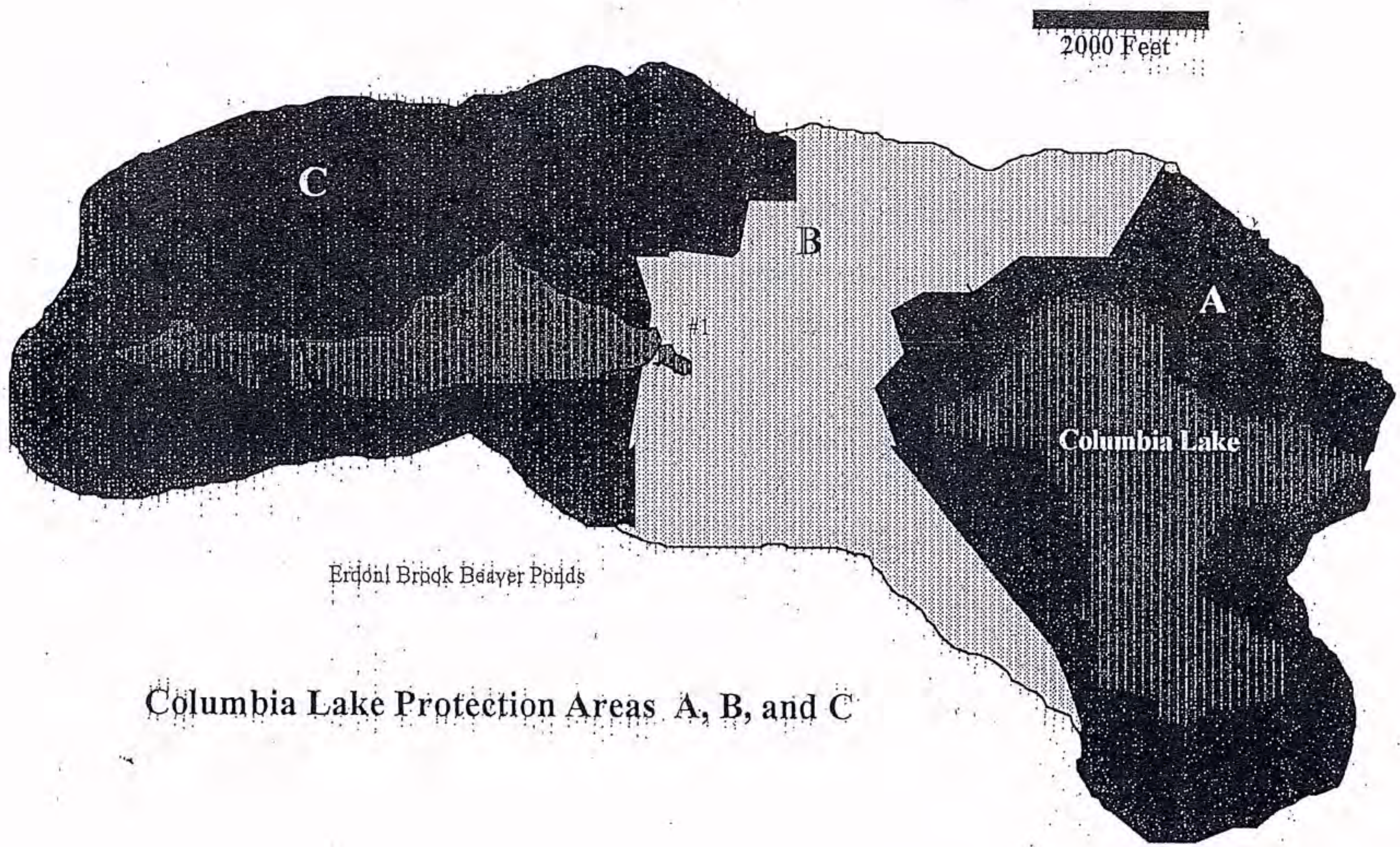
We can also estimate "how much TP is too much for Columbia Lake"? In order to achieve the long-term preservation goals as defined, we need to keep annual TP loading from the watershed below 330 Kg TP / year (less than 727 lb TP / year). Phosphorus export from the watershed must remain below this limit. The Task Force discussed a variety of "allocation strategies", and recommends the following per acre limits for each of three "Lake Protection Areas":

Lake Protection Area A (lake area):	0.32 lb TP / acre / year
Lake Protection Area B:	0.37 lb TP / acre / year
Lake Protection Area C (most remote):	0.42 lb TP / acre / year

Note that the lowest allowable TP export is from areas closest to the Lake (A), and areas which drain directly to the Lake (B). In more remote watershed areas slightly higher limits are allowed.

Using the estimated TP export for each cover type (wooded, semi-pervious, impervious) we can estimate how much TP is/will be contributed by a particular parcel of land. We can also multiply the area of a parcel by the allocation for its Lake Protection Area. The product is the "allocation" for the parcel. A comparison identifies whether too much TP is contributed by the parcel/land-use.

If the proposed or existing land-use exceeds its TP allocation (i.e. its "fair share" of phosphorus export), then best management practices (BMPs) are needed to control water quality impacts. BMPs are methods which reduce the TP export without prohibiting the land-use. Many BMPs have been developed over the past 10-15 years.



Columbia Lake Protection Areas A, B, and C

The Task Force has examined BMPs and selected several which are most appropriate for Columbia. The Task Force has assigned a "reduced amount of phosphorus export" for areas served by approved BMPs. Hence, if a land-use is determined to exceed its TP allocation, the land owner can apply BMPs to control water quality and bring his/her use within the allocation.

Best Management Practices (BMPs)

1.) *Retain more undisturbed woodland.*

The best way to reduce nutrient loading related to development is to minimize areas of semi- and impervious surfaces. The more land area that remains as undisturbed woodland the better. "Undisturbed Woodland" means just that, *undisturbed*, with its closed canopy, shrub, ground cover, and forest floor soils *intact*. Such a woodland is a very valuable watershed asset. Areas retained as undisturbed woodlands are assigned only 0.10 lb TP / acre / year export, which can offset other use area export! Minimizing disturbed areas should be the first step in any land-use proposal in the watershed.

2.) *Creation of Simulated Woodlands*

Conversion of lawns and other semi-pervious areas to a "simulated woodland" can significantly reduce TP export. This "landscaping technique" is particularly applicable to existing development in the Lake Protection Area A. It involves converting areas to a landscape that imitates an undisturbed woodland, though the landscaping can be more "ornamental". Careful design and layout can retain view corridors and not impact the "lake-front" features of the property. Conversion to acceptable "simulated woodland" involves:

- Spreading 2-3 inches of Peat Moss and then Rototiling the entire area to at least 6" deep,
- Covering the rototilled area with woodchip/bark mulch,
- Planting evergreen and/or deciduous tree saplings (>1"DBH) with 20-30 foot on-center spacing,
- Planting lower growing shrubs (5-15 ft tall when mature) for about 50% coverage (when fully grown),
- Planting ground covers (<5 feet tall) over 50% coverage (when fully grown).

This BMP is a landscaping technique which will "function" like a woodland; it is assigned 0.20 lb TP export / acre / year.

3.) *First-Flush Infiltration*

This BMP involves collecting runoff from impervious surfaces (driveways, rooftops) and directing the first ½ to 1 inch of rainfall runoff to an in-ground chamber where it will slowly percolate into the ground before the next storm. The chamber can be any suitable chamber, one identified as a low cost system is 24" diameter polyethylene pipe with end caps and cleanout ports. Such a chamber is shallow (good for high water table areas, low cost, and can be expanded by adding pipe lengths. Areas treated using ½ inches and 1 inch First-Flush infiltration are assigned 0.40 lb TP / acre / year and 0.20 lb TP / acre / year, respectively.

4.) *Runoff Detention and Created Wetlands*

These BMPs can be usefull in certain circumstances, such as to treat runoff from several lots in a development. They are less applicable for individual lots. Basic design criteria and TP export assignments have been assigned to these BMPs.

The Task Force recommends that the Nutrient Allocation Approach be used as an assessment tool for several years. Eventually the allocation approach may be incorporated into Inland Wetland and/or Zoning Regulations for the Columbia Lake watershed.

A computerized Excell™ Spreadsheet has been developed and tested for nutrient allocation assessment. A variety of examples are included in this Appendix.

Town of Columbia, Connecticut

Nutrient Allocation - Land Use Worksheet

Overall Watershed Areal P Export Allocation=	**0.32**	lb P Acre^{-1} Year^{-1}
Watershed District A	**0.32**	lb P Acre^{-1} Year^{-2}
Watershed District B	**0.37**	lb P Acre^{-1} Year^{-3}
Watershed District C	**0.42**	lb P Acre^{-1} Year^{-4}

Base Loading Areal TP Allocations:

Undisturbed Woodlands=	*0.1*	lb P Acre^{-1}.Year^{-1}
Semi-Pervious Area=	*1*	lb P Acre^{-1} Year^{-1}
Impervious Area=	*1.5*	lb P Acre^{-1} Year^{-1}

Land Owner:

Address:

Assessors Location Map, Block, Parcel:

Parcel Area=	sq ft	0	Acres	0 Sq. Feet
Parcel Allocation=	Watershed District A	0	lb P Year^{-1}	
	Watershed District B	0	lb P Year^{-2}	
	Watershed District C	0	lb P Year^{-3}	

Residential Use:

	sq ft	Est P Load (lb P / acre / yr)	No BMP Credits LOAD
Roof		1.3	0
Driveway/Road		1.5	0
Lawn		1	0
Woodland		0.1	0
Pond Surface		0.2	0
TOTAL	0		0

If this exceeds allocation for the District additional BMPs are needed prior to approval.

BMPs and Export Assignments:

If the total P LOAD calculated above exceeds the ALLOCATION for your property (identified above) you will need to incorporate "Best Management Practices" (BMPs) to reduce nutrient export from your proposed use. Areas of your property served by the identified Best Management Practices are then assigned a reduced LOAD Rate, and your total parcel LOAD is recalculated and compared to the ALLOCATION for your property. BMPs will be required to a degree which meets your ALLOCATION, or as deemed "feasible and prudent" for the protection of the Columbia Lake Resource.

	Decrease Semi- and Impervious Areas; Retain More Undisturbed Woodland.	
	Convert Semi-Pervious Area to "Simulated Woodland"	0.2 lb/acre/year
	First Flush Infiltration of 1" Runoff	0.2 lb/acre/year
	First Flush Infiltration of 1/2" Runoff	0.4 lb/acre/year
	Detention Pool Basin >1% of Drainage Area, "Live Storage" for 1" of Runoff	0.6 lb/acre/year
	Created Treatment Wetland: >0.5% Drainage Area as Permanent Pool, plus >0.8% Drainage Area as NRCS-Type Wetland	0.6 lb/acre/year

BMP REVISED PLAN				*Town of Columbia, Connecticut*					
		Nutrient Allocation - Land Use Worksheet							
		Overall Watershed Areal P Export Allocation=					0.32	lb P Acre^{-1} Year^{-1}	
				Watershed District A			0.32	lb P Acre^{-1} Year^{-2}	
				Watershed District B			0.37	lb P Acre^{-1} Year^{-3}	
				Watershed District C			0.42	lb P Acre^{-1} Year^{-4}	
Base Loading Areal TP Allocations:									
	Undisturbed Woodlands=		*0.1*	lb P Acre^{-1} Year^{-1}					
	Semi-Pervious Area=		*1*	lb P Acre^{-1} Year^{-1}					
	Impervious Area=		*1.5*	lb P Acre^{-1} Year^{-1}					
	Land Owner:								
	Address:								
	Assessors Location Map, Block, Parcel:								
	Parcel Area=			sq ft	0	Acres		0	
	Parcel Allocation=		Watershed District A		0	lb P Year^{-1}		Sq. Feet	
			Watershed District B		0	lb P Year^{-2}			
			Watershed District C		0	lb P Year^{-3}			

Residential Use: — No BMP Credits

	sq ft	Est P Load (lb P / acre / yr)	LOAD
Roof		1.3	0
Driveway/Road		1.5	0
Lawn		1	0
Woodland		0.1	0
Pond Surface		0.2	0
TOTAL	0	Total Estimated Load	0

Application of BMPs and Export Assignments:

Residential Use: — No BMP Credits

AREAS NOT SERVED BY A BMP:

	sq ft	Est P Load (lb P / acre / yr)	LOAD
Roof		1.3	0
Driveway/Road		1.5	0
Lawn		1	0
Woodland		0.1	0
Pond Surface		0.2	0

AREAS SERVED BY A BMP:

	sq ft	Est P Load (lb P / acre / yr)	LOAD
Simulated Woods		0.2	0
1" First Flush Infiltration		0.2	0
1/2" First Flush Infiltration		0.4	0
Detention Pool		0.6	0
Treatment Wetland		0.4	0
Total Area=	0	*Total Estimated Load=*	*0*

EXAMPLES- NUTRIENT ALLOCATION ASSESSMENT APPLIED

Several moderate to large scale subdivisions were tested. In general, most were brought into compliance with NAP by preserving adequate undisturbed woodlands. The smaller lots and existing development around the lake provided more of a challenge.

Example A: A 0.40 acre lake front property. It originally had an allocation of 0.128 lb /year and a predicted export of 0.41 lb / year. It clearly exceeded its allocated TP export. Two BMPs were applied: "simulated woodlands" and an infiltration system for roof and driveway first flush runoff treatment. These BMPs resulted in a predicted 0.127 lb TP export per year, *within the allocation for the property.*

Example B: 0.59 acres; estimated export = 0.63 lb / year; allocation = 0.189 lb / year.
Allocation Exceeded.
Application of a first flush infiltration system reduced export to 0.172 lb / year; within the allocation.

Example C: 1.55 acres; Export=1.05; Allocation= 0.496; Export was reduced to 0.492 simply by retaining more undisturbed woodland (no BMPs needed).

Example D: Only 0.218 acres, TP Export = 0.242 lb/year; Allocation = 0.07 lb / year. This is a very small lake-front lot. A very carefully planned landscaping design for "simulated woodlands, and a first-flush infiltrator for roof and driveway runoff were able to bring the use within its allocation (export with BMPs= 0.062 lb/year).

Example E: This was the most "extreme case" evaluated. Area = 0.48 acres with a very large house, etc. No combination of BMPs were able to bring TP export within the allocation. However, BMPs and a reduction in the scale of the proposed use expansion was able to come very close to the allocation. The question of "reasonable use" was raised. The somewhat smaller expansion provides reasonable use with less lake impact.

(A)

Town of Columbia, Connecticut

Nutrient Allocation - Land Use Worksheet

Overall Watershed Areal P Export Allocation=	0.32	lb P $Acre^{-1}$ $Year^{-1}$
Watershed District A	0.32	lb P $Acre^{-1}$ $Year^{-2}$
Watershed District B	0.37	lb P $Acre^{-1}$ $Year^{-3}$
Watershed District C	0.42	lb P $Acre^{-1}$ $Year^{-4}$

Base Loading Areal TP Allocations:

Undisturbed Woodlands=	*0.1*	lb P $Acre^{-1}$ $Year^{-1}$
Semi-Pervious Area=	*1*	lb P $Acre^{-1}$ $Year^{-1}$
Impervious Area=	*1.5*	lb P $Acre^{-1}$ $Year^{-1}$

Land Owner: LOT "A"

Address:

Assessors Location Map, Block, Parcel:

Parcel Area= 17450 sq ft — 0.400597 Acres — 17450 Sq. Feet

Parcel Allocation=		
Watershed District A	0.128191	lb P $Year^{-1}$
Watershed District B	0.148221	lb P $Year^{-2}$
Watershed District C	0.168251	lb P $Year^{-3}$

Residential Use:

	sq ft	Est P Load (lb P / acre / yr)	**No BMP Credits** LOAD
Roof	2969.5	1.3	0.0886214
Driveway/Road	1744	1.5	0.0600551
Lawn	11452.5	1	0.2629132
Woodland	1284	0.1	0.0029477
Pond Surface	0	0.2	0
TOTAL	17450		0.4145374 EXCEEDED

If this exceeds allocation for the District additional BMPs are needed prior to approval.

BMPs and Export Assignments:

If the total P LOAD calculated above exceeds the ALLOCATION for your property (identified above) you will need to incorporate "Best Management Practices" (BMPs) to reduce nutrient export from your proposed use. Areas of your property served by the identified Best Management Practices are then assigned a reduced LOAD Rate, and your total parcel LOAD is recalculated and compared to the ALLOCATION for your property. BMPs will be required to a degree which meets your ALLOCATION, or as deemed "feasible and prudent" for the protection of the Columbia Lake Resource.

Decrease Semi- and Impervious Areas; Retain More Undisturbed Woodland.	
Convert Semi-Pervious Area to "Simulated Woodland"	0.2 lb/acre/year
First Flush Infiltration of 1" Runoff	0.2 lb/acre/year
First Flush Infiltration of 1/2" Runoff	0.4 lb/acre/year
Detention Pool Basin >1% of Drainage Area, "Live Storage" for 1" of Runoff	0.6 lb/acre/year
Created Treatment Wetland: >0.5% Drainage Area as Permanent Pool, plus >0.8% Drainage Area as NRCS-Type Wetland	0.6 lb/acre/year

BMP REVISED PLAN

Town of Columbia, Connecticut

Nutrient Allocation - Land Use Worksheet

Overall Watershed Areal P Export Allocation=	0.32	lb P Acre^{-1} Year^{-1}
Watershed District A	0.32	lb P Acre^{-1} Year^{-2}
Watershed District B	0.37	lb P Acre^{-1} Year^{-3}
Watershed District C	0.42	lb P Acre^{-1} Year^{-4}

Base Loading Areal TP Allocations:

Undisturbed Woodlands=	*0.1*	lb P Acre^{-1} Year^{-1}
Semi-Pervious Area=	*1*	lb P Acre^{-1} Year^{-1}
Impervious Area=	*1.5*	lb P Acre^{-1} Year^{-1}

Land Owner: Lot "A"

Address:

Assessors Location Map, Block, Parcel:

Parcel Area=	17450	sq ft	0.400597	Acres	17450	Sq. Feet
Parcel Allocation=	Watershed District A		0.128191	lb P Year^{-1}		
	Watershed District B		0.148221	lb P Year^{-2}		
	Watershed District C		0.168251	lb P Year^{-3}		

Residential Use:

	sq ft	Est P Load (lb P / acre / yr)	No BMP Credits LOAD
Roof	2969.5	1.3	0.088621
Driveway/Road	1744	1.5	0.060055
Lawn	11452.5	1	0.262913
Woodland	1284	0.1	0.002948
Pond Surface	0	0.2	0
TOTAL	17450	Total Estimated Load	0.414537

Application of BMPs and Export Assignments:

Residential Use:

AREAS NOT SERVED BY A BMP:

	sq ft	Est P Load (lb P / acre / yr)	No BMP Credits LOAD
Roof	0	1.3	0
Driveway/Road	0	1.5	0
Lawn	2000	1	0.045914
Woodland	1284	0.1	0.002948
Pond Surface	0	0.2	0

AREAS SERVED BY A BMP:

	sq ft	Est P Load (lb P / acre / yr)	LOAD
Simulated Woods	9452.5	0.2	0.0434
" First Flush Infiltration	1744	0.2	0.008007
/2" First Flush Infiltration	2969.5	0.4	0.027268
Detention Pool		0.6	0
Treatment Wetland		0.4	0
Total=	17450	*Total Estimated Load=*	***0.127537***
			COMPLIANCE

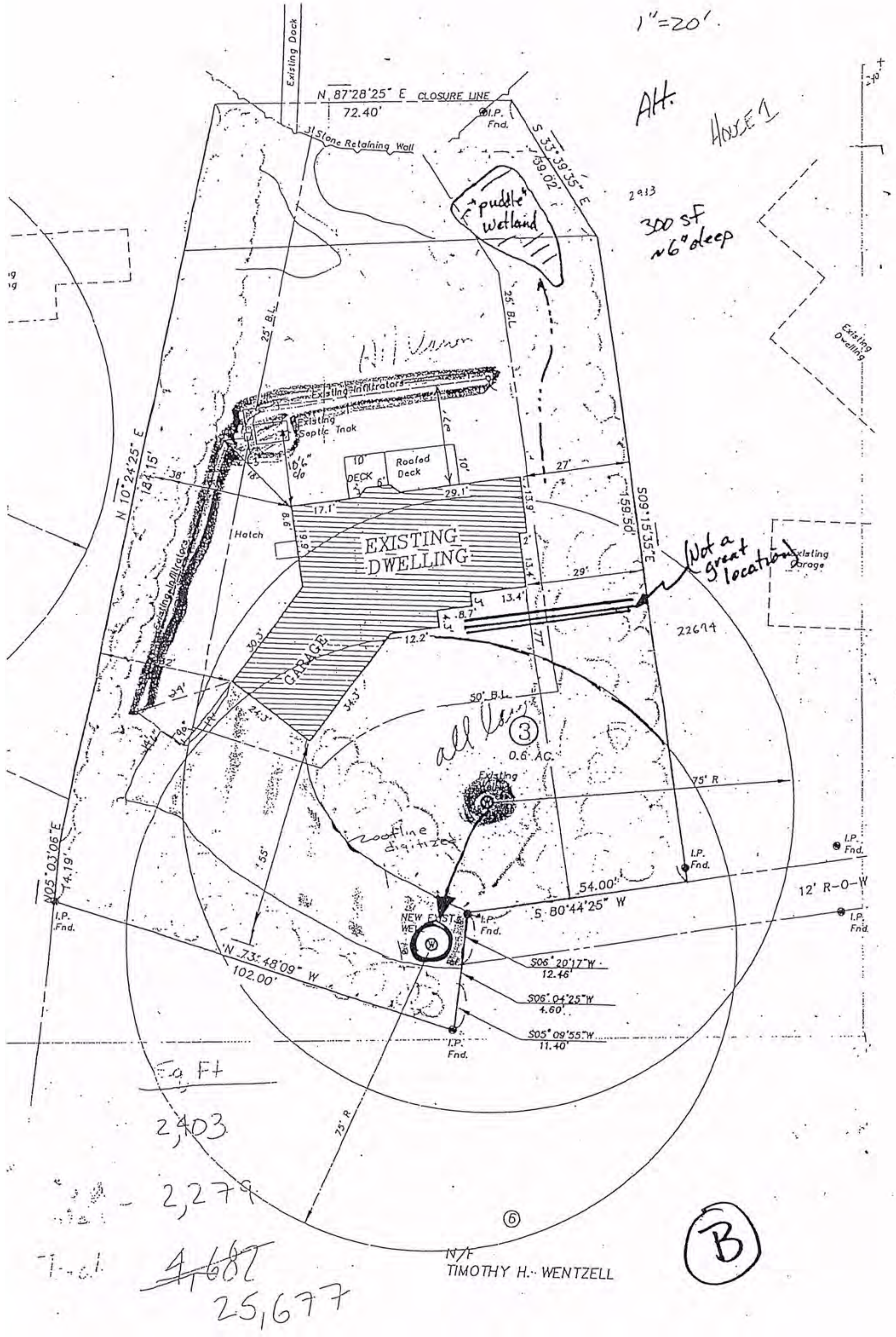
(B)

BMP REVISED PLAN			Town of Columbia, Connecticut				
		Nutrient Allocation - Land Use Worksheet					
		Overall Watershed Areal P Export Allocation=				0.32	lb P Acre⁻¹ Year⁻¹
			Watershed District A			0.32	lb P Acre⁻¹ Year⁻²
			Watershed District B			0.37	lb P Acre⁻¹ Year⁻³
			Watershed District C			0.42	lb P Acre⁻¹ Year⁻⁴
Base Loading Areal TP Allocations:							
Undisturbed Woodlands=		0.1	lb P Acre⁻¹ Year⁻¹				
Semi-Pervious Area=		1	lb P Acre⁻¹ Year⁻¹				
Impervious Area=		1.5	lb P Acre⁻¹ Year⁻¹				
	Land Owner:	"B"					
	Address:						
	Assessors Location Map, Block, Parcel:						
Parcel Area=		25677	sq ft	0.589463	Acres	25677	
Parcel Allocation=		Watershed District A		0.188628	lb P Year⁻¹	Sq. Feet	
		Watershed District B		0.218101	lb P Year⁻²		
		Watershed District C		0.247574	lb P Year⁻³		

Residential Use:				No BMP Credits	
	sq ft	Est P Load (lb P / acre / yr)			LOAD
Roof	2403		1.3		0.071715
Driveway/Road	2279		1.5		0.078478
Lawn	20995		1		0.481979
Woodland	0		0.1		0
Pond Surface	0		0.2		0
TOTAL	25677		Total Estimated Load		0.632172

Application of BMPs and Export Assignments:

Residential Use:				No BMP Credits	
AREAS NOT SERVED BY A BMP:					
	sq ft	Est P Load (lb P / acre / yr)			LOAD
Roof	0		1.3		0
Driveway/Road	0		1.5		0
Lawn	4500		1		0.103306
Woodland	20495		0.1		0.04705
Pond Surface	0		0.2		0
AREAS SERVED BY A BMP:					or
	sq ft	Est P Load (lb P / acre / yr)			LOAD
Simulated Woods			0.2		0
1" First Flush Infiltration	4682		0.2	→	0.021497
1/2" First Flush Infiltration			0.4		0
Detention Pool			0.6		0
Treatment Wetland			0.4		0
		Total Estimated Load=			*0.171853*
TOTAL	29677				*COMPLIANCE*


1"=20'
Att.
HOUSE 1
Existing Dock
N 87°28'25" E CLOSURE LINE
72.40'
I.P. Fnd.
Stone Retaining Wall
S 33°39'35" E
139.02'
"puddle" wetland
2913
300 sf
~6" deep
25' B.L.
Existing Infiltrators
Existing Septic Tank
10'6" c/o
10' DECK
Roofed Deck
10'
27'
29.1'
17.1'
N 10°24'25" E
184.15'
Hatch
EXISTING DWELLING
S09°15'35"E
159.50'
Not a great location
Existing Garage
Existing Dwelling
29'
13.4'
8.7'
22674
12.2'
GARAGE
30.3'
34.3'
24.3'
50' B.L.
3
0.6 AC.
Existing Well
75' R
rootline digitized
55'
N05°03'06"E
14.19'
I.P. Fnd.
54.00'
S 80°44'25" W
12' R-O-W
NEW EXIST. WELL
N 73°48'09" W
102.00'
S06°20'17"W
12.46'
S06°04'25"W
4.60'
S05°09'55"W
11.40'
Sq Ft
2,403
2,279
4,682
25,677
6
N/F
TIMOTHY H. WENTZELL
B

C

BMP REVISED PLAN		Town of Columbia, Connecticut		

Nutrient Allocation - Land Use Worksheet

Overall Watershed Areal P Export Allocation=		0.32	lb P Acre^{-1} Year^{-1}
	Watershed District A	0.32	lb P Acre^{-1} Year^{-2}
	Watershed District B	0.37	lb P Acre^{-1} Year^{-3}
	Watershed District C	0.42	lb P Acre^{-1} Year^{-4}

Base Loading Areal TP Allocations:

Undisturbed Woodlands=	*0.1*	lb P Acre^{-1} Year^{-1}
Semi-Pervious Area=	*1*	lb P Acre^{-1} Year^{-1}
Impervious Area=	*1.5*	lb P Acre^{-1} Year^{-1}

Land Owner: C

Address:

Assessors Location Map, Block, Parcel:

Parcel Area=	67485	sq ft	1.549242	Acres	67485 Sq. Feet
Parcel Allocation=	Watershed District A		**0.495758**	lb P Year^{-1}	
	Watershed District B		0.57322	lb P Year^{-2}	
	Watershed District C		0.650682	lb P Year^{-3}	

Residential Use: No BMP Credits

	sq ft	Est P Load (lb P / acre / yr)	LOAD
Roof	2507	1.3	0.074819
Driveway/Road	2936	1.5	0.101102
Lawn	34000	1	0.780533
Woodland	40557	0.1	0.093106
Pond Surface	0	0.2	0
TOTAL	80000	Total Estimated Load	1.049559

Application of BMPs and Export Assignments:

Residential Use: No BMP Credits

AREAS NOT SERVED BY A BMP:

	sq ft	Est P Load (lb P / acre / yr)	LOAD
Roof	2507	1.3	0.074819
Driveway/Road	2936	1.5	0.101102
Lawn	7000	1	0.160698
Woodland	67557	0.1	0.15509
Pond Surface	0	0.2	0

No BMP needed

AREAS SERVED BY A BMP:

	sq ft	Est P Load (lb P / acre / yr)	LOAD
Simulated Woods		0.2	0
1" First Flush Infiltration		0.2	0
1/2" First Flush Infiltration		0.4	0
Detention Pool		0.6	0
Treatment Wetland		0.4	0
		Total Estimated Load=	*0.491708*
			COMPLIANCE

BMP REVISED PLAN

Town of Columbia, Connecticut

Nutrient Allocation - Land Use Worksheet

Overall Watershed Areal P Export Allocation=	0.32	lb P Acre^{-1} Year^{-1}
Watershed District A	0.32	lb P Acre^{-1} Year^{-2}
Watershed District B	0.37	lb P Acre^{-1} Year^{-3}
Watershed District C	0.42	lb P Acre^{-1} Year^{-4}

Base Loading Areal TP Allocations:

Undisturbed Woodlands=	*0.1*	lb P Acre^{-1} Year^{-1}
Semi-Pervious Area=	*1*	lb P Acre^{-1} Year^{-1}
Impervious Area=	*1.5*	lb P Acre^{-1} Year^{-1}

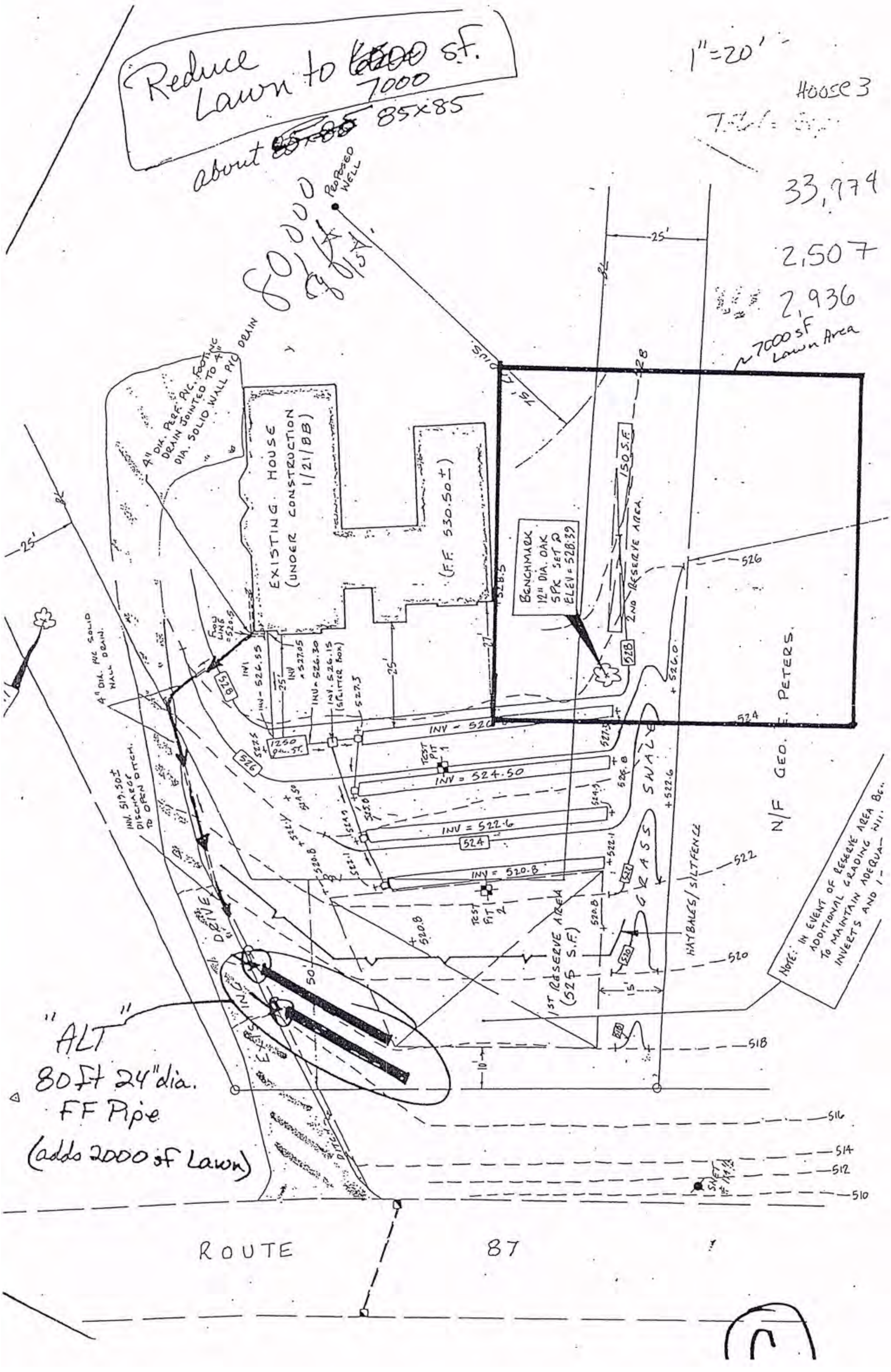
Land Owner:	"C" ALTERNATE			
Address:				
Assessors Location Map, Block, Parcel:				
Parcel Area=	67485	sq ft	1.549242 Acres	67485
Parcel Allocation=	Watershed District A	**0.495758**	lb P Year^{-1}	Sq. Feet
	Watershed District B	0.57322	lb P Year^{-2}	
	Watershed District C	0.650682	lb P Year^{-3}	

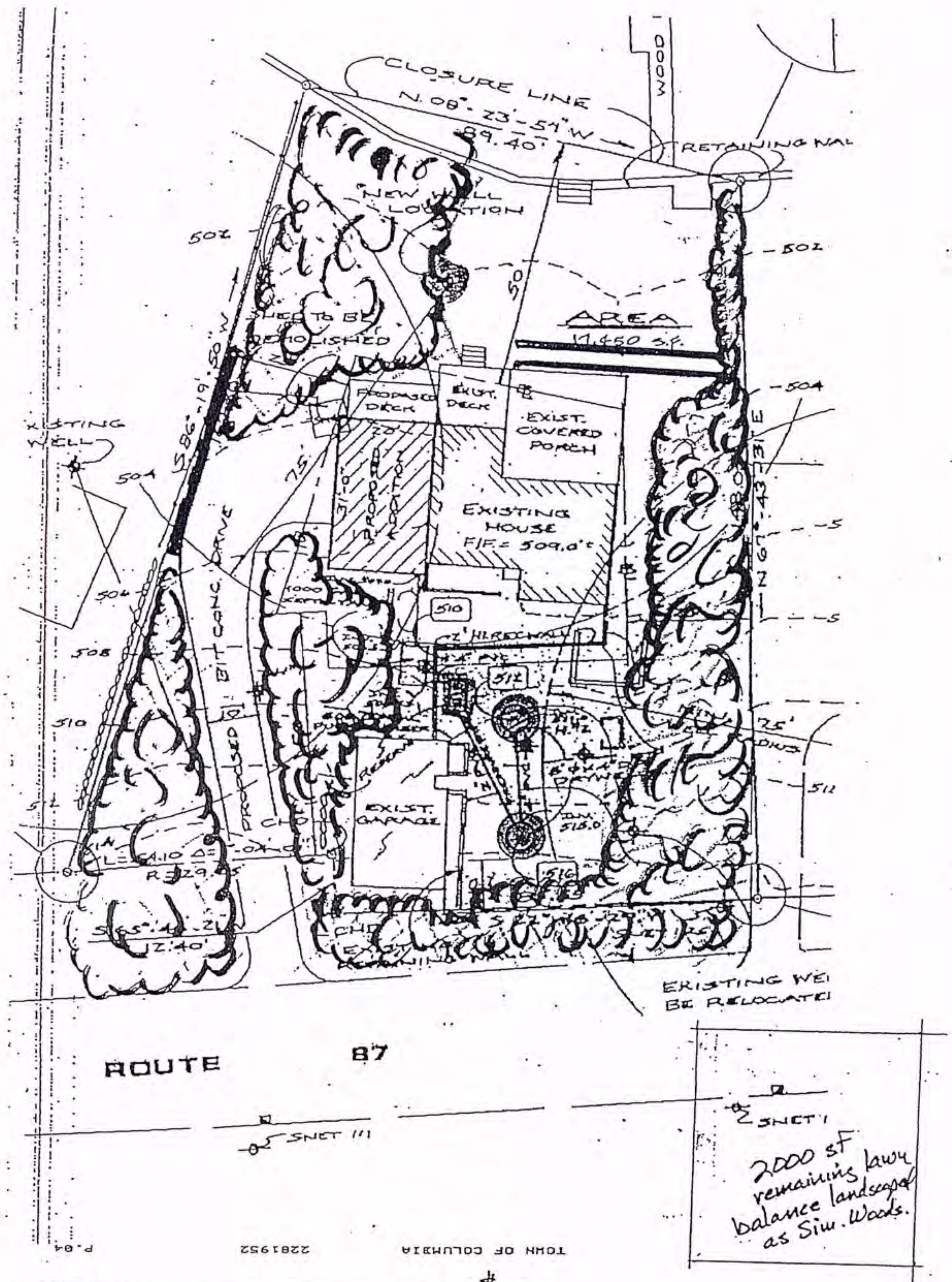
Residential Use:			No BMP Credits
	sq ft	Est P Load (lb P / acre / yr)	LOAD
Roof	2507	1.3	0.074819
Driveway/Road	2936	1.5	0.101102
Lawn	34000	1	0.780533
Woodland	40557	0.1	0.093106
Pond Surface	0	0.2	0
TOTAL	80000	Total Estimated Load	1.049559

Application of BMPs and Export Assignments:

Residential Use:			No BMP Credits
AREAS NOT SERVED BY A BMP:			
	sq ft	Est P Load (lb P / acre / yr)	LOAD
Roof	0	1.3	0
Driveway/Road	2936	1.5	0.101102
Lawn	9000	1	0.206612
Woodland	65557	0.1	0.150498
Pond Surface	0	0.2	0
AREAS SERVED BY A BMP:			
	sq ft	Est P Load (lb P / acre / yr)	LOAD
Simulated Woods		0.2	0
1" First Flush Infiltration		0.2	→ 0
1/2" First Flush Infiltration	2507	0.4	0.023021
Detention Pool		0.6	0
Treatment Wetland		0.4	0
		Total Estimated Load=	*0.481233*
TOTAL	80000		*COMPLIANCE*

or use BMP to allow more Lawn


Reduce Lawn to 7000 sf.
about 85x85
1"=20'
House 3
2,507
2,936
PROPOSED WELL
25'
~7000 sF Lawn Area
4" DIA. PERF. PVC FOOTING DRAIN JOINTED TO 4" DIA. SOLID WALL PVC DRAIN
EXISTING HOUSE (UNDER CONSTRUCTION 1/21/88)
(F.F. 530.50±)
BENCHMARK 12" DIA. OAK SPK SET ELEV = 528.39
150 S.F.
2ND RESERVE AREA
FLOW LINE = 520.5
4" DIA. PVC SOLID WALL DRAIN
INV. 526.15 (SPLITTER BOX)
1250 GAL. ST.
INV = 524.50
INV = 522.6
INV = 520.8
TEST PIT 1
TEST PIT 2
GRASS SWALE
HAYBALES/SILTFENCE
1ST RESERVE AREA (525 S.F.)
INV. 519.50± DISCHARGE TO OPEN DITCH
DRIVE
N/F GEO. E. PETERS
526
524
522
520
518
516
514
512
510
"ALT"
80 ft 24" dia.
FF Pipe
(adds 2000 sf Lawn)
DITCH
ROUTE 87



1" FF need 145 cuft Void
2'x2'x36' chamber
46ft long 24" Pipe

$ ~2300 Pipes

1/2" FF roof needs 769 cuft void
85ft long 24" Pipe

BMPs Needed

- 9453 sf Lawn to Sim Woods
- 1744 sf Drive 1" FF
- 2969 sf Roof 1/2" FF

"Caution Areas"

2000 sf lawn remains
ca 45'x45'

(D)

BMP REVISED PLAN

Town of Columbia, Connecticut

Nutrient Allocation - Land Use Worksheet

Overall Watershed Areal P Export Allocation=		0.32	lb P Acre^{-1} Year^{-1}
	Watershed District A	0.32	lb P Acre^{-1} Year^{-2}
	Watershed District B	0.37	lb P Acre^{-1} Year^{-3}
	Watershed District C	0.42	lb P Acre^{-1} Year^{-4}

Base Loading Areal TP Allocations:

Undisturbed Woodlands=	*0.1*	lb P Acre^{-1} Year^{-1}
Semi-Pervious Area=	*1*	lb P Acre^{-1} Year^{-1}
Impervious Area=	*1.5*	lb P Acre^{-1} Year^{-1}

Land Owner: "D"

Address:

Assessors Location Map, Block, Parcel:

Parcel Area=	9520	sq ft	0.218549	Acres		9520
Parcel Allocation=	Watershed District A		**0.069936**	lb P Year^{-1}		Sq. Feet
	Watershed District B		0.080863	lb P Year^{-2}		
	Watershed District C		0.091791	lb P Year^{-3}		

Residential Use:

	sq ft	Est P Load (lb P / acre / yr)	LOAD
		No BMP Credits	
Roof	1687	1.3	0.050347
Driveway/Road	1022	1.5	0.035193
Lawn	6811	1	0.156359
Woodland	0	0.1	0
Pond Surface	0	0.2	0
TOTAL	9520	Total Estimated Load	0.241899

Application of BMPs and Export Assignments:

Residential Use:

No BMP Credits

AREAS NOT SERVED BY A BMP:

	sq ft	Est P Load (lb P / acre / yr)	LOAD
Roof		1.3	0
Driveway/Road		1.5	0
Lawn	1000	1	0.022957
Woodland	0	0.1	0
Pond Surface	0	0.2	0

AREAS SERVED BY A BMP:

	sq ft	Est P Load (lb P / acre / yr)	LOAD
Simulated Woods	5811	0.2	0.02668
1" First Flush Infiltration	2709	0.2	0.012438
1/2" First Flush Infiltration	0	0.4	0
Detention Pool		0.6	0
Treatment Wetland		0.4	0
		Total Estimated Load=	*0.062075*
TOTAL	9520		*COMPLIANCE*

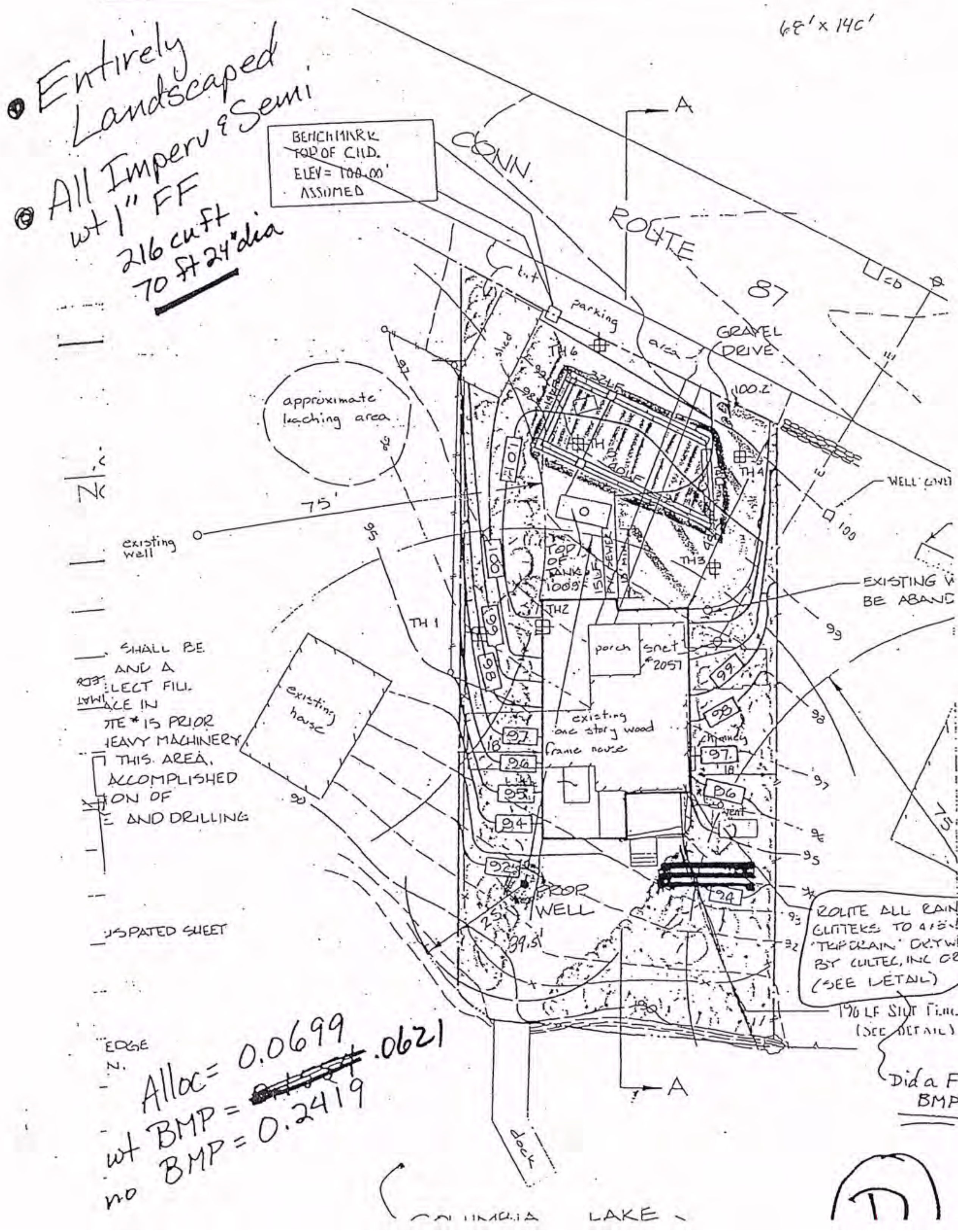
Total = ~~2,709~~ 9520 sf

= 1,479 + 208 = 1,687

[hatched symbol] = 1022

(1" = 20')

HOUSE 2



(E)

Town of Columbia, Connecticut

Nutrient Allocation - Land Use Worksheet

Overall Watershed Areal P Export Allocation=	0.32	lb P $Acre^{-1}$ $Year^{-1}$
Watershed District A	0.32	lb P $Acre^{-1}$ $Year^{-2}$
Watershed District B	0.37	lb P $Acre^{-1}$ $Year^{-3}$
Watershed District C	0.42	lb P $Acre^{-1}$ $Year^{-4}$

Base Loading Areal TP Allocations:

Undisturbed Woodlands=	0.1	lb P $Acre^{-1}$ $Year^{-1}$
Semi-Pervious Area=	1	lb P $Acre^{-1}$ $Year^{-1}$
Impervious Area=	1.5	lb P $Acre^{-1}$ $Year^{-1}$

Land Owner: "E"

Address:

Assessors Location Map, Block, Parcel:

Parcel Area= 20899 sq ft | 0.479775 Acres | 20899 Sq. Feet

Parcel Allocation=	Watershed District A	0.153528	lb P $Year^{-1}$
	Watershed District B	0.177517	lb P $Year^{-2}$
	Watershed District C	0.201506	lb P $Year^{-3}$

Residential Use:

	sq ft	Est P Load (lb P / acre / yr)	No BMP Credits LOAD
Roof	5066	1.3	0.1511892
Driveway/Road	1129	1.5	0.0388774
Lawn	14704	1	0.3375574
Woodland	0	0.1	0
Pond Surface	0	0.2	0
TOTAL	20899		0.527624 EXCEEDED

If this exceeds allocation for the District additional BMPs are needed prior to approval. *(Also POOR SEPTIC Setback)*

BMPs and Export Assignments:

If the total P LOAD calculated above exceeds the ALLOCATION for your property (identified above) you will need to incorporate "Best Management Practices" (BMPs) to reduce nutrient export from your proposed use. Areas of your property served by the identified Best Management Practices are then assigned a reduced LOAD Rate, and your total parcel LOAD is recalculated and compared to the ALLOCATION for your property. BMPs will be required to a degree which meets your ALLOCATION, or as deemed "feasible and prudent" for the protection of the Columbia Lake Resource.

Decrease Semi- and Impervious Areas; Retain More Undisturbed Woodland.	
Convert Semi-Pervious Area to "Simulated Woodland"	0.2 lb/acre/year
First Flush Infiltration of 1" Runoff	0.2 lb/acre/year
First Flush Infiltration of 1/2" Runoff	0.4 lb/acre/year
Detention Pool Basin >1% of Drainage Area, "Live Storage" for 1" of Runoff	0.6 lb/acre/year
Created Treatment Wetland: >0.5% Drainage Area as Permanent Pool, plus >0.8% Drainage Area as NRCS-Type Wetland	0.6 lb/acre/year

BMP REVISED PLAN

Town of Columbia, Connecticut

Nutrient Allocation - Land Use Worksheet

Overall Watershed Areal P Export Allocation=	0.32	lb P Acre^{-1} Year^{-1}
Watershed District A	0.32	lb P Acre^{-1} Year^{-2}
Watershed District B	0.37	lb P Acre^{-1} Year^{-3}
Watershed District C	0.42	lb P Acre^{-1} Year^{-4}

Base Loading Areal TP Allocations:

Undisturbed Woodlands=	*0.1*	lb P Acre^{-1} Year^{-1}
Semi-Pervious Area=	*1*	lb P Acre^{-1} Year^{-1}
Impervious Area=	*1.5*	lb P Acre^{-1} Year^{-1}

Land Owner: "E"

Address:

Assessors Location Map, Block, Parcel:

Parcel Area=	20899	sq ft	0.479775	Acres	20899
Parcel Allocation=	Watershed District A	**0.153528**	lb P Year^{-1}		Sq. Feet
	Watershed District B	0.177517	lb P Year^{-2}		
	Watershed District C	0.201506	lb P Year^{-3}		

Residential Use:

	sq ft	Est P Load (lb P / acre / yr)	No BMP Credits LOAD
Roof	5066	1.3	0.151189
Driveway/Road	1129	1.5	0.038877
Lawn	14704	1	0.337557
Woodland	0	0.1	0
Pond Surface	0	0.2	0
TOTAL	20899	Total Estimated Load	0.527624

Application of BMPs and Export Assignments:

Residential Use:

AREAS NOT SERVED BY A BMP:

	sq ft	Est P Load (lb P / acre / yr)	No BMP Credits LOAD
Roof	0	1.3	0
Driveway/Road	0	1.5	0
Lawn	3300	1	0.075758
Woodland	0	0.1	0
Pond Surface	0	0.2	0

AREAS SERVED BY A BMP:

	sq ft	Est P Load (lb P / acre / yr)	LOAD
Simulated Woods	12714	0.2	0.058375
" First Flush Infiltration	4779	0.2	0.021942
/2" First Flush Infiltration		0.4	0
etention Pool		0.6	0
reatment Wetland		0.4	0
		Total Estimated Load=	***0.15607***
TOTAL	20793		*NON-COMPLIANCE*
			BUT CLOSE

E

BMP REVISED PLAN

Town of Columbia, Connecticut

Nutrient Allocation - Land Use Worksheet

Overall Watershed Areal P Export Allocation=	0.32	lb P $Acre^{-1}$ $Year^{-1}$
Watershed District A	0.32	lb P $Acre^{-1}$ $Year^{-2}$
Watershed District B	0.37	lb P $Acre^{-1}$ $Year^{-3}$
Watershed District C	0.42	lb P $Acre^{-1}$ $Year^{-4}$

Base Loading Areal TP Allocations:

Undisturbed Woodlands=	*0.1*	lb P $Acre^{-1}$ $Year^{-1}$
Semi-Pervious Area=	*1*	lb P $Acre^{-1}$ $Year^{-1}$
Impervious Area=	*1.5*	lb P $Acre^{-1}$ $Year^{-1}$

Land Owner: "E"

Address:

Assessors Location Map, Block, Parcel:

Parcel Area=	20899	sq ft	0.479775	Acres	20899 Sq. Feet
Parcel Allocation=	Watershed District A		**0.153528**	lb P $Year^{-1}$	
	Watershed District B		0.177517	lb P $Year^{-2}$	
	Watershed District C		0.201506	lb P $Year^{-3}$	

Residential Use: No BMP Credits

	sq ft	Est P Load (lb P / acre / yr)	LOAD
Roof	5066	1.3	0.151189
Driveway/Road	1129	1.5	0.038877
Lawn	14704	1	0.337557
Woodland	0	0.1	0
Pond Surface	0	0.2	0
TOTAL	20899	Total Estimated Load	0.527624

Reduced Size of Expansion ("Reasonable Use")

Application of BMPs and Export Assignments:

Residential Use: No BMP Credits

AREAS NOT SERVED BY A BMP:

	sq ft	Est P Load (lb P / acre / yr)	LOAD
Roof	0	1.3	0
Driveway/Road	0	1.5	0
Lawn	3300	1	0.075758
Woodland	0	0.1	0
Pond Surface	0	0.2	0

AREAS SERVED BY A BMP:

	sq ft	Est P Load (lb P / acre / yr)	LOAD
Simulated Woods	12714	0.2	0.058375
1" First Flush Infiltration	4779	0.2	0.021942
1/2" First Flush Infiltration		0.4	0
Detention Pool		0.6	0
Treatment Wetland		0.4	0
		Total Estimated Load=	*0.156074*
TOTAL	20793		*NON-COMPLIANCE*
			BUT CLOSE

(E)

BMP REVISED PLAN			Town of Columbia, Connecticut			
	Nutrient Allocation - Land Use Worksheet					
	Overall Watershed Areal P Export Allocation=				0.32	lb P Acre^{-1} Year^{-1}
			Watershed District A		0.32	lb P Acre^{-1} Year^{-2}
			Watershed District B		0.37	lb P Acre^{-1} Year^{-3}
			Watershed District C		0.42	lb P Acre^{-1} Year^{-4}

Base Loading Areal TP Allocations:

Undisturbed Woodlands=	*0.1*	lb P Acre^{-1} Year^{-1}
Semi-Pervious Area=	*1*	lb P Acre^{-1} Year^{-1}
Impervious Area=	*1.5*	lb P Acre^{-1} Year^{-1}

Land Owner:	"D" E				
Address:					
Assessors Location Map, Block, Parcel:					
Parcel Area=	~~9520~~	sq ft	0.218549	Acres	9520
Parcel Allocation=	Watershed District A		~~0.069936~~	lb P Year^{-1}	Sq. Feet
	Watershed District B		0.080863	lb P Year^{-2}	
	Watershed District C		0.091791	lb P Year^{-3}	

Residential Use:				No BMP Credits
	sq ft	Est P Load (lb P / acre / yr)		LOAD
Roof	5066		1.3	0.151189
Driveway/Road	1129		1.5	0.038877
Lawn	14704		1	0.337557
Woodland	0		0.1	0
Pond Surface	0		0.2	0
TOTAL	20899		Total Estimated Load	0.527624

Application of BMPs and Export Assignments:

Residential Use:				No BMP Credits
AREAS NOT SERVED BY A BMP:				
	sq ft	Est P Load (lb P / acre / yr)		LOAD
Roof	4190		1.3	0.125046
Driveway/Road	1129		1.5	0.038877
Lawn	3300		1	0.075758
Woodland	0		0.1	0
Pond Surface	0		0.2	0
AREAS SERVED BY A BMP:				
	sq ft	Est P Load (lb P / acre / yr)		LOAD
Simulated Woods	12214		0.2	0.056079
1" First Flush Infiltration			0.2 →	0
1/2" First Flush Infiltration			0.4	0
Detention Pool			0.6	0
Treatment Wetland			0.4	0
		Total Estimated Load=		*0.29576*
TOTAL	16643			*NON-COMPLIANCE*

(E)

BMP REVISED PLAN

Town of Columbia, Connecticut

Nutrient Allocation - Land Use Worksheet

Overall Watershed Areal P Export Allocation=	0.32	lb P $Acre^{-1}$ $Year^{-1}$
Watershed District A	0.32	lb P $Acre^{-1}$ $Year^{-2}$
Watershed District B	0.37	lb P $Acre^{-1}$ $Year^{-3}$
Watershed District C	0.42	lb P $Acre^{-1}$ $Year^{-4}$

Base Loading Areal TP Allocations:

Undisturbed Woodlands=	*0.1*	lb P $Acre^{-1}$ $Year^{-1}$
Semi-Pervious Area=	*1*	lb P $Acre^{-1}$ $Year^{-1}$
Impervious Area=	*1.5*	lb P $Acre^{-1}$ $Year^{-1}$

Land Owner: "D" E

Address:

Assessors Location Map, Block, Parcel:

Parcel Area=	~~9520~~	sq ft	0.218549	Acres	9520
Parcel Allocation=	Watershed District A		~~0.0[illegible]936~~	lb P $Year^{-1}$	Sq. Feet
	Watershed District B		0.080863	lb P $Year^{-2}$	
	Watershed District C		0.091791	lb P $Year^{-3}$	

Residential Use:

No BMP Credits

	sq ft	Est P Load (lb P / acre / yr)	LOAD
Roof	5066	1.3	0.151189
Driveway/Road	1129	1.5	0.038877
Lawn	14704	1	0.337557
Woodland	0	0.1	0
Pond Surface	0	0.2	0
TOTAL	20899	Total Estimated Load	0.527624

Application of BMPs and Export Assignments:

Residential Use:

No BMP Credits

AREAS NOT SERVED BY A BMP:

	sq ft	Est P Load (lb P / acre / yr)	LOAD
Roof	3650	1.3	0.10893
Driveway/Road	1129	1.5	0.038877
Lawn	3300	1	0.075758
Woodland	0	0.1	0
Pond Surface	0	0.2	0

AREAS SERVED BY A BMP:

	sq ft	Est P Load (lb P / acre / yr)	LOAD
Simulated Woods	12714	0.2	0.058375
1" First Flush Infiltration		0.2	0
1/2" First Flush Infiltration		0.4	0
Detention Pool		0.6	0
Treatment Wetland		0.4	0
		Total Estimated Load=	*0.28194*
TOTAL	17143		*NON-COMPLIANCE*

(E)

BMP REVISED PLAN

Town of Columbia, Connecticut

Nutrient Allocation - Land Use Worksheet

Overall Watershed Areal P Export Allocation=	0.32	lb P Acre^{-1} Year^{-1}
Watershed District A	0.32	lb P Acre^{-1} Year^{-2}
Watershed District B	0.37	lb P Acre^{-1} Year^{-3}
Watershed District C	0.42	lb P Acre^{-1} Year^{-4}

Base Loading Areal TP Allocations:

Undisturbed Woodlands=	*0.1*	lb P Acre^{-1} Year^{-1}
Semi-Pervious Area=	*1*	lb P Acre^{-1} Year^{-1}
Impervious Area=	*1.5*	lb P Acre^{-1} Year^{-1}

Land Owner: "D"

Address:

Assessors Location Map, Block, Parcel:

Parcel Area=	9520	sq ft	0.218549	Acres	9520
Parcel Allocation=	Watershed District A		0.06[illegible]6	lb P Year^{-1}	Sq. Feet
	Watershed District B		0.080863	lb P Year^{-2}	
	Watershed District C		0.091791	lb P Year^{-3}	

Residential Use:

No BMP Credits

	sq ft	Est P Load (lb P / acre / yr)	LOAD
?oof	5066	1.3	0.151189
)riveway/Road	1129	1.5	0.038877
awn	14704	1	0.337557
Voodland	0	0.1	0
ond Surface	0	0.2	0
OTAL	20899	Total Estimated Load	0.527624

Application of BMPs and Export Assignments:

?esidential Use:

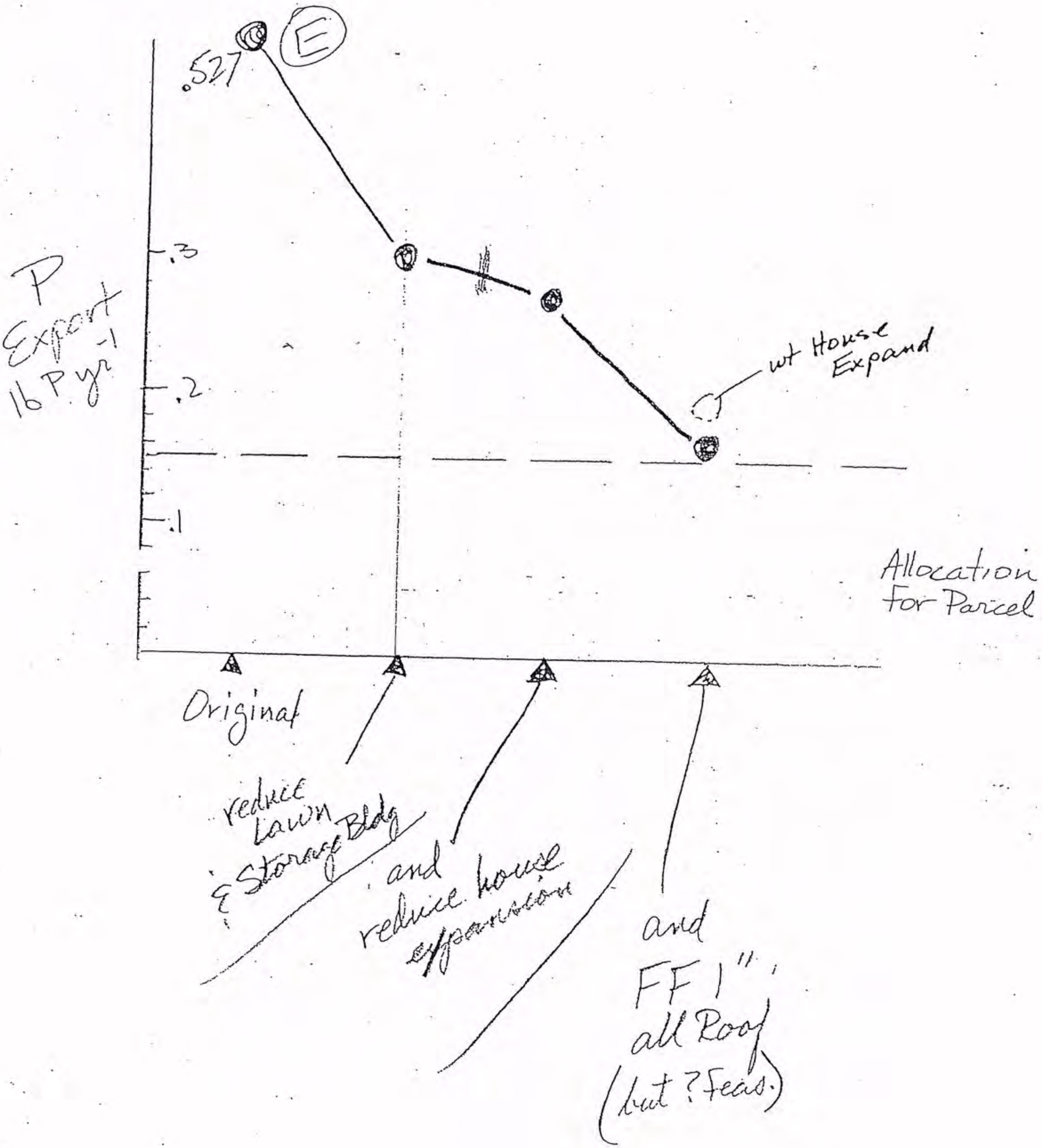
No BMP Credits

REAS NOT SERVED BY A BMP:

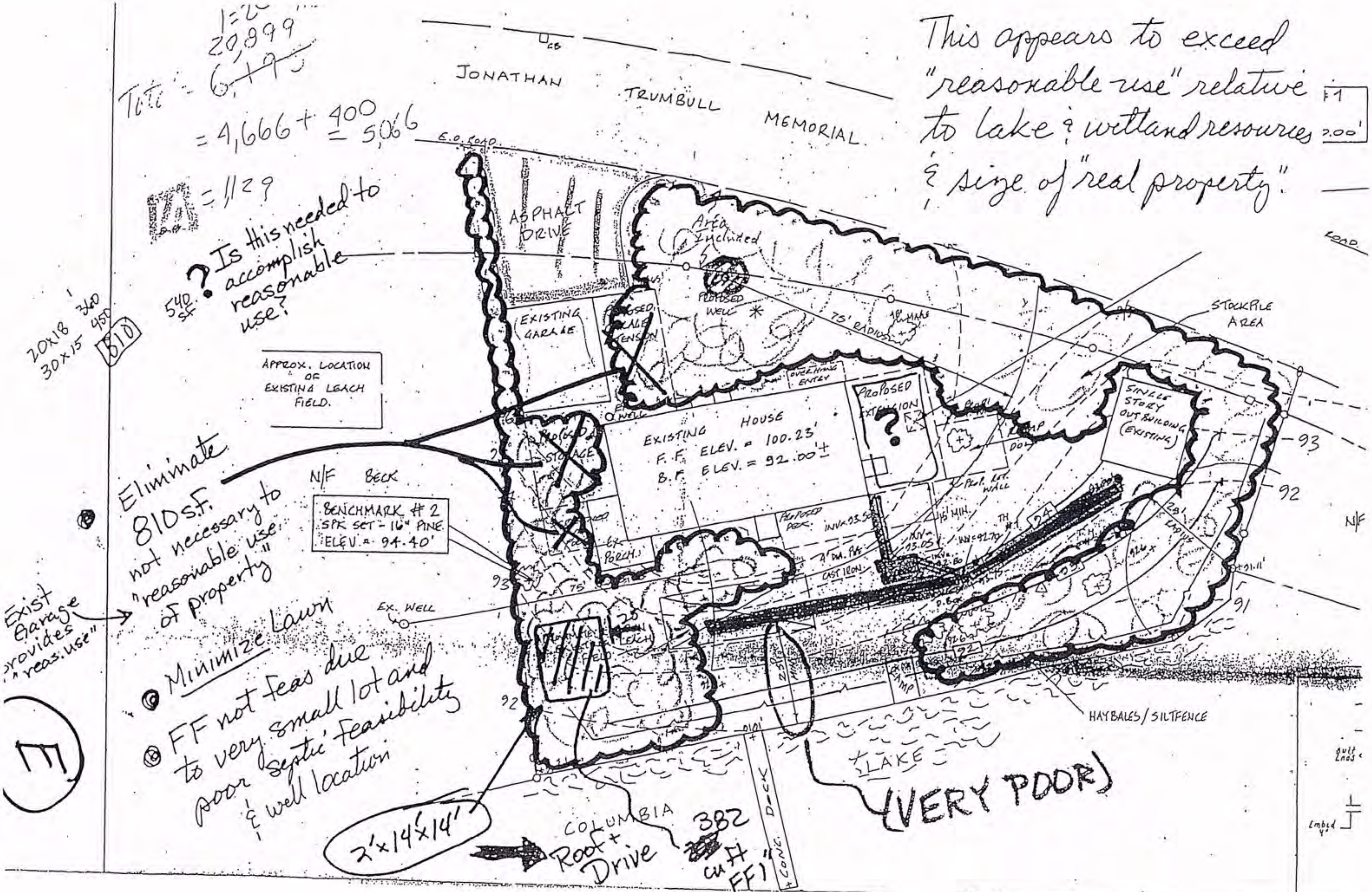
	sq ft	Est P Load (lb P / acre / yr)	LOAD
ɔof	0	1.3	0
iveway/Road	0	1.5	0
ιwn	3300	1	0.075758
oodland	0	0.1	0
›nd Surface	0	0.2	0

?EAS SERVED BY A BMP:

	sq ft	Est P Load (lb P / acre / yr)	LOAD
nulated Woods	12714	0.2	0.058375
First Flush Infiltration	4779	0.2 →	0.021942
:" First Flush Infiltration		0.4	0
tention Pool		0.6	0
›atment Wetland		0.4	0
		Total Estimated Load=	*0.156074*
TOTAL	20793		*NON-COMPLIANCE*



.527
E
P Export lb P yr -1
.3
.2
.1
wt House Expand
Allocation for Parcel
Original
reduce Lawn & Storage Bldg
and reduce house expansion
and FF 1" all Roof (but ? Feas.)


This appears to exceed "reasonable use" relative to lake & wetland resources & size of "real property".
1:20
20,999
6,490
T.I.T. = 4,666 + 400 = 5,066
= 1129
? Is this needed to accomplish reasonable use?
540 sf
20x18 360
30x15 450
810
Eliminate 810 s.F. not necessary to "reasonable use" of property
Exist Garage provides "reas. use"
Minimize Lawn
FF not feas due to very small lot and poor septic feasibility & well location
2'x14'x14'
Roof + Drive
382 cu ft FF
(VERY POOR)
E
JONATHAN TRUMBULL MEMORIAL
E.O. ROAD
ROAD
ASPHALT DRIVE
Area included
EXISTING GARAGE
PROPOSED WELL
75' RADIUS
STOCKPILE AREA
APPROX. LOCATION OF EXISTING LEACH FIELD.
OVERHANG ENTRY
PROPOSED EXTENSION
SINGLE STORY OUT BUILDING (EXISTING)
EXISTING HOUSE
F.F. ELEV. = 100.23'
B.F. ELEV. = 92.00' ±
N/F BECK
BENCHMARK # 2
SPK SET - 16" PINE
ELEV. = 94.40'
EX. PORCH
PROPOSED PORCH
CAST IRON
EX. WELL
HAYBALES / SILTFENCE
LAKE
COLUMBIA
DOCK
CONC.
N/F
93
92
91

Proc. Natl. Acad. Sci. USA
Vol. 76, No. 11, pp. 5426–5429, November 1979
Applied Biology

Phosphorus in Connecticut lakes predicted by land use

(eutrophication/nutrient export/models/nonpoint source/phosphorus cycle)

W. A. NORVELL, C. R. FRINK, AND D. E. HILL

Department of Soil and Water, The Connecticut Agricultural Experiment Station, P.O. Box 1106, New Haven, Connecticut 06504

Communicated by Paul E. Waggoner, July 5, 1979

ABSTRACT The concentration of phosphorus in parts per billion (ppb) in 33 Connecticut lakes was predicted from information on land use and simple models for concentration decreases in lakes. The best predictions were obtained from

$$P = \frac{(Q + 1.2)}{(Q + 12)}(170\ U + 54\ A + 10\ W)/D,$$

where P is the concentration of phosphorus in ppb, Q is the water load on the lake in meters per year, D is the water export from the entire watershed in meters per year, and U, A, and W are the fractions of urban, agricultural, and wooded land, respectively, in the watershed. The phosphorus export coefficients and SEM, estimated by least squares regression, were 170 ± 21 mg per m²/yr for urban, 54 ± 15 mg per m²/yr for agricultural, and 10 ± 3 mg per m²/yr for wooded land. P ± (SEM) 6.9 ppb was predicted.

Efforts to reduce eutrophication of lakes by managing watersheds can be rational only if the contributions of nutrients from different land uses are known. Because phosphorus controls the degree of eutrophication in most lakes (1–4, *), we must know how much P reaches lakes from homes and cities, from agriculture, and from woodlands. Unfortunately, the export coefficients for P from most uses of land are not known within an order of magnitude (Table 1). These coefficients are too uncertain to guide effective watershed management or to predict reliably concentrations of P in lakes.

We have combined a simple empirical model for the reduction of P concentrations in lakes with a simple logical model for the export of P from nonpoint sources to estimate P export coefficients and predict concentrations of P with a standard error of 6.9 parts per billion (ppb) in 33 Connecticut lakes. The results are reported here.

THEORY

Derivation of a direct relation between P in lakes and land use required a joint solution of two separate and largely independent problems. First, the extent to which lake processes regulate concentrations of P within the lake had to be established. For this purpose we assumed that the fraction of incoming P that remains in the lake water could be related to the rate of water movement through the lake. Second, the total amount of P entering the lake had to be related to land uses in the watershed. For this purpose we assumed that the P contributed by each use was proportional to the fraction of the watershed area in that land use.

The concentration of P in lakes is decreased by such processes as sedimentation and growth of aquatic plants. These decreases are related to the rate of water movement through lakes (10–12). Lakes with little inflow and long times of retention tend to have P concentrations that are small fractions of average incoming concentrations. Conversely, lakes receiving much water but holding it briefly tend to have P concentrations close to the average concentration in the incoming water. From functions proposed to describe these effects, we selected two simple expressions to describe the average concentration of P in a lake as a fraction of the average concentration in incoming water. We have called this concentration fraction F to distinguish it from the sometimes similar ratio of the mass of P discharged from a lake to the mass of P entering the lake. The first function chosen for F was $Q/(Q + V)$, where Q is the water load on the lake surface in meters per year and V is the "apparent settling velocity" for P, with values estimated from 10 to 16 m/yr (12–15). The parameter V may be viewed as a depth of water containing P equivalent to that lost within the lake during a year. The second function was $\sqrt{\rho}/(1 + \sqrt{\rho})$, where ρ is the hydraulic flushing rate in year^{-1} (16–18). These functions approach zero as Q and ρ become small and increase rapidly when Q and ρ increase, approaching 1.0 asymptotically. Measurements of F and Q in many lakes (12, 19) suggest that $Q/(Q + V)$ approaches zero too rapidly as Q becomes small. Thus, we also examined a third function for F equal to $(Q + I)/(Q + V)$, where I/V sets a minimum which appears to be greater than 5% but less than 20%.

The mean concentration of P entering a lake during a year may be expressed as the ratio of incoming P to incoming water, hence

$$P_{(\text{entering})} = \sum_i a_i X_i / D \qquad [1]$$

where a_i (mg per m²/yr) is the P export coefficient from land in the ith use, X_i is the fraction of watershed in the ith use, D (meters per year) is the average export of water from the entire watershed including the lake surface, and P (concentration of P) has units of mg/m³ or ppb. Within the lake, this concentration is reduced to the fraction F, making

$$P = F \cdot \sum_i a_i X_i / D. \qquad [2]$$

In watersheds where lakes lie in series, the P contributed by the upstream watershed is first reduced by F for the upstream lake, and then reduced again by F characteristic of the downstream lake.

METHODS

Thirty-three lakes in Connecticut were selected to provide a range of trophic states, water loads, and uses of watershed land (20, 21) (Table 2). Water samples were collected and analyzed during 1974–1978 as described (4). Concentration of P at spring overturn was chosen to represent the concentration of P in each lake. The water loads in Table 2 were calculated from hy-

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Abbreviation: ppb, parts per billion.

* W. A. Norvell (1978) *Abstracts of Papers for 41st Meeting of American Society of Limnology and Oceanography*, Victoria, BC.

Table 1. Phosphorus exported from different uses of land

Land use	P export coefficients, mg per m²/yr				
	Literature*			NES† for eastern U.S.	Connecticut watersheds‡
	Extreme range	Common range	Averages		
Urban	5–1500	25–600	100–200	30	170
Agricultural	2–1000	10–200	20–80	31	54
Forested	0–500	2–100	5–25	8	10

* Adapted in part from reviews (5–8).

† National Eutrophication Survey (9). The value for urban land is for category "mostly urban" which was ≥40% urban.

‡ Estimates from our study of 33 lakes and watersheds.

drologic data (23) and include net precipitation on the lake surface. The average annual export of water from the watershed, D, equals Q divided by the watershed to lake area ratio. The flushing rate ρ equals Q divided by mean depth.

Uses of watershed land were obtained from maps prepared for the Office of State Planning from a 1970 aerial survey. We summarized the categories into three major uses: urban land, including all residential and commercial land; agricultural land; and wooded land, consisting primarily of wooded land but also including wetlands and the lake surface. The fractions X_i of each watershed in the three land uses are included in Table 2.

Export coefficients in Eq. 2 were estimated by least squares regression by programs 1R, 2R, and 3R in the BMDP77 series (24). In the form $P = \Sigma a_i(FX_i/D)$, P was expressed as a linear function of independent variables (FX_i/D) with regression coefficients a_i and zero intercept. Multiple linear regression was used to predict P and evaluate the a_i. With Eq. 2 expressed as $P = F\ \Sigma a_i X_i/D$, nonlinear regression was used to predict P and investigate alternative formulations of the fraction F.

Residuals were calculated and plotted versus the predicted variable and various lake characteristics. In some cases, regression analyses were weighted by estimates of 1/variance in order to homogenize variance and eliminate bias in the distribution of residuals.

RESULTS AND DISCUSSION

The three functions describing attenuation of P concentration were first tested for compatibility with our data: $Q/(Q + V)$ and $(Q + I)/(Q + V)$ calculated from lake water load, and $\sqrt{\rho}/(1 + \sqrt{\rho})$ calculated from lake flushing rate. An I/V of 10% and a V of 12 m/yr were selected from the literature as initial approximations.

All three functions for F markedly improved predictions of lake P by Eq. 2. When attenuation of concentration was ignored by setting $F = 1$, the multiple R^2 for Eq. 2 was 0.43. The R^2 rose

Table 2. Characteristics of 33 Connecticut lakes and watersheds

Lake	Spring P, ppb	Mean depth, m	Lake area, ha	Watershed to lake area ratio*	Water load (Q), m/yr	Land use fractions: Urban	Agricultural	Wooded
Alexander	10	7.4	76	4.0	2.3	0.133	0.155	0.711
Amos	19	5.8	43	5.1	3.1	0.078	0.097	0.823
Ball	37	6.9	36	2.6	1.4	0.387	0.146	0.468
Bantam†	26	4.4	371	23.2	14.9	0.049	0.168	0.781
Beseck	26	3.4	48	11.2	7.8	0.177	0.080	0.741
Candlewood†	13	8.9	2193	8.1	4.3	0.117	0.085	0.799
Cedar	47	3.3	8.8	25.2	13.9	0.112	0.131	0.757
Coventry	25	8.8	153	5.6	3.1	0.281	0.045	0.676
Cream Hill	14	4.8	29	5.6	3.1	0.027	0.032	0.940
Crystal	14	6.0	81	8.9	4.7	0.099	0.006	0.895
East Twin	20	9.9	228	4.7	2.3	0.064	0.066	0.871
Gardner	14	4.2	197	7.3	4.6	0.119	0.102	0.777
Hayward	23	3.1	81	8.0	5.3	0.107	0.087	0.804
Linsley†	51	6.2	9.4	35.5	19.6	0.190	0.114	0.696
Long†	11	4.6	40	29.6	19.1	0.049	0.027	0.922
Mudge†	27	6.7	81	36.6	19.1	0.046	0.362	0.592
Norwich	10	7.0	11	11.2	6.8	0.000	0.006	0.993
Pataganset†	15	3.8	50	20.3	13.6	0.030	0.049	0.871
Pocotopaug	17	3.4	207	5.6	3.3	0.174	0.038	0.787
Powers	7	2.1	62	4.0	2.3	0.030	0.000	0.969
Quassapaug	16	8.7	110	4.3	2.3	0.053	0.132	0.817
Quonnipaug	15	4.1	45	16.1	10.3	0.057	0.091	0.852
Rogers	10	6.1	107	18.2	11.1	0.058	0.051	0.926
Roseland†	33	3.1	36	221	139	0.025	0.329	0.648
Shenipsit	18	9.1	212	20.1	11.0	0.048	0.095	0.856
Squantz	15	7.0	117	12.6	6.9	0.126	0.005	0.868
Taunton	41	6.6	51	6.7	3.9	0.331	0.028	0.639
Terramuggus	22	6.5	34	4.1	2.2	0.361	0.000	0.638
Waramaug	27	6.7	275	13.4	8.1	0.038	0.108	0.855
West Hill	9	9.7	96	3.5	2.3	0.249	0.000	0.750
West Side	14	4.6	17	51	31.6	0.002	0.121	0.877
Wononpakook†	33	3.5	66	17.0	10.4	0.094	0.302	0.604
Wononscopomuc	36	11.1	143	4.7	2.3	0.207	0.086	0.707

One hectare (ha) = 10,000 m².

* Watershed includes lake surface.

† Significant inflow received from upstream lakes (20, 22).

to 0.60 when $Q/(Q + 12)$ or $\sqrt{\rho}/(1 + \sqrt{\rho})$ were used to specify F and rose to 0.66 for $F = (Q + 1.2)/(Q + 12)$. These results and others (12–18) confirm the need to consider changes in concentration related to rates of water movement in lakes.

Although predictions of P were improved by all three functions, we selected $(Q + I)/(Q + V)$ for further investigation. This function was chosen partly because it provided as good or better predictions of P than did the function based on ρ and, more importantly, because water loads can be approximated easily from lake surface areas whereas flushing rates require much less readily available information on lake volumes.

The choice of values for I/V and V was investigated by mapping contours of the residual sum of squares for Eq. 2. Fig. 1 shows that the residual sum of squares reached a minimum for values of V ranging from 7 to 14 m/yr and for values of I/V of 7 to 13%. Within this region, predictions of P were about equally good with the absolute minimum sum of squares for our set of lakes occurring for $I/V = 10\%$ and for $V = 10–11$ m/yr. These results supported our initial choice of values for V and I/V. Thus, the function $(Q + 1.2)/(Q + 12)$ was compatible with our results for 33 Connecticut lakes as well as with literature data on P retention by numerous lakes of the temperature zone (12, 15, 19).

In choosing $(Q + 1.2)/(Q + 12)$ to represent the attenuation of P concentrations in lakes, we kept in mind an important characteristic of Eq. 2. The relationship between F and exported P is multiplicative, making F and the export coefficients a_i inversely related. Hence, the choice of F determines in part the values of a_i obtained by regression because the sum of Fa_iX_i/D must still predict the same concentrations of lake P. This relationship between F and the a_i emphasizes the importance of selecting values or functions for F that have independent support from direct measurement or other lake studies.

Having selected a function for F, we returned to investigating the effect of land use. Export coefficients were estimated by multiple linear regression, using the product terms $F(X_i/D)$ as independent variables and P as the dependent variable. The resulting equation was

$$P(\text{ppb}) = \frac{(Q + 1.2)}{(Q + 12)}(184\ U + 52\ A + 8\ W)/D, \qquad [3]$$

where U, A, and W are the fractions of urban, agricultural, and wooded land, respectively, in the watershed. Eq. 3 had an R^2 of 0.66 and reduced the standard error of estimate from 14.7 ppb about the mean to 6.8 ppb about the regression. Export coefficients were estimated as 184 ± (SEM) 19 mg per m²/yr for urban, 52 ± 13 mg per m²/yr for agricultural, and 7.8 ± 3.5 mg per m²/yr for wooded land.

Residuals calculated from Eq. 3 increased slightly as concentrations increased. Recognizing that variance in P usually increases with P, we analyzed Eq. 2 further by weighted regression. Successive regressions were weighted iteratively by using $(5 + 0.2P)^2$ as an estimate of variance. For each regression, the weight was calculated from P predicted by the preceding regression. Regression coefficients stabilized quickly, yielding the equation:

$$P = \frac{(Q + 1.2)}{(Q + 12)}(170\ U + 54\ A + 10\ W)/D. \qquad [4]$$

Eq. 4 was very similar to Eq. 3 and provided an R^2 of 0.65 and a standard error of 6.9 mg/m³ when used to calculate lake P. Estimated export coefficients from Eq. 4 were 170 ± (SEM) 21 mg per m²/yr for urban, 54 ± 15 mg per m²/yr for agricultural, and 9.6 ± 3.2 mg per m²/yr for wooded land. Although neither predictions nor regression coefficients for the two equations differed significantly, Eq. 4 was preferred because its weighted residuals were distributed somewhat more uniformly than the unweighted residuals of Eq. 3 and because Eq. 4 provided slightly better predictions of P in lakes with lower concentrations of P.

Although Eq. 4 was the major outcome of our analysis, we also investigated the adequacy of the three land use categories by subdividing them. Urban land was divided into very low (<1 family/acre), low (1–2 families/acre), and medium to high density (>2 families/acre). The category of woodlands was subdivided by defining the lake surface as an independent category. Using these six rather than three categories did not improve prediction of P concentrations. In addition, export coefficients for the three urban categories differed insignificantly and neither the coefficient for the lake surface nor that for wooded land was significantly different from zero. Thus, our three general categories of land use U, A, and W were adequate as well as simple.

Prediction of P by Eq. 4 was better than predictions based on land use alone, as shown in Fig. 2. Considering land use only (Fig. 2A) decreased the standard error from 11.3 ppb about the mean to 8.9 ppb about the regression and yielded an R^2 of 0.43. When $F = (Q + 1.2)/(Q + 12)$ and land use were combined in Eq. 4, the fit of the predicted line to the data was improved further (Fig. 2B) with the standard error of estimate reduced

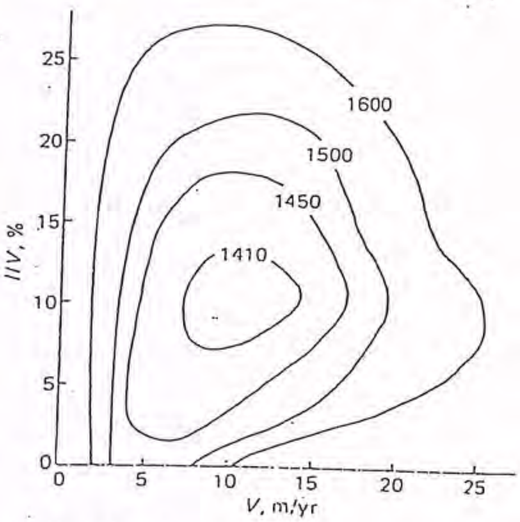

FIG. 1. Variation of residual sum of squares for prediction of P by Eq. 2 with variation of I/V and V in $F = (Q + I)/(Q + V)$.

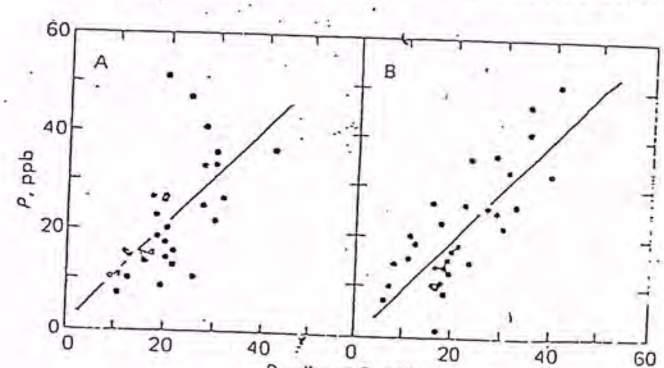

FIG. 2. Comparison of measured and predicted concentrations of P in 33 lakes. (A) P predicted from land use: $P = (35\ U + 42\ A + 5\ W)/D$. (B) P predicted from land use and $F = (Q + 1.2)/(Q + 12)$ by Eq. 4.

by more than 20% to 6.9 ppb and the R^2 increased by more than 50% to 0.65.

Despite the improved prediction of P by Eq. 4, it is well to recognize that the standard error of estimate of 6.9 ppb is substantial, particularly for oligotrophic lakes. In addition to possible errors in the data and the model, known sources of probable error include: (*i*) separation in time between land use data from 1970 and lake data from 1974–1978, (*ii*) lack of discrimination between seasonal and year-round residences; and (*iii*) inherent differences in watershed fertility which may coincide accidently with regional patterns of watershed development.

Phosphorus export coefficients obtained in other studies can be compared with our results (Table 1). We have tried to simplify the diverse values reported (5–8) by grouping them into ranges representing extreme, common, and average values for the three land uses. Because the uncertainty in reported coefficients is large, it is not surprising that our results fall within their range. Nevertheless, it is significant that our export coefficients, estimated from lake P, are consistent with averages obtained from direct studies of export from watersheds.

Export coefficients obtained recently by the National Eutrophication Survey (NES) for 473 watersheds in the eastern U.S. (9) can also be compared to our estimates (Table 1). Agreement for agricultural and forested land is good but is not good for urban land. Eleven watersheds with an average of 55% urban land were included in the NES category "mostly urban" land. Export of P from the 11 watersheds ranged from 8.5 to 59 mg per m^2/yr with a mean of 30 mg per m^2/yr. Even after adjustment for extent of urbanization, the NES coefficients appear low compared to most reported coefficients (Table 1) and to our estimate of 170 mg per m^2/yr.

Recently, the Universal Soil Loss Equation (25) has become increasingly popular as an estimator of P export. The approach is appealing because it disaggregates total export into individual contributions as a function of soil, climate, and land use characteristics. However, many necessary parameters, such as enrichment ratios, overland transfer coefficients, sediment delivery ratios, and percentage of available P are not known within a factor of two or even within an order of magnitude. Hence, although these models may be detailed (26, 27), they are unlikely to soon provide better estimates of P contributed to lakes in New England than does the simple export model and generalized export coefficients contained in Eq. 4 from our study of 33 lakes and watersheds in Connecticut.

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APPENDIX E ERDONI BROOK BEAVER DAMS

SITE WALK HANDOUT
September 1996

COLUMBIA LAKE WATERSHED MANAGEMENT PLAN
Component: Erdoni Brook Subbasin   Beaver Dam Management

Background and Purpose

The large wetland areas in the Erdoni Brook watershed subbasin provide numerous functions, including:

*** Storm Runoff - Flood Storage Volume**

During periods of high runoff these wetlands store water, being inundated to a greater depth temporarily. This "fluctuation" of water level improves water quality, controls peak flows, and establishes conditions which results in high diversity and interspersion of obligate and facultative hydrophytic vegetation. In the past, these wetlands were primarily deciduous wooded swamp/scrub-shrub wetlands (Pka soils-Organic).

*** Wildlife**

As a result of the hydrologic regime described above, a variety of habitat forms are supported (with long ecotone edges between habitat types). Hence, diverse flora and fauna are supported.

*** Water Quality Renovation**

Wetlands tend to be "net nutrient sinks." Water flowing through these types of wetlands tends to have sediments and nutrients removed. This is an important function relative to the Columbia Lake Ecosystem.

Beaver Dams: Flooding of Wetland Areas:

Beaver have constructed dams in three main locations (see figure on back), raising normal water level by 2.5 - 3.5 ft at each site. Each dam is constructed in a location where prior "human activity" took place.

The beaver dams have caused changes in the wetlands they flood:

- * The wetlands remain flooded to a greater depth year 'round. Flood storage volume function has been diminished.
- * Much of the inundated wetland has been changed to "Dead Wooded Swamp"/Emergent Marsh.
- * Although the wetlands are probably still a "net sink" for nutrients and sediment in runoff, testing has shown that they become a significant seasonal source of nutrients to Columbia Lake.

Management Concepts: The Town Of Columbia (several Boards, Commissions, Task Force) wishes to manage the water level impounded by beaver dams in a manner which

- restores flood storage capacity and reduces risk of a breach in the dams,
- reduces the seasonal release of phosphorus due to extensive anaerobiosis
- maintains/restores a diverse and complex wetland floristic and habitat structure.

Alternatives include:

- a small outlet ("equalizing culvert) to maintain water level in Beaver Dam#2 at the Beaver Dam #1 elevation (preferred alternative)
- no change/management (let nature take it's course)
- install an outlet(s) to maintain another normal water level elevation.

Robert W. Kortmann, Ph.D.
Ecosystem Consulting Service, Inc.
430 Talcott Hill Road
Coventry, CT 06238
203/742-0744

September 14, 1995

Town of Columbia
c/o Adella Urban, 1st Selectman
Rt. 87
P.O. Box 165
Columbia, CT 06237-0125

COLUMBIA LAKE MANAGEMENT PLAN
Erdoni Brook Subbasin
Beaver Dam Management Plan

Note: This preliminary report describes the conceptual approach for management of the three beaver dams in the Erdoni Brook watershed basin. Detailed plans and assessments of how implementation will affect wetland structure and function are in preparation.

Background and Purpose

The large wetland areas in the Erdoni Brook watershed subbasin provide numerous functions, including:

*** Storm Runoff - Flood Storage Volume**

During periods of high runoff these wetlands store water temporarily, being inundated to a greater depth temporarily. This "fluctuation" of water inundation improves water quality, controls peak flows, and establishes hydrologic conditions which results in high diversity and interspersion of obligate and facultative hydrophytic vegetation. In the past, these wetlands were primarily deciduous wooded swamp/scrub-shrub swamp.

*** Wildlife**

As a result of the hydrologic regime described above, a variety of habitat forms are supported (with long ecotone edges between habitat types). Hence, diverse flora and fauna are supported.

* Water Quality Renovation

Wetlands tend to be "net nutrient sinks." Water flowing through these types of wetlands tends to have sediments and nutrients removed. This is an important function relative to the Columbia Lake Ecosystem.

Over the past 6-8 years, Beaver have constructed dams in three main locations (see figure attached), raising normal water level by 2.5 - 3 ft at each site. Each dam is constructed in a location where prior "human activity" took place. Dam #3 uses an old abandoned roadbed as a foundation. Dams #1 and #2 use old "farm road crossing berms" or stonewalls as a foundation.

The beaver dams have caused changes in the wetlands they inundate:

* The wetlands remain flooded to a greater depth year 'round. Flood storage volume function has been diminished.
* Much of the inundated wetland has been changed to "Dead Wooded Swamp"/Emergent Marsh.
* Although the wetlands are probably still a "net sink" for nutrients and sediment in runoff, testing has shown that they become a significant seasonal source of nutrients to Columbia Lake.

Management Concept

In order to restore the historic hydrology (fluctuating water level, storm detention, etc.) and the Wooded Swamp/Scrub-Shrub character of the wetlands, a "Control Outlet" is suggested for Dams #1 and #2. The beaver dam at Route 66 (#3) is to remain undisturbed. The "Control Outlet" would consist of a small diameter PVC pipe (ca. 6") installed through the beaver dam. The invert of the pipe would be at the estimated elevation of previous normal water elevation in the wetland. The capacity of such a small pipe would be exceeded during storm runoff episodes (hence restoring water level fluctuations). The inlet to the PVC pipe would be designed in a manner which the Beaver could not "re-dam." For example, the "invert section" would be horizontal; on the inlet side two 45° angles would deepen the intake, which would be a perforated section of PVC (permanently submerged). The Control Outlet would be installed manually.

Anticipated Effects -

The described outlet would restore the hydrologic fluctuations in inundation level that existed before the beaver dams. Hence, wetland structure and function would also revert to its previous condition. The beaver would be able to persist using Dam #3, which would not be disturbed.

The main purpose of this project is to restore the water quality function of the wetland system prior to beaver dam construction. This is a particularly important function because Erdoni Brook flows to a lake ecosystem (where nutrient-eutrophication relationships exist). Such a project would be less desirable if no "lacustrine systems" (lakes, etc.) existed downstream. We believe that this approach will have net positive impacts on wetland values (wildlife, storm detention, water quality).

Respectfully Submitted,

Robert W. Kortmann, Ph.D.
E.C.S., Inc.

RWK/lr

Robert W. Kortmann, Ph.D.
Ecosystem Consulting Service, Inc.
430 Talcott Hill Road
Coventry, CT 06238
(860) 742-0744

September 11, 1996

Town of Columbia
P.O. Box 165
Route 87
Columbia, CT 06237-0125

Re: **Revised Beaver Dam Outlet Design**

Based on input from two recent site walks with participation by Joshua's Tract, U.Connecticut, Town Boards and Commissions, and others, it seems that a consensus regarding the Erdoni Brook Beaver Dams may be iminent. Some of the concerns expressed include:

- is the pipe sizing adequate,
- can "adjustable" level be incorporated,
- monitoring of an "experimental" outlet with adjustments to optimize wildlife habitat and water quality.

I have developed a modified plan for an outlet in order to provide for adjustment of water level, adequate flow, seasonable adjustments, etc. A sketch of a revised plan is attached.

After evaluating several alternatives, I am suggesting two 8" diameter polyethylene pipes with "T's" into a collection pipe (perforated to reduce inlet velocities). To install the outlet, the beaver dam would be "incrementally breached" by hand over about a week. The piping system would be placed and secured with sandbags in the dam breach. The collection pipe would be supported by posts driven into the bottom. The outlet pipe ends would also be supported by driven posts. Either end could be raised or lowered to adjust water level (the pipe is flexible enough to accomplish the illustrated 1.5 ft. range). Two 8" pipes running full would release 3.7 acre-ft per day (100 acre-ft in 27 days). When water level rises above the pipes, outflow accelerates (due to additional head). This outflow capacity appears to be adequate to lower the water level 1.5 ft. during dry periods, while retaining water level fluctuation and storm peak detention. This configuration will not drain the wetland. Raising either the inlet or outlet ends would reduce outflow rate and raise water level. This could be used to establish and maintain a somewhat higher winter/spring level, which may be desirable.

Please give me a call if you have questions or want additional features incorporated.

Sincerely,

Robert W. Kortmann, Ph.D.
E.C.S., Inc.

RWK:cjl

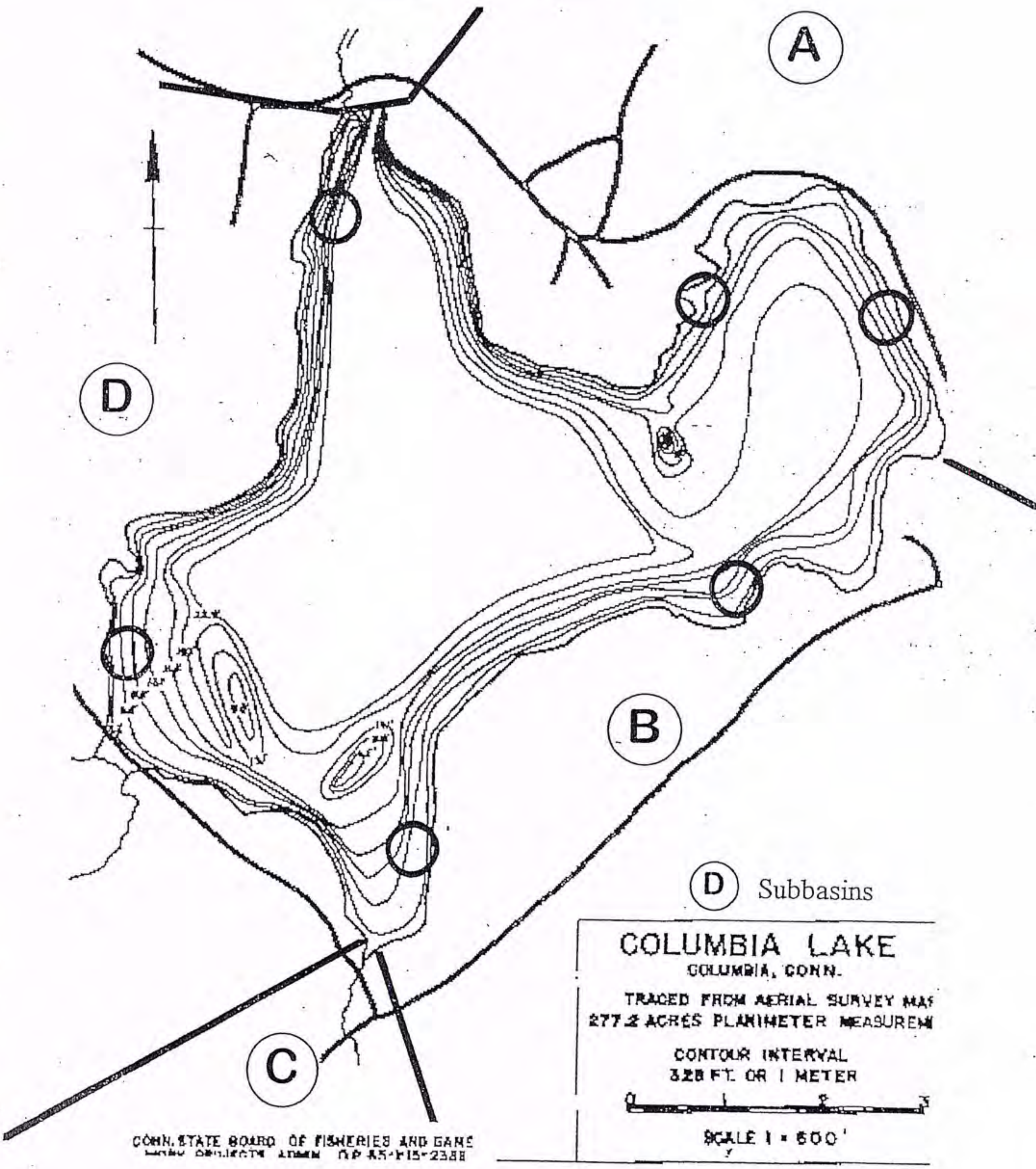
Attachment

Insert Sketch Plan (from Click) after this page

APPENDIX F ADDITIONAL LAKE PERIMETER AND SEEPAGE DATA

Surface Inflow Tests
November 1994

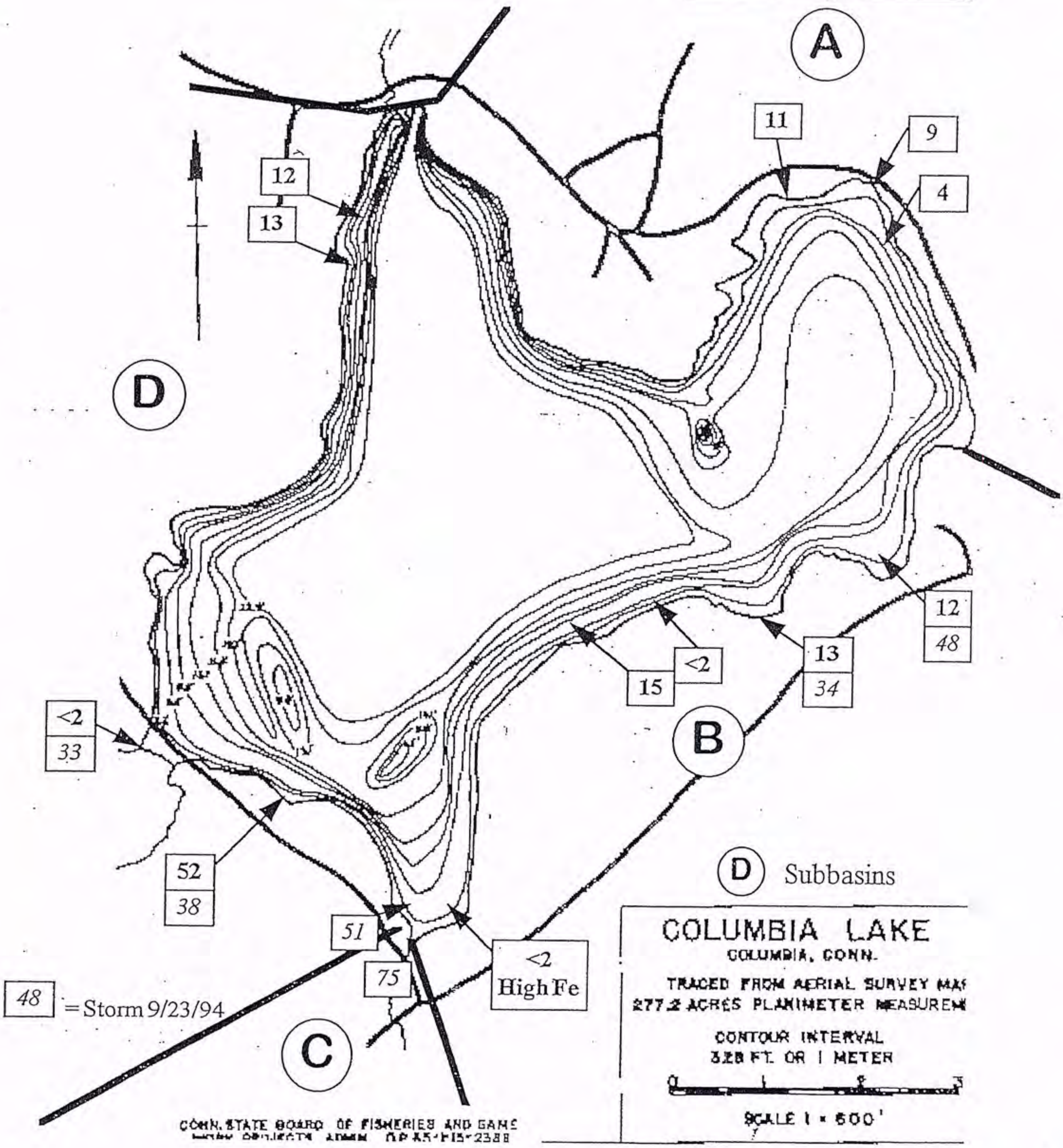
Total Phosphorus
TP (mg/m3)



Surface Inflow and Pipe Tests November 1994

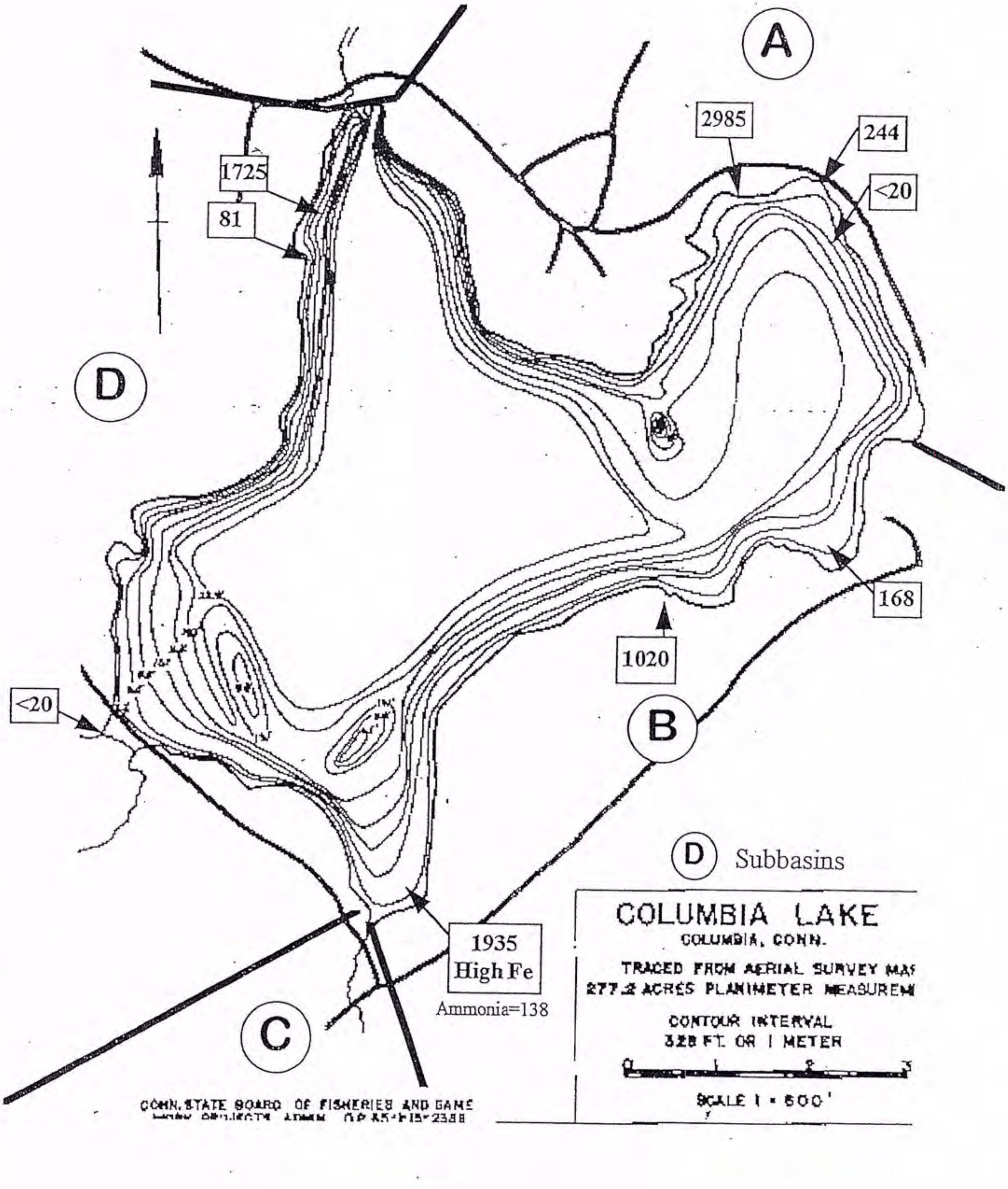
Total Phosphorus
TP (mg/m3)

All Ammonia Tests < 15 mg/m3



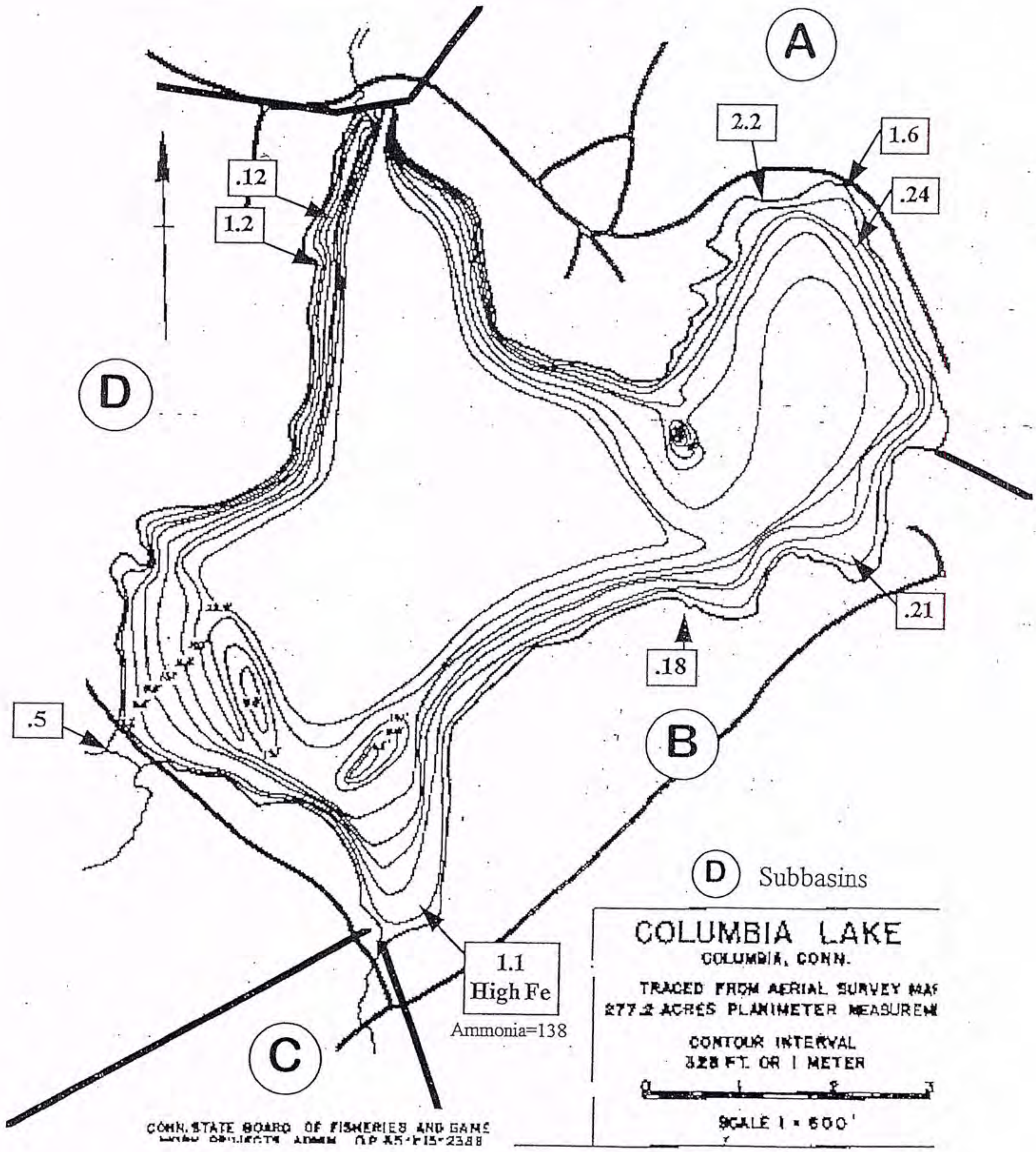
Surface Inflow and Pipe Tests November 1994

Nitrate
as N (mg/m3)



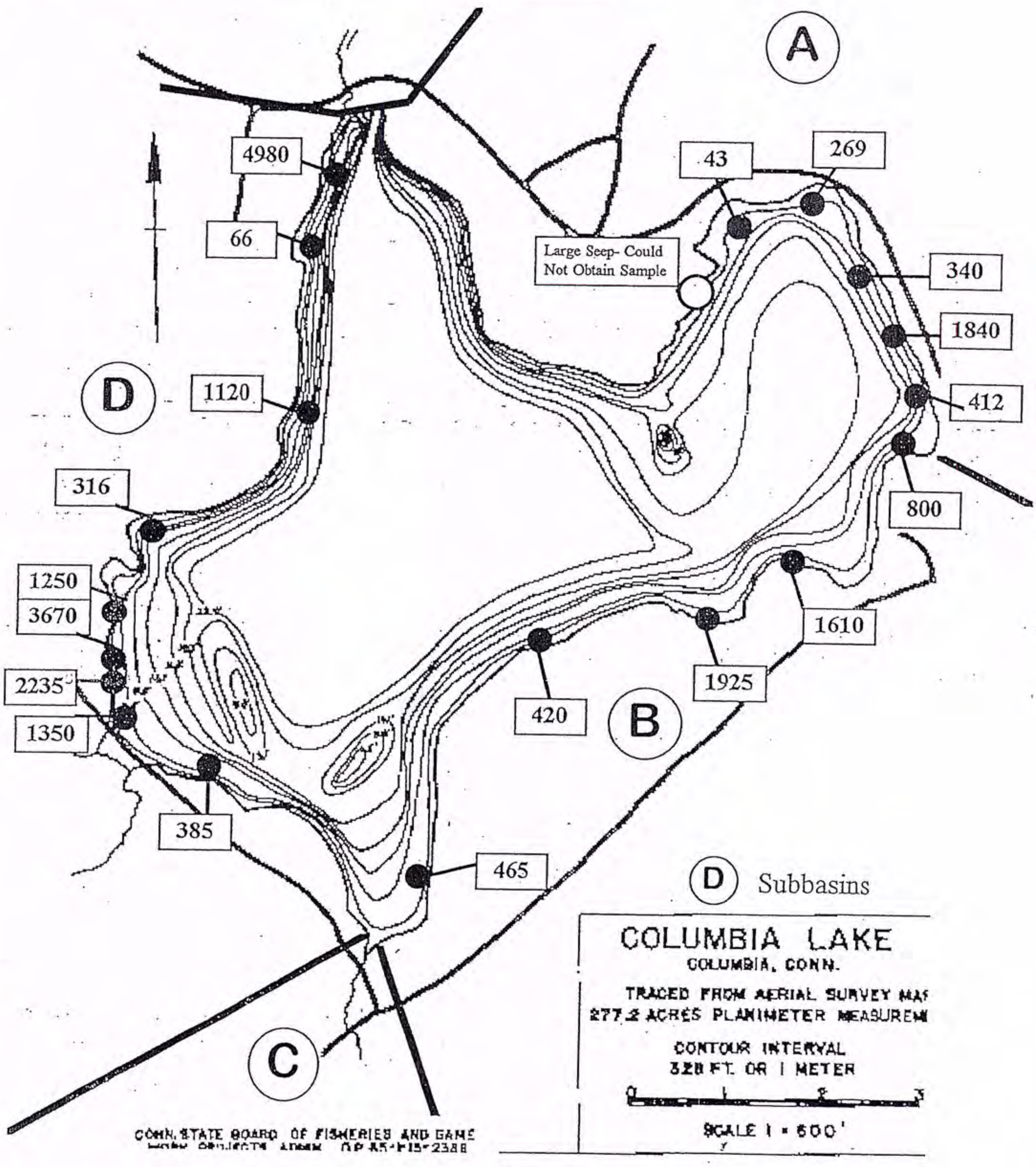
Surface Inflow and Pipe Tests November 1994

Turbidity
NTU



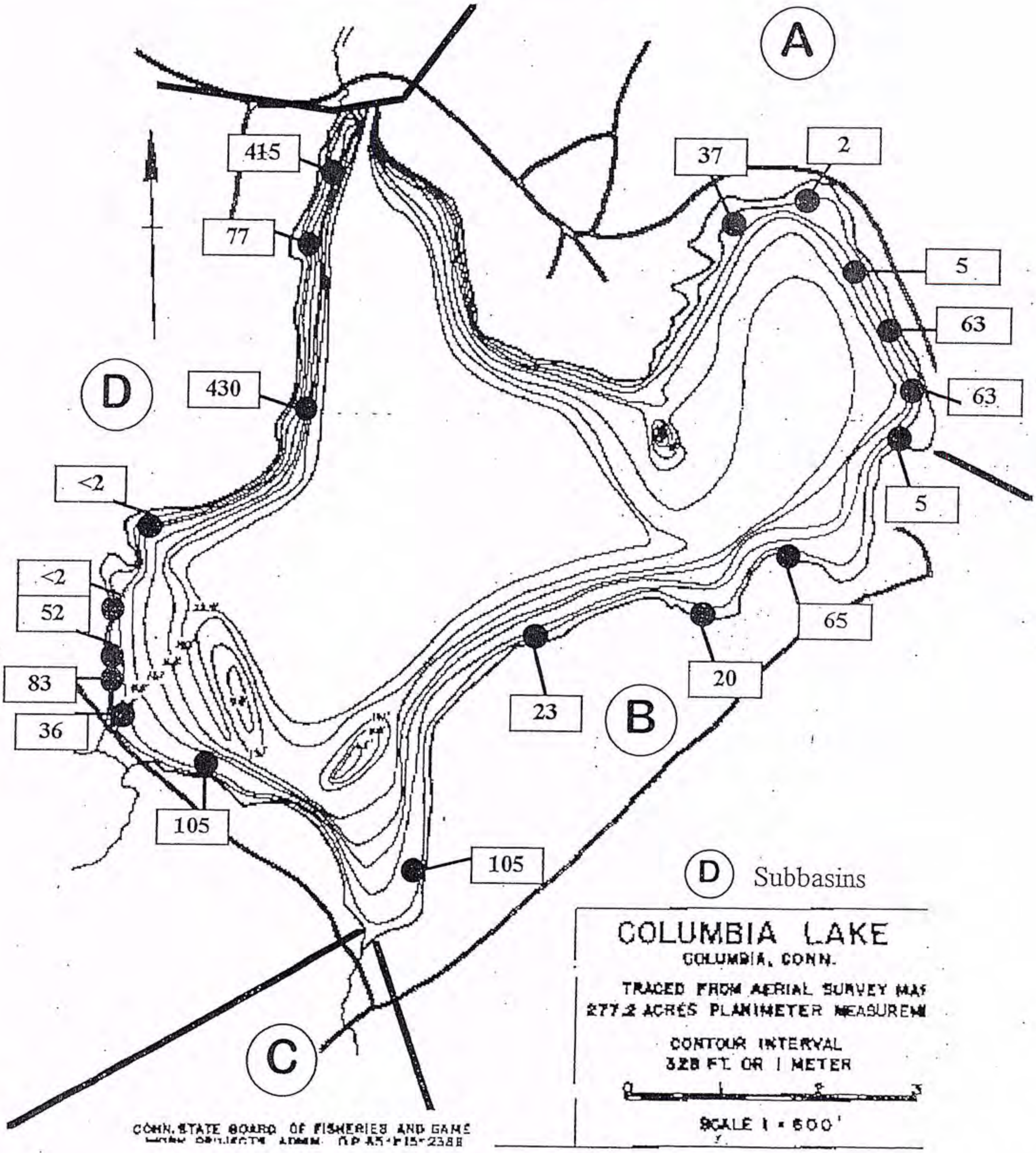
SeepageTests November 1994

Nitrate
as N(mg/m3)



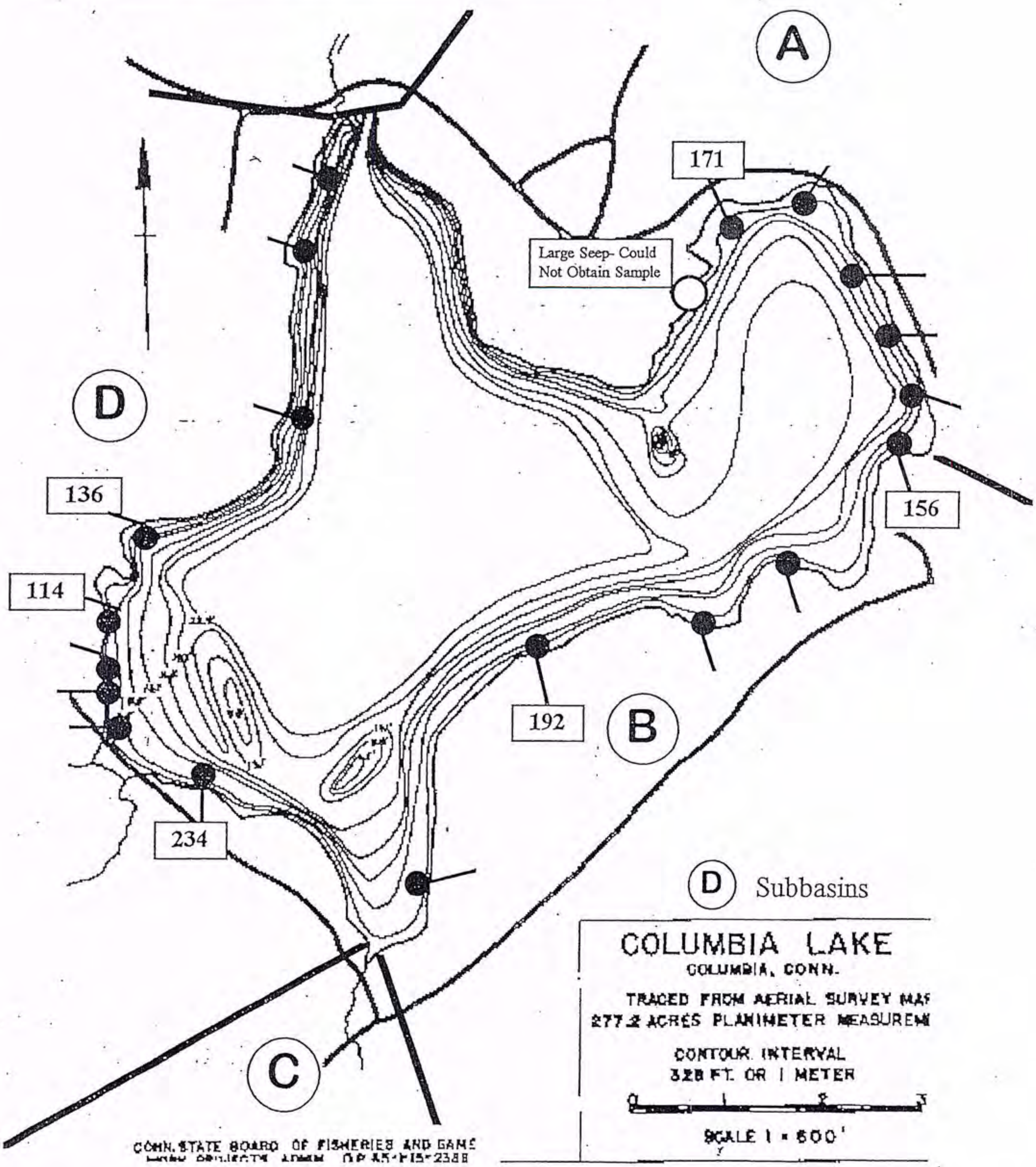
Seepage Tests
November 1994

Total Phosphorus
TP (mg/m3)



SeepageTests
November 1994

Ammonia if > 100
as N(mg/m3)



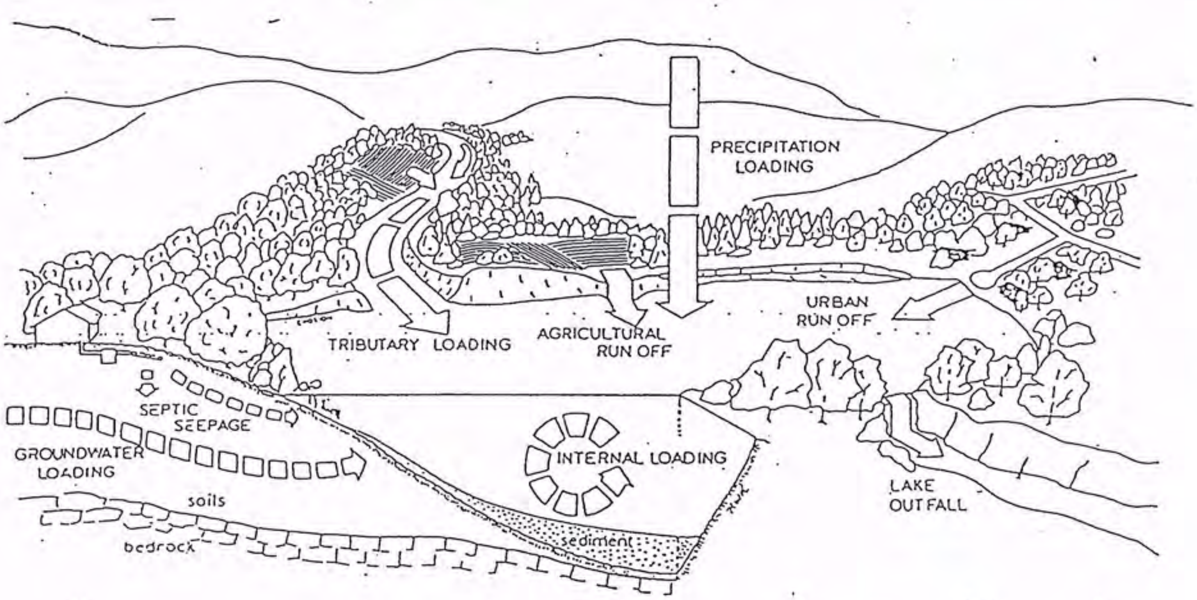
EXCERPTS
G

Columbia Lake

Watershed Management

prepared for:
The Town of Columbia, Connecticut

prepared by:
Ecosystem Consulting Service, Inc.



Draft: June 1988

Streambelt Watercourse means any named brook within the watershed drainage basin, and unnamed tributaries which drain an area larger than 25 acres.

Streambelt Wetland means any area containing a soil type defined as a wetland by the Connecticut Inland Wetland and Watercourses Act which is contiguous to a Streambelt Watercourse.

Recommendation:

* A wetland detention/renovation area equal to 5% of an area to be developed shall be created to mitigate the adverse effects of "urban runoff" for developments greater than 5 acres, with more than 25% disturbance of the site.

Recommendation:

* All activities which disturb the natural soil and vegetative cover shall be deemed "regulated activities" under Inland Wetlands Regulations if proposed within 200 ft. of a streambelt watercourse or within 100 ft. of a streambelt wetland.

Recommendation:

The zoning regulations should require agricultural uses in the watershed to follow a management plan developed by the owner and U.S.D.A.-Soil Conservation Service. Management Plans and implementation practices should be reviewed by the zoning agent periodically.

Recommendations:

* Pervious pavement should be required for all new and reconstructed roadways, driveways, and parking areas in the watershed basin.

* Stormwater Management Plans should be required for all new development plans. These plans should detail how both quantity (zero peak increase) and quality (contaminant loads) effects will be controlled. Similar requirements to those for Sediment and Erosion Control Plans should be imposed.

* Existing wetlands should be protected to the greatest degree possible under the Inland Wetlands and Watercourses Act.

* New wetland detention/renovation facilities should be required for significant development proposals (as discussed previously).

* All new and reconstructed drainage systems should incorporate infiltration drainage components wherever possible (e.g. "seep-aways", infiltration piping, etc.).

Recommendation:

* An evergreen shrub buffer strip should be encouraged around the shoreline wherever possible; feeding of waterfowl should be strongly discouraged.

Recommendations:

* Detailed Soil Erosion and Sedimentation Control Plans should be required for any disturbance effecting 1/2 acre or more (as provided for in PA 83-388).

* The detailed S&E Control Plan should include:

  1) a detailed narrative defining a specific sequencing of construction and control activities

  2) definition of specific design criteria used to determine appropriate S&E control methods ("Source Methods" should be emphasized)

  3) Construction details for S&E Control Methods. "Typical Details" reprinted from "Guidelines" are not specific to an individual site, nor are they in accordance with specific site design criteria. Construction details for all S&E Control Methods should be incorporated throughout site plans and specifications. An attached, separate sheet illustrating "typical details" should not be considered adequate.

  4) S&E Control Plans should include detailed design criteria and construction detail on a lot-by-lot basis as well as plans to incorporate measures for an entire site. Perimeter controls in the absence of detailed lot-by-lot source controls should not be considered adequate.

  5) Installation and/or application procedures proposed for erosion and sediment control measures and timing/ sequencing should be clearly and specifically defined and incorporated throughout plans and specifications. Control measures should be in place prior to the disturbance activity initiation which they are designed to control whenever possible. When such methods as mulching of disturbed area is proposed, all materials should be on site for immediate application following disturbance.

  6) An operation, inspection, and maintenance program with an associated reporting procedure should be defined on a lot-by-lot basis as well as for general control measures. Control systems should be inspected and maintained on a storm episode schedule throughout the period of disturbance.

* All S&E Control Plans should be certified by an agent of the Town Commission or County Soil and Water Conservation District.

* All S&E Control Plans should include the identification of the individual responsible for its implementation, a compliance agreement from that individual, and a reporting mechanism for demonstration to the "Certifying Agent" on a monthly basis that all S&E Control Methods have been implemented, maintained, and are effectively controlling erosion problems. Additional measures should be required as field conditions dictate. A checklist summarizing S&E Control plan elements should be included on site plans for each lot and an overall site, and shall be used by the individual responsible for implementation to demonstrate compliance to the certifying agent.

1. Any septic system to be installed in a soil type identified in "Soil Interpretations for Waste Disposal" as exhibiting severe limitations and low potential for leaching fields due to poor filter characteristics shall have active and reserve leaching fields sized 50% larger than that computed based on perc rate.

2. Any leaching field constructed in a soil type as defined above shall have a minimum depth from distribution tiles to seasonal high groundwater of 3 feet. If existing seasonal high watertable depth is less than or equal to 3 feet, the leach field length and setback to nearest wetland shall be in accordance with the approved setback table.

3. Leaching field fill material used in the construction of systems in soils as identified above shall have a minimum phosphorus attenuation coefficient of 0.005 $kgP/ft.^3$ (equivalent to a Charlton Soil Type).

4. The down-gradient septic leachate plume shall not intersect any other system leaching plume for a distance of 500 feet.

5. A public awareness program should be initiated to improve the understanding of the public as to the importance of using non-phosphate detergents in the watershed, and other septic system use and maintenance procedures. This program could involve newsletters, newspaper articles, school programs, resolutions of local governing boards implementing a voluntary phosphate detergent ban, etc.

6. Areas identified as exhibiting severe limitations/medium potential due to slow percolation, wetness, and/or seasonally high watertable should require seasonally restricted percolation testing, enlarged leaching fields to increase soil contact volume (2 times the perc test criteria for both active and reserve fields), and necessary fill should have a minimum phosphorus attenuation coefficient of 0.005 $kgP/ft.^3$.

7. Within the watershed, leaching fields should have a minimum depth to high watertable of three feet in soils not identified as "poor filters". If existing seasonal high watertable depth is less than or equal to 3 feet, the leach field length and setback to nearest wetland shall be

8. For rehabilitation of existing systems where the capacity of the system for phosphorus removal has been exceeded:

   * leach fields can be relocated to new, "reserve" areas to provide another effective lifetime for phosphorus removal,

   * phosphorus/nitrogen removal systems (such as the "RUCK" denitrification system, appended) can be used for system rehabilitation,

   * domestic "package treatment plants" can be installed.

Suggestion:

9. A detailed inventory of all watershed areas should be conducted to identify septic systems which either failing or not failing but which have exceeded their capacity for phosphorus removal. These systems should be tested (via observation wells) to determine whether phosphorus loading is indeed problematic. Systems which are problematic should be rehabilitated by appropriate means. A cooperative funding mechanism should be established to assist homeowners with improvements necessary for protecting water resources and the "public good".

Recommendations:

* A public awareness/education program should be initiated regarding the use and maintenance of septic systems. For example, garbage disposal systems should be discouraged or prohibited where septic systems are used, paints, chemicals, solvents, etc. should not be disposed of in septic systems, phosphate detergents should be banned, importance of regular pump-out should be stressed, etc. This program could involve newsletters, newspaper articles, school programs, etc.

* A mandatory minimum pump-out frequency program should be ~~developed~~. (Perhaps requiring a receipt for septic system pump out every 2-3 years when local property tax payments are made.)

* A requirement for leach field construction in a single work day, (with sanitarian notification required) should be considered to avoid "smearing" effects.

* Seasonal testing requirements, especially in soil areas where a seasonally high water table exists, should be developed and implemented.

* Drainage system outfalls should be to wetland areas rather than directly into tributary flow wherever possible, with appropriate outfall protection (e.g. level spreaders).

* Roof downspouts and driveway drainage should be directed into "first flush" treatment structures such as drywells, perforated chambers, etc. Such structures should be sized to contain the first 1/8" of runoff from impervious surfaces (see Appendix). The balance of runoff (in excess of the first 1/8 inch) should be allowed to bypass such structures.

* Stormwater Management Plans should be based on the following design criteria: