December 1973

Proceedings: First Wetlands Conference

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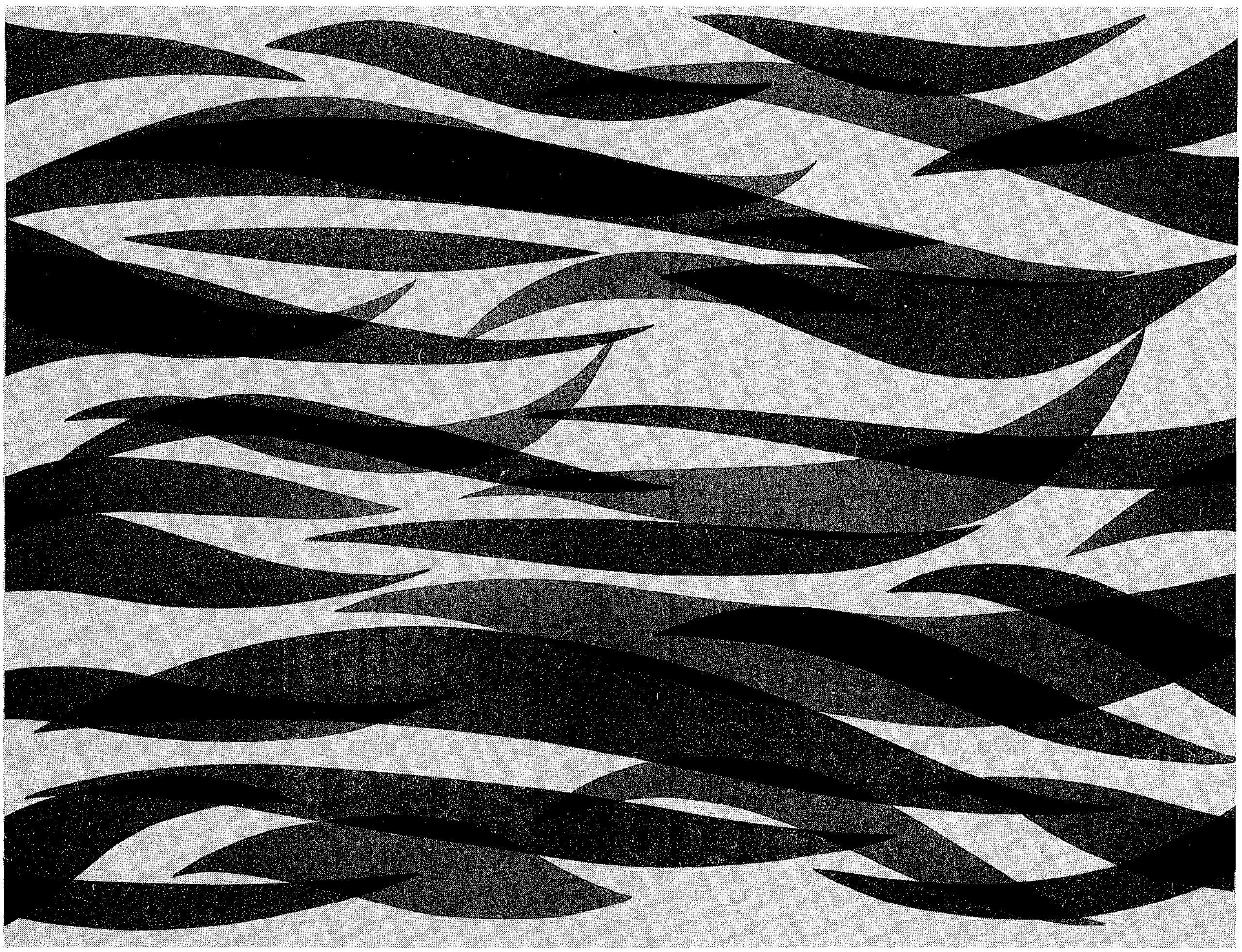
PROCEEDINGS:

WETLANDS CONFERENCE

HELD ON JUNE 20, 1973 AT STORRS, CONNECTICUT

Report No. 21 December 1973



INSTITUTE OF WATER RESOURCES
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WETLANDS CONFERENCE

June 20, 1973

T. Helfgott[1], M. W. Lefor[2] and W. C. Kennard[3]

Editors

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ABSTRACT

Proceedings: First Wetlands Conference

June 20, 1973

T. Helfgott, M. Wm. Lefor and W. C. Kennard (Editors)

University of Connecticut

This is an edited and reviewed proceedings of a conference on wetlands held at the University of Connecticut on 20 June 1973 under the auspices of the Institute of Water Resources. The conference, emphasizing inland wetlands, brought together experts in geology, hydrology, soils, water chemistry, floristic and faunistic biology with other ecosystems researchers and with social and political scientists, policy makers and interested laymen. They reviewed what is known on wetlands as well as the limitations of each approach. Much detail is offered, and some specific conclusions drawn; the general conclusion is that wetlands are a part of the larger ecosystem and that each worker had contrasting views and different definitions; a holistic overview of the environment is needed to effectively define in order to delineate and protect wetlands.

FOREWORD

The importance of wetlands has been popularly discovered only recently; therefore, the body of literature on wetlands, technical and political, theoretical and practical, as expressed in texts, journal and the law is limited. This conference was organized through the auspices of the University of Connecticut's Institute of Water Resources to bridge this information gap on the wetland water resource. The conference proceedings compiled by the editors of this symposium volume deal with wetlands and are definitional in scope. The emphasis here is on inland wetlands, but information on coastal wetlands is also presented for contrast.

Introductory and welcoming remarks at the 20 June 1973 conference on wetlands held here at the University of Connecticut Storrs campus were made by Dr. W. C. Kennard, the Director of the Institute of Water Resources (IWR). They are repeated here in part: ". . . For those at the University of Connecticut for the first time, I would like to briefly comment on the Institute of Water Resources. The Institute is an administrative unit of the University and is charged with developing and conducting a program in research, graduate training and technology transfer in the field of water resources. The Institute is concerned with helping to solve practical problems in the use and management of Connecticut's water and, at the same time, in contributing to basic knowledge on water sciences. The Institute is multi-disciplinary and outreaching in nature.

To date, scientists and students from over 25 different academic departments at the University have been involved in Institute of Water Resources research. Many students have received Masters and Doctorate degrees under this program while solving basic problems involving water resources and contributing

to the theoretical understanding of the aquatic environment.

The Institute interacts with many agencies, organizations, businesses, industries, communities and individuals who have an interest in or a responsibility for the technical management of Connecticut's waters. The research program is dynamic in scope, shifting and changing as experiments are completed, innovations are realized and water problems are recognized.

Other activities of the Institute include seminars, conferences, publications, radio and television presentations and service on state, regional and national committees -- all concerned with water resources.

Scientists and laymen have come to recognize the vital role that wetlands play in the hydrologic cycle, the name given to nature's never ending recycle of water from the oceans through the atmosphere, through the land and then back to the seas. The principal purpose of this conference on wetlands is to develop a comprehensive understanding of wetlands as an ecological system in that cycle. In addition to the University of Connecticut's Institute of Water Resources, three groups have contributed significantly to the conference's program: The Connecticut State Department of Environmental Protection, the Connecticut Association of Water Conservation Districts and the Soil Conservation Service of the United States Department of Agriculture.

The Conference Committee that developed this wetlands conference include Dr. Gary Griffin, Associate Professor of Agronomy at the University of Connecticut and conference co-chairman; Dr. Ted Helfgott, Assistant Professor of Civil Engineering in the Environmental Engineering program also here at the University of Connecticut and chairman of the afternoon session; Mr. Elmer Offerman, Resource Planning Specialist, Soil Conservation Service, U.S. Department of Agriculture, headquartered at Storrs, Connecticut; and Mr. E.

Zell Steever, biologist and Acting Director, Water and Related Resources Unit, Connecticut State Department of Environmental Protection, Hartford, and the morning session chairman . . ."

Mr. Steever further set the tone of the conference with the following remarks: ". . . On behalf of the Department of Environmental Protection, I would like to express our delight in participating in this cooperative conference on wetlands with the Institute of Water Resources. We sincerely hope that this program continues a long and friendly relationship between the academic scientific community and the State of Connecticut's Department of Environmental Protection.

It is extremely important that the Department of Environmental Protection encourage, support and utilize the research efforts from the scientific institutions of the state. It is only with correct and sufficient information that a regulatory agency such as the Department of Environmental Protection can render responsible and intelligent decisions concerning the protection and use of natural resources and can maintain a high environmental quality for the people of Connecticut.

The central theme of this symposium is the holistic view of one of the most vital natural resources: the inland wetlands. The authors contributing to these proceedings give us information concerning the state-of-the-art in various disciplines as applied to wetlands. It is important and significant to keep in mind the interdisciplinary nature of this symposium. . ."

The editors of this proceedings original intent was only to publish abstracts of the papers; but the response to the conference was so large (over 260 persons in attendance), the need for information on wetlands so great and the technical information so appropriate that it was decided to publish the entire proceedings for its academic and practical value. A tape of each presentation was sent to

each author and the resulting papers returned to the Institute of Water Resources for publication. Almost all of this original material was altered in some way for purpose of uniformity and conversion into more formal technical papers rather than the spoken presentations originally offered. After return to the IWR office, the polished drafts were next edited and formally reviewed. We have included the formal reviews as editorial commentaries on each of the papers offered. The shorter panel presentations, also edited and with reviewer's commentary, are offered here as a set of brief comments of value. The text has been edited with a view toward producing a coherent document (not necessarily following the conference order). Apologies are hereby tendered to those who "didn't say that!" On the other hand, the editors resisted the temptation to alter the over-statements of some of the contributors allowing the dialogue to speak for itself. The editorial commentaries tend to balance the overemphasis of some authors as well as bring in supplementary information, constructive criticism and didatic questions. The conference has been ably summarized at the end of this volume by Dr. Lincoln Brower of Amherst College. The editors hope they have assembled a contribution to the literature which reflects the excellent presentations at this first IWR Wetlands Conference. The current Connecticut legislation involving wetlands is appended to this proceedings, as requested by attendees at the conference, for the convenience of persons in need of this information. The conference attendee's names are also listed in the appendix to this proceedings.

Special thanks is deserved by Carol Edelen and Roy Deitchman, Research Assistantsin the Institute of Water Resources, who contributed to the editing and program coordination; and to Michele Greaves, Jean Hopkins, Donna Slavin and Kenneth Lohmann, who were consistently able to decipher the manuscripts along with numerous and varied reviews and editorial notations and type the

entire report in such an excellent form. Mr. Hal Ridgeway, surveying instructor in the Civil Engineering Department, contributed to the final review of the manuscript. Two University of Connecticut graduate students assisted; Ron Waghorn, Civil Engineering, helped physically with the conference arrangement and Paul Marin, Geology, gave us a student's eye review of the manuscript before it was finalized.

No matter how well written or critically reviewed, the papers generated by this conference should be known by the conclusions drawn in them. The conclusions drawn from this first wetlands conference at the University of Connecticut include:

1. Wetlands can be defined differently by workers in different fields. There are widely different views on wetlands expressed by the geologists, engineers, biologists, ecologists, soils scientists, surveyors, resource managers and other environmentalists interested in wetlands. Therefore, for legal purposes, wetlands should not be defined unilaterally -- a holistic view is needed.

2. Wetlands should be thought of as part of a larger biological and social ecosystem not as a separate resources unit. This is especially true since over 800,000 acres, or 25%, of Connecticut's land area can be called inland wetlands. Contrast this to the original 40,000 acres of Connecticut coastal wetlands of which only 15,000 acres are estimated to be left today.

3. The role of wetlands in the hydrologic cycle leaves much to be explored in practice and research of this segment of the ecosystem. Since Connecticut inland wetlands were formed geologically some 12,500 years ago, they are not likely to return soon if destroyed now. The younger coastal wetlands, formed only some 3,000 - 7,000 years ago, are also being altered by man's current activities and nature's modifications; downwarping may result in a 2 meter lowering of the coastline from present levels.

4. Hydrogeologically, upland wetlands in eastern Connecticut are influenced significantly by the groundwater flow system. Since it is estimated that only 2 inches of Connecticut's annual 45 inches of rain is needed to maintain the regional groundwater flow system and ground water runoff is about 7 inches, the bulk of the ground water recharge to wetlands is from local ground water flow systems.

5. More information is needed on the precision of existing methods for determining the wetland/non-wetlands interfaces and in fixing the location of boundary lines and transition zones between wetlands and neighboring areas. The delineation of the interface lines will depend on present and future land use, but accuracies of ± 10 feet or less are in order.

We hope that this conference volume forms a significant source of current technical, legal and policy information and serves as an interdisciplinary keystone for future work on wetlands and other water resources.

T. Helfgott, M. W. Lefor and W. C. Kennard,
(Editors)

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THE CONNECTICUT TIDAL WETLANDS SURVEY

Michael Wm. Lefor*

I. Introduction

The preservation of Connecticut's tidal wetlands has aroused widespread and significant interest only within the last decade. Thanks to this environmental interest, Connecticut has now passed legislation to protect and regulate the use of tidal wetlands, and new statutes for the preservation of inland wetlands are in effect. This discussion is limited to the tidal wetlands of Connecticut, which have had a legal shield since October of 1969.

Because of the economic and aesthetic attractions of Connecticut's shoreline and its consequent growth in population, the tidal marshes have been almost systematically destroyed, bit by bit. Their rivers and channels were fouled with every sort of organic and inorganic matter. The marshes became dumping grounds for everything from household sewage to wholesale industrial pollutants. Because of the widely held ideas about mosquito control, almost all of the saltmarshes were ditched, thereby destroying natural drainage patterns and changing the attendant plant zonation. Many marshes were impounded, excludingthe life-giving sea water altogether; channels were blocked or restricted by highways and railroads; inadequate culverts were installed; and sometimes tide gates and sluice gates changed or excluded the flow of water into the marsh. These modifications caused a change in soil salinity, thus effecting a change in the vegetation. Where once one could see vast plains of Cattails or the Spartinas, now there is the Reed, <u>Phragmites communis</u>. Where marshes

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were not eliminated by filling, tidal blockage or pollution, whole areas were dredged out and carted to sea or dumped on adjacent marshes for additional landfill.

A notable example of these conditions is the alteration or destruction of many of the Quinnipiac Marshes in New Haven resulting from urbanization: railroad trackbeds, junkyards, and industrial plants cover what once were marshes; the construction of State and local highways has also played a major role.

Connecticut's coast was graced with approximately 40,000 acres of salt-water tidal marshes after the retreat of the last glaciation, which occurred about 7-14,000 years ago. Today, some 15,000 of these remain, or less than half. This does not include a possible 5,000 acres of brackish and fresh water tidal marshes in Connecticut's estuaries.

Goodwin[1] gives the following figures for salt-water tidal marshes, now perhaps somewhat out-of-date:

Area of marshes in 1914	23,360 acres
% destroyed by 1965	50%
Acres lost, 1955-1965	2,179
% of 1954 acreage lost by 1965	12.8%

Causes of 12.8% loss:

Miscellaneous filling	48%
Waste disposal (dumps)	14%
Roads and parking	9%
Industry	7%
Airports	5%
Marinas	6%

1. Goodwin et al., 1961. Connecticut's Coastal Marshes--A Vanishing Resource. Connecticut Arbor. Bull. No. 12: 1961. Second printing with supplement, 1966.

Housing	6%
Recreation	3%
Schools	1%

Losses of marshland, 1955-1965, based on 1954 acreage, by county:

Fairfield	45% or 923 acres
New Haven	13% or 888 acres
Middlesex	6% or 263 acres
New London	3% or 95 acres

It is readily apparent from these figures that the major cause of marsh destruction in Connecticut has been indiscriminate filling by the private landowner.

Some have overlooked the value of tidal marshes to the estuarine system. Profits from the State's shellfish industry have declined markedly in the last 50 years, and have only begun to return. We have also overlooked the value of the marshes as protection against flood waters. Recent filling of marshes has caused basement and street flooding in many adjacent populated areas. Consider a recent storm disaster along the southwestern segment of Connecticut's coastline: How much of the destruction of life and property could have been averted on June 17 - 18 of 1972 if marshlands in these areas had not been filled?

Not everyone has been so blithely disinterested in tidal marshes. Through the efforts of some concerned legislators, scientists, conservation groups and others, the Connecticut State Legislature unanimously passed "An Act Concerning the Preservation of Wetlands and Tidal Marsh and Estuarine Systems" in 1969. This came to be known as the "Wetlands Act", or Public Act No. 695.

This Act gave the Commissioner of Agriculture and Natural Resources (and now the Commissioner of Environmental Protection) a clear mandate to take the

steps necessary to preserve Connecticut's tidal marshes. The Act clearly stated that an immediate mapping and inventory be made of Connecticut's salt marshes. After funds were made available, the Wetlands Division of the Department of Agriculture and Natural Resources was created. The Wetlands Division was given charge of the surveys and empowered to hire biological consultants and engineers to assist in the task of bringing the wetlands under regulation.

The Wetlands Act clearly defined what was to be surveyed and included by the State in its section dealing with the definition of terms:

> "...wetlands means those areas which border on or lie beneath tidal waters, such as but not limited to, banks, bogs, salt marsh, swamps, meadows, flats, or other low lands subject to tidal action, and whose surface is at or below an elevation of one foot above local extreme high water; and upon which may grow, or be capable of growing, some, but not necessarily all, of the following..."

The Act goes on to list those species of higher plants which form the dominant vegetation of salt marshes. Clearly, this Act was meant to protect salt marshes only, despite its rather general title:

Typha latifolia L. - Cattail

T. angustifolia L. - Cattail

Distichlis spicta (L.) Greene - Spike grass

Agrostis alba L. var. *Palustris* (Huds.) Pers. - Carpet bent

Spartina pectinata Link - Cord Grass

S. alterniflora Loisel. - Salt-water cord grass

S. patens (Ait.) Muhl - Salt meadow grass

Eleocharis rostellata Torr. - spike rush

Scirpus americanus Pers. - Saltmarsh bulrush

S. robustus Pursh. - Saltmarsh bulrush

S. paludosus Nels. var. *atlanticus* Fern.

Juncus gerardi Loisel. - Black grass

Salicornia Bigelovii Torr. - Glasswort

S. europaea L. - Glasswort

Spergularia marina (L.) Griseb. - Sand-spurrey

Limonium carolinianum (Walt.) Britt. - Sea-Lavender

Iva frutescens L. var. *oraria* (Bartl.) Fern. & Grisc. - High tide bush

In the mapping it was required to strike a balance between the curved-line boundaries of the marsh itself and the straight-line boundaries which the State requires for legal purposes. Straight-line boundaries can be reestablished in the field if the occasion arises; curved-line boundaries of plant zonation, with the exception of their demarcation by ledges, steep banks and other permanent features, cannot. In walking the boundaries of each marsh, six-foot oaken stakes, surveyor's flagging, blazes on trees, or existing permanent markers such as boundary monuments, bridge abutments and telephone poles have been regularly used as markers for the boundary points.

Because the acreage of salt marsh to be dealt with was not large, it was jointly decided to conduct the surveys on the ground, actually driving stakes according to the legal biological criteria. A line *on the ground* is firmly established by this means. When dealing with larger surveys such as those of Connecticut's inland wetlands, different means of delineating these natural areas must be taken. Presently the DEP has decided to base the inland wetland surveys on U.S.D.A. soils maps as an inexpensive expedient. Estimates for an inland wetlands survey from photointerpretation of existing maps run at about $50 per square mile for a finished map. These black-and-white maps would have shown the boundaries of Connecticut's inland wetlands at a scale of 1:2400 (1"=200') along with boundaries and owners of effected property.

While the survey of the State's marshes has in general gone very smoothly, there have been some matters of special concern with the actual field work.

First is the relative impermanence of the boundary point markers. Oaken stakes will rot in time, or are often pulled up by passers-by and property owners. Flagging becomes brittle and bleaches with exposure to the elements (especially sunlight), and is often removed because of its unsightliness. Despite this, we have had no difficulty in reestablishing boundaries when called upon to do so.

The base maps deserve to be treated carefully. These are diazo contact prints made from a 4' x 4' enlarged half-tone mylar master. The original negative from which the transparent mylar is produced is about 1' x 1'; in the enlargement process, some detail may be obscured. The light sensitive dye on the maps breaks down slowly with exposure to sunlight, water and acids (fingerprints, sweat). This means that field work is almost impossible in the rain, and that the maps must be stored out of the light and handled carefully. Also, the grade of photosensitive paper is not well suited for field use. Maps of this size and on this grade of paper are very hygroscopic, and may expand up to one-half inch in every direction in humid weather, making tracing an accurate final copy from an already physically damaged field map an impossibility. Thus the maps must be copied by hand, in the manner of the medieval monks.

Coordinating the natural marsh boundaries with what is present on the aerial photographs has been fairly easy in the salt marshes, where there is usually a sharp distinction between the marsh and the upland zones. Further, the restricted number of plant species in a salt marsh can often be well correlated with their appearance in aerial photographs. This sort of work is regularly done in photo-interpretation studies. The plants themselves occur in an altitudinal zonation with respect to mean tidal levels, so that boundaries almost always correspond with the zone of *Iva frutescens* (high tide bush) and/or *Panicum virgatum* (switch grass). *Iva frutescens* occurs just at the level of

the seasonal extreme high tide, when the surface of the marsh is inundated to a depth of about six inches. The _Panicum virgatum_ zone corresponds with the level of the occasional storm tides.

Color-infrared photography can be even more valuable in this sort of mapping work since the species of the salt marsh zonation can be readily differentiated in the final print once ground truth has been established.

Surveying the fresh and brackish water tidal marshes from black-and-white aerial photographs is more difficult since there is often a gradation between herb, shrub, and tree zones in this usually dense and complex vegetation. Natural boundaries do not always show up as well on the two-dimensional photographs. Stereoscopic interpretation overcomes this, however. Still, it is an easy matter to exactly locate boundary points on the ground and on the maps by landmarks and/or triangulation.

Referring back to the Wetlands Act, it is important to point out the two most salient features of the wetlands definition:

1. The land must be subject to tidal action, or it must be connected to tidal waters; and
2. It must bear an association of plants characteristic of salt marshes, or have the capability thereof.

An amended definition of wetlands, including some fifty additional plant species* was recently passed by the Connecticut State Legislature for the purpose of including all of those tidal areas which supported none of the plants of the first definition. These surveys, now almost complete, have thus been extended to the marshes of Connecticut's major rivers and to the backwaters of many of our salt-water tidal wetlands.

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*See list on pages 17, 18 and 19.

The phrase "now or formerly connected to tidal waters" of both wetlands definitions allows the survey teams the proper latitude in delineating these new areas. The indicator species of tidal influence in a fresh-water tidal marsh vary from place to place; this also applies in fresh and brackish tidal areas where a marsh is also supplied with landward watershed run-off or a sub-surface water table. By and large the field observations have shown that the inner margin of the shrub zone or the beginning of flood plain vegetation constitutes this tidal boundary area. Not only is one dealing with a variable series of plant associations, but the relative indecisiveness in determining the exact line where tidal influence stops and watershed run-off begins makes it necessary to justify the inclusion of entire areas connected to tidal waters.

For all practical purposes, the phrase "subject to tidal action" of the wetlands definition has been taken to mean "subject to regular, daily, tidal action".

The phrase "connected to tidal waters" of the wetlands definition is one of unusual latitude, since all of Connecticut's wetlands can be said to be connected to tidal waters in one sense or another. In order to avoid overlapping with projected surveys of inland wetlands in Connecticut, and to remain clearly within the light of the other facets of the tidal wetlands definition, it was decided that the surveys should only include "connected to" areas as far inland as sharp increases in elevation, such as rapids and dams. So far we have had no difficulty in applying this rule. Any areas of marsh excluded by this rule will eventually come under the inland wetlands statutes. Since the biologists' maps remain in Hartford as matters of legal record, those in charge of the surveys of inland wetlandsshall have already had the boundaries

of these gray areas set for them.

There are those who feel that the idea of a biologist driving stakes into a marsh is neanderthal; we would disagree. Modern technology has given birth to a great many highly sophisticated systems for plotting surface features in two dimensions in addition to those designed to plot three-dimensional ones. Surely any of these are usable in the proper circumstances. The aim here has been the immediate and reliable reproduction of boundaries in the field in the face of legal challenge.

Any system of aerial photography, be it black-and-white, color, infrared, color-infrared, or color enhanced densitometry can provide a picture of conditions on the ground. The colors, patterns and textures of the photographic image can be ascribed to areas of land dominated by certain plant species. A correlation must be made, however, between those colors or patterns of the photographic image and the actual conditions on the ground (ground truth). In a limited species association, this is a fairly reliable system to work with; however, when faced with a series of variable plant associes which change from marsh to marsh, each new and separate area must be checked for ground truth.

In other states with vast areas of marsh, e.g., Maryland with over 250,000 acres of tidal wetlands, a new aerial survey might be feasible. Still, in this case, every time a question or challenge is put to the wetlands bounds, field survey teams have to go out in the field and establish the boundaries on the ground. This is practical with a large acreage like Maryland's but with Connecticut's limited acreage where legal challenges can arise at any minute, the field survey method is more direct. Legal boundary lines are established immediately on the ground, and both the property owner and the State know where they stand without any equivocation.

II. Steps for Implementation

In Connecticut, the process of preserving even a square inch of marsh is sure but ineluctably slow after the biologists have mapped the wetlands. As detailed in the Tidal Wetlands Act, the following steps are taken:

A. Biological Phase

1. Field mapping by the consultant biologists.

2. Copying of the maps and data sheets; preparation of report. Two copies of report with data sheets and maps sent to Wetlands Division in Hartford.

B. Implementation Phase

1. Biologists' maps submitted to engineers, who determine affected property owners from old maps, town assessor's records, etc. These property lines are superimposed on a new map showing both biological boundaries and property lines.

2. Owners of affected property notified by registered letter of a hearing on proposed bounds not less than 30 days before the hearing.

3. Notice of the hearing published in town newspapers at least 30 days before the hearing.

4. Copies of Biological Report and final engineer's maps on file in local town clerk's office at least two weeks before the hearing.

5. Representative of the Wetlands Division available at town hall or other public area in the affected area on the morning of the day of the hearing.

6. Written and/or oral testimony and/or statements received prior to and during the public hearing are made part of the record for that hearing. No other testimony is gathered after the hearing is closed. Here facts are gathered relating to the proposed bounds as shown on the engineer's maps, i.e.,

discrepancies, omissions, additions and appeals for exclusions.

7. Field check of the bounds to make any necessary adjustments in the lines.

8. Typing of transcript completed.

9. Preliminary Findings Report on bounds submitted to the Commissioner of Environmental Protection.

10. Final Findings Report on bounds submitted to the Commisssoner of Environmental Protection.

11. Order of establishment of bounds signed by Commissioner.

Until the wetlands bounds are legally established by the Commissioner, regulated activity, as defined by the Act (e.g., dredging, dumping and filling) can take place. The Commissioner, however, is empowered to impose a moratorium on such activity before the wetlands bounds are established, provided that a hearing on these bounds is held within 60 days of the issuance of the moratorium order. The procedure for application to conduct regulated activity on an established wetlands follows much the same course.

At one time, the Commissioner of Agriculture and Natural Resources suggested that it might be necessary to set up a classification system whereby it would be possible to decide the value of any given marsh; that is, which ones should be kept inviolate, and which ones can be used or developed by Society. This idea was never fulfilled, but a paper submitted to the Commissioner illustrated some of the many factors centering on the value of a marsh.

III. Value Assessment

The following interrelated factors should be considered in assessing the value of any tidal marsh before we allow it to be developed:

A. Biotic Factors

1. Physical parameters of the marsh

a. Area: Will the loss of all or part of the area in question be detrimental to the estuarine ecosystem?

b. How much of the marsh is to be developed?

c. In what manner?

d. What are the surface and substratal characteristics of the marsh? Would it be foolish to fill or develop the marsh because of its water-retention capacity?

e. Would any structures proposed for the marsh be capable of withstanding the depredations of hurricanes? Would there by any subsidence or settling of the marsh?

f. Will provisions be made against erosion in cases where configuration of the seaward border of the marsh is to be changed?

g. Would any proposed structure pass pollutants into the nearby waters, or onto the surface of any remaining marsh?

B. Biota

1. Will the loss of all or part of the marsh in question eliminate some member(s) of the biotic community? What are the data on wildlife populations for the area? Is it an especial breeding ground for any species? (Ducks, for example, use the tidal marshes as breeding grounds, despite their appearance elsewhere at other times of the year.) Both terrestrial and marine flora and fauna must be taken into account, especially insofar as loss of the marsh will effect the neighboring estuarine ecosystem.

2. Will any proposed development of the marsh increase the amount of human traffic, by land or water, in the area? This is potentially damaging to the ecosystem in question, especially in case of boat traffic.

3. Is the marsh presently heavily polluted? If so, is this pollution reversible in the course of time, or can its elimination only be done at great cost?

C. Societal factors

1. What is the present use of the land?

2. What is the average property value per acre?

3. What is the assessed value per acre?

4. What amount of tax revenue does the marsh provide to the town which resides around it?

5. Will zoning of the marsh as a protected area be detrimental to the tax base of the town?

6. Could the town derive this needed income from another source?

7. Will development of the marsh provide extra tax revenue for the town?

8. Is the marsh in a residential or industrial area?

9. Is this area growing or static?

10. What is the zoning status of the marsh?

11. Is there any projected change in that status?

12. Of what value is the marsh for flood protection of the surrounding lands?

13. Is there, or can there be, any alternative site for the proposed development?

14. Can any precise monetary value of the acreage in question be assigned on the basis of its importance to commercial fisheries or recreational areas?

These factors must be weighed one against the other in deciding whether or not to permit the loss of any one marsh. Of the factors, the biotic ones are

among the most difficult to measure quickly. The following information is absolutely necessary, and much of this has been obtained in the present study:

1. What is the floristic composition of the land portion of the marsh and of its upland margins?

2. What wildlife live on or visit the marsh?

3. What is the composition and extent of the micro-flora and -fauna?

4. Core samples must be taken to measure the water-holding capacity of the marsh.

5. What is the extent and nature of any vertebrate and invertebrate life in the neighboring waters?

6. Assessment of any pollutants presently on or in the marsh, within reason; oil spills, garbage, pesticides, industrial wastes, including marinas, harbors, etc., sewage.

The following additional information will be required in any classification of a wetland:

1. All available surveys of the area in question, as made by any Federal Environmental Agency.

2. Town zoning maps for the area.

3. Assessor's figures on land in question.

4. Any available estimates on the growth of the community neighboring the marsh.

5. A report from the town planning commission (should one exist on the future plans for the area, if any, and similar reports from State and Federal Agencies, if needed).

6. Knowledge from the U.S. Army Corps of Engineers as to future plans for the area, especially as regards flood protection control potential.

7. Any information from State and Federal Highway Planners regarding their possible future plans for the area.

Conservationists should study this list before proceeding with any legal challenges, as it asks many of the questions they may have to answer in court.

IV. Summary

Connecticut's shoreline contains some of the highest-priced land in the state, especially in the industrially zoned regions of the southwestern end of the coast. While the small landowner who wants to fill in the back of his lot has only the loudness of his voice and one lawyer, those who wish to wreak wholesale desecration for commercial purposes can summon a whole battery of lawyers, consultants and lobbyists to aid their cause.

We often hear the argument, "this marsh has been polluted for twenty years, and it is zoned industrial; all the other marshes around it have been filled in, so why not fill this one, and put up fine new buildings on it--think of the jobs it will create!" What these people are saying is defeatist from the environmentalist's standpoint: "it-doesn't-look-too-good-so-let's-fill-it-in." So often when ecology has tilted with money in the past, money has won.

Despite the well-documented worth of wetlands to society, landowners understandably object to the Wetlands Act, since, they say, it is essentially confiscatory. They cite as reasons the lack of remuneration by the State, lack of town tax rebates in many cases, and the apparent denial of their rights to do with their property as they wish. On the other hand, many towns could grant tax rebates under open space statutes, and the only infringement of the rights of the property owner is that <u>some</u> of his rights to the land are being regulated for the public benefit. Some of this remains to be settled in court. Any law which attempts to regulate the use of private lands for the public good must try to balance the greater end of the State's environmental health against the

rights of the property owner to be effective.

During the actual process of writing environmental laws, several measures should be taken to ensure that the greater good of both the public and the environment are served. It can be said that anything for the greater good of the environment is also, at least eventually, to the greater good of the public.

In so far as possible, environmental law should not be formulated only by lawyers, but by lawyers working together with competent and realistic scientific professionals in the area concerned. While the scientific community can point out the long-term environmental effects and well-defined scientific phraseology to the lawyer, the lawyer can point out matters of legal conflict or precedent to the professional. In today's environmental crisis, why take the risk of passing an unadministrable, unconstitutional or unenforceable law?

Connecticut's tidal wetlands program has proved to be a working example of just this sort of cooperation. The law and its attendant administrative pathways work; marsh has been saved from destruction for future generations. With continued environmental awareness by her public, Connecticut can continue to set a standard of environmental policy for others to follow.

FRESH TO BRACKISH WATER INDICATOR SPECIES OF VASCULAR PLANTS, ADDED TO PUBLIC ACT 695 AS PUBLIC ACT 132 (1972)

Osmunda regalis L. - Royal fern

O. claytoniana L. - Interrupted fern

O. cinnamomea L. - Cinnamon fern

Onoclea sensibilis L. - Sensitive fern

Dryopteris thelypteris (L.) Gray - Marsh fern

Sparganium eurycarpum Engelm. - Bur-reed

Sparganium androcladum Morong - Bur-reed

S. americanum Nutt. - Bur-reed

S. chlorocarpum Rydb. - Bur-reed

S. angustifolium Michx. - Bur-reed

S. fluctuans (Morong) Robins. - Bur-reed

S. minimum (Hartm.) Fries - Bur-reed

Zannichellia palustris L. - Horned pondweed

Alisma subcordatum Raf. - Water-plantain

Sagittaria subulata (L.) Buchenau - Arrowhead

S. graminea Michx. - Arrowhead

S. eatoni J. G. Sm. - Arrowhead

S. engelmanniana J. G. Sm. - Arrowhead

S. latifolia Willd. - Tuckahoe

Zizania aquatica L. - Wild rice

Peltandra virginica (L.) Schott & Endl. - Arrow-arum

Calla palustris L. - Water-arum

Symplocarpus foetidus Salisb. - Skunk cabbage

Acorus calamus L. - Sweet flag

Pontederia cordata L. - Pickerel weed

Heteranthera dubia (Jacq.) MacM. - Water stargrass

Juncus effusus L. - Soft rush

Veratrum viride Ait. - False hellebore

Iris prismatica Pursh - Slender blue flag

I. versicolor L. - Blue flag

I. pseudacorus L. - Yellow flag

Saururus cernuus L. - Lizard's tail

Alnus rugosa (DuRoi) Spreng. - Speckled alder

A. serrulata (Ait.) Willd. - Common alder

Polygonum sagittatum L. - Arrow-leaved tear thumb

P. arifolium L. - Halberd-leaved tear thumb

Nuphar variegatum Engelm. - Spatter dock

Nuphar advena (Ait.) Ait. f. - Spatter dock

Caltha Palustris L. - Marsh marigold

Rosa palustris Marsh - Swamp rose

Lythrum alatum Pursh - Loosestrife

L. salicaria L. - Loosestrife

Cornus stolonifera Michx. - Red osier

C. amomum Mill. - Red willow

C. obliqua Raf. - Silky dogwood

Clethra alnifolia L. - Sweet pepper-bush

Rhododendron viscosum (L.) Torr. - Swamp azalea

Vaccinium corymbosum L. - Blueberry

V. macrocarpon Ait. - Cranberry

Cephalanthus occidentalis L. - Buttonbush

Mikania scandens (L.) Willd. - Climbing hemp-weed

Eupatorium purpureum L. - Joe-pye weed

E. maculatum L. - Joe-pye weed

E. perfoliatum L. - Thoroughwort

EDITORIAL COMMENTARY

The Connecticut Tidal Wetlands Survey

by

Dorothy S. McCluskey[1]

With enactment of the Inland Wetlands and Water Courses Act, the 1972 General Assembly gave the state and towns of Connecticut a powerful new tool for land use planning. Here for the first time public recognition was given to inland wetlands and water courses as "an indispensable and irreplaceable but fragile natural resource with which the citizens of the state have been endowed." (Public Act No. 155, Sec. 1) Preservation of vital inland wetlands and water courses was thus declared the public policy of the state.

Connecticut's tidal wetlands program has earned Dr. Lefor's praise for its reflection of legal and scientific cooperation resulting in an administratively workable law. To what extent can the same be said of the inland wetlands law? Will it prove to be administrable, enforceable and constitutional?

At first glance, inland wetlands legislation might be expected to closely resemble that of tidal wetlands; however, upon closer examination of the available basic technical and scientific information, the need becomes apparent for fundamental differences in the inland wetlands legislative approach. What are the act's major differences from the tidal wetlands act, what policy issues were involved in its passage, what initial implementation problems are being encountered, and what solutions being proposed? The answers to these questions provide the ingredients for an understanding of Connecticut's evolving inland

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1. Project Manager, Connecticut Inland Wetlands Project, Middletown, Connecticut, 06457. David Lavine, Director.

wetlands preservation program.

PROVISIONS OF THE ACT AND LEGISLATIVE HISTORY

Distinctive features of the Inland Wetlands and Water Courses Act are its definition of inland wetlands by soil classification rather than by vegetation, and the delegation of regulatory authority to municipalities until January 1, 1974, after which time the state Department of Environmental Protection is authorized to act.

Inland wetlands are defined as "... land ... which consists of any of the soil types designated as poorly drained, very poorly drained, alluvial, and floodplain by the National Cooperative Soils Survey..." (P.A. No. 155 as amended). This direct contrast to the definition of tidal wetlands by plant species reflects the fact that a vegetative list is not definitive for the diverse freshwater wetlands where a series of variable plant associations may be encountered. This is not to say that vegetation may not be a useful indicator of inland wetlands; but only that soils classification, by providing well established, scientifically accurate criteria that are easily determined and widely available, is preferable. A great deal of thoughtful consideration preceded the decision not to include a vegetative definition in the inland wetlands act.

The inland wetlands legislation passed by the 1972 General Assembly had its source in two tributary bills submitted the previous year: An Act Concerning Inland Wetlands, Bill #631, and An Act Concerning the Establishment of a Scenic and Protected Rivers System for Connecticut, Bill #298.

Bill #631 was Connecticut's first attempt to preserve inland wetlands. It extended the tidal act to cover inland wetlands but contained no definition of inland wetland and for this reason encountered opposition. At the

Environment Committee public hearing on the bill it was suggested a study committee be formed to define inland wetlands and resubmit another bill.

Scenic rivers legislation was first proposed in 1969 and again in 1971, at which time Bill #298 passed the Senate but was defeated in the House by a roll call vote of 86 to 75. The bill's purpose was to establish and preserve a system of rivers possessing outstanding scenic, natural and recreational values by establishing stream setback regulations.

In December 1971 an informal study committee was established by Representative David Lavine, Chairman of the Environment Committee's Clean Water Subcommittee. It was composed of representatives from the Department of Environmental Protection (DEP), including Counsel Russel Brenneman, several conservation organizations, and student interns from Yale and Wesleyan Universities. This committee examined drafts of both scenic rivers and inland wetlands legislation. As an outgrowth of its discussions, the Environment Committee scheduled a public hearing on January 11, 1972 on these legislative concepts. Testimony presented led to the decision to introduce a bill combining the purposes of the 1971 inland wetlands and scenic rivers bills, thereby encompassing protection of both freshwater wetlands and water courses.

By the last week in January 1972, a combined bill had been drafted by Attorney Sam Chambliss with the cooperation of Russel Brenneman. Wetlands were defined in this bill both in terms of vegetation and soils type. At about this time legislative changes were being drafted for an amendment to the botanical definition in the coastal wetlands act (Bill #5175, 1972). In establishing coastal wetlands boundaries, it had been found that some brackish and freshwater tidal marshes in estuarine areas could not be included because the vegetation indigenous to them was not in the original definition. Consequently, a legislative amendment was required before these areas could be protected. This aspect of coastal wet-

lands legislative experience was an influential factor in deciding not to include a botanical definition in the inland wetlands and water courses bill.

Various proposals for definitions of inland wetlands were looked at and their limitations examined. A vegetative definition required a new map of the entire state. A soils definition did not carry with it the inherent problem of compiling a new map. Detailed soils maps are completed for over two-thirds of the state and general soils maps for the remainder, providing well-established, easily identified criteria for delineating wetland boundaries. Subsequent experience has proven the soils definition is workable, although not without problems.

Unlike the scenic rivers bills, stream setback lines were not established in the combined bill. Rivers and streams were included in the all-encompassing definition of water courses: "Water courses means rivers, streams, brooks, waterways, lakes, ponds, marshes, swamps, bogs and all other bodies of water, natural or artificial . . ." In many, though not all, instances the water courses are underlain by the soil types designated as inland wetlands.

Prospects for passage of the 1972 inland wetlands and water courses bill (Bill #5257) were exceedingly slim. At this point the bill met with some opposition from veteran legislators who feared raising the specter of statewide zoning and of restriction of private property rights. It also lacked the widespread educational campaign that preceded the tidal wetlands legislation. The values of inland wetlands have traditionally received little recognition. Their functions are diverse and complexly interrelated, making quantification difficult.

The coalition of opposition focused on the basic issue of protection of individual property rights vs. protection of public rights. The bill's opponents considered wetlands primarily as a commodity to be used or marketed for economic profit, while its supporters viewed wetlands as a scarce and valuable resource to be managed for the public benefit. To the former swamps and marshes are considered

largely worthless wasteland until drained or filled and "improved"; to the latter wetlands are viewed as performing valuable natural functions such as flood prevention, streamflow regulation and sediment control--functions that when destroyed must be replaced by costly drainage construction and dams. Those who emphasize a landowner's right to use his land entirely as he wishes overlook his responsibility to other landowners and the effect his use may have on others.

The basic fear of statewide zoning aspects of the bill was appeased to some extent by listing permitted uses and by giving local municipalities the option to adopt regulations before January 1, 1974. Although no appropriation for compensation accompanied the bill, Section 10 provided that any loss of fair market value resulting from denial of a permit be reflected by tax reevaluation of the property.

Skillful management was a decisive factor in the final passage of the inland wetlands and water courses bill. Significant support was provided by the department of Environmental Protection and Commissioner Dan Lufkin. The bill's sponsor, Representative Lavine, adroitly guided it through the legislative labyrinth, using supporters effectively, evaluating the political climate accurately, and compromising when necessary.

IMPLEMENTATION PROBLEMS AND ATTEMPTS AT SOLUTIONS

Legislative authority provides only the initial step of an effective inland wetlands and water courses preservation program. Implementation problems are inevitable. Some are similar to or shared by the coastal and freshwater wetlands programs, others are unique to the inland wetlands program. Here four major problem areas developed: (1) ambiguity of specific wording of the act, (2) possible costs to the local municipality, (3) initial establishment of a new and innovative program, and (4) constitutionality.

The first problem involves the act's circularity in phrasing of "regulated activities" and "permitted uses." The problem arose from different interpretations of the relationship between Section 4(13) of the act which stated a "regulated activity ... shall not include the specified activities in section 3 of this act....," and section 3 which specified uses which were permitted "... as of right except as they involve regulated activities...." This ambiguity was resolved in 1973 by an amendment that deleted the phrase "except as they involve regulated activities...." (Public Act No. 571).

Many towns were reluctant to assume the regulatory authority without knowing who would pay any land acquisition costs and how much they might be. In its appeals provision the act provided for acquisition of a perpetual easement on property when the denial of a permit constituted a taking; however, no appropriation accompanied the act. This question was resolved by the 1973 amendment which eliminated the town's obligation to buy a wetland when a permit has been denied. The amendment substituted for the original appeals provision a procedure, similar to that of existing zoning enabling legislation, that the court may direct the wetland agency to set aside or modify its denial of a permit.

Initial legal, administrative and technical difficulties must be expected in establishing a new and innovative program, especially when jurisdiction is shared by local and state government. Several approaches were taken to help municipalities cope with this third problem area. The DEP has provided inland wetland maps and guidelines giving initial direction for local administrative procedures. But without any additional funding, the DEP lacked the staff and technical resources to provide towns with the needed assistance for effective implementation of the act.

In March of 1973 the Connecticut Inland Wetlands Project was formed for the purpose of meeting this need. The Project is conducting a one year pilot program in the Midstate Planning Region to assist communities in that region

with implementation of the act. Information developed in the pilot program is being made available to wetland agencies throughout the state. The Project is directed by former state representative David Lavine, sponsor of the Inland Wetlands and Watercourses Act.

Two publications are presently available: "Implementation Aids for Inland Wetlands and Watercourse Agencies," and "Administrative Handbook for Inland Wetland Agencies." The former was written by an ad hoc committee formed in November 1972 and composed of representatives of various agencies involved in implementing the act. It describes a process for inventorying priority inland wetlands, contains a suggested checklist for assessing the environmental impact of a proposed activity, and outlines a procedure for handling permit applications. The Handbook provides sample ordinances, regulations and application forms, illustrational examples of some possible permit applications, and a detailed explanation of available map resources and their use.

At the request of the DEP, Drs. W. A. Niering and R. H. Goodwin have written a botanical guide entitled Inland Wetland Plants of Connecticut, which compiles information needed to identify wetlands by vegetation. The authors define five wetland ecological types, identify significant functions, and describe and illustrate forty characteristic wetland botanical species.

The fourth major problem--constitutionality of the act--is a legal one that is similar to that encountered by the tidal wetlands program. Both inland and tidal wetlands legislation constitute an extension of the police power and raise new issues regarding the protection of private property rights. These issues, reflecting changing and often conflicting values of society, must ultimately be resolved in the courts. Recent supreme court decisions in Wisconsin and Massachusetts have upheld wetlands statutes against charges that they constitute an unconstitutional taking of property without compensation[1].

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1. Turnpike Realty Co. v. Town of Dedham, 72 Mass. 1303, 284 N.E. 2nd 891 (1972), and Just v. Marinette County, 201 N.W. 2nd 761 Wis. (1972).

CONCLUSION

Some of the administrative problems of the inland wetlands program reflect a general misunderstanding of the act's intent. Familiarity with administration of the tidal wetlands act led to questioning the wisdom of a different set of procedural requirements for the preservation of freshwater wetlands.

The act is regulatory--not prohibitive. It is, however, an approach to regulation requiring in effect an evaluation of the environmental impact of a proposed regulated activity upon a wetland. This in turn involves an examination of the wetland's function within the watershed and an evaluation of the significance of the wetland to the community.

What is the value of any individual wetland to society? Dr. Lefor asks this question and answers it with a list of interrelated factors to be considered before deciding whether the marsh should be preserved or developed.[2] A similar list would be equally useful in evaluating inland wetlands. But documentation of inland wetland functions is far more complex. They cover a vastly greater acreage, are far more diverse in size and importance, and any one may perform an intricate combination of functions that are often difficult to quantify. A wetland cannot be considered as an isolated parcel of land. Niering and Holzer have stressed in this conference that the coastal wetland system is inseparable from and dependent on the inland wetland system flow. Similarly, any individual wetland is inseparable from its watershed; its role within the watershed must be identified.

A predominant technical implementation problem has arisen in delineation of boundaries. Even if an appropriation had accompanied the inland wetlands and watercourses act, it would not be feasible to use coastal wetland mapping techniques. There are about 800,000 acres of inland wetland soils in Connecticut

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2. Lefor, M. W., The Connecticut Tidal Wetlands Survey, p. 11-15.

covering approximately 25 percent of the land surface.[3] Inland wetland mapping at a scale of 1 inch = 200 feet would be prohibitively expensive and time consuming. State and local funding could, however, accelerate completion of the state Soil Conservation Service's (SCS) mapping program for the 850,000 acres that are not yet covered by detailed soils maps. But technical and administrative problems will still remain in applying the SCS soils maps to the new role as a basis for land use regulation.

The SCS maps were never intended for use as zoning maps. They were designed to provide a general identification of soil type boundaries but not as a legal delineation. The limitations must be understood and respected. Major technical problems are discussed by Dr. Suffern and Dr. Hill in their conference presentations. How can the edge of a wetland be legally defined when SCS soils maps boundary lines may be "50 feet wide" and at a scale (1 inch = 1320 feet) that does not coincide with U.S.G.S. topographic maps (1 inch = 2000 feet) nor most town property or zoning maps? Map scale differences can be easily and inexpensively overcome by enlargement or reduction, but in doing so it is essential to recognize that the accuracy limitations of the original maps may be distorted. The resultant composite map will only be as accurate as its component parts at their original scale. More precise legal delineation of specific boundaries will require field inspection and, in disputed areas, field testing by a soils scientist.

There is an immediate research need now to attempt to refine boundary delineation in terms of soils classification, and a long-term research need to explore the use of aerial photography as a tool for identification of wetland functions. As long as their limitations are recognized and respected, the soils maps afford the best available tool for delineating inland wetland boundaries.

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3. Hill, D. E., in Niering and Goodwin, 1973, Inland Wetland Plants of Connecticut, The Connecticut Arboretum, New London, Connecticut 06320, p. 2.

Although Connecticut's wetlands preservation program differs substantially for tidal and inland areas, both approaches have broad basic similarities. The inland wetlands legislation, like the tidal, was formulated with close co-operation between lawyers, scientists, legislators and administrators. If anything, it allows more overall flexibility for what activities may be carried out.

It provides Connecticut an excellent tool for including natural resource data in making land use decisions. Zoning regulations based upon land use planning are nothing new when for the purpose of protecting the public health, safety and welfare. However, introduction of ecological considerations into the development decision-making process is new. Reasonable administrative implementation of Connecticut's innovative inland wetlands and watercourses regulatory tools will determine the act's ultimate effectiveness.

INLAND WETLAND SOILS

David E. Hill*

I. Introduction

Inland wetlands, as defined by Public Act 155 of the 1972 Connecticut General Assembly, are "land, including submerged land . . . which consists of any of the soil types designated as poorly drained, very poorly drained, alluvial and flood plain by the National Cooperative Soils Survey." The act thus encompasses more than 410,000 acres of wetlands soils in Connecticut as measured in three complete county surveys and estimated in the other five counties from the 1959 Conservation Needs Inventory of the U.S. Department of Agriculture. Add the water courses of the state, such as rivers, streams, brooks, lakes, ponds and marshes and the total acreage probably exceeds 20 percent of Connecticut's more than 3,200,000 acres.

Inland wetlands mean many things to many different people. Botanists can describe the plant species that occupy wet sites; the hydrologist can describe the water regime and its influence on flooding and discharge to rivers; and the soil scientist can describe the morphology of those wetland soils whose development has been influenced by both plants and water. The general description of wetland soils shall be the first task of this paper, which discusses some of the problems inherent in the mapping and classification of soils that are now used to identify inland wetlands.

II. Identification of Wetland Soils

In Connecticut, experience from more than 70 years mapping has produced

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a state soil legend which lists 15 poorly drained soils, 10 very poorly drained mineral soils, 4 very poorly drained organic soils and 7 well drained and moderately well drained alluvial soils. Each of these 36 soils, known as a soil series, has distinct soil properties and is given a name. Many of these soil series have minor variations in color, texture, depth and stoniness. In addition, some mapping units are complexes of two or three soil series which must be combined because their spatial relationship with one another prohibits separation at the current map scale of 1:15,840. In all, approximately 81 mapping units are delineated on soil survey maps in Connecticut which may be included in Public Act 155. Sixty-eight of these mapping units have morphological characteristics which are associated with wetness. The remaining alluvial soils lack profile development due to their recent origin.

Consider the morphology of the soils that are encompassed by the Inland Wetlands Act. They can be divided into three categories:

A. Poorly Drained and Very Poorly Drained Mineral Soils

These soils commonly have water standing on the surface or beneath the surface for significant portions of the year. The soil interpretations describe them as being saturated with water within three feet of the surface for two to twelve months of the year. Saturation with water, whether produced by a slowly permeable layer of clay, hardpan, or bedrock or low topographic position, is usually accompanied by poor aeration. Under these conditions, iron compounds are mostly in a reduced state and the colors are predominantly a grayish or bluish. Some segments of the soil are oxidized to yellows, browns, and reds especially around structural cracks and root channels. The soil forming process is called gleization and its manifestation is the appearance of soil mottling or variegated soil colors. The mottles are produced by chemical and biological processes. They are described by estimating color contrast between the mottles

and the matrix, the relative abundance and size. Mottling remains even if the water table falls during the summer months. Soils with distinct mottles occurring within six inches to ten inches below the surface are commonly mapped as poorly drained series; those with distinct mottles just below the surface are mapped as very poorly drained soils. Other characteristics include a thicker, darker A horizon* where organic matter has accumulated due to slower rates of decomposition.

B. Very Poorly Drained Peat and Muck

Organic materials which have accumulated over long periods in water filled depressions on the land surface have created peat and muck deposits ranging from 1 to 30 feet thick or more. The surface layer of wooded swamps is commonly black and is more highly oxidized than the underlying brownish layers which are less decomposed. The blackish decomposed peat is commonly called muck and is the result of a fluctuating water table. Unwooded, grassy marshes, on the other hand, generally lack the black surface layer because the water table rarely falls below the surface. Many organic deposits that exceed six to eight feet in depth contain a bottom layer of greenish, grayish or redish sedimentary peat, silt, and clay. These sediments indicate that these wetlands were originally open bodies of water. Most contain algal remains and others contain diatoms or shell material.

C. Well Drained and Moderately Well Drained Alluvial Soils

Soil materials deposited on floodplains during floods are relatively young geologically. The alluvium was probably deposited during occasional catastrophic floods rather than in small more frequent increments by minor floods.

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*Horizon - any of the reasonably distinct layers of soil or its underlying material seen in a vertical section or profile; designated from surface to subsurface as A horizon or B horizon.

A notable characteristic of alluvial soils is the presence of buried, organic-rich horizons which represent former floodplain surfaces. Another important characteristic which segregates them from older, upland soils is the lack of profile development. The rust colored weathered B horizon common in upland and terrace soils is absent or very weakly developed in the alluvial soils due to their more recent origin. The soil may become mottled, however, when internal drainage is impeded so that drainage classes are assigned as in upland soils.

III. Problems in Mapping Soils

As the soil surveyor traverses the landscape, observing land forms changes in slope and topography and soil characteristics in the holes that he digs, he places lines on a survey map to delineate areas of different soil types. The use of the soil survey as a regulatory tool has placed great emphasis upon the lines drawn on the map. We are primarily interested in those lines that delineate poorly drained, very poorly drained and alluvial soils, for these lines have been transposed to other maps to designate inland wetlands boundaries. The lines drawn on a map by the soil surveyor not only represent the surveyor's interpretations of changes in topography and profile morphology but also his interpretation of where his points of observation lie on the aerial photograph he uses for his base map. Since each line is an interpretative line, each may become subject to dispute when applied to a regulatory function. It is important, therefore, to evaluate the variability in interpretive judgment by the soil surveyor.

A. To accomplish this, a field exercise was conducted to determine the variability in placement of soil boundaries by soil surveyors. Six surveyors of the Soil Conservation Service, working independently mapped each of three areas at a scale of 1:2400, the scale of a class D survey, and one area at a scale of 1:12,000. Each area represented differences in topography and cover

as follows:

1. Open land, containing some sharp slope boundaries between poorly drained and well-drained terrace soils.

2. Wooded land containing long gentle slopes underlain by hardpan.

3. Partly wooded-partly open land containing a long complex slope from drumlin top to adjacent valley where the soils were underlain by hardpan.

The surveyors were instructed to segregate only poorly drained, very poorly drained, and alluvial soils; they did not have to identify the particular soil types. The soil boundaries of all six surveyors were superimposed to produce a composite map that delineated areas of undisputed wetlands, areas of undisputed upland, and a disputed zone between the two, Figure 1. We then compared each surveyor's boundary with the undisputed wetland boundary. In open land the average disputed area for all surveyors was only 12 percent of the 13 acres mapped, Table 1. In wooded land, the average disputed area was only 14 percent of the 13 acres mapped but the range in variability was greater than in the open area. Where sharp breaks in slopes occurred, map lines varied as little as 10 feet. Where slopes were more gradual, boundary lines on the map in both wooded and open terrain varied from 70 to 260 feet, Figure 1.

B. Mapping on the complex slope of the drumlin was completed at two scales, 1:12,000 or one inch equals 1,000 feet, and 1:2400 or one inch equals 200 feet. The surveyors mapped along a transect from ridgetop to valley floor and placed boundaries on the map between moderately well drained and poorly drained soils. At a scale of 1:12,000, the disputed zone was 21 percent of the total distance of the transect. At a scale of 1;2400, a five-fold increase in scale, the disputed zone was 20 percent of the transect, Table 2. Mapping at a larger scale then did not significantly improve the accuracy of boundary

placement. The high variability in this test is somewhat misleading because the transect contained three separate areas of poorly drained soil and variability is accumulative. One poorly drained area was near the beginning of the transect in open land, one was at the end in wooded land and the third was on the intervening wooded slope. All surveyors agreed that the width of the poorly drained area on the wooded slope was 90 to 120 feet but no one could agree where it was. The disputed zone was 290 feet wide at the larger scale and 340 feet at the smaller scale. We concluded from this exercise that:

1. variability in mapping was largely due to the surveyor's difficulty in accurately locating his points of observation on the map. Mapping at larger scales will not improve the accuracy of placing lines on a map: it will only permit more boundaries to be placed on the map.

2. use of the soil survey as a regulatory tool to define wetland boundaries may be limited if high degrees of accuracy are required in the location of the boundaries on a map. Greater accuracy, if needed, can be accomplished by first establishing the boundaries on the ground and then transfering them to a map of appropriate scale by conventional land surveying techniques.

IV. Problems in Classifying Soils

Before stating the problems a few definitions of soil terms are in order. The key words in the definition of inland wetland soils are ". . . soil types designated as poorly drained, very poorly drained, alluvial and flood plain soils . . ." Soil surveyors segregate areas on the landscape that contain soils with such morphological similarities as arrangement and thickness of soil horizons, the color, texture, structure, and chemical composition. The areas they segregate are given a name in the classification system and are called soil series (i.e. Merrimac, Paxton, Whitman). Many series have

subdivisions based on texture variations and these are called soil types (i.e. Merrimac fine sand loam, Merrimac sandy loam). Each series or type is assigned one or more drainage classes to describe its hydrological behavior. Merrimac is described as well drained soil and Whitman is a very poorly drained soil. The drainage class is based on observations of runoff, permeability, and internal drainage and inferences of these properties expressed by the presence and depth of soil mottling. There are seven drainage classes.[3] The surveyor must use soil mottling as a guide because water tables are not static, but fluctuate seasonally. Fluctuation of water tables throughout the year often prevents the observation during summer months. Reliance on direct observation alone of water tables would require long-term studies of depth and duration of the water tables. Relationships between depth of mottling and water table depth and duration have been found. In New Hampshire, Lyford[1] found that examinations of soil morphology can be used to make a close estimate of maximum water table heights provided there has been no artificial drainage. In Washington State, Simonson and Boersma[2] found that when color features are considered jointly with permeability and internal drainage there is high correlation between morphological indicators of soil drainage and water table regimes.

The first problem of classification of a soil lies in the fact that in glaciated regions soil textures and structures, which influence internal drainage, often vary over short distances in the landscape. The definition of each soil series must be broad enough to encompass these variations. Thus, two drainage classes are often assigned to a soil series or type. Of the 15 poorly drained mineral soil series mapped in Connecticut, 12 have ranges in morphological characteristics that extend them into the somewhat poorly drained

class. For example, the Ridgebury soil is assigned to the poorly drained class but also includes the wetter part of the somewhat poorly drained class. Hence, some land underlaid by the 12 soil types will not fall within the current definition of inland wetland soils. This is not to suggest, however, that the somewhat poorly drained class be added to the inland wetland definition because the soil series that are clearly somewhat poorly drained are not associated with prolonged wetness; thus the hydrologic behavior of these soils are less restrictive to use. Further, the series definition in the National Cooperative Soil Survey cannot be narrowed to exclude the somewhat poorly drained portions because the natural range in properties on the landscape would be arbitrarily divided for a special use. Furthermore, narrowing ranges of properties would produce less accurate maps at the current scales of mapping. Clearly then, soil series and types that encompass the somewhat poorly and poorly drained classes will have to be reexamined by a soil scientist in cases that require precise identification.

Another minor problem also should be noted. In some soils of the Northeast United States the expression of mottling infers the drainage class is masked in places by soil colors inherited from the parent material. This especially applies to the red soils of the Connecticut River Lowlands developed on red sandstone and shale. Thus, a few acres of soils that behave hydrologically as wetlands can escape delineation as poorly drained soils in the soil survey.

Despite the fact that the soil survey, as a regulatory tool, has mapping and classification limitations, it does provide the most complete inventory presently available of wetland areas. In the hands of a local regulatory agency, it can be used as a starting point for the necessary regulatory functions.

TABLE 1. VARIABILITY OF WETLAND BOUNDARIES IN OPEN AND WOODED LAND

	Open		Wooded	
	Mean %	Range %	Mean %	Range %
Undisputed Upland	57	53-63	55	43-64
Disputed Zone	12	6-17	14	5-26
Undisputed Wetland	31	31	31	31

TABLE 2. VARIABILITY OF WETLAND BOUNDARIES AT DIFFERENT SCALES

	1:12,000		1:2400	
	Mean %	Range %	Mean %	Range %
Undisputed Upland	60	57-65	58	55-61
Disputed Zone	21	16-23	20	17-23
Undisputed Wetland	19	19	22	22

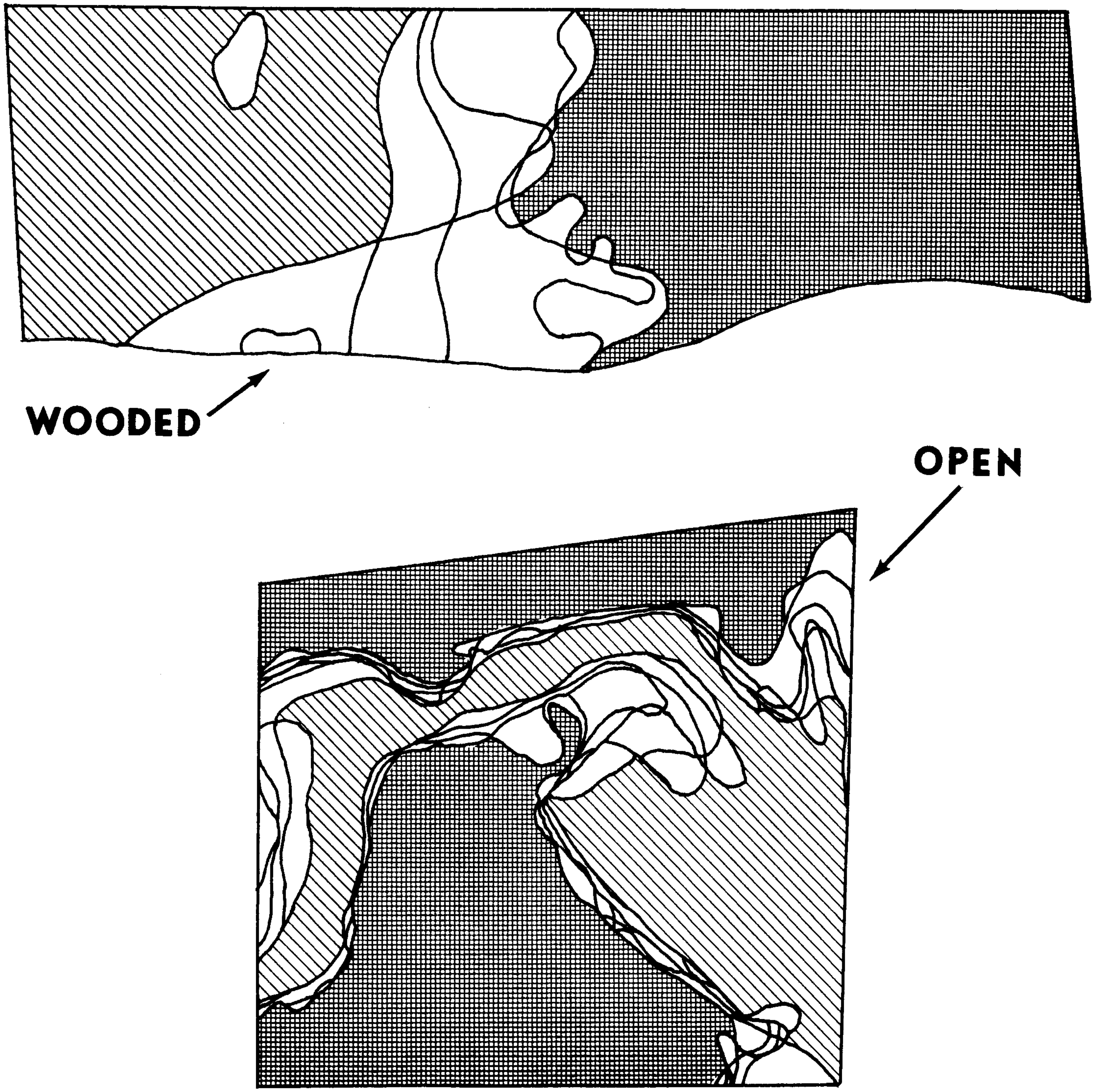

Figure 1. Composite of six soil surveyors' maps showing variability in boundaries segregating poorly drained soils of wetlands from well drained soils of uplands in open and wooded areas

Undisputed upland

Undisputed wetland

Disputed Zone

Scale 1" = 200'

EDITORIAL COMMENTARY

Inland Wetland Soils

by

K. A. Healy and T. L. Holzer

The paper describes very clearly the way in which wetlands are defined and the way they are mapped by the Soil Conservation Service.

The importance of a correct definition of inland wetlands is revealed by the cited estimate that in excess of 20 percent of the acreage of Connecticut is affected by Public Act No. 155. The intent of Public Act No. 155 is to protect from destruction the biologic and hydrologic processes of wetlands. These are beneficial to the quality of the human environment. Soils are presently the basis for the legal definition of inland wetlands; however, wetland soils are the result of these hydrologic and biologic processes. The protection of areas underlain by these soils does not guarantee protection of inland wetlands because we are preserving the product of the processes and not the processes themselves. It is unfortunate that the term "wetland" is applied to all areas where the water table is within three feet of the ground surface more than two months a year. There are many such areas that are not swamps or marshes and are readily adapted to use as house lots, recreation and other dry land uses.

The paper is concerned primarily with the accuracy of the maps of soil surveys. Interestingly, the paper reports that at the mapping scales used by soil surveyors, the greatest uncertainty in the location of boundaries between mapping units is the uncertainty of the soil surveyor's position on his map. Under unfavorable field conditions, uncertainties in the plotting of boundaries on maps can range from 70 to 260 feet when mapping at a scale of 1:2400.

Mapping at a larger scale does not improve the situation. Soil surveyors mapping at a larger scale still have the same degree of uncertainty in drawing boundaries on maps. As the paper indicates, this suggests that the use of a soil survey as a regulatory tool for protecting wetlands can be limited if precise location of boundaries is required. It also raises the technical question of whether or not the imprecision of the maps might inadvertently cause serious impairment of the natural functioning of some wetlands by failing to protect a part of the wetland.

The description of the subjective nature of wetland mapping points out the need for more extensive site evaluation before a specific use should be prohibited.

WETLAND GEOLOGY

Robert F. Black*

I. Introduction

The purpose of this paper is to formulate a broad geologic framework of the wetlands of Connecticut that hopefully places them in geologic perspective, yet not duplicate unduly the specifics of the many disciplines represented in this publication. The term wetlands is used broadly to include water courses of all sizes and both inland and coastal submerged land and wet areas as described in the various State statutes. In Connecticut wetlands are a continuum from the saline areas of the coast, through the brackish estuaries and tidal flats, into the fresh-water wetlands of the interior.

This paper first considers the geologic processes and history of events that brought about the first wetlands immediately upon deglaciation of the southeastern part of the State perhaps 15,000 or 16,000 radiocarbon years ago. Deglaciation apparently proceeded northward and northwestward by combined downwasting and backwasting, clearing the rest of the State by perhaps 12,500 radiocarbon years ago.[6] Thus major streams and some lakes and numerous inland swamps and marshes date back to those early times. None of the existing coastal wetlands, however, appeared until after 7,000 years ago when rising ocean waters approached, but still had not reached, present levels.[4] Moreover, most of those initial coastal wetlands did not begin to assume characteristics similar to what we see today until after 3,000 years ago.[4]

This paper then concludes with some comments on man's role in Connecticut's wetlands, which has been traumatic to say the least, and on what the geologic

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history, including man as a part of the whole earth ecosystem, portends for the future.

II. Geologic Processes

Table I is an outline of the geologic processes that produce wetlands. The internal processes are those generated inside the earth. We know of no wetlands in the State of Connecticut which are due to volcanic activity. We do not know of any related to tectonism per se, yet as you read in the newspapers from time to time, weak earthquakes do occur in Connecticut. These show that tectonism or mountain building processes are going on today, albeit very slowly. They may be related some time in the future to some of Connecticut's wetlands, but for this paper we must dismiss them.

Table I - Geologic Processes That Produce Wetlands

- Internal
  - Volcanism
  - Tectonism
- External - work of
  - Water
  - Ice
  - Wind
  - Gravity
  - Organisms
- Extraterrestrial
  - Meteoritic impact

The external processes act on the surface of the earth. It is convenient to discuss them as the work of water, ice, wind, gravity, and organisms. These are important ones from our point of view. The extraterrestrial process of meteoritic impact has not produced any known wetlands in Connecticut.

If we go back to those external processes (Table I) and look at them more carefully, starting with with work of water (Table 2) we see that erosional and and depositional processes are taking place in a variety of situations. Some

of these processes are more important for wetlands than others; e.g., streams and other water courses may be wetlands in themselves by definition in the wetlands act.

Table II - Work of Water

Raindrop impact
Sheet wash
Rills
Streams
Solution
Illuviation
Waves, currents, tides, tsunami

We must start water work with the initial raindrop impact on the earth. You have seen this effect on the basement windows of your home when soil is dislodged from the ground and thrown up on the panes of glass during storms. By and large the role of raindrops is to put into motion the soil particles on those areas which are unprotected by vegetation. The rain water is gathered on the surface as sheet wash, spreading out uniformly over the surface. That which does not infiltrate the ground works its way down slopes to accumulate in small rills or channels. The rills in turn combine into little streamlets, gullies, or brooks, and finally into the major streams. All these processes erode and deposit material, forming or modifying wetlands.

In the coastal processes waves and currents, which of course are also found in our larger lakes, erode and deposit material. In the ocean, tides are very important. Tsunami, or earthquake waves, affect many parts of the globe, but are of minor importance on Connecticut's coast. Ground water also moves clay particles and other substances downward in the soil profile to produce, in an illuviation process, a hard pan which in turn creates impermeable conditions for wetland formation. Throughout all of the work of water obviously we have a host of processes which may be directly or indirectly related to wetlands.

Table III - Work of Ice

Glaciation
Eustatic changes of sea level
Isostatic effects
River ice, ice flows, and ice jams
Lake ice, ramparts
Ground ice

If we look at the work of ice (Table III) in particular glaciation, it clearly is a dominant process in the origin of the landforms of this State. To appreciate the effects of glaciation, we have to start with the bedrock and preparation of that bedrock by weathering and erosive processes before glaciation took place. Glaciers advanced several times over the State, molding the landscape in part by erosion, and in part by deposition of materials. Both processes are involved directly in wetland formation. Just as important for our coastal wetlands is the indirect effect of glaciation which is listed as "eustatic changes of sea level". When water was taken from the ocean basins and put into perennial snow and glacial ice which covered so much of the continent, sea level was lowered. The subsequent return of that water to the sea as the glaciers waned caused the water level to rise as it is still doing today.

Isostatic effects are direct effects of glaciation. Because ice has weightroughly one third that of the rocks on which it advanced into this State, it depressed the land. Therefore, it changed the relationship of the levelof the land and the sea. The effect of depressing the land is to raise relative sea level. The increase in amount of water in the ocean also has the isostatic effect of depressing the ocean basin relative to the continent.

We have ice in other forms, such as the familiar loose river ice, ice flows and ice jams. There are of lesser importance in wetlands. Particularly before the building of numerous dams on our water courses, spring floods with

large masses of river ice at time of breakup dammed the channels. The resulting overflow wiped out the adjacent vegetation and left abandoned channels or wetlands. The direct effects of river ice were more important prior to urbanization than in recent years.

Lake ice contracts and cracks during cold nights, and water freezes in the cracks. This process repeated frequently enlarges the ice on the lake and produces ramparts around the shore in places blocking off marshy areas.

Ground ice is listed in Table III even though we do not know for sure that it has ever actually existed in Connecticut, other than seasonally. In the polar regions perennial ice - permafrost - is a very common feature of the landscape and a very important modifier of the external processes which are acting on the land. It may have existed here temporarily immediately upon deglaciation of the last ice advance or it may have been here at times prior to the last ice advance, but we have relatively little information on it in this State.

A. Origin of Connecticut's Wetlands

Water and ice are just two of the major categories of external agents of geologic importance that we must consider in our wetlands. Let us ignore wind and gravity as they are of limited importance in making wetlands in Connecticut, and we can practically ignore the work of organisms; yet man obviously is just as important, or even more so, than some of the normal geological agents. At times past beavers have built their own wetlands, although they are of lesser importance today. Growth and deposition of vegetation also impede surface drainage and make or enlarge wetlands directly as biologic processes. So, if we look at the wetlands of Connecticut from a geologic point of view, we can see that they fall generally, (not all are being listed here) into the various kinds of processes which have been involved in their formation (Table IV).

Man is put first for the simple reason that his work in building dams is so obvious. He has made or modified most of the lakes in the State. Direct and indirect effects of glacial action, however, have made most other wetlands. The glacial erosion and deposition of the rocks and soil that make up the landscape provided the topographic relief, the closed depressions, which in turn made it possible for many wetlands to be produced. The ice in moving over the landscape picked out the weakest rocks first. Those rocks which we call igneous, such as the granites or granitic types, commonly are massive and hard to get at by the erosive agents, so they stand as highlands.[14] The weaker rocks, such as some of the schists, marbles and shales, provide us with our valleys. Joints and faults also weaken the bedrock, and make it more erodable. Hence, differences in the erodability of the bedrock have provided us with a topographic grain to the surface of Connecticut which in turn has controlled the distribution of the water courses and localization of many of the wetlands.

Table IV - Origin of Wetlands of Connecticut

- Man made, beavers, vegetation
- Glacial
  - Erosion
  - Deposition
  - Kettles
- Fluvial
  - Cut and fill
  - Base-level changes
- Coastal
  - Drowning
  - Barrier Bars
- Soil Processes

Concomitantly with erosion by glaciers is deposition of materials which in turn has provided us with a host of ice-stagnation features, but very few moraines[11] which represent the former edges of the ice. The numerous depressions, which we collectively call kettles, from the melting out of buried ice blocks, are isolated in Table IV, because so many of the isolated patchy

wetlands fall into this category. These are poorly drained depressions, many of which have standing water throughout the year as marshes, swamps and ponds. These are probably wet throughout the year because of ground water replenishment.

After deglaciation streams were established upon the initial topography. Some flowed directly from the ice margin as the ice margin in part retreated upslope to the north and northwest. Their valleys were partly filled in by sediments, and the rivers were braided or meandered back and forth across the valleys. Their cut and fill features provide us with a host of wetlands. Again since man has intervened by placing his dams across the water courses, the floods that used to exist periodically in those valleys have been diminished, and many of these wetlands are not now being affected by direct overflow nor are they being produced as rapidly as they have been in times past.

Those streams flowing to the sea have been affected by changes of water level of the ocean. Some inland tributary streams have also been affected by their master streams which filled their valleys, blocking off the tributary valleys and forming wetlands behind them. Such base-level changes, as we call them, both regional and local, have formed some valley wetlands.

The coastal wetlands are mostly caused by drowning of the landscape by the latest eustatic rise of sea level. The isostatic effect of the increased water load in turn pushed down the edge of the continent. It was after sea level approached its present level that barrier bars and beaches, lagoons, tidal flats and estuaries could be produced. So, we have a host of indirect glacial effects which are, for convenience, separated from the direct glacial category.

Finally, we have the soil processes which can be casually dismissed with reference only to the concept of the downward migration of clays and iron

oxides in the soil profile which generate hardpans and in turn create impermeable conditions and certain kinds of upland wetlands.

B. Examples of Wetlands

Quonnipaug Lake, Figure 1, along route 77 northeast of New Haven lies in a lowland directly on a supposed fault plane which is hidden beneath the lake and valley fill. The fault is inferred from a reconstruction of rock distribution and structure. Lithology and structure controlled the erodability of the rocks as water and then ice moved southward, forming a valley. A dam at the south end of the lake now controls water level. This is typical of landscape evolution - a complex interplay of many processes. First, tectonic deformation of ancient sediments were followed by igneous action, weathering, erosion by ancient streams, glaciation and finally by man's effects.

A reconstruction of the process of formation of kettles in response to the deglaciation of the Connecticut Valley as shown in Figure 2, where gradual wastage of glacial ice in the valley allowed for burial of ice blocks. Their subsequent melting produced the pits or kettles, Figure 3, that are our most common wetlands in the Connecticut Valley. Depressions are of all sizes, ranging from only a few meters across to those measured in kilometers.

Glaciation caused numerous changes in the stream network of Connecticut of which only one example is shown in Figure 4. It is the hypothetical change of the Connecticut River Lowland involving the Connecticut and Farmington Rivers before and after ice advanced down the valley. See Harvey[12] for other examples.

Figure 5 shows part of the bed of Glacial Lake Hitchcock[1] in the Connecticut River Lowland just north of East Hartford. Some low areas of the ancient lake bed are shown by typical marsh symbols on the U.S. Geological

Survey Topographic Quadrangle map. (Portions of the lacustrine sediments are overlain by a thin capping of nonlacustrine sand deposits.) Kettles, some with water, are also present. That lake immediately followed deglaciation perhaps 12,000 radiocarbon years ago and covered all the map area eastward to the highlands on the right. These wetlands have been inherited from glacial times, and are underlain by complicated deposits.[1]

Other wetlands associated directly with the Connecticut River are shown in Figure 6. These are channels made when the Connecticut River could flood over the entire lowland. These hollows are wetlands of only some centuries or a few millennia in age. Other streams in addition to the Connecticut River, the Quinebaug for example, have changed their courses during the gradual evolution of the streams in post-glacial time. The wetlands forming a loop in the center of Figure 7 is an abandoned meander, the former channel of the Quinebaug River. Its time of formation is not known, but it also is young.

When we look back through the historical time since deglaciation, which started perhaps 15,000 or 16,000 years ago, we see that the climate has changed.[7] As a consequence, the vegetation and the processes that were working on the surface of the earth changed in intensity or in kind. Figure 8 shows the location of Rogers Lake, Connecticut. Pollen in a core through the sediment at the bottom of Rogers Lake[7], showed that 12,000 to 14,000 radiocarbon years ago the vegetation around the lake was like the tundra of northern Ungava Peninsula today (at X; 12-14,000 in Figure 8). Progressively younger pollen, buried in the lake bottom 9,500 to 12,000 radiocarbon years ago, was like that of the mixed forest tundra to the south, and 8,000 to 9,500 years ago like that of the mixed forest of coniferous and deciduous trees of southern Canada. One sees a gradual transition from the glacial climate, through deglaciation with

a tundra zone adjacent to the ice, to the continued warming of the climate, and the moving in of the different forest ecosystems which had been pushed far to the south by glaciation. Hence, the inland wetlands of Connecticut started out with markedly different conditions than they experience today.

Figure 9 shows sea level changes on the Connecticut coast during the last 7,000 years. Earlier on many coasts of the world mean eustatic rise of sea level was about 10 meters per thousand years from a low of -100 meters or more. Hence, coastal wetlands not now submerged could not have existed until such time as sea level approached that of today. A typical coastal wetland is shown in plan in Figure 10 and in cross section in Figure 11. Details of the upward transition of the sediments through time are given by Bloom and Ellis.[5] They discuss the materials and history of several coastal wetlands in Connecticut, and Bloom[4] treats the entire Connecticut coast. In spite of many complexities[2], it seems clear that about 7,000 years ago at an abrupt slowdown in the rate at which the sea was encroaching upon the land, it was still three meters below the present. Hence, marked changes in sedimentation rates and in type of material and in vegetation and other biota occured in the last 3,000 years from those which preceded.[2,4] The coastal barrier bars and beaches that protect the wetlands from the direct onslaught of the ocean waves cannot date back more than 3,000 years either, because the sea was too low. In fact, Long Island Sound probably was dry land with lakes following deglaciation.[10] Bloom[2] concludes that the present shoreline is perhaps one kilometer inland of its position 3,000 years ago, mostly from submergence but in part erosion. Bloom[3] concludes from a study of submergence histories of various coasts that the Connecticut coast at Clinton, Figure 10, might have a potential downwarping of another 2 meters from isostatic adjustment of the adjacent water load. Of course, concurrent erosion and deposition will also occur in complicated patterns.[9,15]

III. Conclusions

This paper has attempted to show that the effects of glaciation on a complicated bedrock landscape have provided the geologic setting for a variety of wetlands in interior Connecticut. Glacial erosion of bedrock hollows and irregular deposition of drift combine to produce depressions that are poorly drained - hence, now lakes, swamps and marshes. In the lowlands especially the melting out of glacial ice in part buried in drift has produced a variety of ice-stagnation features and depressions, many of which we call kettles. Man has dammed many water courses and depressions to create numerous new lakes or recreate old lakes drained during the geologic evolution of the landscape subsequent to glaciation. Streams established themselves on the landscape following deglaciation, and by cutting and filling in the valleys have created a variety of wetlands. Base-level changes of some streams and blocking of other stream valleys have made additional wetlands. In the last few thousand years rising sea level has drowned much of the coast and through the building of coastal bars and beaches established a variety of lagoons, estuaries, and other coastal wetlands. Illuviation of clay in the soils to make hardpans has provided us with still other kinds of wetlands.

All these wetlands attest to the geologic youthfulness of the landscape, even though we speak of thousands of years in their evolution. What nature without man's influence has made possible in these millenia, man has altered traumatically in a few centuries. Most lakes in Connecticut are either man-made or have had their water levels raised by dams. More than half the original swamps and marshes are filled or drained. Many of the water courses are interrupted by dams, but at least their pollution levels are down from their peaks, and that can't be said for many other wetlands.

In addition to these obvious direct effects of man's actions, we must add the more subtle indirect effects. For example, in cutting the forests and in farming or settling around lakes, or around swamps and marshes, man has accelerated erosion of soil into those depressions and increased the amount of nutrients for biologic activity. These hasten drastically the rate of eutrophication and ultimate death of the wetland. In a sense we are killing the inland wetlands by overfeeding them, just as many Americans are doing with themselves. In contrast we are literally starving a vital part of the coastal wetland ecosystem. Not by withholding nutrients (they get their share of man's waste) but by withholding fromthe coast the sand formerly carried by flooded rivers or derived from the drift outcrops along the coast which are now protected by riprap, groins, and other structures. A barrier bar across a coastal marsh always has some annual loss of sand to deep water that must be replenished by longshore drift. With no resupply the bar is reduced in volume and ultimately breached and destroyed.

Man has set into motion a chain of events on the Connecticut coast that augments the normal increase in coastal erosion to be expected from the continual and accelerating rise of sea level. Already, but with increasing crescendo, we shall hear the hue and cry for more artifical battleworks to stop the destruction of man's property along the coast, yet man already has made it impossible for nature to heal herself or to do the job himself short of astronomical costs. Consequently, there go more wetlands.

We likely will build more interstate highways, not seemingly because we need them, but because enough people in the right places hope to gain by them. They will destroy or disturb more of Connecticut's wetlands and other resources, even though such roads are already outmoded and will stand as tombstones for our lack of foresight. We have made considerable progress in our wetland zoning

laws in this state but not enough. As a geologist, I see them as a retardation in the rate of destruction of wetlands, but not a major deterrent. Compromise always leads to deterioration of wetlands. At any one moment the so-called rights or interests of a local group of people, a utility, or of governments may take precedence. Those who know or care still seem to be in a minority. If people have difficulty in destroying a particular wetland directly, they can do so indirectly by simply changing their use of the adjacent land.

We can talk of making wetlands, and forming a basin is easy, but it takes centuries or millennia to establish the ecosystem to go with it. Upon deglaciation thousands of years ago a complete ecosystem was ready to expand into the new wetlands made for it. Today and in the future, with more and more extinct and dislocated or disjunct species no longer available, we must look upon man's overall role somewhat pessimistically. A wetland must be treated as a part of the whole e osystem not only a local self-sufficient entity. Particularly, the coastal wetlands know no political boundaries. Ocean waters travel world wide, and many ocean species are dependent on and are a part of particular coastal wetlands. Hence, Connecticut alone does not really have ultimate control on what happens to her own coastal wetland ecosystems.

As I see it now, all remaining major wetlands of the world need to go into the public trust to be administered by scientists for the ultimate good of mankind - not for our present-day enjoyment, mindless exploitation, or personal right of profit. This in turn calls for a major change in man's social structure on a world-wide basis which just does not seem possible in the limited time available. I am very much afraid we will not realize the depth of our destruction of natural resources until it is too late to salvage enough for a rosy future for man. In my judgement as a geologist, man seems

to have the distinction of being that species that most rapidly obtained the zenith of evolution and dominance in the world yet of retaining that position the shortest time of any species - in spite of the fact that he alone has been the one species that could control his destiny if he put his will and mind to it. For the sake of future generations of man, and even for my own later years, I hope I am wrong in this assessment.

FIGURES

1. Quonnipaug Lake occupies part of a lowland etched out by streams and glaciers along weaknesses in the bedrock. After de Boer (1968, fig. 2).
2. Generalized cross-sections depicting a hypothetical sequence of events during deglaciation of part of the Connecticut River Valley and the origin of kettles. From Thornbury (1965, fig. 9.13).
3. Little River Valley west of Westminister contains numerous typical inland wetlands of which many occupy kettles, such as those outlined by hatchured contours. Part of U.S. Geological Survey Topographic Map, Scotland Quadrangle, 7.5 minute series.
4. Hypothetical changes in drainage caused by glaciation in the Connecticut River Lowland in Connecticut. The lefthand sketch shows the drainage before glaciation; the righthand sketch shows the present drainage. The original Farmington River (F) has had its headwaters diverted northward to join the Connecticut River (C), and the lower course altered to form the present Quinnipiac River (Q), leaving Mill River (M) as a short independent stream. From Longwell and Dana (1932, fig. 37).
5. Part of ancient Glacial Lake Hitchcock that indundated much of the Connecticut River Lowland is shown centered on Foster Road, north of East Hartford, on U.S. Geological Survey Topographic Map, Manchester Quadrangle, 7.5 minute series. The marsh symbol indicated wetlands derived from poorly drained parts of the old lake floor.
6. Part of the floodplain of the Connecticut River northeast of Middletown shows river bars outlined by single contours and swales between symbols. From U.S. Geological Survey Topographic Map, Middle Haddam Quadrangle, 7.5 minute series.

7. An abandoned meander of the Quinebaug River, west of Plainfield, is shown by marsh symbols bordered in part by a dashed line. From U.S. Geological Survey Topographic Map, Plainfield Quadrangle, 7.5 minute series.

8. Rogers Lake, Ct., is located by the large "X" at the word "modern". Using pollen from a core in Rogers Lake, Davis (1969) reconstructed vegetational changes around the lake. During the time 12-14,000 radiocarbon years ago Rogers Lake was surrounded by tundra like that in northern Ungava Peninsula today (indicated by the large "X" and date). Typical younger dates and vegetational comparisons are also shown, as the pollen in the core changed upward, reflecting forest tundra, boreal conifer forest, mixed conifer and deciduous forest, and finally to the modern mixed forest.

9. Submergence curve for the Connecticut coast from Bloom (1967B, fig. 1). Dotted rectangles show radiocarbon ages (before the present) and depth of peat samples used to plot the submergence. Solid rectangles show sample ages in calendar years.

10. Hammock River tidal marsh originated when barrier bars, such as Clinton Beach and Hammock Point Beach, were thrown up by waves and currents from Long Island Sound during the submergence of the coast. See Figure 11 for a cross section along the line AA'. From Bloom and Ellis (1965, fig. 4).

11. Cross section of Hammock River tidal marsh, following the line AA' in Figure 10. Radiocarbon ages of peat samples are indicated at some bore holes. The stratigraphy shows clearly the transition upward with time of an open estuary into a closed tidal marsh. From Bloom and Ellis (1965, fig. 5).

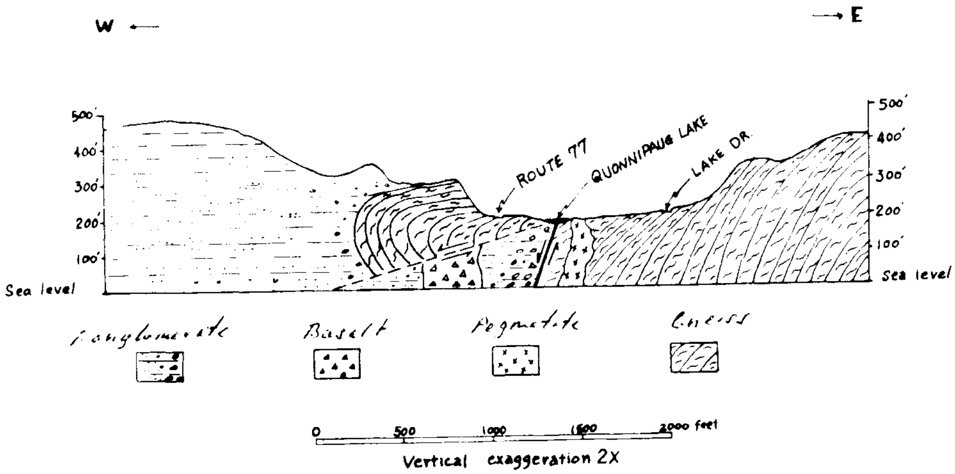

Figure 1

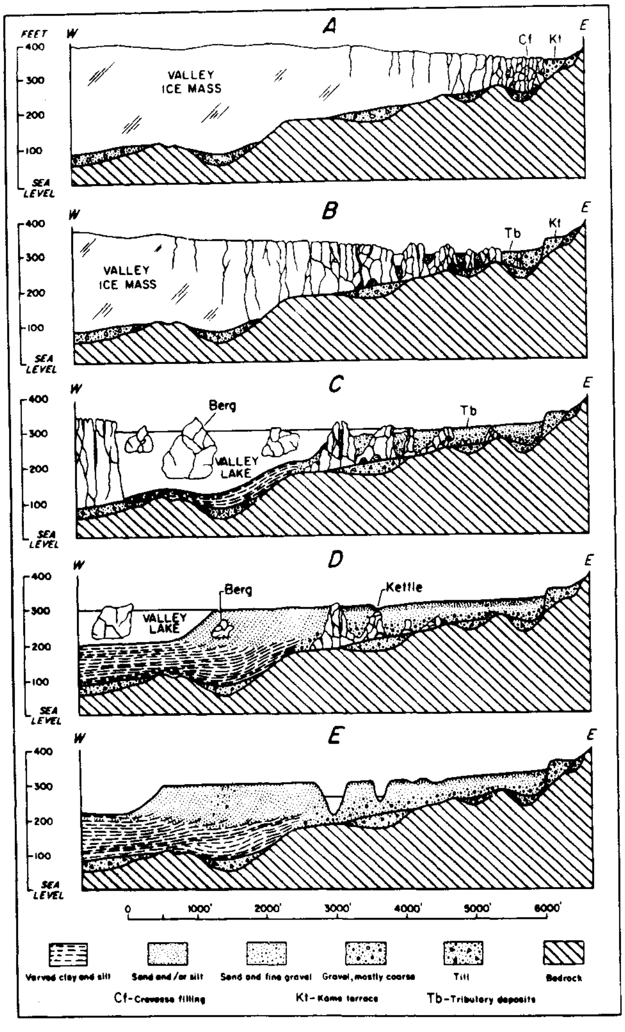

Figure 2

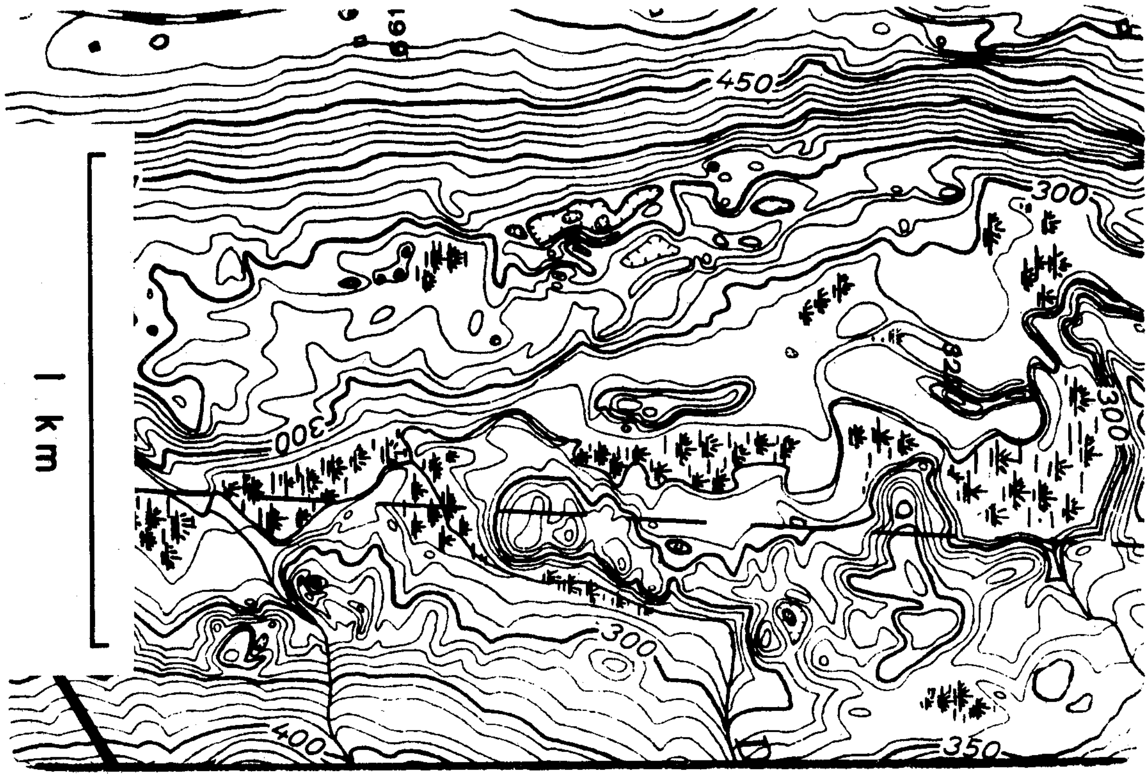

Figure 3

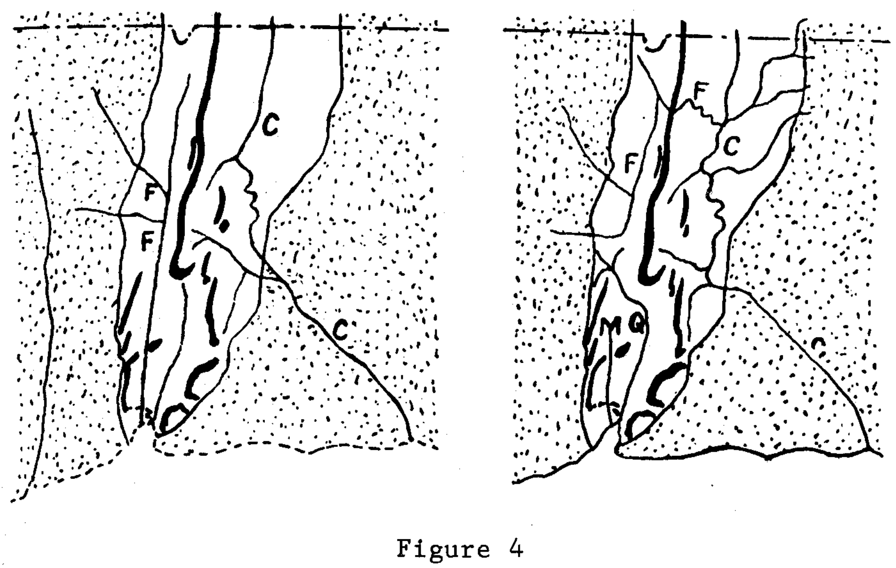

Figure 4

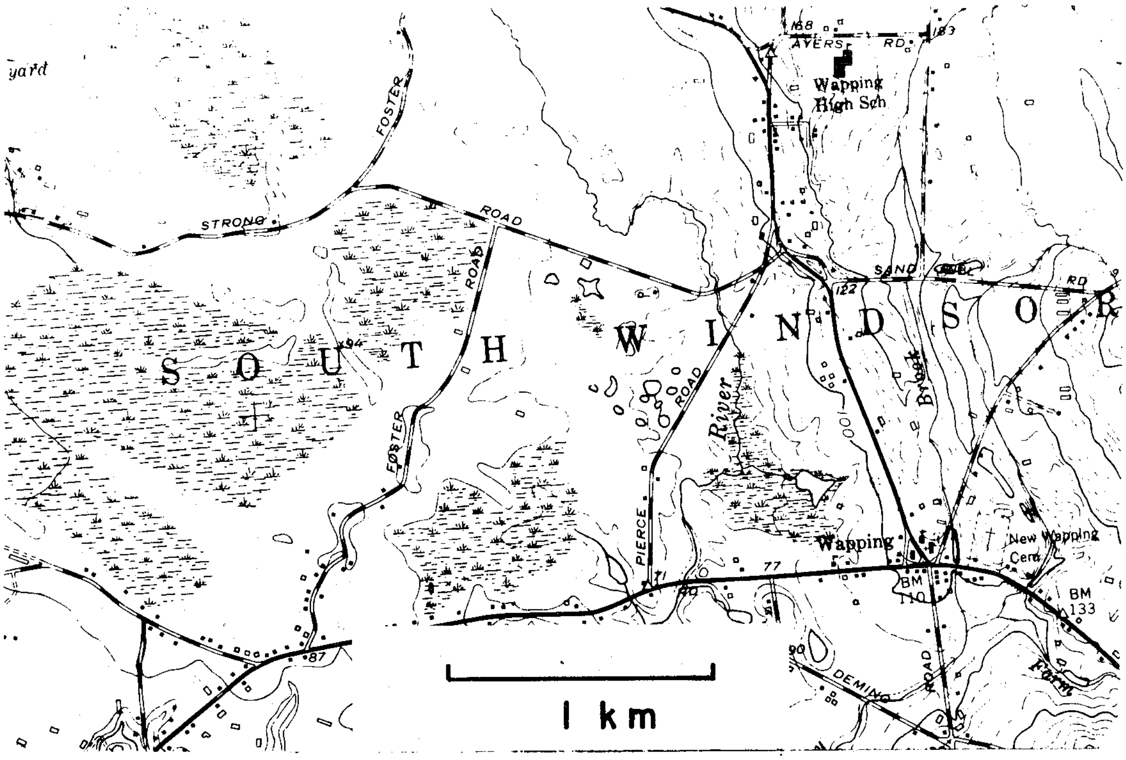

Figure 5

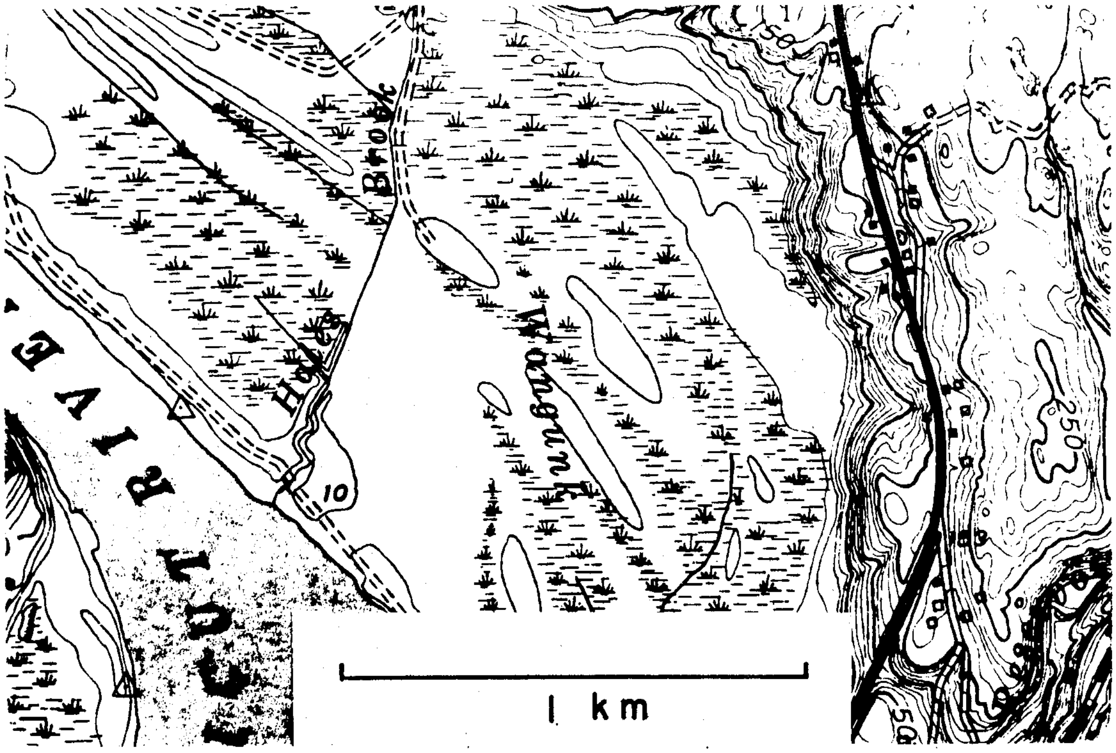

Figure 6

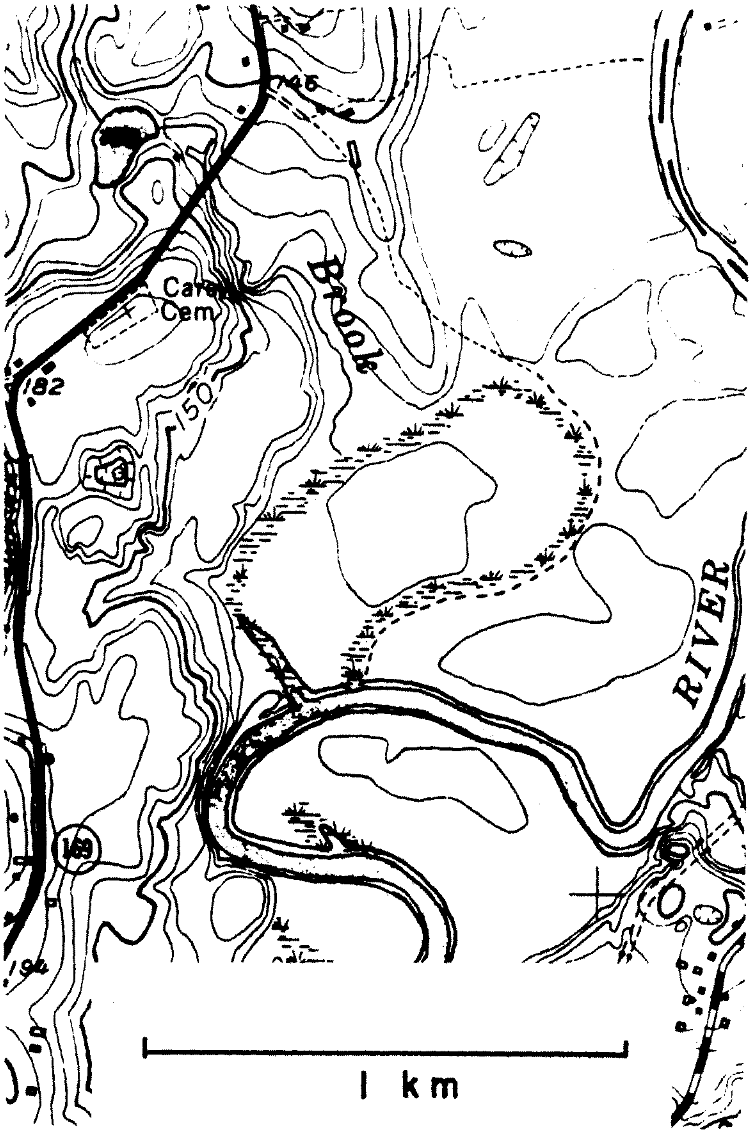

Figure 7

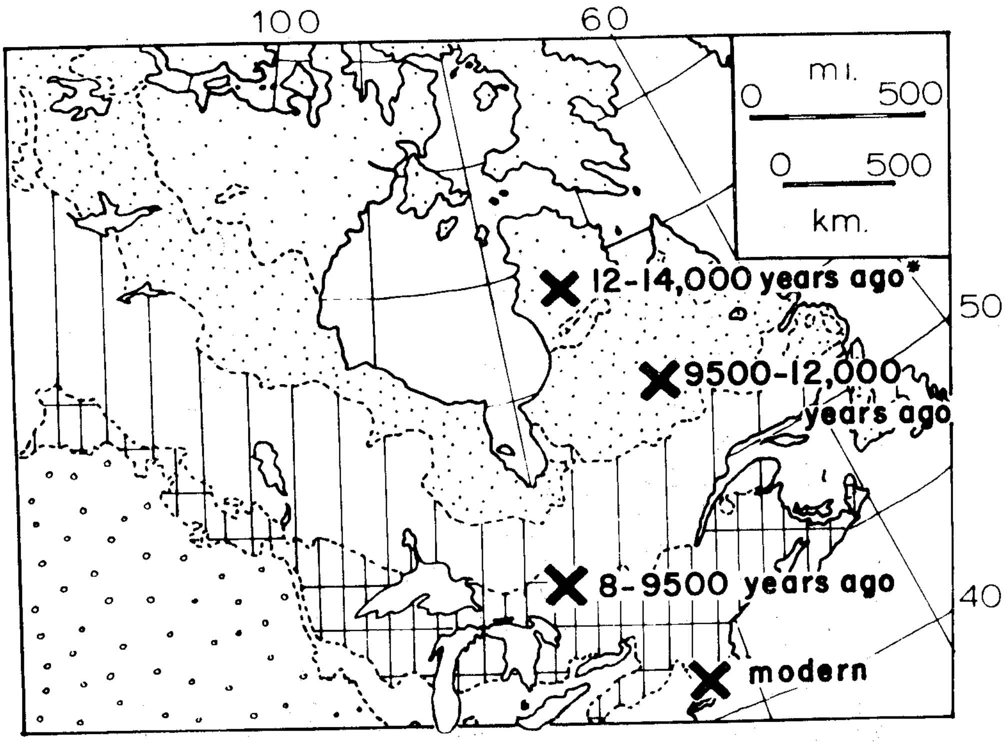

Figure 8

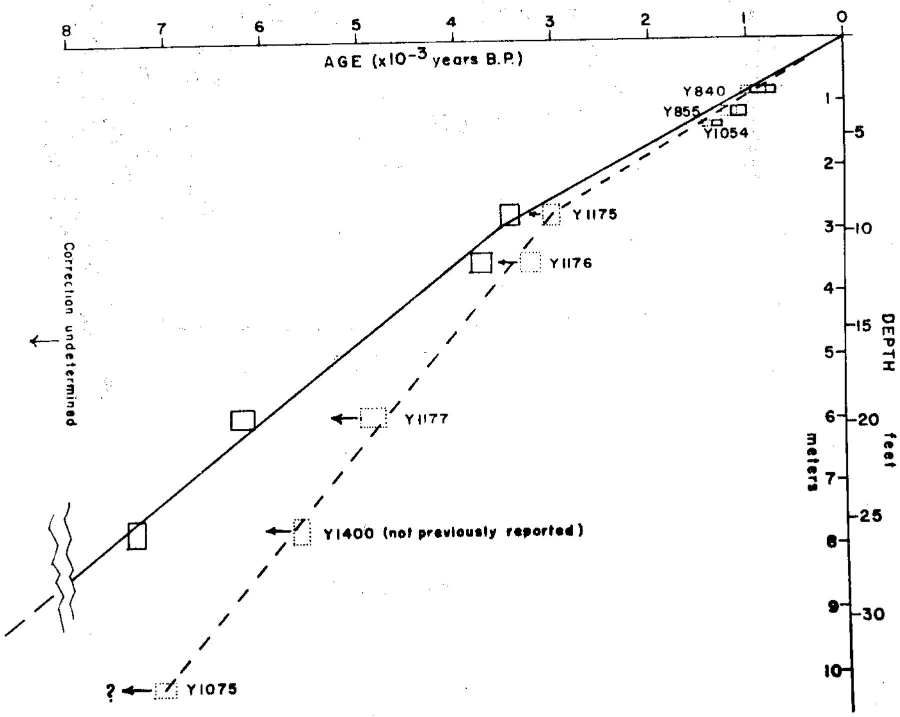

Figure 9

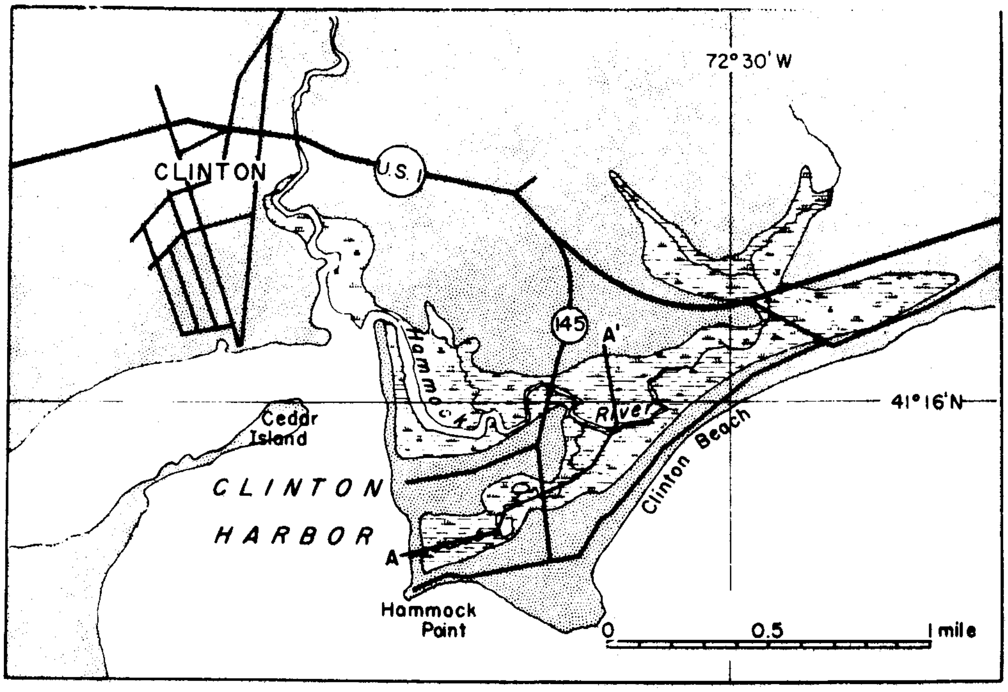

Figure 10

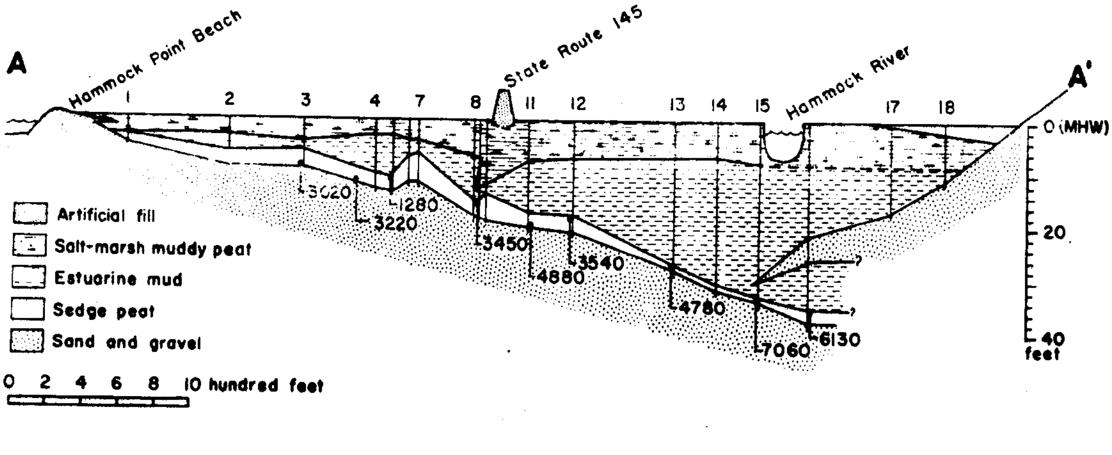

Figure 11

EDITORIAL COMMENTARY

Wetland Geology

by

K. A. Healy and M. W. Lefor

The paper offers a comprehensive description of the geology and origin of the various types of swamps and marshes in Connecticut. The statements that man-made dams have created ponds, lakes and swamps yet have been detrimental to wetlands (because they reduce flood peaks) should be qualified somewhat. There are hundreds of small dams throughout Connecticut that have increased the number of wetlands, the associated biota in the wetland area and groundwater recharge. The reduction of flood peaks could be considered an asset to at least man's short term interests along with the benefits from the reduction of erosion and sediment load in the rivers.

The paper notes that in Connecticut, as in most of New England, glacial geology and glacial history are fundamental to a geologic understanding of wetlands. Although the paper's stated purpose is to formulate a broad geologic framework of the wetlands of Connecticut, one might question the attention to so many processes which are dismissed without discussion because of irrelevance to wetlands geology in Connecticut. The variety of wetlands in till-covered upland portions of eastern and western Connecticut are virtually ignored. Most of the wetlands delineated on the basis of poorly drained soils are in these areas. Some critical questions can be asked of this presentation: Is there a relationship between these soils and geology? What about the history since deglaciation occurred on wetlands underlain by peat and muck? Hill (this

volume) notes the presence of clay beds with diatoms underlying peat and muck. Are these beds the record of a deglaciation phenomenon, or are they a record of the evolution of these wetlands since deglaciation? Just how dynamic is the post-glacial geologic history of inland wetlands?

In contradiction to the theme of the paper, however, scientists alone should not be the only segment of society that control how wetlands or other physical and biological systems are to be protected or used. The applied scientist and engineer, law creator, policy maker and most significantly the general public of which we are all members, need to interact to achieve the best plan to preserve and utilize wetlands. No one segment of society, no matter how expert or how naive should have the last word. Scientists can provide valuable assistance in helping Mankind solve its problems, provided that appropriate channels of intercommunication remain open with the public at large.

INLAND WETLANDS AND GROUND WATER IN EASTERN CONNECTICUT

Thomas L. Holzer*

I. Introduction

Climate, geology and topography determine the relationship between inland wetlands and ground water. In eastern Connecticut, geology and topography are the most important controlling factors because of the high precipitation and relative uniformity of the climate over the region. Seasonal variations of climate,however, can be important in giving a particular wetland its character. For example, seasonal variations of the water table may partially account for the dry conditions observed in Fall and the very wet conditions observed in Spring in many wetlands. This is illustrated in Figure 1, which shows the depth of water in a well as a function of the seasons. In Connecticut, the geologic and topographic settings of the wetland usually determine the magnitude of climatic influence, and may therefore be regarded as the fundamental controlling factors. In eastern Connecticut, geology, particularly surficial geology, and topography, are intimately related because of relatively recent glaciation.

There is a dense crystalline bedrock which is overlain by a blanket of till ranging in depth from a few inches to more than 100 feet, but averaging approximately 10 to 15 feet, as shown in Figure 2. Thicker deposits of stratified glacial drift, consisting predominantly of sand and silt commonly overlie the till and bedrock in major valleys. The till is usually poorly sorted, consisting of particles ranging from clay to boulders; and in some areas it is

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quite dense. Hence the permeability of the surficial deposits tends to be lower in upland areas than in major valleys.

Few systematic and detailed investigations of the relationship between ground water and wetlands in Connecticut have been reported. Hydrologic considerations suggest that most inland wetlands are areas of ground water discharge. It is important to distinguish between wetlands in major valleys underlain by stratified glacial drift, called here lowland wetlands, and wetlands in the upland areas underlain by till, called here upland wetlands. The discussion that follows concerns this distinction. Lowland wetlands are the result of depressions in topography which are sufficiently deep to intersect the water table. Although similar observations concerning topography can be made for upland wetlands, the upland wetlands can have a significant role in the ground water system of upland areas. The low permeability of the crystalline bedrock causes significant moulding of the water table in the bedrock. Local discharge to upland wetlands prevents the water table from rising to the surface.

II. Lowland *vs.* Upland Wetlands

Consider first the lowland wetlands. Deposition of stratified glacial drift in eastern Connecticut occurred while blocks of stagnant glacial ice remained in the valleys. The melting ice created an irregular topographic surface. Because the permeability of the stratified glacial drift is relatively high, ranging from 400 to 1,900 gallons per day per square foot (gpd/ft^2) in fine- and coarse-grained deposits, slopes of water tables tend to be gentle even though large quantities of ground water flow through the deposit. Most wetlands in stratified glacial drift occur where depressions in the topographic surface are sufficiently deep to intercept the regional water table.

If a depression were not present, the water table at the site of the wetland would be somewhat higher, but the regional water table would not

necessarily rise significantly. This is because of the high permeability of the stratified glacial drift; a relatively small increase in thickness of the stratified drift would suffice in most cases to accommodate the quantity of ground water previously discharged to the wetland. A wetland in Coventry, Connecticut which has been studied in great detail can be used to illustrate this situation. The wetland is underlain by stratified glacial drift, and is in a long topographic depression. The water table in the stratified glacial drift intersects the depression causing discharge of ground water to the wetland throughout the year; see Figure 3. If the wetland were to be filled, the effect on the regional ground water flow system in the stratified glacial drift would be negligible although the water table at the former site of the wetland would rise considerably. Figures 4 and 5 illustrate these features.

Although most lowland wetlands in Connecticut are probably areas of ground water discharge, water-budget investigations of ponds in the midwestern United States revealed that some ponds are effectively isolated from underlying ground water by organic material lining the bottoms.[2] My experience in eastern Connecticut includes only one wetland which approached this under natural conditions, although there are undoubtedly others. At the time of the study, the wetland had been essentially destroyed by the dumping of dredge spoils. In this case a large surface area drained into a closed depression. Surface water runoff apparently contributed to the accumulation of organic material within the depression to a maximum thickness of ten feet, as illustrated in Figure 6. During the accumulation of this material, ground water seepage from the depression gradually diminished to the extent that a "wetland" condition was created.

In upland areas the relationship between topographic depressions with wetlands and ground water can be inferred to be similar to the situation usually

encountered in valleys. Figure 7 is a cross section through several hills covered by till in which data on water levels were available from water wells cased to and drilled into bedrock. The water table (or potentiometric surface) in bedrock roughly conforms to the topography, but it intersects many topographic depressions forming areas of ground water discharge. Ground water discharge for many upland wetlands is in agreement with the behavior of streams draining upland areas. Most streams draining upland areas flow year round, even flowing during long periods of negligible precipitation. Since upland wetlands are the source of water to the streams and the surface storage capacity is inadequate to supply the baseflow to upland streams, the wetlands most likely are receiving replenishment from ground water.

Upland wetlands, however, can serve a more significant function in the regional ground water system of upland areas than do lowland wetlands in the major valleys. It was previously argued that the filling of a lowland wetland most likely would have a negligible effect on the regional ground water flow system. By contrast, the upland wetland may be functioning in the ground water system as an "overflow" or "safety valve". This is caused by the low average permeability of crystalline bedrock. To demonstrate the principle, consider parallel major valleys separated by a distance 2a = 20,000 feet. If we use permeabilities of bedrock ranging from 2 to 3 gpd/ft^2,[3] and a depth, z_a, ranging from 100 to 200 feet as the depth at which fractures in the bedrock are closed, then with the Dupuit assumption we can compute how much recharge is required to maintain the relief, $z_o - z_a$, in the water table in the bedrock which is observed at the scale of 2a = 20,000 feet; see Figure 8. The required recharge from rain is estimated to range from 1.3 to 2.9 inches per year. Annual baseflow measured in drainage basins covered only by glacial till averages

approximately seven inches per year in eastern Connecticut; Figure 9 shows the representative data. The baseflow computed for these basins is attributed to ground water discharge to streams.[3] These estimates of baseflow, or ground water runoff, probably are smaller than ground water recharge because some ground water in the basin is evaporated or transpired and hence does not leave the basin as baseflow. Therefore, the calculated quantity of recharge to ground water required to maintain the regional flow system is exceeded by actual recharge estimated from baseflow. Assuming the validity of the approach, the most straightforward reconciliation of the two estimates of recharge is to appeal to discharge of ground water via local ground water flow systems. The implication for many upland wetlands, as well as watercourses, then is that together with upland streams they represent the "spill over" which the regional ground water flow system is unable to handle because it is already transmitting all of the ground water it can.

III. Wetlands as Recharge and Discharge Areas

Although most inland wetlands in eastern Connecticut are areas of ground water discharge under natural conditions, they can function to man's benefit as recharge areas when conditions change. During flooding, the direction of ground water flow in a wetland (or floodplain) may reduce the peak flood flow by storing flood water temporarily as ground water. This effect is most pronounced when flood waters are in direct contact with permeable materials such as stratified glacial drift. Another condition under which ground water recharge may be induced is by heavy pumping from water wells adjacent to wetlands or water courses. An example of this is the well field on the Fenton River belonging to the University of Connecticut.[1] Large withdrawals of ground water by the University induce recharge from the Fenton River. During the drought in the northern United States during the early 1960's, the entire flow of the Fenton River was diverted

at times to the University's well field so that the streambed was dry in the vicinity of the well field. Streamflow did not begin again until ½ mile downstream from the well field.

IV. Conclusion

In summary, it is argued here that most wetlands in Connecticut under natural conditions are areas of ground water discharge. They form where topographic depressions are sufficiently deep to intersect the water table. The upland wetlands, however, may be more significant in terms of ground water flow than are most valley wetlands. Upland wetlands in many cases probably are the result of the low permeability of crystalline bedrock. The low permeability of the bedrock makes the bedrock unable to transmit the water which percolates through the overburden over long horizontal distances. Consequently, the water courses and wetlands in the upland areas keep the water table from rising to the surface.

FIGURES

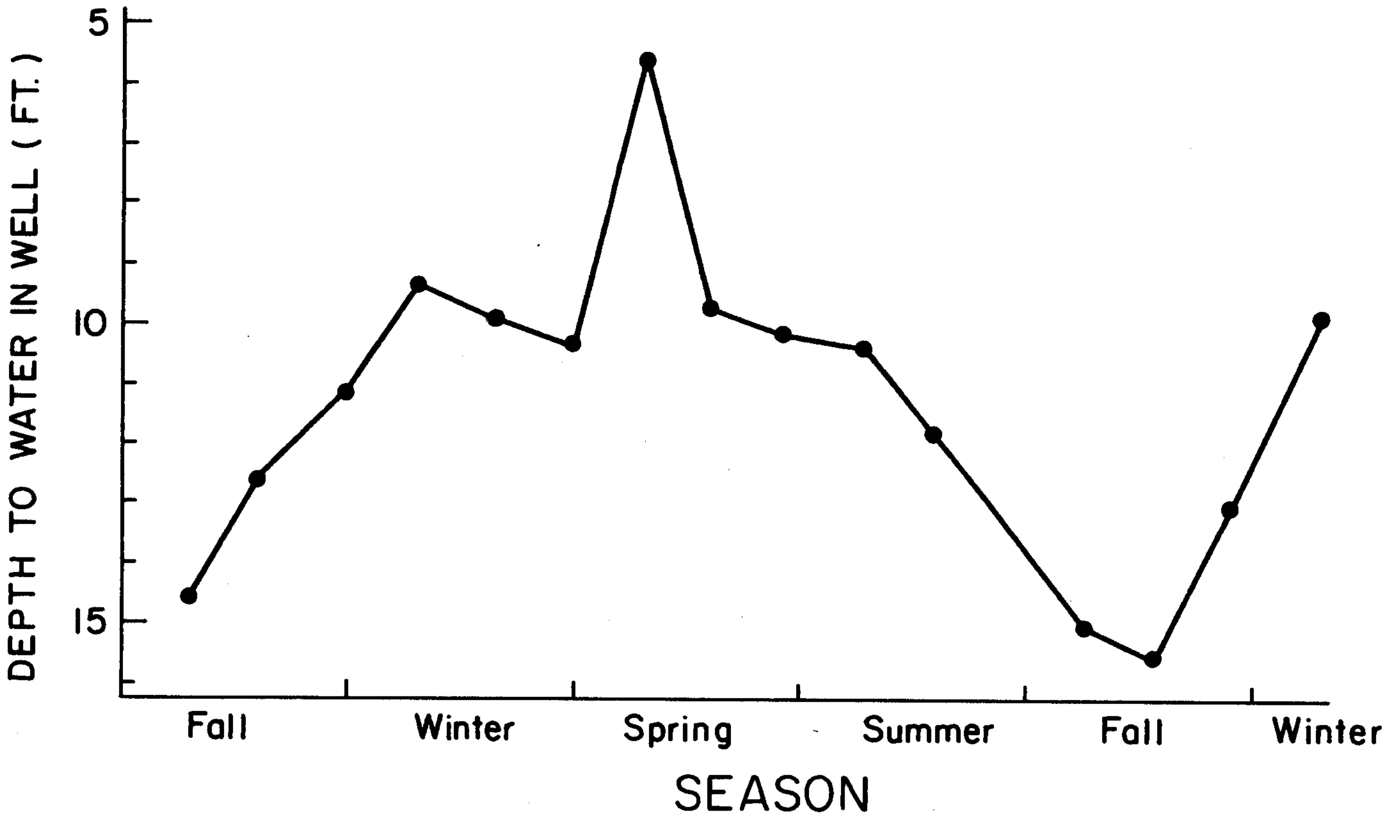

5
10
15
DEPTH TO WATER IN WELL (FT.)
Fall
Winter
Spring
Summer
Fall
Winter
SEASON

Figure 1

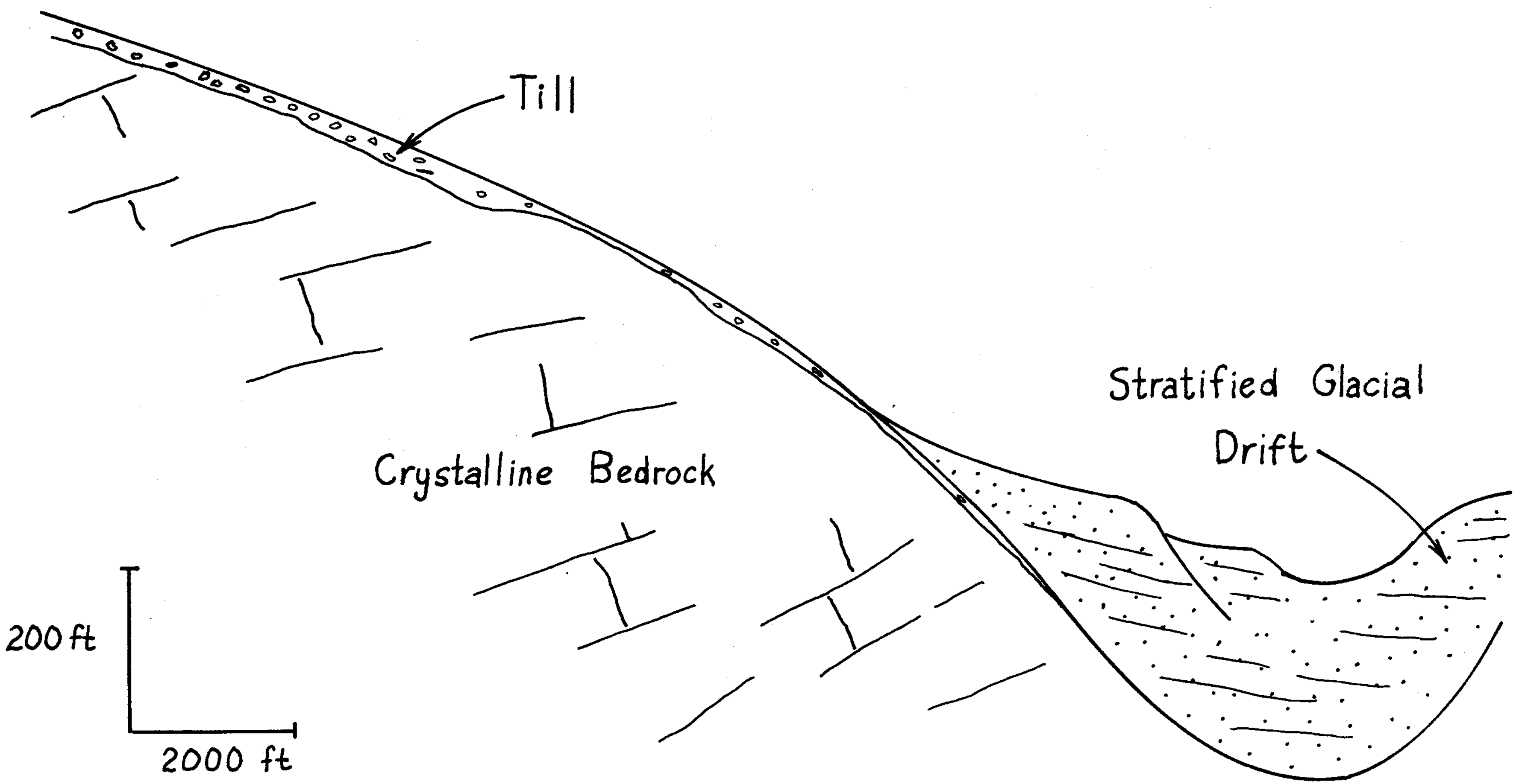

Till
Stratified Glacial
Drift
Crystalline Bedrock
200 ft
2000 ft

Figure 2

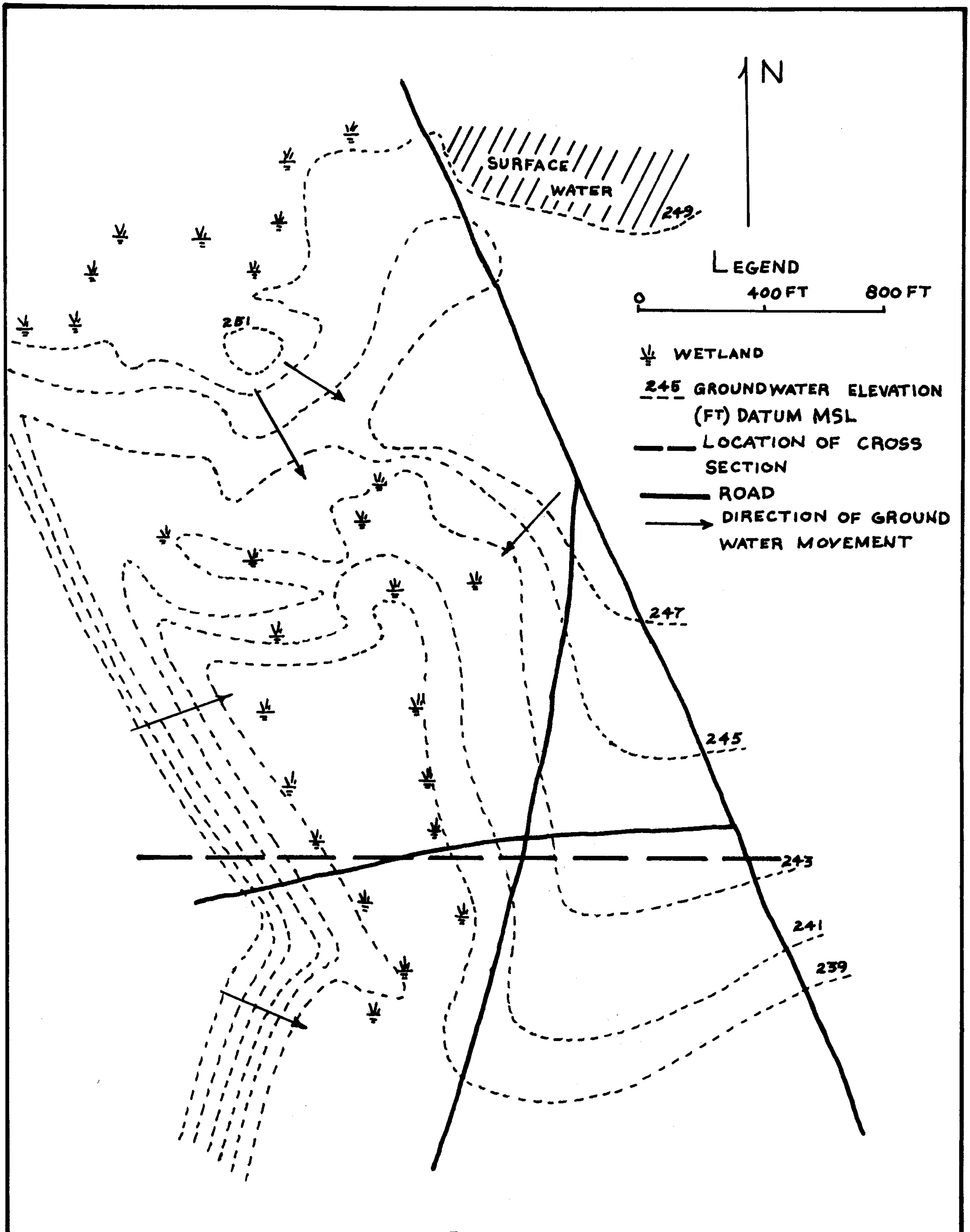

N
SURFACE WATER
249
251
247
245
243
241
239
LEGEND
0
400 FT
800 FT
WETLAND
245 GROUNDWATER ELEVATION (FT) DATUM MSL
LOCATION OF CROSS SECTION
ROAD
DIRECTION OF GROUND WATER MOVEMENT

Figure 3

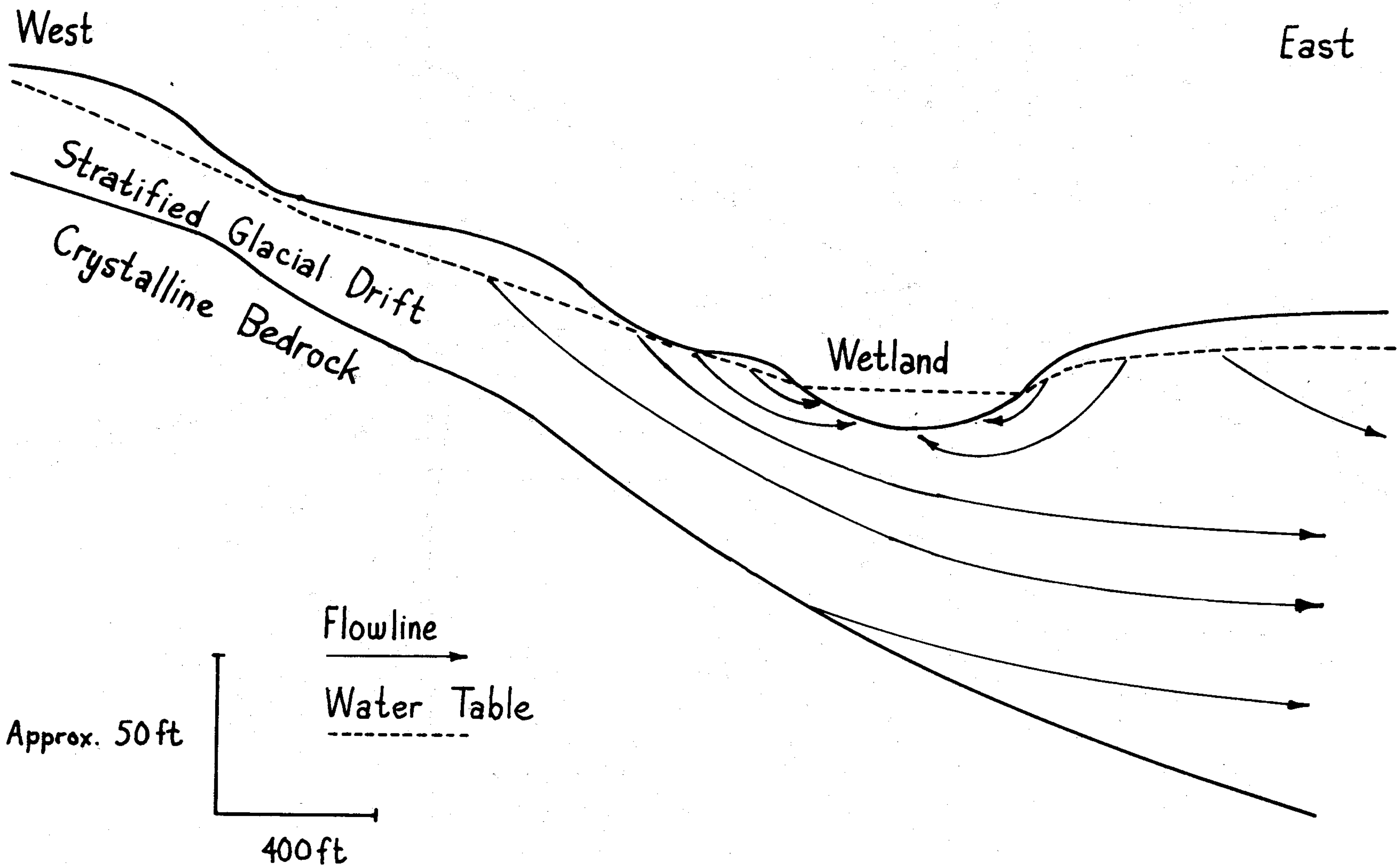

West
East
Stratified Glacial Drift
Crystalline Bedrock
Wetland
Flowline
Water Table
Approx. 50 ft
400 ft

Figure 4

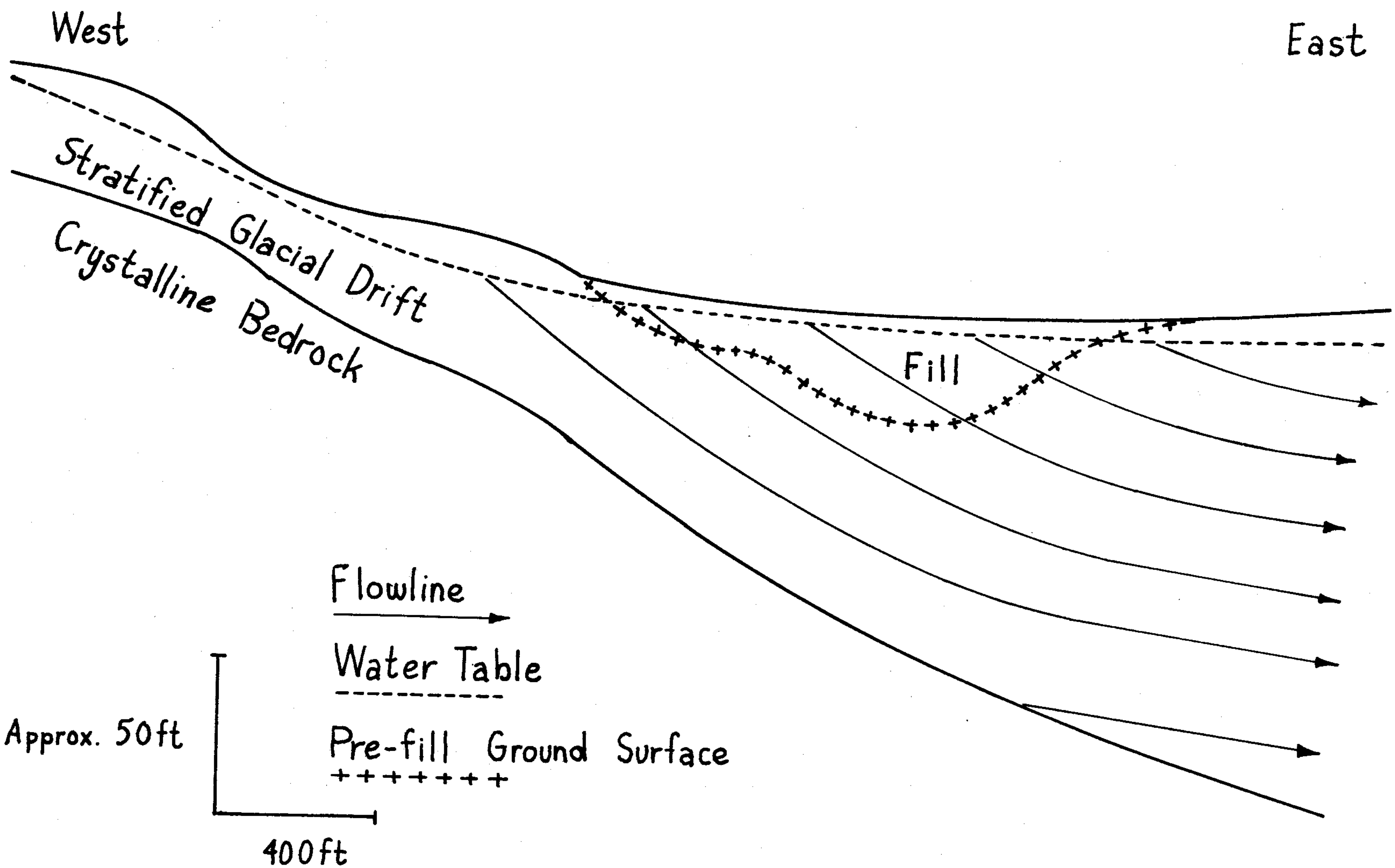

West
East
Stratified Glacial Drift
Crystalline Bedrock
Fill
Flowline
Water Table
Pre-fill Ground Surface
+ + + + + + + +
Approx. 50ft
400ft

Figure 5

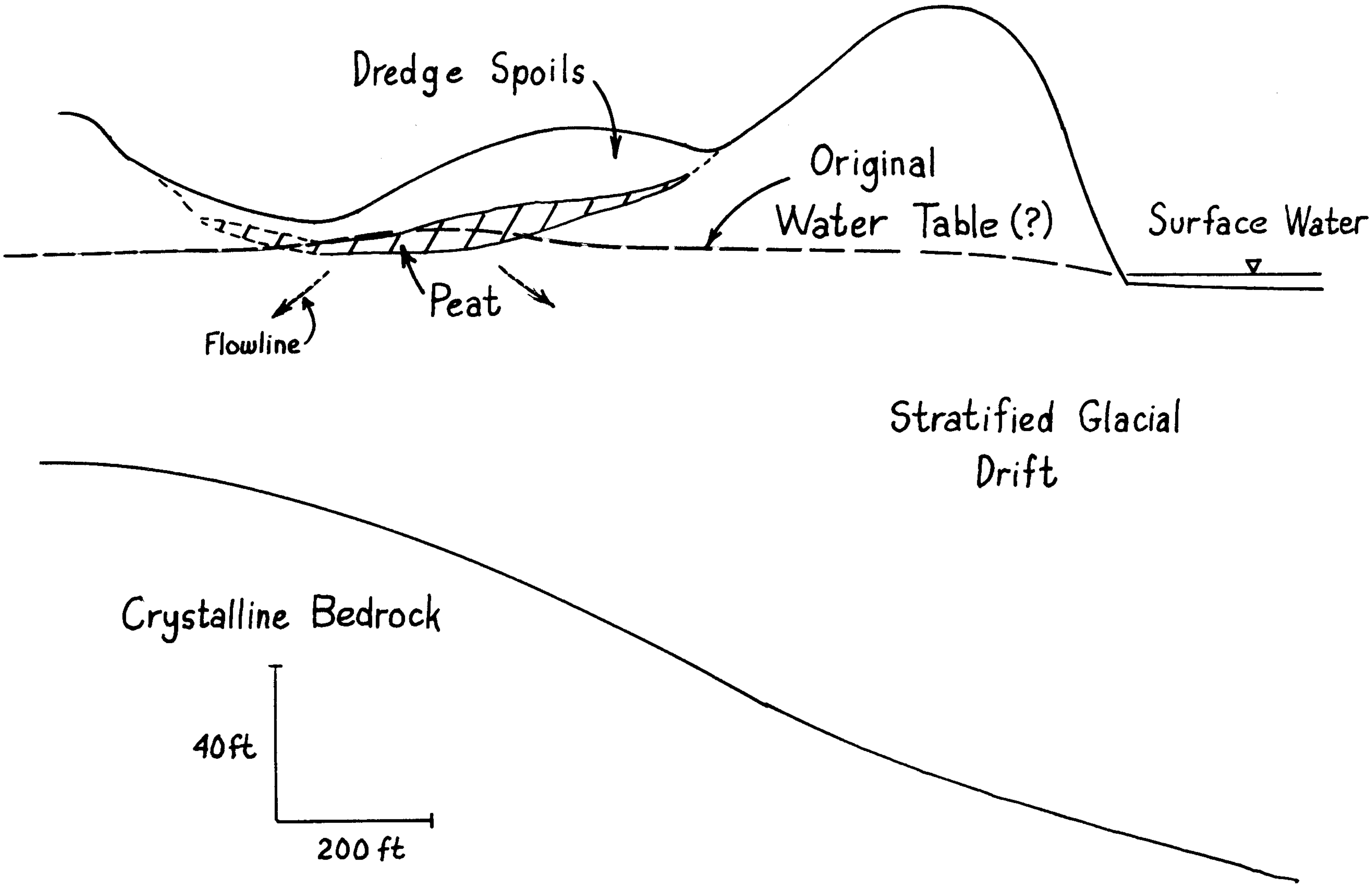

Dredge Spoils
Original
Water Table (?)
Surface Water
Peat
Flowline
Stratified Glacial
Drift
Crystalline Bedrock
40ft
200 ft

Figure 6

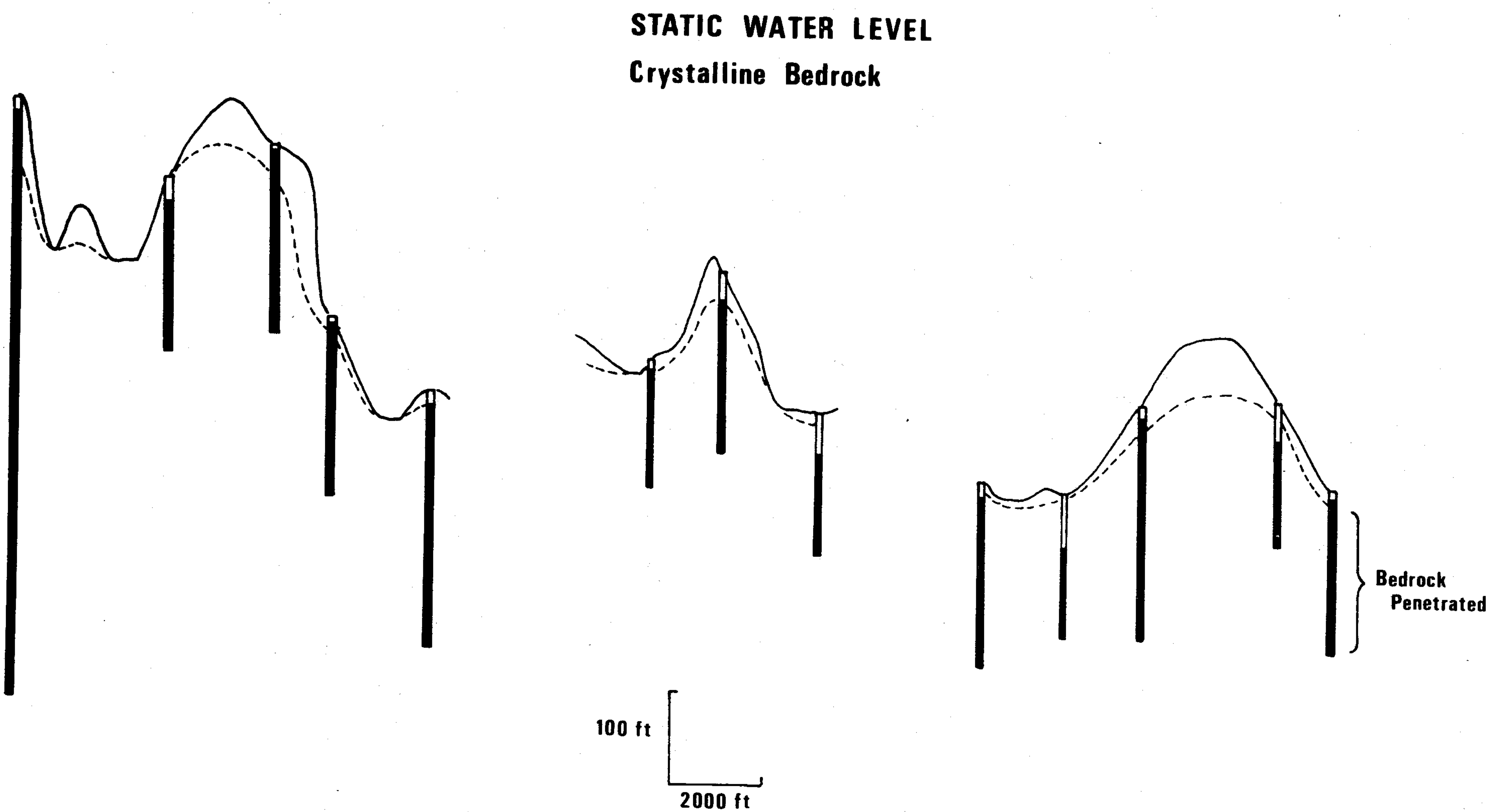
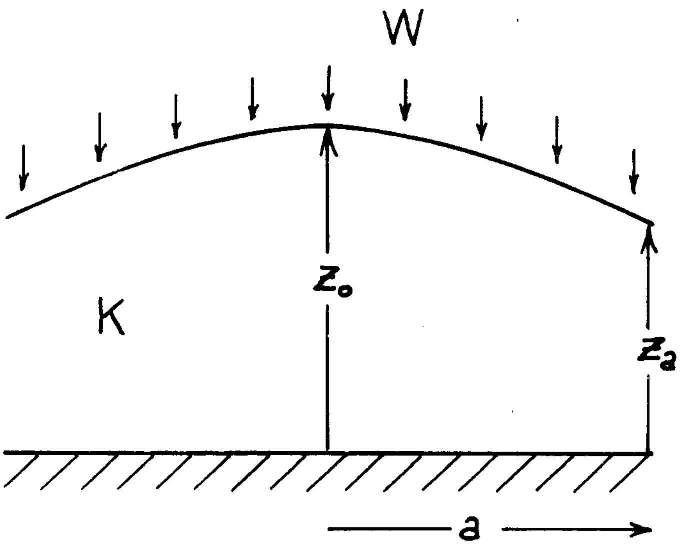

STATIC WATER LEVEL
Crystalline Bedrock
Bedrock Penetrated
100 ft
2000 ft

Figure 7



$$\frac{d^2 z^2}{dx^2} = -\frac{2W}{K}$$

Boundary Conditions:

$$\frac{dz}{dx} = 0 \quad \text{at } x = 0$$

$$z = z_a \quad \text{at } x = a$$

Solution:

$$z^2 = \frac{W}{K}(a^2 - x^2) + z_a^2$$

$a = 10{,}000$ ft $\qquad z_o - z_a = 250$ ft

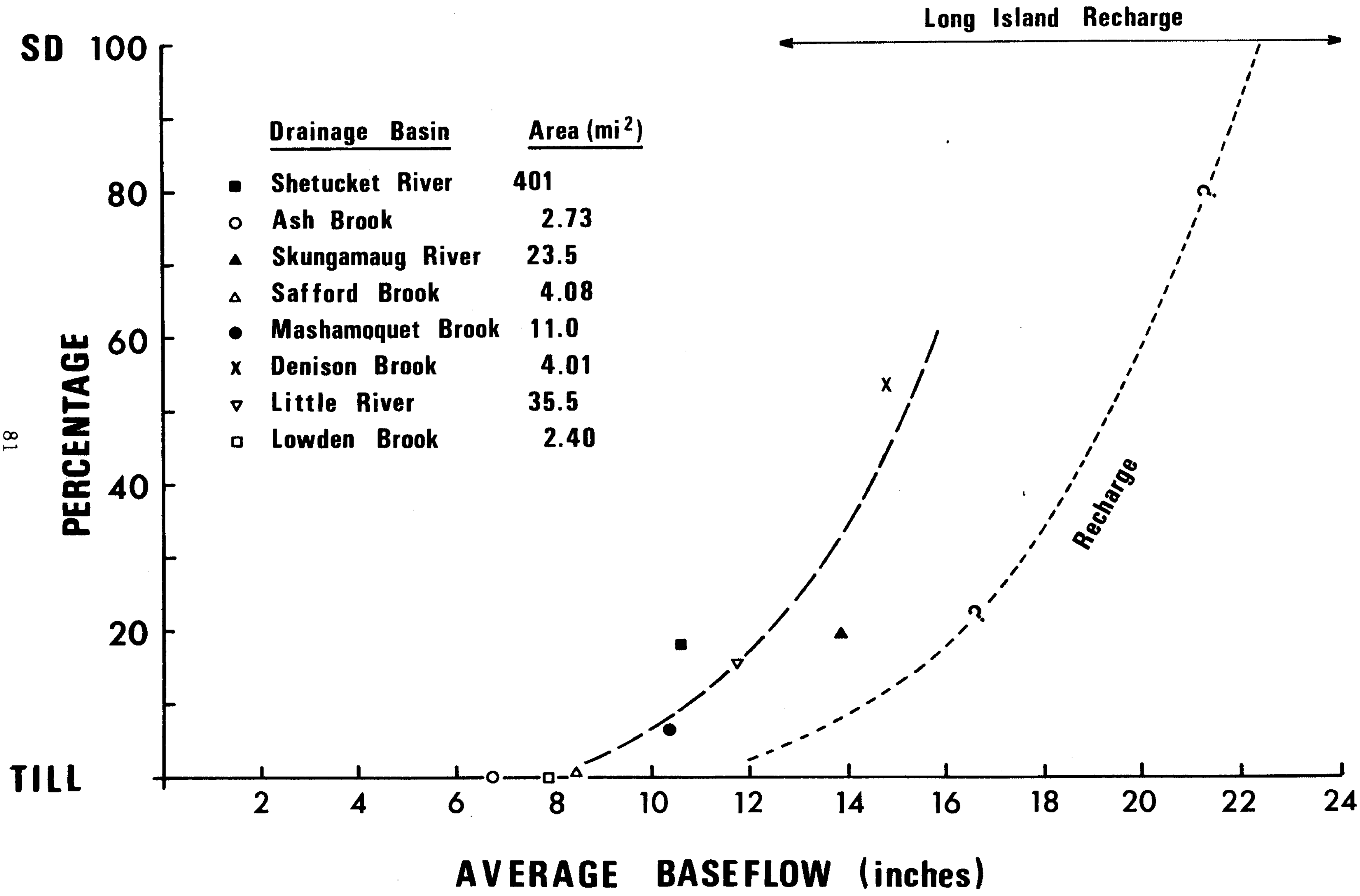
$z_a = 100$ ft

K (gpd/ft²)	W (inches/year)
2	1.31
3	1.96

$z_a = 200$ ft

K (gpd/ft²)	W (inches/year)
2	1.87
3	2.85

Figure 8



Long Island Recharge
SD
100
80
60
40
20
TILL
PERCENTAGE
Drainage Basin
Area (mi2)
Shetucket River 401
Ash Brook 2.73
Skungamaug River 23.5
Safford Brook 4.08
Mashamoquet Brook 11.0
Denison Brook 4.01
Little River 35.5
Lowden Brook 2.40
Recharge
?
?
2
4
6
8
10
12
14
16
18
20
22
24
AVERAGE BASEFLOW (inches)

Figure 9

EDITORIAL COMMENTARY

Inland Wetlands and Ground Water in Eastern Connecticut

by

K. A. Healy* and J. A. Baker

The principal conclusion made in the reviewed paper is that in eastern Connecticut inland wetlands are formed in, and occupy sites, that under natural conditions are in discharge areas with respect to the regional ground-water system. This is consistent with studies of wetlands in New Hampshire, Massachusetts and New Jersey. The paper points out, but perhaps with less emphasis than should be applied, that wetlands function as a relatively small part of a much larger system in which streams under natural conditions are the principal discharge areas for ground water.

As the paper infers, the term "wetland" only implies water at or near ground surface for a significant portion of the year, and does not indicate the source of the water.

A wetland may be a closed basin intercepting the water table, a drainage channel providing a relatively free outlet of surface and ground water to lower elevations, or something inbetween the above two extremes such as semi-closed basin created by a dam across a stream.

The effect of a wetland on the ground water regime can be assessed by looking at what would happen if the wetland were eliminated by either filling or draining. Filling a closed basin would have essentially no effect on the water table as the paper suggests, whereas draining the basin would lower the

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water table. Filling a drainage channel would inhibit drainage and raise the water table, whereas improving the drainage would lower it. Removing a dam from across a stream would improve the drainage and lower the water table. In addition, it is not uncommon for a semi-closed basin to be a ground water discharge or drainage zone at one end and be a ground water recharge zone at the other end.

The use of the Dupuit assumption is a valid approach for demonstrating the function of the upland wetlands and streams as discharge areas for ground water. However, the values of permeability (K) for bedrock that are used in the example provide estimates of recharge required from precipitation to satisfy the condition of no accretion to the water table that probably are too low for direct comparison with recharge estimated from ground-water runoff in basins underlain by both till and bedrock.

As illustrated in the paper, the use of ground water flow theory to describe wetlands is essential for making knowledgeable evaluations.

WETLAND HYDROLOGY

John A. Baker*

I. Introduction

Wetlands in Connecticut were classified and inventoried in 1953-54 as part of a national inventory by the United States Fish and Wildlife Service. The Connecticut State Fish and Game Department participated in the 1953-54 inventory and a reinventory in 1959. A value was placed on each wetland inventoried with respect to its capacity for providing habitat to wildlife -- primarily water fowl. To meet the objectives of the national inventory, wetlands were classified into three wetland categories and 20 wetland types (Table 1). The classification is based on water quality, drainage characteristics, and vegetation. Those types that occur in Connecticut are shown in Figure 1.

In 1969 the Connecticut General Assembly passed legislation concerning tidal wetlands, and in 1972 the Assembly passed legislation concerning inland wetlands and water courses.

II. Wetland Definitions

Since this presentation deals with fresh-water wetlands, it is appropriate to cite the definition of inland wetlands from the 1972 law. PA-155 Section 4, item (15) reads: "Wetlands means land, including submerged land, not regulated pursuant to sections 22-7h to 22-7o, inclusive, of the 1969 supplement to the general statutes, as amended, which consists of any of the soil types designated as poorly drained, very poorly drained, alluvial and flood plain by the National Cooperative Soils Survey, as may be amended from

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time to time, of the Soil Conservation Service of the United States Department of Agriculture."

The Connecticut Department of Environmental Protection has compiled a two page list of soils types that are covered by PA-155. In addition to this list of soils types, the Department of Environmental Protection has prepared maps showing the locations and distributions of wetlands (as defined in PA-155) to assist towns in the State to begin implementation of the law.

Recently the United States Environmental Protection Agency announced a policy to protect the Nation's wetlands. In this policy announcement[1], contained in Environment News, No. 3, 1973, U.S. Env. Prot. Agency, N.E. Reg. Office, Boston, Mass., wetlands are defined as follows:

> "Wetlands include marshes, swamps, bogs, and other lowlying areas which during some period of the year are covered in part by natural non-flood waters."

These definitions are given to illustrate the fact that wetlands may be classified in different ways to suit the purpose of the classifier. One point that I would like to make is that whatever definition of wetland you accept, wetlands are part of a larger system and should be considered in the context of this larger system. The major purpose of this paper is to consider wetlands in the context of the hydrologic system, and for this purpose I would like to add my definition to the list.

Hydrologically, wetlands are defined as land areas covered with shallow water or subject to intermittent flooding and subsequent slow drainage and which, generally, are characterized by an accumulation of organic matter, hereafter termed swamp deposits. Further, for this discussion, wetlands are those

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1. For a statement of EPA's policies on wetlands, see the remarks of Dr. Royal J. Nadeau in the panel discussion of this volume. (Ed.)

in which the water is fresh and (1) the swamp deposits are directly underlain by glacial till and bedrock; (2) the swamp deposits are directly underlain by clay and silt; and/or (3) swamp deposits are directly underlain by glacial outwash or alluvium, consisting mostly of sand or sand and gravel.

This definition would include most if not all of the "Inland Fresh" category of wetlands as defined by the Fish and Wildlife Service, and would include some but not all of the wetlands as defined by PA-155.

III. Wetlands as Hydrologic Systems

In plan view, the larger hydrologic system of which wetlands form a part can be illustrated by a surficial geologic map of the Tariffville quadrangle. The geologist has placed boundaries around "Marsh" (swamp) symbols on the topographic base map, and the legend on the geologic map indicates that the areas within these boundaries contain "Swamp deposits". Swamp deposits are defined by this mapper as "Partly decomposed organic matter, commonly with some silt and clay". From this map it is possible to determine that "Swamp deposits" underlain by glacial till are topographically high, and "Swamp deposits" underlain by glacial outwash and/or alluvium consisting mostly of sand or sand and gravel are topographically low. It is also possible to see that in some cases the geologist does not agree with the topographer, and that some "Marsh" (swamp) symbols on the topographic map are without boundaries on the geologic map indicating that swamp deposits are not present.

In the third dimension the larger hydrologic system of which wetlands form a part is illustrated by a diagrammetic cross section (Figure 1) of a typical valley. Wetlands, as defined for this discussion, occupy positions in minor flow systems of smaller tributary stream valleys in upland (topographically high) areas and in major flow systems of larger perennial stream

valleys in lowland (topographically low) areas. Adding geology to the diagram, wetlands in upland areas are underlain by glacial till and bedrock; and wetlands in lowland areas are underlain either by clay and silt, by glacial outwash or by alluvium consisting mostly of sand or sand and gravel. In these areas surface water, ground water, and soil water are closely interrelated, as they are for the hydrologic environment in general.

As can be seen from the flow lines on the diagram, wetlands occupy positions in the regional hydrologic system where ground water under natural conditions is moving toward the streams -- therefore, wetlands occupy areas of discharge for the regional ground-water body.

Wetlands in which swamp deposits are underlain by glacial outwash or alluvium consisting mostly of sand or sand and gravel are more widespread than wetlands underlain by till and bedrock and clay and silt. Furthermore, glacial outwash often forms an extensive semicontinuous ground-water reservoir in lowlands; and ground-water reservoir, the wetlands, and the streams together form a major water-supply system.

Geologic and hydrologic conditions representative of this system are illustrated by a cross section of the Ipswich River Valley at Reading Massachusetts (Figure 3). Swamp deposits are underlain by glacial outwash consisting of sand or sand and gravel which is underlain, in order downwards, by glacial till and under the till, bedrock. The swamp deposits overlying glacial outwash range in thickness from less than one foot to about fifteen feet. At other localities in the Ipswich River valley, swamp deposits may be several tens of feet thick: the maximum known thickness is reported to be 55 feet.

The swamp deposits consist of brown peat and muck interbedded or mixed

in some places with sand or silt. Porosities of swamp deposits based on samples collected at five locations (Figure 4) in the Ipswich valley range from 55 to 92 percent; specific yields range from 42 to 86 percent; and permeabilities range from 0.2 to 1,960 gallons per day per square foot. The smallest values of permeability are for samples of muck, and the smallest values of specific yield are for peat. The ten samples for which permeability was determined are paired; each pair consists of one sample oriented in a horizontal plane and the other sample oriented in a vertical plane. For muck, there is no significant difference in the horizontal and vertical permeabilities; but for peat the vertical permeability is notably smaller than the horizontal permeability.

The low vertical permeabilities of swamp deposits (of glacial outwash relative to the typical permeabilities) suggest that the swamp deposits impede the movement of water between the wetland surfaces and the more permeable outwash deposits that underlie the swamp deposits.

Swamp deposits are not completely impermeable, however, and ground water in the sand and gravel is able to move upward and discharge in the wetlands. The upward vertical component of ground-water movement at one location is illustrated by hydrographs (Figure 3) from a pair of observation wells ten feet apart in the Wilmington-Reading area. During the period of record the water level in the deeper well (Wilmington 447), which penetrated outwash deposits, remained higher than the water level in the shallower well (Wilmington 448), which penetrated only the swamp deposits overlying the outwash. The higher water levels in the deep well indicate that water in the underlying outwash deposits is under greater hydrostatic head than water in the swamp deposits and, therefore, can move upward into overlying swamp deposits.

Water in this wetland is at or near land surface throughout most of the year. The piezometric surface of ground water beneath the wetland is relatively

flat, and the hydraulic gradients in the ground water are relatively low. This suggests that movement of water beneath the wetlands is relatively slow.

Quantitative data with regard to storage and movement of water in wetlands are not generally available. For example, the amount of water stored in swamp deposits is unknown because of the sparseness of subsurface data from wetlands. Porosities as great as 92 percent, the maximum measured in the Ipswich Valley swamp deposits, permit large volumes of water to enter storage when antecedent moisture contents are low; laboratory data, however, indicate that if saturated swamp deposits are fully dried and then rewetted, they regain their initial moisture content slowly.

The amount of water ponded on wetland surfaces at any given time is not generally known because of the proximity of most wetland areas to streams and large flat areas. The low gradients permit ponding of streamflow during flood stages which helps to reduce peak discharges. Slow release of ponded waters and water in storage in the swamp deposits can increase subsequent base runoff in streams. On the other hand, open water surfaces and dense vegetation in wetlands afford maximum opportunity for evapotranspiration losses which tend to reduce base runoff during the growing season.

The effect of wetlands on base runoff was documented in a study in Great Swamp in the headwaters of the Passaic River basin in northern New Jersey which showed that at times, less water flowed out of the swamp than flowed in. During the period of study, all the examples of diminished streamflow out of the swamp occured during the period June-September. It was concluded that high evapotranspiration rates accompanying the growing season caused the reduction of base flow.

Wetlands also may affect water quality. Organic compounds derived from organic material in swamp deposits may impart color and odor to water and increase

concentrations of iron in water.

The effect of wetlands on the iron concentration of stream water is illustrated by analyses (Figure 5) of several water samples collected in and near a wetland south of Quinebaug Pond in southeastern Connecticut. Water entering the wetland from Quinebaug Pond contained only 0.01 ppm of iron and water entering from James Brook contained only 0.06 ppm of iron at low flow when concentrations could be expected to be relatively high. On the other hand, water in the wetland and in Quandock Brook just below the wetland contains increased concentrations of dissolved iron at both high and low streamflow. The source of increased iron is decaying wetland vegetation. Plants extract iron from water or soil during the growing season; after the growing season the iron requirements of the plants diminish and dissolved iron is released to water in the wetland.

Decaying organic material in the wetland imparts a brownish-yellow color to water draining from them. Iron may be a significant constituent of organic color in water, but the amount of iron does not necessarily correlate with the amount of organic color. Like dissolved solids in general, color is greatest during period of low streamflow and decreased during period of high streamflow.

The seasonal role of wetlands in the hydrologic system serves to illustrate how the system operates. In October the surfaces of wetlands generally are dry, and the water table stands in the swamp deposits or possibly below them at some places. Streamflow is low and is derived principally from the ground-water reservoir. Vegetation is discharging water as vapor to the atmosphere from the swamp deposits either from soil-moisture storage or from the ground-water reservoir. With the first killing frost the discharge of water by

vegetation is turned off. The first appreciable precipitation thereafter is accompanied by recharge of ground water, a rise in the water table, and an increase in runoff, including an increase in the base flow of the streams. From late fall throughout the winter the water table remains at or near land surface in the swamps. Ponded water is present during most of this time on the swamp surfaces. Perhaps some of this ponded water is a result of precipitation catch, some comes from streams by overbank flooding, and some may come from upward seepage of ground water. In the spring, the melting snow and the spring rains assure a high water table and a fully recharged ground water reservoir. Water remains ponded on the swamp, and the rate of runoff is high.

As the growing season begins and progresses, water is discharged from the swamps to the atmosphere by evaporation and transpiration. The ground-water reservoir continues to discharge to the streams. There is very little, if any, recharge to the ground-water reservoir. For a time streamflow is sustained by water temporarily stored on the wetland surfaces and by ground-water runoff. Finally the wetland surfaces dry up and streamflow is sustained principally by ground-water runoff. If the summer is unusually dry, antecedent moisture conditions in the swamp deposits may generally be unfavorable to direct runoff except after heavy extended rains -- and so on to the end of the water year.

IV. Conclusion

This picture is, of course, highly generalized. Nevertheless, it shows that the swamp deposits and the wetland surfaces have a role in the operation of the water system. Wetland surfaces store flood waters. Swamp deposits store water. With respect to the ground-water reservoir, the wetlands serve as discharge areas for much of the year, but they may receive recharge occasionally.

The understanding of this role of wetlands in the larger hydrologic system is important with respect to management of wetlands.

WETLAND CLASSIFICATION--CONNECTICUT
(from "Wetlands of Connecticut" U.S. Department of the Interior, Fish and Wildlife Service, June 1954 - revised June 1959)

WETLAND CATEGORY	WETLAND TYPE
INLAND FRESH	Seasonally flooded basins and flats Fresh meadows Shallow fresh marshes Deep fresh marshes Open fresh water Shrub swamps Wooded swamps Bogs
COASTAL FRESH	Shallow fresh marshes Deep fresh marshes Open fresh water
COASTAL SALINE	Salt flats Salt meadows Regularly flooded salt marshes Sounds and bays (area exposed at mean low tide) Open water seaward from mean low tide

Table 1. Classification of Connecticut Wetlands

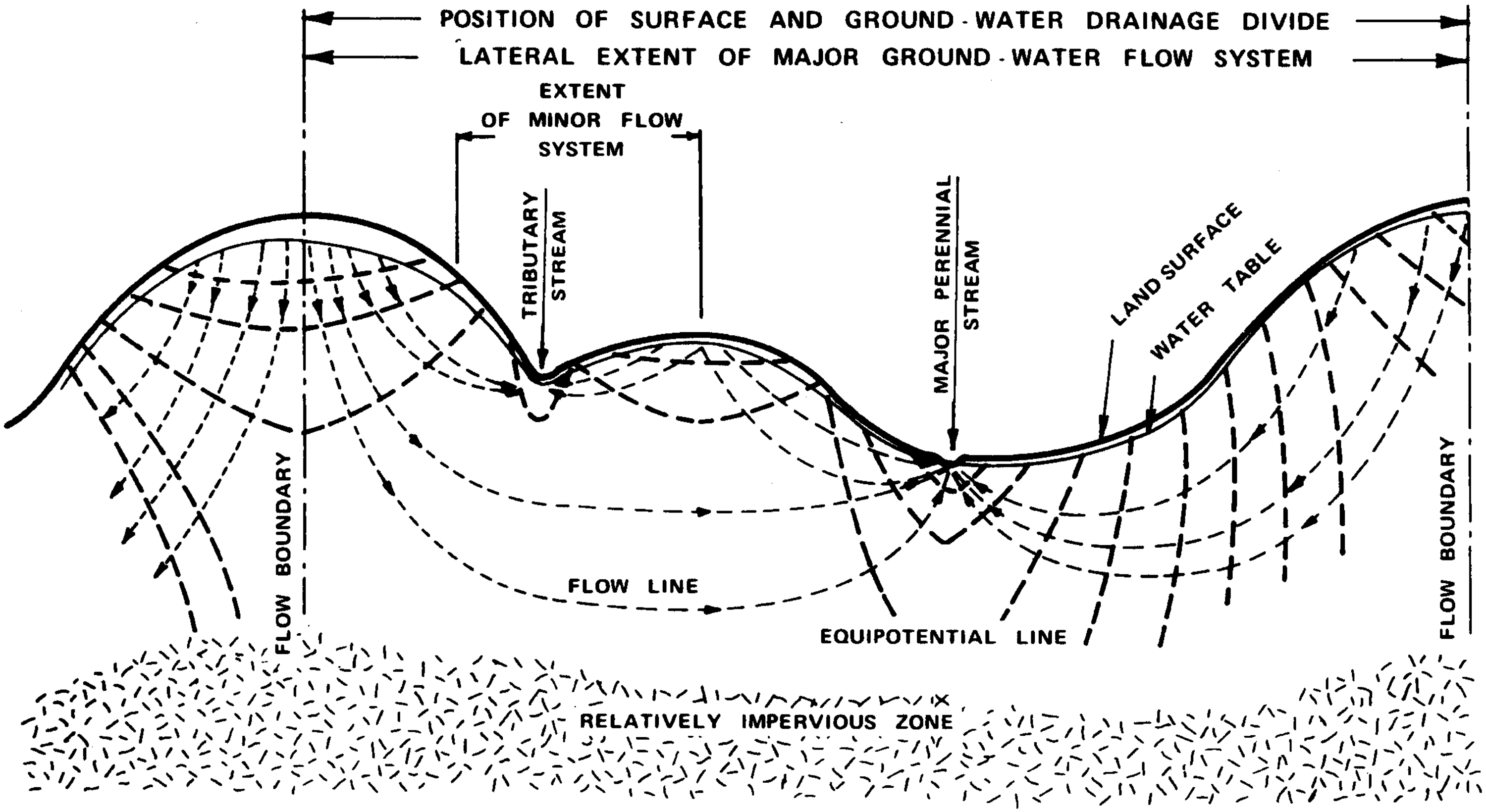
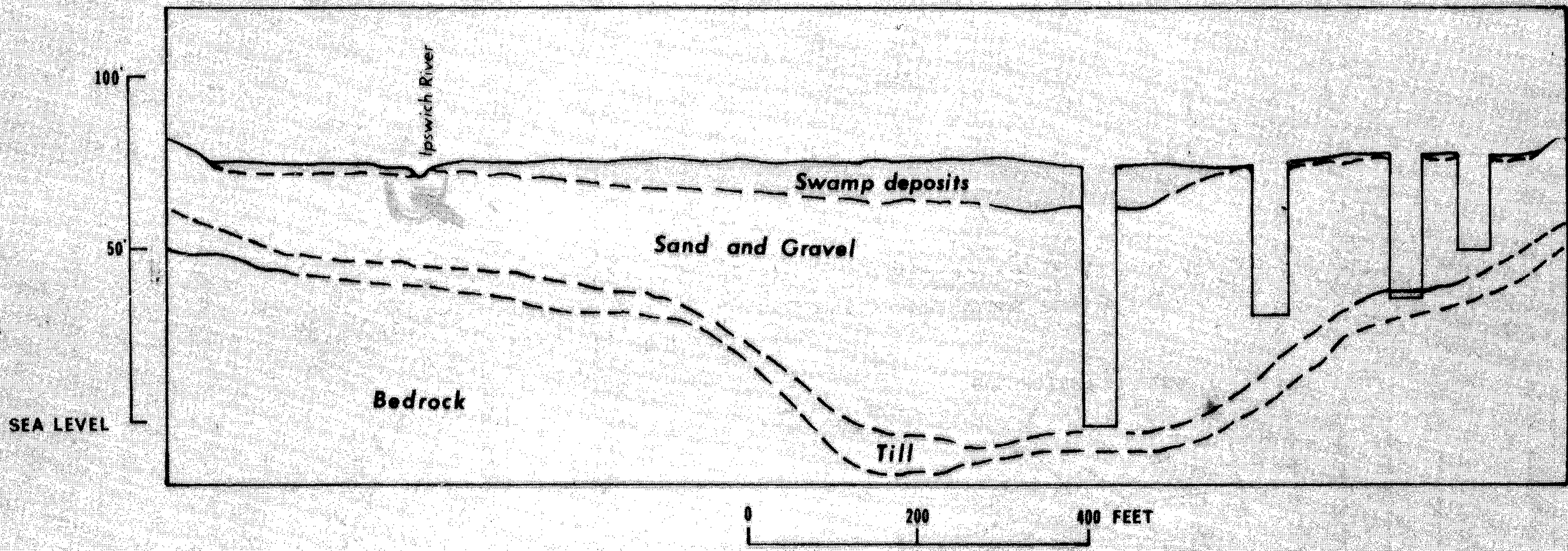
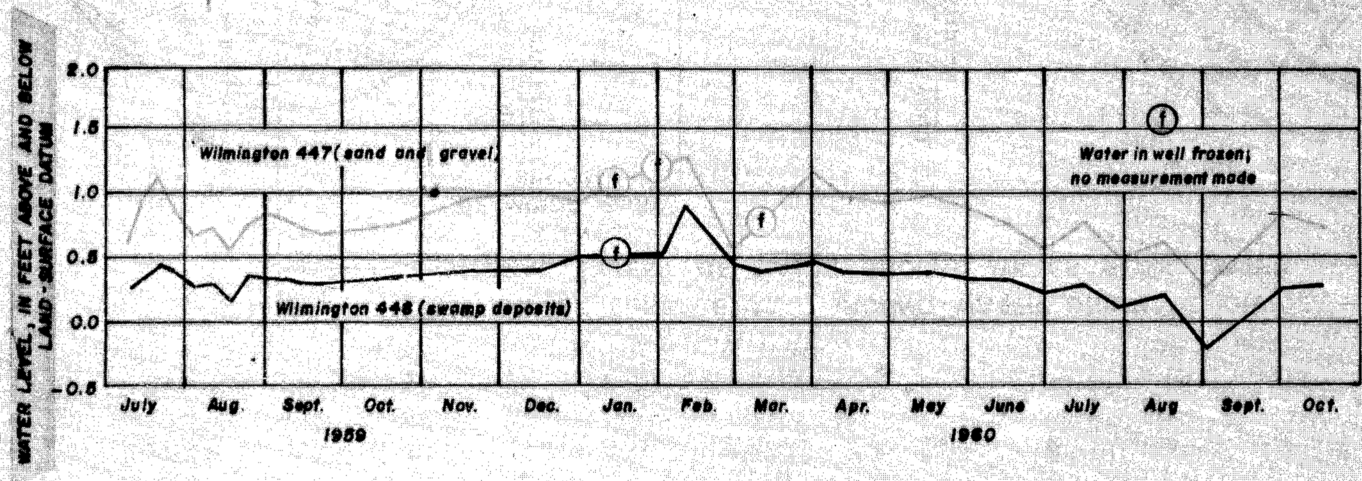

POSITION OF SURFACE AND GROUND-WATER DRAINAGE DIVIDE
LATERAL EXTENT OF MAJOR GROUND-WATER FLOW SYSTEM
EXTENT OF MINOR FLOW SYSTEM
TRIBUTARY STREAM
MAJOR PERENNIAL STREAM
LAND SURFACE
WATER TABLE
FLOW BOUNDARY
FLOW LINE
EQUIPOTENTIAL LINE
FLOW BOUNDARY
RELATIVELY IMPERVIOUS ZONE

Figure 1



GEOLOGIC SECTION AT READING 100 ACRE WELL FIELD



Hydrographs showing water-level fluctuations in paired wells in swamp deposits and in confined beds in sand and gravel in the Wilmington-Reading area, Massachusetts.

Figure 2

Sample	Depth (ft.)	Orientation of sample	Moisture content (percent)		Specific retention (percent)	Specific yield (percent)	Porosity (percent)	Coefficient of permeability (gpd. per sq. ft., Meinzer units)
			Natural	Oven dried1/				
103	1.5	Vertical......	103.4	118.9	7.7	75.3	83.0	53
104	1.5	Horizontal....	....	....	6.9	76.4	83.3	870
105	1.5	Vertical......	159.4	65.8	8.5	69.1	77.6	28
106	1.5	Horizontal....	....	....	6.1	75.8	81.9	1,960
107	.5	Vertical......	96.0	46.3	15.6	50.1	65.7	2
108	.5	Horizontal....	....	....	12.4	42.3	54.7	1

1/ Moisture content after dried samples were wetted by capillary action.

Table 2. Hydrologic Characteristics of Swamp Deposits From the Wilmington-Reading Area, Mass.

SITE NO.	SITE DESCRIPTION	IRON IN PPM	
		April 23, 1963	June 27, 1963
1	Quinebaug Pond outlet	0.01	0.01
2	Within swamp	.18	.77
3	James Brook	.03	.06
4	Quandock Brook	.11	.47
5	Public water-supply well (Ki 60)	.05	.01
		High Flow	Low Flow

0 SCALE 1/2 mile

Dissolved-iron concentrations in water in and near swamp below outlet of Quinebaug Pond

Figure 3

EDITORIAL COMMENTARY

Wetland Hydrology

by

T. L. Holzer and C. J. Posey*

This technical paper points out that definitions of wetlands reflect different interests as well as the difficulties of achieving precise descriptions suitable for statutes and regulations. This paper classifies the fresh water wetlands resulting from typical surficial geology patterns into three commonly occurring types and explains how each, with its accumulated swamp deposits, affects water flow and quality. He illustrates the differences by citing specific examples and traces a swamp through a complete water year.

There are four definitions of fresh water wetlands discussed in the paper; interestingly the two strictly hydrologic definitions differ. The definition used by the United States Environmental Protection Agency (EPA) includes land areas "which during some period of the year are covered in part by natural non-flood water". The definition used in the paper includes these areas but adds those areas "subject to intermittent flooding and subsequent slow drainage". The paper's addendum to the EPA definition is necessary in order to discuss the role of flood plain areas in reducing flood peaks. From the standpoint of wetlands hydrology, the EPA definition is incomplete.

Three physical hydrologic functions of wetlands are noted in <u>Wetland Hydrology</u>: (1) most wetlands in the northeast are areas of ground water discharge; (2) wetlands, by storing flood water, may reduce peak discharge; and (3) evapotranspiration of water from wetlands can reduce total streamflow.

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This paper and others (e.g., Holzer, this volume) have suggested that most wetlands in Connecticut under natural conditions are areas of ground water discharge. Both field and theoretical evidence are cited in support of this contention. Justification for the preservation of wetlands from a ground water recharge aspect appears questionable under these circumstances. The ground water discharge characteristic of most wetlands does not necessarily mean they are insignificant from a ground water perspective. The elevation of surface water in wetlands can help maintain ground water levels in adjacent land at lower elevations than they would be if the wetland area were filled.

Probably the primary physical hydrologic benefit to man of wetlands is the reduction of peak discharge of streams. The magnitude of this effect varies over a wide range depending on the position of the wetland in the river system, the size of the wetland, and the vegetation and configuration of the wetland. A classification of wetlands based on this function would be of great benefit for decision making.

As the paper indicates, wetlands can reduce total streamflow by increasing evapotranspiration of surface and ground water. This in some respects could be interpreted as a detrimental function of wetlands from a physical hydrologic perspective since total water supply and recreation could be diminished. A classification of wetlands based on this function also might be of benefit.

The net effect of wetlands on the chemical quality of water passing through them is another area requiring additional investigation. The paper cites evidence of increase concentrations of dissolved iron caused by flow through wetlands. Others (e.g., Niering, this volume) have suggested wetlands may help purify water. Undoubtably there are seasonal variations. What is the net effect of wetlands on water quality?

This paper provides a basis for an understanding of the nature of fresh water wetlands; something that is surely essential for those who are trying to assess their value and plan for their future.

THE ECOLOGICAL ROLE OF INLAND WETLANDS

William A. Niering *

I. Introduction

Probably no set of ecosystems has been more ruthlessly treated as wastelands than the inland wetlands. Filling, draining, and dredging have been practiced nationwide. In Connecticut no precise data are available on wetland losses, but the toll has been severe. In addition to filling for residential and commercial developments, highway construction and solid waste disposal have all had a major impact on the fresh water wetlands of the State.

A. General Description of Inland Wetlands

On the basis of the Connecticut soils-based definition of inland wetlands and water courses there are about 800,000 acres of these areas in the state covering approximately 25 per cent of the land surface.[8] Eight of the fresh water wetland types recognized by the U.S. Fish and Wildlife Service [11] are found in Connecticut; these can be reduced for the purposes of this paper to four major types--floodplains, marshes, swamps and bogs. Floodplains are characterized by alluvial soils and are periodically flooded. Marshes, swamps and bogs are sites usually underlain by silty or peaty soils where the water table is at or near the surface throughout much of the year. The discussion which follows concerning the major wetland types and the ecological role they play in the biosphere is based primarily on a recent Connecticut Arboretum bulletin--Inland Wetland Plants of Connecticut.[10] This guide illustrates 40 of the dominant wetland plants of the state.

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B. Types of Wetlands

Marshes are dominated by soft stemmed herbaceous plants such as cattails (Typha spp.) and pickerel weed (Pontederia cordata) which grow with their stems partly in and partly out of the water. Marshes may persist, or as the water table recedes over a long period of time, they may with the lowering of the water table be replaced by the vegetation of a wet meadow or a woody swamp.

Wooded swamps in Connecticut are dominated by red maple (Acer rubrum). Other conspicuous associates include black gum (Nyssa sylvatica), black ash (Fraxinus nigra), and yellow birch (Betula lutea). A shrubby undergrowth of highbush blueberry (Vaccinium corymbosum), spicebush (Lindera benzoin), winterberry (Ilex verticillata), sweet pepperbush (Clethra alnifolia), and clammy azalea (Rhododendron viscosum) may develop and a rich diversity of wild flowers such as marsh-marigold (Caltha palustris), skunk-cabbage (Symptocarpus foetidus), jewel weed (Impatiens capensis) and cardinal flower (Lobelia cardinalis), may also be present. Shrub swamps represent another phase in the succession marsh-meadow-swamp, where alders (Alnus spp.), willows (Salix spp.), buttonbush (Cephalanthus occidentalis) and other shrubs form relatively pure or mixed stands. Occasionally trees may occur here as well. A high water table, however, often favors the development of shrubs over trees.

As in marshes, the underlying deposits of wooded swamps are often relatively shallow and usually highly organic or silty in nature. Swamps may develop through the gradual invasion of marshes by woody species, or they may arise directly in poorly drained depressions.

Bogs constitute a distinctive wetland type usually characterized by evergreen trees and shrubs underlain by peat deposits of considerable depth.

Poor drainage normally leads to a highly acid condition of the substrate. The typical northern bog is easily recognized by the presence of black spruce (Picea mariana) and larch (Larix laricina). In southern Connecticut the spruce and larch are replaced by the evergreen southern white cedar (Chamaecyparis thujoides), or, in some cases by red maple along with the typical swamp shrubs previously mentioned. In the absence of evergreens the deep underlying peaty organic deposits help to identify a bog.

Bogs have frequently developed in former glacial lakes by the gradual accumulation of organic material falling from beneath a floating mat of vegetation which advances out over the water. Depths of peat deposits of twenty to forty feet are not uncommon.

Botanically, bogs are among the most fascinating wetlands. Here one frequently encounters a group of northern species growing several hundred miles south of their normal range. Plants of especial interest include two insectivorous species, the pitcher-plant (Sarracenia purpurea) and sundew (Drosera spp.) usually growing in Sphagnum moss, as well as a distinctive group of evergreen shrubs--leatherleaf (Chamaedaphne calyculata), bog laurel (Kalmia polifolia) and bog rosemary (Andromeda glaucophylla)--that form a bog heath. Rare orchids and other wildflowers are often associated with the bog vegetation. The underlying deposits may preserve a 15,000 year record of the past vegetation in the form of fossil pollen.

Flood plains fringing the water courses are vital geomorphic features. Their normal function is to handle large volumes of water in times of flood. The periodic overflowing of the banks of a stream builds alluvial soil deposits upon which flood plain vegetation develops. Flood plains usually support a mosaic of vegetation types, including marshes, swamps and flood plain forests.

In the last, black willow (Salix nigra), cottonwood (Populus deltoides) and silver maple (Acer saccharinum) are especially adapted to withstanding flooding and frequently form a series of belts--the willow along the eroding edge of the river, the cottonwood in an intermediate zone and the silver maple on the older, more stable deposits. Annual plants, such as the nettles (Urticaceae) may form a dense undergrowth by the end of the growing season.

Since flood plains are periodically flooded and are constantly undergoing change, ecologically enlightened towns are restricting land use practices on these sites to agriculture, recreation, and those other activities which permit the river to use this physiographic feature without costly destruction of capital improvements. Any development which restricts the river's flooding potential is undesirable.

Elements of flood plain vegetation may develop along the smaller streams. These streambelts, including the adjacent vegetation and various wetlands along their courses, represent belts of open space that should be preserved and in which development should be restricted.

II. The Ecological Role of Wetlands

Wetlands make many significant contributions to the maintenance of environmental quality (5, 9, 12). Among these are their role in flood control, in recharging the water table, in pollution filtration, in oxygen production, in various types of productivity, in maintaining a balanced nitrogen cycle, in preserving biological diversity and in providing areas for education and recreation.

A. Flood Control

Wetlands are of major importance in Connecticut's hydrologic regime, since they act as storage basins, lower flood crests, minimize erosion and serve

to reduce the destructiveness of severe floods.

In urban areas this is especially significant, since development intensifies the speed and amount of run-off. Streets, buildings and parking lots waterproof the land surface thus destroying soak-in areas and concentrating large volumes of rainfall. Hence, run-off is usually rapid and excessive. Wetlands, and especially flood plains if properly situated, can act as catchment areas and thereby tend to lower flood crests and slow the speed of flood waters, thus minimizing damage. The erosive capacity of running water increases as the fifth power of its velocity. The flood plain is a geomorphic safety valve and an integral part of the river system. On it has evolved a distinctive flood plain vegetation of marshes and forests well adapted to periodic flooding.

The role of bogs in flood control was dramatically illustrated during the severe flood of 1955 in the Pocono Mountains of northeastern Pennsylvania. Many bridges were washed out; however, two bridges of the type destroyed elsewhere were still intact below the Cranberry Bog, a Natural Area preserved by The Nature Conservancy. A six-inch rise in water over a ten-acre wetlands places more than 1,500,000 gallons of water in storage with no harm to the surrounding biota. In addition, by slowing the velocity of flow, wetlands also act as siltation traps.

B. Recharging the Water Table

One of the more subtle but significant aspects of many wetlands, especially those underlain by alluvial deposits, is the potential for recharging the water table. The U.S. Geological Survey has demonstrated this in the Ipswich basin of Massachusetts. On the Yellow River in North Carolina it has been reported that the water table of the flood plain is hydraulically contiguous with the surface waters of the stream. As we study Connecticut's wetlands

further there is little doubt that the importance of their hydrologic role will become better appreciated.

C. Pollution Filtration

One of the most significant roles of wetlands may be their ability to remove pollutants from the water flowing through them. Although it has long been recognized that wetlands have a certain self-cleaning ability, recent studies have documented this extremely important role of marshes and swamps. The Tinicum Marshes on the outskirts of Philadelphia are part of a mosaic of highly productive brackish and fresh-water plant communities which receive effluent sewage from nearby sewage facilities. Studies indicated that within three to five hours after the water had moved across the 512 acres of marsh there was a 57 percent reduction in biological oxygen demand (BOD), 63 percent reduction in nitrates, 57 percent in phosphates. This amounted to a reduction of 7.7 tons of BOD, 4.3 tons of ammonia nitrogen, 138 pounds of nitrate and 4.9 tons of phosphate.[6] In Georgia, a similar role has been reported for the river bottomland swamps along the Flint and Alcovy Rivers.[14] Along Mountain Creek, a tributary of the Alcovy, extreme pollution due to human sewage and chicken offal has been reported. After passing through 2.75 miles of swamp forest along the Alcovy, however, the water was designated as clean and, after moving through seven additional miles of river swamp, water quality had increased to excellent.

The role of Connecticut's wetlands in pollution filtration is yet to be fully documented. Preliminary observations would suggest that they can play a significant role. In the Hunt's Brook watershed in Montville, where an estimated million cubic yards of fly ash from the power plant of a major utility has been placed in the streambelt, wetlands downstream have served an important

role as a sediment trap. Fine fly ash has been trapped in one depression where a red maple swamp has been converted into a reed grass (Phragmites communis) marsh. Much of the sediment would now be further downstream had it not been caught by this wetland. It must be stressed that utilizing wetlands as pollution filters does not excuse inadequate water pollution controls or irresponsible actions in sound land use. Connecticut, like other states, has a large ecological debt to overcome in the years ahead. Reserving the wetlands to assist in getting on the positive side of the ledger seems most prudent at this time. Further destruction of wetlands can only intensify the difficult preserving a high level of environmental quality.

D. Oxygen Production

In the processes of photosynthesis, green plants produce oxygen in excess of what they require for respiration and thereby add this oxygen to the atmosphere. In recent studies on Pennsylvania's Tinicum Marshes, it was reported that a net increase of 20 tons of oxygen per day is produced by the marsh.[6] Unfortunately, since this study was made, an interchange on an interstate highway has been constructed in the center of the marsh, which has drastically reduced the size of the wetland. In an intriguing article, "In Defense of Mud," Dr. Edward S. Deevey[3] has pointed out that not all the oxygen produced in a wetland comes from green plants. In the wetland muds, the reduction of nitrogen and sulfur compounds containing oxygen also results in the production of oxygen. This is a hitherto little-understood role of the wetlands--oxygen production from mud!

E. Productivity.

Fresh-water marshes and swamps are among our most productive biological systems. In absolute terms, they compete with the best agricultural land in the total production of organic materials. Although we often do not use com-

pounds directly, indirectly they can lead to timber or, through the food chain, to wildlife production. Dr. Charles Wharton reported studies on the Alcovy River in Georgia which estimates that the value to the taxpayer of the Alcovy River system is $7,000,000 annually.[14]

It should be emphasized that these monetary estimates do not include the value of primary production as food for wildlife or fur-bearing animals. Furbearers are locally important in Connecticut. On the 750-acre Quinnipiac Marsh in Connecticut, Smith[12] estimated the 1971 population of muskrats at 7,675 individuals. This could yield an annual harvest of 5,700 muskrat pelts, assuming normal winter mortality.

The wetlands have long been recognized as our nation's "duck factories". Those in Connecticut are playing an important role in providing nesting and feeding sites and resting areas for migratory waterfowl along the Atlantic Flyway.

F. Aid in Maintenance of a Balanced Nitrogen Cycle

Modern man has drastically modified the nitrogen cycle. The annual natural turnover of nitrogen compounds in the U.S. has been calculated to be about 7 or 8 million tons.[1] Currently our agricultural fertilizers add another estimated 7 million tons of nitrogen to the cycle, and nitrogenous compounds produced as by-products from power plants and automobiles, add another 2 to 3 million tons. By more than doubling the nitrogen input into the biosphere a serious deterioration of environmental quality has taken place in various parts of the country.

Denitrifying bacteria have the ability to take the deleterious nitrogen oxides that are accumulating and convert them back into the atmospheric nitrogen of which most of the atmosphere is composed. Most wetlands support vast numbers

of these micro-organisms and thus serve to reduce the load of dissolved nitrogen washed into them. With over half of original tidal marshes already destroyed[7] and with a considerable acreage of the inland wetlands filled or drained, an increased burden is being placed upon the remaining wetlands to help restore the nitrogen balance in the ecosystem.

G. Maintaining Diversity

The flora and fauna of our wetlands exhibit a rich diversity of species. Among these are rare orchids, unusual insectivorous plants, and wetland birds, including the secretive rails and spectacular egrets.

Most ecologists agree that diversity tends to stabilize biological systems. A corn field is much less stable ecologically than a marsh or swamp forest. In artificially managed ecosystemssuch as corn fields, man must add considerable energy to them to keep them productive. Such is not the case with the natural wetlands. They represent a set of dynamic self-sustaining biological systems. Marshes, swamps, bogs, flood plains and streambelts are an important aspect of biotic diversity in Connecticut. At the present time we do not know how far we can go in altering natural areas before the entire ecosystem upon which we depend will collapse! Dasmann[2] makes a strong plea for the preservation of natural diversity in the hope that the trend toward ecosystem uniformity can be arrested and that the world can be kept a fit place in which to live.

III. Education and Recreation

Wetlands can serve as resource and study areas for scientific research and as outdoor educational exhibits--living museums where the dynamics and ecological role of these ecosystems may be taught. Examples of recent wetlands research have already been cited (1, 3, 6, 11, 13).

In education these outdoor laboratories can be used to emphasize such basic ecological principles as energy flow, the stability of diversity, recycling and limited carrying capacity. All of these are directly related to man and the environmental problems he has created by failing to recognize their pertinence to human ecology. A practical example of the educational usefulness of a wetland is the Connecticut Arboretum Trail Guide.[4] The booklet makes the point that "The swamp below the dam is roughly an acre in size. If flooded to a depth of one foot, it would hold 330,000 gallons of water in temporary storage. Thus whenever a swamp is filled or drained, another large quantity of water is lost from the underground water supply and made to run off more quickly to aggravate flooding problems downstream."

Wetlands also provide a great recreational outlet. Hunting is still an important form of recreation in Connecticut. Others stalk the wetlands with binoculars, where the great diversity of waterfowl and spectacular waterbirds give pleasure and inspiration. Wetlands should be incorporated into the untouched, open spaces of every town, thus becoming a part of our necessary commitment to open lands.

EDITORIAL COMMENTARY

The Ecological Role of Inland Wetlands

by

Michael Wm. Lefor and T. Helfgott

The introductory section of the reviewed paper clearly defines and categorizes the various forms of inland wetlands and the plants associated with them. It is important to understand the many ways in which inland wetlands can be defined. Vegetation cover is one of these. With both vegetation and the hydrologic regimes of these areas, inland wetlands can be readily delineated by a great number of techniques not the least of which is remote sensing with computer-enhanced densitometry.

Because of their unique biotic, topographic and edaphic qualities, inland wetlands have many seldom realized functions important for man's health and welfare as he participates in the ecosystem.

In the section on the ecological role of wetlands, the most important and well-put concept is that of the geomorphic safety valve as part of the vital function of the flood plain. Wetlands, in various descriptive configurations, serve as temporary water-storage areas and siltation traps.

When it comes to the possible function of wetlands as groundwater recharge areas, it should be pointed out that the more likely case is that wetlands can be either recharge or discharge areas, depending on the individual case. Each wetland proposed for development in the future must be thoroughly studied hydrologically to determine the individual recharge/discharge function, and how this may bear on the proposed development, and *vice versa*.

The data from the studies on pollution filtration in the Tinicum marshes (Philadelphia) is impressive; however, we must be careful in ascribing this capability to other wetland areas without a careful study of each wetland ecosystem proposed for this use. In an estuary, where there is a high nutrient concentration and turnover along with a large water flow (the entrance of a river or tidal flushing) the system may work well if oxygen demanding and refractory organics are removed from the primary effluent water before it reaches the marsh ecosystem. Nevertheless, the addition of large amounts of nutrients can exceed the enrichment capacities of the ecosystem, increase BOD and result in a drastic change in the biota present.

It may be advisable to leave an ecosystem alone unless we know exactly how to improve or utilize it. On the other hand, man cannot exist without reacting with the wetland environment. In any case, we need to know our ecosystems.

The idea of wetlands as pollution filters has a better chance of success in areas of high species diversity than in the lower diversity marine (saltwater) estuarine environment of the Spartina and Typha marshes. Unfortunately, the most common response to a pollutional load is to decrease diversity and increase the proportion of more adaptable, often undesirable biota.

We should be very careful before using wetlands for "pollution filtration". While any natural ecosystem does indeed have some "self-cleaning" ability it must be emphasized that the wetland will respond to a pollutional load by a change in biota, often increasing the numbers of some undesirable species of plants, algae and bacteria while lowering diversity through the elimination of sensitive species.

The oxygen production of aerobic portions of wetlands which is about

8 to 10 mg/l at best can easily be dropped to zero, especially at night, due to an overload of biochemical oxygen-demanding organic materials found in wastewaters. Furthermore, even common municipal wastewaters contain more than degradable organics; and industrial wastes usually contain even more refractory (non-biodegradable) materials, toxic components (e.g. pesticides) and heavy metals. In addition, the effects of harmful micro-organisms (e.g. viruses), the stimulation of undesirable flora (e.g. blue-green algae), must be considered before depositing sewage into wetlands. The use of wetlands as a dumping ground for untreated waste is clearly highly questionable; however, the disposal of sewage effluents pre-treated to remove harmful pollutants by depositing these relatively cleaner waters into the wetlands should be investigated.

The removals reported in the paper are relatively modest; much pollution still remains to pass into the environment to alter and even disrupt the natural ecosystems. Furthermore, not all natural biodegradation is of the desired aerobic type. Anaerobic environments that result in the reduction of nitrogen and sulfur are notable for producing offensive odors from hydrogen sulfide and amines. In these systems sulfides serve as electron acceptors (not producing free oxygen) and decarboxylation produces amines fromamino acids.

Despite the pioneering efforts of conservationists, the wetlands are still beleaguered by monumental social and ecological pressure. The nitrogen and oxygen cycles are clearly cited in the paper as part of these problems, as in the plea for the maintenance of diversity.

With further concerned contributions such as this paper and an increased intercommunication between the public sector, the legal sector, and the scientific community, we may be able to stay the onslaught of environmental deterioration.

ECOLOGICAL HISTORY OF WETLANDS

Margaret Bryan Davis*

I. Introduction

Sediment accumulation is characteristic of wetlands. The chemical contents of the sediments reflect the concentrations of these same constituents in the wetland itself; and the remains of animals and plants preserved as fossils reflect numbers and kinds of organisms in the wetlands and on the surrounding landscape. As the fossils accumulate year by year they record events in and around the wetlands, the lake or the bog providing an archive of events.

The ecological history of wetlands is therefore relatively easy to obtain. Of particular interest to this symposium is the historical record of recent events, events for which man is responsible. The examples given in this paper are from lakes in the Midwest, but the general techniques and results are applicable to wetlands in Connecticut.

The particular value of the historical record is, first, that it measures background levels prior to any influence of industrial man. This information provides a baseline for attempts to restore a wetland to its original condition. Second, historical records tell us the rate of change and the nature of change since pollution of a particular water body began. In some cases we can even obtain a record of the change back again as the wetland is restored to its original condition.

II. Use of Sediment Cores

Historical records are obtained from cores of undisturbed sediment. The cores, which may be a meter in length, include sediment deposited over the last

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two or three centuries. After collection they are taken into the laboratory and sectioned, providing a series of samples extending from the present back into time. A characteristic constituent of sediments is pollen from terrestrial plants, of importance in the present connection because it records land use. When the forests were cut down in colonial times, a major change occurred in the proportions of pollen produced by the vegetation. This shows with particular clarity in sediments from Michigan, where settlement in the early 19th century was accompanied by rapid and complete clearance of the land, Figure 1. Before settlement there were very high frequencies of pollen from trees, oak in particular. It is known from early accounts and surveys that the landscape at that time was forested. After settlement, the abundance of tree pollen declined; and pollen from weeds, especially ragweed, increased. This is a spectacular effect in Michigan, as ragweed, which is a prolific pollen producer, increased from less than one percent of the total to thirty or forty percent. A change in pollen frequencies at nine centimeters in depth in Figure 1 marks sediment dating from the time of clearance of forest and inception of farming, an event that occured about 1835 A.D. in the watershed of the lake from which this particular core was taken.[5] Toward the surface the ragweed declines again and tree pollen increases, recording local farm abandonment. The lake is in a sandy region of southern Michigan where in the early part of this century farming became unprofitable, and the forest was allowed to regenerate. A similar record of land use is to be expected in Connecticut. The landscape here was settled in the 17th and 18th centuries; over 80 percent of its area was cleared by the early part of the 19th century. Much of this later was allowed to revert to forest as the Midwest was opened up for settlement in the 19th century.

Frains Lake, a small (6.7 ha) lake in southern Michigan, provides an example of the results that can be obtained from intensive study. Frains Lake is now highly eutrophic with bottom waters depleted of oxygen by the end of the first week in May, and with hydrogen sulfide detectable below the thermocline before the first of June.[10] Historical studies of this lake have been helpful in elucidating the cause of its present extreme eutrophic condition. The type of pollen diagram shown in Figure 1 was used to distinguish post settlement sediment from pre-settlement sediment.

As a first step, sediment yield from the landscape under different types of land use was estimated. This was possible in Frains Lake because there is no outlet; any material which has come into the lake from its watershed has been trapped there. By measuring the total amount of material accumulated in the lake, the total amount of material that has come off the watershed is in fact measured.

Post-settlement sediment was identified and its total volume estimated. It was then ashed to measure the total weight of inorganic constituents. Knowing the total tonnage of sediment which has accumulated in the lake over the last century and a half, and knowing the area of the watershed, it was possible to express the amount of sediment as sediment yield, that is, tons of inorganic material taken from the watershed per square kilometer per year. The rate calculates at about 125 tons per square kilometer per year.

Sediment yield from the primeval, forested landscape was calculated from older sediment in the lake. Radiocarbon dates were obtained at several levels in long cores in order to calculate rates of accumulation. The rates were extrapolated to the entire lake permitting calculation of the total annual input of inorganic material in the millennium prior to settlement. With this calculation

we have the contrast between forested landscape and farmland in the same watershed. Sediment yield prior to settlement was about 12 tons per km^2 per year. A ten-fold increase in erosion from the watershed occurred as a result of man's activities, an increase from 12 to 125 tons. Investigators using different methods to measure erosion in various parts of the country also estimate a 5-fold to 20-fold increase following the removal of forest.[1,8,9]

Studying the sediment in greater detail, events can be estimated that occurred during the 140 year interval after the forest was removed from the watershed. This was done using the detailed stratigraphy of a core, collected in the central portion of the lake, where the sedimentation rate is high and abundant detail is preserved. Bands of clay rich material alternate with bands of organic rich material. Most of this complex stratigraphy is in sediment deposited immediately after forest clearance. Influx of inorganic material was clearly highest, and most variable, in the years immediately following forest clearance, tapering off somewhat and approaching the average value for the entire interval around 1900 A.D. Assuming that events in the center of the lake are linearly related to events over the whole lake, then we can use this core as an indication of whatis happening in the whole basin. Average influx to this particular sampling point would then be proportional to the average influx to the lake as a whole, which is a measurement of average sediment yield from the watershed. Using this line of reasoning, the influx values have been calculated by equating the average influx of inorganic material to the average sediment yield. The entire sedimentary sequence since settlement can then be expressed as erosion rates from the watershed.

Figure 2 shows the resulting estimated sediment yields from the watershed through time; first the very low rate before the landscape was cleared, and then

the rapid increase as the forest was removed. During short intervals erosion rates peaked at values 20-40 times the pre-settlement rate. There were also periods of heavy organic input, probably due to the breakdown of soils and the inwash of organic humus. After 1900 A.D. the sediment yield steadied at a rate 10 times the pre-settlement rate.

Similar reconstruction of the history of sediment yields near Baltimore, Maryland, has been made by Wolman.[11] His reconstruction is based on analogies with modern streams flowing out of different kinds of landscape. The estimates of sediment yield are similar, although Wolman was not able to measure erosion from completely forested landscapes. He estimates erosion rates in pre-settlement time at about 25 tons, increasing to 250 tons as the landscape was cleared and used for farming. These rates persisted into the first years of this century, declining somewhat as active farming declined and then increasing sharply in the 1950's due to construction of housing in the Baltimore area. The high rates of erosion around construction sites are analogous to the high rate that is postulated for the first years after settlement, when the forest was being cleared, farm houses were being built, and roads were put in around the lake; all in all, activities similar to those at construction sites at the present time. Wolman shows that as urban areas are built up and more or less paved over, erosion rates fall again to low levels.

Changes in the sediment from the Frains Lake watershed have had profound effects on the lake. Living and fossil plankton in the lake have been studied by W. C. Kerfoot.[7] He has been able to show that the fauna changed dramatically in 1830 when the forest was cleared. The dominant zooplankter changed from *Daphnia* to *Bosmina*. The abundance of water plants increased, and there is evidence for a change in fish abundance. These changes are presumably due to

the fertilization effect of the dissolved nutrients which came in from the watershed at the same time as the clay and silt.

Changes in sediment chemistry and microfossil content resulting from human disturbance have been observed in a number of lakes. At Shagawa Lake in Minnesota, for example, a rapid increase in erosion at the time of settlement is indicated by increased numbers of fungal hyphae from the soil humus horizon. This change was followed by an increase in diatoms and zooplankton as the lake became more productive in response to the fertilization caused by increased sediment yield.[3,4] Chemical analyses of sediment from Lake Mendota, in Wisconsin, show a dramatic increase in phosphorus near the sediment surface, probably as a result of sewage input. A matter of particular interest here is the long sedimentary record. Phosphorus levels have been low throughout the lifetime of this lake, for at least ten thousand years, until 200 years ago, when pollution began. Suddenly after a long period of stability the entire lake chemistry was changed as the result of man's activities.[2]

III. Conclusion

One more example should be mentioned in order to end on a hopeful note. Lake Washington, near Seattle, is a lake where restoration has been accomplished. This lake had had a complex pollution history, involving raw sewage input in the early years of this century, followed by abatement in the 1930's after secondary sewage treatment plants were built. Continuing rapid growth of the city, however, resulted in increasing input of phosphorous-rich treated sewage. By the 1960's the results of enrichment were evident in increased turbidity and the appearance of blue-green algae such as Oscillatoria rubescens.[6] The sediments record changes correlated with these changes in sewage input. Sediments deposited in the 1920's for example, show increased proportions of a group of diatom species of the

Araphinideae in response to the input of raw sewage. The Araphinideae declined as the treatment plants were built. A second increase, however, is found in sediments from 1940-1960, reflecting the input of treated sewage. After 1963, when sewage was diverted from the lake, the lake began to recover. Sediment just below the surface records this recovery, as the microfossil flora preserved in the sediment returns to the flora characteristic of the unpolluted lake.[12]

In Connecticut, wetlands have had a similarly complex history, including disturbance by the extensive agriculture of the early 19th century, recovery in some areas as farms were abandoned, and renewed pollution in recent years as the population has increased. Guidelines for management need not be based on analogy with distant sites; guidelines can be based on knowledge of the effect previous treatments have had on these same lakes and bogs. Damage from agricultural usage or pollution can be assessed, and the recovery, or lack of it, from past episodes can be measured. The sedimentary record of these changes provides the documentation needed to adopt sensible protective measures for the wetlands of Connecticut.

FIGURES

1. Pollen percentages in very recent sediment from Blind Lake, Pinckney County, in southern Michigan. Sediment depth is indicated on the originate. pollen percentages on the abscissa. The dashed line marks the level of the decline of oak pollen and increase in herbs caused by clearance of forest for farming. Farm abandonment in very recent years has been accompanied by regrowth of forest for farming. A corresponding increase in tree pollen percentages appears in the sediment near the surface (Redrawn from Davis, et al., 1971).
2. Generalized graph showing changing sediment yield through time from the Frains Lake watershed.

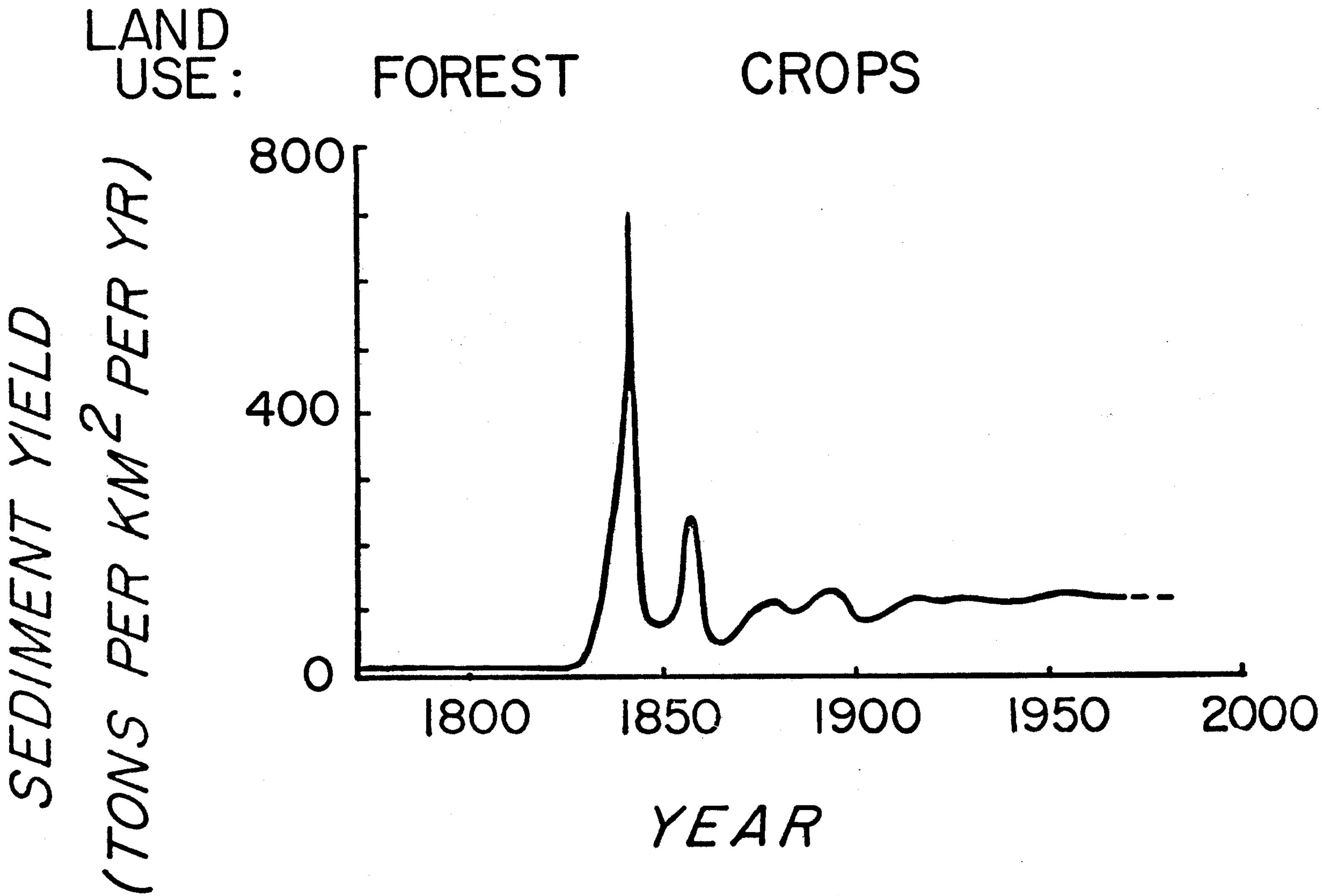
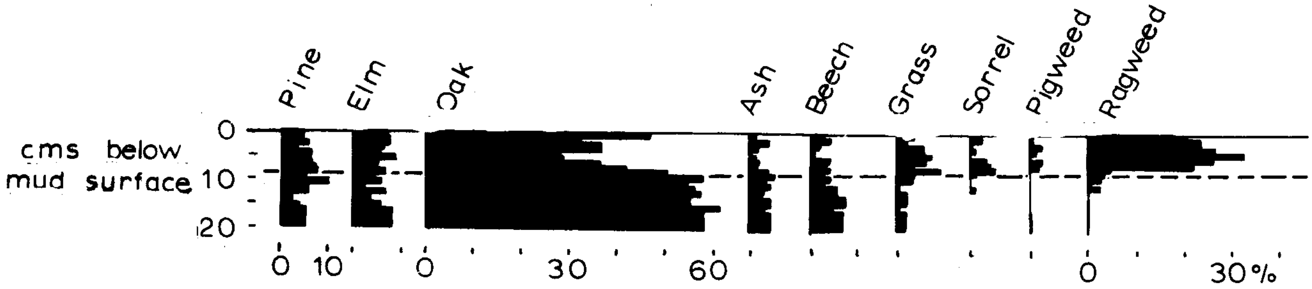

LAND USE:
FOREST
CROPS
800
400
0
1800
1850
1900
1950
2000
YEAR
SEDIMENT YIELD
(TONS PER KM2 PER YR)

Figure 1



Pine
Elm
Oak
Ash
Beech
Grass
Sorrel
Pigweed
Ragweed
cms below
mud surface
0
10
20
0 10
0
30
60
0
30%

Figure 2

EDITORIAL COMMENTARY

Ecological History of Wetlands

by

P. G. Gensel* and M. W. Lefor

The reviewed paper provides an interesting means of documenting the ecological history of wetlands. The approach is to sample a lake, pond or bog by taking a core of the bottom sediments, then analyzing the sediments in that core along with any additional fossil remains contained in each stratum. Dating of the core is done by the radiocarbon method. The sedimentary record of a given pond, lake or bog can give a picture of the changes produced in and around it through time. This record can be used to show that environmental changes affect wetlands, and to some extent, how.

As with any field, certain initial assumptions must be made. The paper assumes that the rate and amount of sediment accumulation between one part of a given lake and another are equally proportional. This can be established, but sedimentation depends a great deal on such factors as the presence or absence of currents, the carrying capacity of the water for individual sediment species, and particle size and charge. Sedimentation rates are therefore very variable from place to place and from time to time. In establishing the relationship of time and sedimentation rates, radiocarbon dating is certainly helpful, but it also is subject to a variance in the final result.

Another assumption made in this paper is that increasing amounts of certain inorganic and organic components of the sediment system are a direct result of

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environmental pollution. There may be other explanations; for example, a stream can be "polluted" by an excessive sediment load (erosion) resulting from a heavy rainfall. This could result in a decrease in the amount of available oxygen and an increase in nutrients. Can one separate natural disaster from pollution?

Further, any fossil pollen, spores or other material may only represent a percentage of the diversity and density of past biota, and not fully representative of the former ecosystem. Sediment studies of preserved pollen can be useful in establishing past ecological history when the neighboring area can be otherwise shown to have been vegetated by species having wind-borne pollen; i.e., in the colder temperate zones. Prevailing winds and climatic conditions and the intimate nature of each pollen type also influences the distribution of pollen species in the sediments.

As in any palaeobiological study, it is often necessary to draw general conclusions from a large body of data and related knowledge. Experience has shown the utility of sediment studies in the framework offered in the paper.

INSECTS (CHRYSOPS FLIES) IN CONNECTICUT SALT MARSHES

John F. Anderson*

I. Introduction: Wetland Zoology

Man is able to exist almost anywhere on earth and he can occupy and encroach upon a vast number of niches. The occupancy of and encroachment upon various environments by man sometimes result in unforeseen problems. This paper illustrates one such situation that has arisen in Connecticut.

The subject is wetlands zoology; specifically, the parasitic types of insects associated with wetlands.

II. Insect Problems of the Wetlands

Many biting flies are vectors of arthropod-borne diseases. Arthropod-borne diseases of man in Connecticut are not the problem today that they were in earlier times. Malaria was a formidable disease from the time of settlement until the early 1900's. An outbreak of mosquito-borne yellow fever occurred in New Haven in 1794. The most recent outbreak of disease in man occurred in the early 1950's, when an outbreak of mite-carried rickettsial pox was recorded in Hartford. There have been horses and domestic birds that have died from encephalitis in Connecticut, but no person is known to have contacted eastern, western, or St. Louis encephalitis here. Neither Rocky Mountain spotted fever nor plague have been recorded in Connecticut. Tularemia has been reported in the state, but arthropods have not been implicated as vectors of the bacterium causing this disease. Arthropod-borne diseases in domestic animals are more prevalent. Dog heartworm is common, and equine infectious anemia in horses and equine

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encephalitis in horses and pheasants occurs sporadically. In summary, arthropod-borne diseases of man are a rarity in this society, though some, particularly the encephalitides, are potentially dangerous diseases; the major problem year in and year out with biting flies is their nuisance.

Ecologically, insect parasites of vertebrate animals are divided into three categories: host-dwelling parasites, nest-dwelling parasites, and field-dwelling parasites. Body lice are host-dwelling parasites. These insects can complete their entire life cycle on the body of the host and they seldom occur off their host.

Fleas and bedbugs are examples of nest-dwelling parasites. These parasites complete their life cycle in the "nest" of the host and feed on the host at intervals.

Mosquitoes, deer flies and horseflies are examples of field-dwelling parasites; they are parasites that do not remain on their hosts throughout their life cycle. They often find their hosts in areas away from the nest of the host and they have specific ecological requirements quite different from and independent of their hosts. Many field-dwelling parasites are associated with wetlands. Other insects of this type that occur in Connecticut include the punkies or no-seeums, stable flies, and black flies.

The encroachment of man upon the salt marshes and adjoining wetlands, and associated insect problems resulting from this encroachment are used here to illustrate the interaction between biting flies and man in Connecticut. Although this example pertains to the salt marsh and involves only one type of biting fly, deer flies, similar problems could be illustrated for freshwater habitats and for other biting flies.

A. Deer flies

Deer flies are field-dwelling parasites associated with broken

woodlands and feeding predominantly on large mammals. One of the more serious problems with deer flies has arisen in an area immediately adjacent to a salt marsh in Milford. Although numerous species of deer fly are present in Connecticut, in this marsh two species of deer flies--*Chrysops fuliginosus* and *Chrysops atlanticus*--are extremely abundant. The Milford marsh is of approximately 750 acres and is dominated by *Spartina alterniflora*. There is a 2-3 acre island within the marsh where much of our observations were carried out. The upland adjacent to the marsh has been developed as a residential area accomodating several hundred persons. This residential upland is cloaked by a mantle of trees.

The problem posed by an abundance of biting deer flies along the upland arises for the following reasons:

1. The marsh provides all the requisites for the maintenance of populations of deer flies. Essentially, these are

    a. suitable rendezvous sites for mating

    b. suitable sites for the deposition of eggs

    c. a suitable medium for the growth and survival of the juvenile forms.

2. These flies are autogenous; that is, they deposit their initial batch of eggs without feeding on the tissues of vertebrate animals (a "blood meal"). It is important to remember that vertebrate blood is not a requirement for the maintenance of populations of these flies. This is quite unlike the situation with most species of mosquitoes, tsetse flies, ticks and many other biting arthropods.

3. Adult deer flies are associated with broken woodlands.

Shortly after the female fly has deposited her initial batch of eggs, her behavior changes from that of the docile non-biting fly of the marsh to the active biting fly of the upland.

4. As reported, adult deer flies feed predominantly on large mammals, although there have been a few reports of deer flies feeding on birds. Man has selected the upland along the marsh as a place to live and in the process he has driven out whatever wild, large mammals might have once inhabited the area, leaving himself and his domestic animals, primarily the dog, as the only available hosts for female deer flies.

We have data on two species of deer flies which substantiate the statements just made. Adult deer flies begin emerging from the marsh during the latter part of May and early part of June and continue doing so throughout June and early July. Mating of the Chrysops atlanticus deer fly was observed only in the marsh and for about an hour to an hour and a half in the morning. Males hover in open areas in the marsh and capture females as they fly across the openings. Chrysops fuliginosus also mates in the marsh. The marsh is an absolute necessity for the carrying out of this life function.

Following mating, females deposit their initial batch of eggs in the marsh without feeding on a vertebrate host. This was determined by examining the internal reproductive organs of Chrysops atlanticus. Virgin females collected in the marsh all possessed follicles that would proceed to the formation of fully formed eggs without additional nutriment. Females collected during mating contained reproductive systems in a similar condition. These data demonstrate that this species of deer fly is autogenous and that vertebrate blood is not necessary for the maintenance of

populations of these flies.

Following the deposition of eggs in the marsh, the majority of females fly to the upland where they spend most of their time resting on the leaves of trees and shrubs. At the same time the flies become agressive and readily bite man and other large mammals. The reproductive system of these flies is markedly different from those mentioned previously. All biting flies we examined had mated and follicular relics were present, indicating that the females had already deposited eggs. None of the follicles in the ovaries were found to be in a stage of development that would lead to the formation of fully formed eggs without the female obtaining additional nutriment. In other words, these flies must now feed on tissues of vertebrate animals in order to deposit a second batch of eggs.

As noted the upland is not only residential but also a broken woodland, though artificially developed. The roads and sidewalks are often lined with trees as are the yards surrounding the houses. Flies rest on the foliage, and at certain times of the day they drop to lower levels when suitable hosts pass by their resting sites. The importance of trees was demonstrated in part by taking biting counts along a transect from a road through a cleared area and into a woodland. The number of flies landing on man in the wooded area was significantly higher than in all other sampling sites.

Almost all deer flies are known to feed during the daylight hours. The two species discussed here are no exception to this generalization, although their feeding patterns differed markedly. The periodicity of biting was determined by recording the number of flies landing on a human host for 3 minutes every 30 minutes throughout the day from early morning

until late evening. The biting cycle of <u>Chrysops atlanticus</u> is biphasic. There is a peak feeding time beginning shortly after sunrise and lasting about 3 hours, and a second, less intense peak beginning about 2 hours before sunset and terminating shortly before sunset. <u>Chrysops fuliginosus</u> has a monophasic feeding cycle. The peak is reached in late morning and continues for about 3 hours. There is a tapering off of biting activity until 6 P.M. and little, if any, biting occurs thereafter.

Man is most active in the outdoor environment during the daylight hours during the period when the deer flies are most active. He normally is not exposed to the early morning peak feeding of <u>Chrysops atlanticus</u> because he is then asleep, but he is out of doors during the latter part of the morning when both species are biting. Mothers and children are particularly active out of doors during the peak feeding period of <u>Chrysops fuliginosus</u>. All members of the family are often exposed to the evening period of biting of <u>Chrysops atlanticus</u>. The numbers of flies that are present in a single yard can at times be quite high. For example, a weather balloon coated with a sticky substance was left for one hour in one backyard; over 500 female <u>Chrysops fuliginosus</u> flies were caught on the sticky surface of the balloon.

Although <u>Chrysops</u> flies actively seek blood after laying their initial batch of eggs, both species have difficulty ingesting blood from man. Of 59 females of <u>Chrysops fuliginosus</u> that were allowed to feed once, only 4 were able to ingest blood in their initial attempt at feeding. Of 41 that were allowed to feed a second time, only 1 additional fly engorged. One fly was allowed to feed 16 times, yet it was never successful in ingesting blood. <u>Chrysops atlanticus</u> also had difficulty ingesting blood, though it was slightly more successful than <u>Chrysops fuliginosus</u>. The

nuisance of these flies to man is accentuated by this pattern of biting since female deer flies continue to search for hosts until they become satiated or die.

B. Control Methods

Satisfactory methods of controlling deer flies have not yet been developed. Methods that have been attempted include the use of insecticides, temporary impoundment of marshes, trapping of adults and reduction of excess brush around housing areas. All of these methods have their limitations. There are no insecticides that can be used for the control of larval deer flies, and those that may be applied against the adults are either relatively ineffective in killing large numbers of flies or else they are not persistent enough to kill flies for more than a day or two. Inasmuch as deer flies emerge from the marsh over a period of 3 to 6 weeks, frequent applications would be necessary to reduce their numbers. The destruction of biting flies in the upland would have little effect upon the population for the following year since the adults would have already laid their first batch of eggs.

Impoundments properly timed for a period of 3 to 6 weeks are highly effective in destroying juvenile deer flies, but are often difficult to make, and the effects on the marsh are not known.

Various types of traps have been used; for example, box traps are used in Cape Cod to catch horseflies. A single trap can catch several thousand flies a day. Unfortunately, the percentage of flies caught in relation to the total population is very small. Nevertheless, it is possible that traps might be effective in reducing the annoyance caused by deer flies and horseflies in small, isolated areas of marsh.

Deer flies are generally a problem only in areas of trees and brush. One can reduce the incidence of biting by removing unnecessary foliage, but this obviously has limitations. One should note that although horseflies also develop in wetlands, adult horseflies are usually associated with open prairies or meadows rather than with broken woodlands. It is possible that one may reduce the number of deer flies by removing unnecessary brush but increase the number of biting horseflies as a result.

III. Conclusion

This discussion has attempted to give an idea of one insect problem that has arisen because of man's encroachment into wetlands areas. The danger exists that arthropod-borne diseases will increase in Connecticut as man continues to modify the environment, especially in regions of high population and low biotic diversity.

State-wide land use planning is needed to minimize any more harmful interactions of man and the ecosystems with which he has been entrusted.

EDITORIAL COMMENTARY

Insects (Chrysops flies) in Connecticut's Salt Marshes

by

M. W. Lefor and T. Helfgott

The paper brings forth an example of the consequences of human encroachment on an ecosystem of low diversity by discussing the problems of insect population in wetlands. In general, low diversity equals high populations. The aesthetic, botanical, and zoological aspects of Connecticut's salt marshes are thought by many to far outweigh the great nuisance value of the associated insects (mosquitoes, mites, and biting flies). Those who live in developed areas near our coastal marshes disagree, since the haemophagous insects are not only a serious annoyance but a potential health threat.

Since it is largely impossible to move the populace from saltmarsh boundaries, and difficult to establish the large buffer zones necessary to provide a distance-shield for the neighboring populace, there are two possible solutions to the problem: 1) suffer with the insect situation, or 2) control the insects. Obviously the second is the most logical alternative. The reviewed paper indicates that biotic controls such as reducing unnecessary brush will only serve to favor the proliferation of other potentially vexatious species (here the biting horseflies). The use of cyclic hydrocarbon and organophosphorus pesticides is to be discouraged not only in the treatment of Chrysops spp. but also in decimating the vast clouds of Aedes mosquitoes (A. solicitans, A. cantator) common to salt marshes. More specific biotic controls have to be developed for noxious

species. Male sterilization programs, such as those which were so successful in eliminating the Screwworm fly are now underway for mosquitoes.

Life cycle, behavior, and habitat studies such as Dr. Anderson's lay the foundation for male sterilization programs for the *Chrysops* flies. Hopefully, such a program can be initiated and made to work before the problem of arborvirus diseases becomes a greater threat to Connecticut's ever-increasing human population. The warning given in this paper to the limits of man's effective control of wetlands need be heeded.

STATEMENTS OF PANELISTS

"Legal Aspects of Wetlands Protection - Limits of the Police Power"

Haynes N. Johnson, Attorney; Stamford, Connecticut
Panel Discussion Leader

This conference has as one of its objectives the task of showing each of us how to handle wetlands problems in a practical and unambiguous manner. Therefore, a preliminary comment on some of the legal aspects of wetlands protection is in order from this practicing attorney.

The law relating to wetlands protection is a branch of what we refer to as the "police power": it deals with the extent to which government may regulate people's conduct. In the instance of wetlands, it relates to the extent to which the state may regulate one's use of his own wetlands without being confiscatory. That is, on the one hand, police power exercised within reasonable limits is deemed proper for protection of the general welfare; on the other, police power exercised to an extreme is deemed to be a confiscation of one's property, and, if engaged in, the state must pay for the taking of that property. The issue that is going to have to be resolved by the courts is where the line should be drawn between the valid exercise of police power and taking of property.

It is of value to consider and briefly compare the police power as it has evolved in the last 50 years relative to the zoning laws. Until the mid-nineteen twenties, zoning did not exist. If one owned a piece of property in this country, he could do with it very much what he pleased, subject to no control other than challenges by his neighbor or his municipality if he were to

create a nuisance by his use of the property. Zoning law developed from nuisance law, under police power, to establish that all property can be charged with restrictions upon its use for the benefit of other property owners. Simple examples of this, for instance, are the limited zoning requirements that property may only be used for residential purposes, or only have one house per acre, or the like. Reasonable police power of this nature has long since been upheld by the courts.

We are now entering the phase where police power is being used to protect the ecosystem, once again for the benefit of the general welfare. Here, however, it sometimes occurs that the land use restrictions needed to protect such things as wetlands affect one land owner more severely than another. Thus, in this developing body of law, we find that the police power is being put to a new test in which we must determine the proper limits of police power before such power becomes confiscatory.

Test cases have been filed in various states throughout the country, including Connecticut. Though definitive rulings have not come down from the Connecticut courts, rulings have come down in various other courts, including strong language that wetlands must and should be protected under the police power. It would appear that the phrase "general welfare" means just what it says; and that ecological protection, especially when directed to matters of broad public interest, is necessary.

"Inland Wetlands from the Administrators Viewpoint - Based On Experiences with Connecticut's Inland Wetlands and Water Courses Act"

Dr. Samuel Suffern
Deputy Director, Inland Wetlands and Watercourses Section
Water and Related Resources Unit
Connecticut State Department of Environmental Protection

Connecticut's law applies to both water courses and wetlands. Water courses are defined as rivers, streams, brooks, waterways, lakes, ponds, marshes, swamps, bogs, and all other bodies of water, natural or artificial. Inland wetlands are defined as land, including submerged land, which consists of any of the soil types designated as poorly drained, very poorly drained, alluvial, and flood plain by the National Cooperative Soils Survey.

Wetlands were defined by soil type because the soils data was thought to be the best available at the time. Water courses are undefined in the act. Although not a part of the legislation on Inland Wetlands, we have defined marshes, swamps and bogs botanically and published a booklet Inland Wetland Plants of Connecticut.[1]

The problems encountered in administering the bill are very practical ones. Foremost among these is the definition of edges. Due to scale inaccuracy in the soils maps, a wetlands "boundary", when transposed onto the ground is on the order of 50 feet wide. This haziness of definition is unacceptable. It is necessary to refine the techniques to the point where we can define the wetland boundary to within a very few feet or less.

A second problem is that of assessing the value of wetlands. We need more data on the effects of wetlands: the role of wetlands in water purification,

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1. The Connecticut Arboretum, Connecticut College, for Department of Environmental Protection, State of Connecticut (1973)

aquifer discharge or recharge and flood control, as well as the factors that influence these functions. This information is necessary if we are to make wise decisions on the uses allowed for any given wetland.

A third, more theoretical problem we must deal with is the effect of this type of legislation on people's attitudes toward land ownership. Many consider land use regulation to be an infringement on their rights as owners of private property. Converting societal attitudes from traditional private property concepts to those of land stewardship is a slow process, and will require years of patient education.

A fourth and final problem is that of incremental use. In a hypothetical case, it is obvious that total development of a given wetland will have serious environmental consequences. It is much more difficult to evaluate piecemeal uses. We are faced with the problem of deciding how much development is enough - ahead of time. Here again, the problem is a lack of data.

"The Soil Conservation Service and Its Role in Wetland Management for Connecticut"

Mr. Elmer E. Offerman
Resource Planning Specialist
U.S. Department of Agriculture, Soil Conservation Service

The mission of the Soil Conservation Service (SCS) is to assist in the conservation, development and productive use of the nation's soil, water and related resources so that all Americans may enjoy the following:

1. Quality in the natural resource base for sustained use;
2. Quality in the environment to provide attractive, convenient and satisfying places to live, work and play; and
3. Quality in the standard of living based on community improvement and adequate income.

In the 40 years that the Service has been in existence, this mission has not changed; however, our concerns have changed. In the mid-nineteen thirties, the Service worked almost exclusively with farmers. In the past 15 years, however, the Service has become more and more involved in problems of land use, soil erosion, and sedimentation in urbanizing areas. Most of the technical assistance provided by the Soil Conservation Service is through local soil and water conservation districts organized in Connecticut more than 25 years ago.

The technical assistance provided to individual land owners, groups, or units of government is based on a planning approach. This approach is to help land users or decision makers to plan each land unit as a whole, integrating all aspects of land use and treatment. The Soil and Water Conservation Districts are primarily concerned with land use planning as it related to use and treatment of land based upon soil characteristics, while planning commissions and local

decision makers are concerned with land use planning as it related to location planning within the total community. Programs of the Soil Conservation Service recognize the interactions between resource management systems and the proper use and treatment of land and water resources. Among these resource management systems and sub-systems is wetlands management.

Some major accomplishments of the SCS in Connecticut during 1972 include assistance to over 2,200 district cooperators with 900 of these cooperators applying one or more conservation practices. An additional 360 individuals and 107 units of local government received inventory and evaluation reports for some specific resource management question. Some 280 units of government and local commissions were assisted in the development of resource plans for their communities. Conservation practices related to wildlife include 110 ponds, 588 acres of wetland wildlife management and 1,000 acres of upland wildlife management.

The soil survey program, one of our basic activities, is part of the national cooperative survey. In Connecticut, the Service cooperates with the Connecticut and Storrs Agricultural Experiment Stations in this program. The program has been in progress for about 20 years.

Approximately 75 percent of the state has a modern detailed soil survey. Some mapping has been done in all counties; and Hartford, Tolland and Litchfield counties are completely surveyed, and the reports have been published. In other counties, interim soil survey reports have been prepared so that people can use the information immediately.

Soil survey information in Connecticut is being used at town, regional and state levels. Local experience has shown that detailed soil surveys are essential for comprehensive planning.

One of the new uses for this information is a basis for defining inland

wetlands as outlined in Connecticut Public Act 155, the Inland Wetlands and Watercourses Act. In an appendix to these proceedings, soils included in the definition are the poorly and very poorly drained, alluvial and the floodplain soils. In order to obtain a picture of the extent of these soils the following analysis was made based on published soil surveys for Connecticut's Hartford, Tolland and Litchfield Counties.

ACREAGE AND PERCENTAGE OF FLOODPLAIN AND WET SOILS

	Hartford	Tolland	Litchfield	Total Area Study
TOTAL ACREAGE IN COUNTY:	473,600	266,000	600,000	1,339,600
FLOODPLAIN SOILS:				
Acres	30,352	5,093	16,166	51,611
Percent of total acreage	6.4	1.9	2.7	3.9
POORLY AND VERY POORLY DRAINED SOILS:				
Terrace Soils				
Acres	33,095	3,483	9,352	45,930
Percent of total acreage	7.0	1.3	1.6	3.4
Upland Soils				
Acres	20,342	21,910	37,194	79,446
Percent of total acreage	4.3	8.2	6.2	5.9
Organic Soils				
Acres	4,921	8,236	13,441	26,598
Percent of total acreage	1.0	3.2	2.2	2.0
TOTAL ACREAGE, FLOODPLAIN AND POORLY AND VERY POORLY DRAINED SOILS:				
Acres	88,710	38,722	76,153	203,585
Percent	18.7	14.6	12.7	15.2

These three surveys cover about 45 percent of the state. Slightly over 15 percent of the soils in these three counties fit into the categories of poorly and very poorly drained and floodplains as defined in Public Act 155.

It should be emphasized that these figures are based on the conditions as they existed when the soil scientist was on the land. Since some mapping was done 15 years ago, it can be assumed that some soil areas have been changed by filling or draining for urban use and in other cases they have been drained for agricultural use ("made" land).

The Soil Conservation Service in Connecticut, with public support and encouragement, has developed the basic ideas and guidelines which are being used to delineate and identify streambelts on environmental corridors. These corridors have an important relationship to wetlands management systems.

Streambelts are defined as areas of land which are in close proximity to streams. These streambelts include the stream, land subject to overflow, associated wetlands, shorelines of lakes and ponds, and areas of land where certain land uses would have probably adverse environmental effects on the stream. Also included is a buffer area that helps protect the streambelt areas.

Wetlands as defined by Connecticut's Public Act 155, constitute approximately 80 percent of the streambelts. Generally 60 - 90 percent of the wetlands of a town are included in streambelts. With very few exceptions, all the significant wetlands are included. About 30 percent of the towns in Connecticut have streambelt systems identified, and several have ordinances to implement the systems.

The Soil Conservation Service has joined in a cooperative effort with the Bureau of Sport Fisheries and Wildlife and the U.S. Forest Service to compile a nationwide inventory of wetland resources. The wetlands will be outlined on

county and state maps and will be summarized on a map of the United States. The SCS' immediate job is to indicate wet soil types for counties with published soil surveys. The definitions of wetlands are being developed by the cooperative agencies. These will be national definitions, including both soil and vegetation criteria.

In Connecticut the Conservation Districts and Soil Conservation Service are renewing emphasis on the problems related to soil erosion and sedimentation. The control of erosion and reduction of sediment damage as related to man's action on the land have been a major part of our program since the agency came into existence; however, we are now adding to those additional problems of erosion and sedimentation by urban uses of the land.

The problems of erosion and source of sediment in Connecticut are many and varied in complexity. Nationwide the greatest pollutant of streams (by volume) is silt. Problems related to sediment and erosion can be solved by the uses of proven methods and techniques.

The soil and water conservation districts in Connecticut have had a remarkable influence on good land use practices by individual property owners and units of government. It is important to remember that most land in Connecticut, including wetlands, is in private ownership.

The Soil Conservation Service, working in cooperation with the Conservation Districts, the Department of Environmental Protection, the Agricultural Extension Service, the Institute of Water Resources and other agencies can continue to demonstrate leadership and exert influence on land users and local decision makers in order to preserve and protect Connecticut's natural resources so that we may all enjoy a quality environment.

"Federal Policy Towards Wetlands"

Dr. Royal J. Nadeau*
Federal Water Programs
Environmental Protection Agency
Edison, New Jersey

The value of tidal and non-tidal wetlands is now being recognized as one of the Nation's most valuable natural resources. Extraordinary primary productivity coupled with a unique species array make the marsh ecosystem most important within the biosphere.

With the increased awareness of the ecological importance of wetlands, legislative movement has been promulgated towards protection and judicious use of wetlands. Mr. William J. Ruckelshaus, as Chief Administrator of the U.S. Environmental Protection Agency (EPA), issued a statement outlining the EPA's policy toward wetland usage:

a. The Agency will take particular note concerning decisions on proposals that potentially will damage wetlands; to recognize the interrelationship between man and the wetlands and to preserve and protect them from damaging misuses.

b. The Agency will minimize alterations of natural water flow that nourishes wetlands by protecting them for adverse dredging or filling practices, solid waste management practices, siltation or pesticide contamination or toxic material spills and through construction activities; and to maintain applicable water quality standards.

c. The Agency will not grant Federal funds for construction of municipal waste water treatment facilities if such activities will interfere

*Dr. Nadeau was unavoidably absent from the conference; his previously prepared abstract was read for him by the panel chairman.

with the existing wetland ecosystem; the exception being that no other alternative of lesser environmental damage is found to be feasible. A full assessment of potential damage will be requested with a complete delineation of various alternatives.

d. Public hearings may be held concerning site selection for waste water treatment facilities involving impact upon wetlands. The Department of the Interior will be consulted in such matters concerning the probable effect of the pollution abatement program on the fish and wildlife resources.

This policy implicates and involves all EPA program activities.

"Industrial Aspects of Wetland Uses"

Clyde O. Fisher
Northeast Utilities Service Company

Reasons for past industrial development of low-lying and wet areas include: (1) the large level tracts available, often with few close neighbors; (2) relatively low-cost land, even after drainage and filling (and sometimes good building foundations because of impervious and underlying material causing the surface to remain wet); and (3) planning and zoning policies that encouraged industrial use by earmarking such areas for this use, or by failing to earmark enough other land for industrial use.

Current public planning policies are: (1) recognizing wetland values previously underestimated, and helping to preserve wetland areas; (2) questioning how well these wetland policies have been related to overall conservation and development policies; e.g., what relations exist between wetland mapping and maps in plan of conservation and development; (3) further question was the relation between maps in plan of conservation and development and land use requirements under different growth policies or projections.

This latter question is really whether public policies should not estimate future land requirements of essential development (housing, jobs, utility facilities) and specify where that development <u>should</u> be located, not just where they cannot be located (as in wetlands).

A state land use policy should: (1) address needs for both preservation and development; (2) consider pending National Land Use Policy legislation that would require both protection of critical environmental areas and provision for key facilities such as major electric utility facilities.

Industry planning for future generating and transmission facilities should: (1) evaluate generating sites which must be located well in advance of need. Connecticut's inventory of acceptable sites is very low, and future sites will involve careful weighing of costs and benefits. Though some wetland or other environmental impact areas may be unavoidably used, other wetlands and/or natural areas may be preserved as a result of incorporation into a generating site; (2) assess transmission lines; wetlands pose extra construction costs and difficulties and routes through them are avoided (and, where they cannot be avoided, effort is made to place structures on high points). But a route through wetlands may at times be preferable to a route through other areas, especially fully developed ones. The transmission easement prohibits other development from infringing on the wetlands within the right-of-way, thus serving to preserve that area from major change.

As a closing question, let me pose the following: (1) We are making a commendable, albeit belated, effort to protect inland wetlands. But how adequate will that effort be without a broader examination of all major needs for developable land in light of the supply of that land? (2) Is an examination needed that deals with alternative rates and patterns of growth, and gives us both a sense of direction and a specific framework for our wetlands preservation efforts?

PANEL REVIEW AND COMMENTARY

Roy Deitchman
Research Assistant, Institute of Water Resources
University of Connecticut

The panel discussion was designed to let a group of knowledgeable persons with differing perspectives present their views on wetlands. Therefore, one might expect a series of slightly tilted comments. These presentations, however, are straight-forward with little inherent bias from the individual's professional position. The remarks are probably conservative by environmentalist standards, too establishment-oriented by radical standards, and too brief and practical by academic standards; but, they are progressive and serve as a response by professionals operating in the field to a declared public need in wetlands preservation and use.

Several points were brought up in the discussion that need some further development and possible opposing arguments. These include, in no particular order of importance, the following:

1. Mission-oriented research at the University: There may be conflicts between theory and practice in this area. The University must try to remain out of politics yet try to serve the state by offering experts and research.

2. Wetlands as separate resource units: Can wetlands be considered and administered as separate independent units or must they fall within massive land use plans?

3. Problems of soil definition: The use of a soils definition seems to have several weak spots, including legal and technical boundary problems and the fact that the State of Connecticut will not be completely mapped until 1976.

4. Public attitudes toward wetlands: Education and public information must be part of any wetlands preservation and use program. Public resistance and lack of appreciation of wetland values should be changed by the process of learning. The concept of wetlands as mere swamps fit primarily for dumping and filling should be altered so the public can help in the enforcement of state codes.

5. Use of police power for legal justification: Several states are now moving to consider a public trust doctrine for regulation of land use. Under the public trust, the state serves as a fiduciary for the citizens of the state and for the administration of land uses.

6. Change in concepts of property ownership: This would be a long-term response in thinking of land as part of the larger ecosystem and that individuals have no inherent rights to land ownership. Possible changes in inheritance would force more land on the open market or to governmental take-over. Such tools as easements can divorce land ownership and land use values.

7. Reaction of regulatory and extension agencies to constituents' problems: This is probably the best way a bureaucratic agency can operate; however, this places a much greater value on short-run problems over long-term effects.

8. National definition of wetlands: Will the present moves to determine a national definition for wetlands, and then an inventory, conflict with Connecticut's statutes?

9. Industrial exploitation of wetlands: Since wetland land values appear to be a poor indicator of the worth of these resources to society, are industries and municipalities using, or abusing, these areas as an external diseconomy? Is this another case of an externality or social cost that is not reflected in the costs of production and not paid by either industry or consumer?

Each of these points could probably result in another conference. The point of this commentary is to add some balance to the panel discussion which has brought up some very interesting areas of concern on wetlands.

SUMMARY REMARKS ON THE SYMPOSIUM

Lincoln P. Brower*

Let me congratulate the conference organizers Professors Kennard, Helfgott, and Griffin for bringing together this diversity of talent to share their views on wetlands. It is very encouraging to note the large number of people of different backgrounds and interests, from various professions, who have come to this conference. It signals an encouraging guidepost to the future, namely that the problems we have coped with in this conference are very complex and interdisciplinary, and that all our viewpoints have to be shared in order to find solutions.

The conference attempted to define wetlands in this gathering and we have heard many different views of how one may go about this. Let me point out a couple of difficulties in definitions and the philosophical basis for trying to define things in the first place. Recently I heard a lecture pointing out that the first step in science is to give something a name, often a giant step forward. Defining a process or here, defining a wetland, does not necessarily lead to a solution of the problem. In fact, definition often precedes understanding.

This leads to a general problem in taxonomy, that is classification. Taxonomists in classifying animals and plants try to group them into manageable proportions in such a way as to reflect some kind of evolutionary basis. These scientists divide broadly into two sets: those taxonomists who group organisms into large categories and those taxonomists who split them into ever more small categories. So we have the "splitters" vs. the "lumpers",

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the specificists vs. the generalists. When it comes to law and personal property rights, the specifics about exactly where the line is to be drawn loom large in the minds of those who have economic interests in the land. On the other hand, from the point of view of conservationists and the great environmental movement that is going on in this country today, the generalists aim not only to save as much as possible of the wetlands but, as Dr. William Niering proposed, to additionally have a buffer zone around a wetland include a portion of the adjacent ecosystem.

I think that perhaps one of the more important points that emerged in this gathering is the necessity of a holistic view in defining wetlands, as Mr. Zell Steever presaged in his introductory remarks, holistic in several different senses.

First of all, we must look at a wetland in the perspective of its geological history. Any wetland of concern (or which a state environmental agency is trying to define) must be understood in its past as well as its recent history. In general, the present is but one stopped frame in a continuous motion picture that goes back at least to the end of the Pleistocene epoch, and often much further. This perspective has been elegantly developed by Dr. Margaret Davis and Dr. Robert Black, who have demonstrated how many of our wetlands owe their origin to the glacial phenomena of the Pleistocene. It is essential for all of us to realize that today on earth (and particularly in the northern hemisphere) we have a Pleistocene heritage of more wetlands than was the case prior to glaciation.

Another and perhaps more important way in which wetlands have been formed is by rivers. I have studied rivers for the last two or three years, particularly in relationship to how they change their courses in floodplains as a result of interacting biological and geological processes as mediated by

the hydrological cycle. Rivers are almost never considered holistically. If we look, for example, at the Connecticut River, we can think of it as a single holistic unit, namely the entire 12,000 square mile drainage basin in Canada, New Hampshire, Vermont, Massachusetts, and Connecticut, with all the tributary streams leading into the main stem of the river and then to the estuary. What I emphasize here is the process by which wetlands are formed in the riverine floodplain environment. Irrespective of whether the river is small or large, the process is similar. And it is a cyclic process, like many of the natural features of this world. In all floodplains, rivers meander and move about through lateral cutting. While cutting away land on one riverbank, the river deposits land on the other side, thereby generating new habitats. The net change through a short time is zero. As shown in the film, The Flooding River, presented during our luncheon recess, the river becomes unstable through this process of lateral cutting; the bends which are cut off become bodies of still water known as oxbow lakes. The oxbow lakes gradually silt in due to the deposit of sediment brought in by tributary streams and during the annual flood cycles of the parent river. As the lakes fill in the deeper portions remain as a series of interconnected ponds. As time passes these become marshes or temporary ponds (with water in them only during the yearly flood season). Eventually the floodplain forest is reestablished only to be cut away when the meandering river changes its course again in the floodplain. The meandering river has been the single most important process by which wetlands are created and evolve; thus, any given wetland is an ephemeral event in a natural cyclic process. The natural diversity of wetlands created by the meandering river is very great. It involves not only a progression in the physical characteristics of the

wetland itself, but also in the species of organisms which undergo an ecological succession as the environment changes via siltation and organic buildup through time.

Another needed holistic approach is the marriage of philosophy and technology in order to solve our problems. We may find ourselves with strange bedfellows, but interesting offspring may well result. For example it was suggested we define wetlands in terms of soil types. Dr. David Hill and Mr. Elmer Offerman gave us a great deal of background information on how it is possible to map wetlands on the basis of existing soils. This is obviously one very important input to defining wetlands; however, as Dr. Helfgott pointed out, soil analysis alone is inadequate in any holistic definition of wetlands.

Dr. David Hill stated that one of the big problems in defining Connecticut wetlands by soil types is that survey maps of sufficiently large scale to accurately pinpoint boundaries are not available. Therefore, attempts to delineate wetlands boundaries often end up on maps that are in error by as much as 60 feet! My feeling here is that if it is possible to land a man on the moon and have people running around in space, it is certainly possible to make wetland maps with less than a 60 foot boundary error. The problem of mapping should be solved by more efficient utilization of the methods of the Geologic Survey and topographic mapping, together with high resolution aerial photography and other sensing mechanisms.

Dr. Michael Wm. Lefor has given an example of a field survey of a more clearly definable system, the salt marshes, defined jointly by vegetation and tidal influence. The holistic need to view wetlands in their true temporal perspective is perhaps best exemplified by Dr. Davis'

presentation of pollen records and carbon-14 dates. These provide us with yardsticks of temporal sequences of events and how they changed in the distant and recent past, without and then with the influence of man. By these methods we can assess life spans of wetlands as well as see how the rates of processes have changed as a result of modern man's impact.

In order to understand wetlands we obviously have to consider the hydrologic implications, noted particularly by Dr. Thomas Holzer, Mr. Baker and Dr. Zubkoff. Is a wetland a recharge area, capturing runoff and feeding the groundwater supply, or is it a discharge area delivering water to the downstream system? These are obviously important factors not only in defining the wetland but also in determining the potential of that wetland for the benefit of man.

It is also eminently clear from the presentation of Dr. William Niering that botanical indicators, particular species of plants, can be used to great advantage in defining wetland boundaries.

Another problem in defining wetlands is the tendency of each political subdivision to set up different criteria. It is thus very important to develop national criteria based on universally accepted scientific knowledge. For example, the state of Massachusetts is now mapping its wetlands on the basis of a different definition of wetlands than used by the state of Connecticut. In Massachusetts, open bodies of water are not considered wetlands, even though every single large oxbow lake obviously will become a marsh. The maps are therefore being made without proper reference to the historical process which led to the development of wetlands, and without understanding where or how future wetlands will arise. Clearly criteria for wetlands should be developed scientifically, and applied not only in Connecticut and Massachusetts but throughout North America, taking into

consideration special differences in climatic and geological areas.

In wetlands policy we also need to anticipate the possibility of changing societal values. Today, an instant battle usually occurs the minute a political unit tries to define a wetland. Seeing their economic rights threatened, property owners, developers, or industry move powerfully to ascertain that their ox will not be gored. Attorney Haynes Johnson elegantly described the sort of problem that landowners will be forced to face by wetlands zoning. Suppose that 100 lots could be developed on a given wetland. Let us say that 50 of those would be damaging, and 50 would not. Will the people who by chance happen to own the 50 lots that will cause damage and therefore be zoned against development have to bear the entire economic loss, or should they, as part of that ecological unit, be able to spread their loss over the 50 people, who, if they built on their lots would not damage that wetland? These are the kind of social problems that have to be addressed in the future if we are going to do anything with a wetland after it has been delineated. And here is where the changing values of society towards land use may play a key role in preserving intact wetland ecosystems.

Related to this, we need to balance the value of short term gain <u>vs</u>. long-term deterioration of the environment. Mr. Clyde Fisher made a very compelling case that it is unrealistic to set up a whole legislative process to protect only wetlands. Some wetlands are in one way or another going to be used for industry, and some are inevitably going to be used for other wrong reasons. The real problem is to try to take a long-term view in a fair planning process. We have to face the fact that many industries afraid of the environmental movement may do a lot in terms of "cosmetics" in respect to environmental problems while doing little in substance.

Decisions to utilize wetlands for economic or related benefits should include in their cost-benefit ratios a long term goal of minimizing entropy.

Most wetlands are self-cycling, that is they are run by the sun at little cost to man. It is a substantial expense to build a dam to control flooding downstream. The expenditure of this large amount of money is in the long term increasing the entropy of the system, because that dam will eventually silt in and downstream flood protection will no longer exist. We shall have increased the entropy of that system. Alternatively, we can enact a floodplain zoning law which maximizes the natural benefits of wetlands by allowing them to play their natural role as absorbers and sponges which capture the flood. If people are not in the wetlands, if industries are not in the wetlands, if the wetlands are not channelized and so forth, then they can pay for themselves. We don't have to put energy into this system in order to maintain it.

As Dr. Samuel Suffern emphasized, one of the big problems facing us in the decision making process regarding wetlands is to place a dollar value on them. Here we have an example of the legal and social sectors' concerns with which Atty. Haynes Johnson deals. Whereas it is easy to measure the value of water for industry, we do not yet have an equitable system of determining the dollar value of the less materialistic aspects of the ecosystem. It is encouraging to know from Dr. Paul Zubkoff that wetland ecosystems are being studied in detail as to their basic manipulation of energy; it is from basic studies such as this that more realistic judgements about wetland values can be made.

Finally, Dr. Anderson's discussion of the problem of biting flies which breed in the estuary, extrapolated in a more general way, is a very important human problem: namely, if we preserve an ecosystem in its natural state, there will be those animals that may be unpleasant to man. And how do we cope with them? Well, there are varieties of ways, one of which is

obviously to find a biocide. But, as we know, when biocides enter the system, they cause all sorts of additional problems. Here again more knowledge is needed to arrive at a solution. For example, the rapidly developing field of chemical communication among insects indicates that certain specific chemicals that the insects themselves produce control their behavior. These are absolutely species specific. It is possible through further development in this field to discover lures which would be attractive to the males of the species, thereby reducing its population to a non-problem level without deleteriously affecting the rest of the environment.

Our environment is as complex as it is vital to our well-being. The defining of wetlands is a very important first step in intelligent land use policy. And so, I see the future as difficult, but nevertheless, not insoluble. It is incredibly important that we all work together with our diverse knowledge, and our different viewpoints, recognizing that we shall have our battles occasionally we must try to solve our problems together through the very honest sort of interchange that I feel was so successfully achieved in this symposium.

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House Bill No. 5175

PUBLIC ACT NO. 132

AN ACT CONCERNING TIDAL WETLANDS.

Be it enacted by the Senate and House of Representatives in General Assembly convened:

Section 1. Section 22-7i of the 1971 supplement to the general statutes is repealed and the following is substituted in lieu thereof: The following words and phrases, as used in sections 22-7h to 22-7o, inclusive, shall have the following meanings: (1) "Commissioner" means the commissioner of environmental protection; (2) "wetland" means those areas which border on or lie beneath tidal waters, such as, but not limited to banks, bogs, salt marsh, swamps, meadows, flats, or other low lands subject to tidal action, including those areas now or formerly connected to tidal waters, and whose surface is at or below an elevation of one foot above local extreme high water; and upon which may grow or be capable of growing some, but not necessarily all, of the following: Salt meadow grass (Spartina patens), spike grass (Distichlis spicata), black grass (Juncus gerardi), saltmarsh grass (Spartina alterniflora), saltworts (Salicornia Europaea, and Salicornia bigelovii), Sea Lavendar (Limonium carolinianum), saltmarsh bulrushes (Scirpus robustus and Scirpus paludosus var. atlanticus), sand spurrey (Spergularia marina), switch grass (Panicum virgatum), tall cordgrass (Spartina pectinata), hightide bush (Iva frutescens var. oraria), cattails (Typha angustifolia, and Typha latifolia), spike rush (Eleocharis rostellata), chairmaker's rush (Scirpus americana), bent grass (Agrostis palustris), and sweet grass (Hierochloe odorata), ROYAL FERN (OSMUNDA REGALIS), INTERRUPTED FERN (OSMUNDA CLAYTONIANA), CINNAMON FERN (OSMUNDA CINNAMOMEA), SENSITIVE FERN (ONOCLEA SENSIBILIS), MARSH FERN (DRYPOTERIS THELYPTERIS), BUR-REED FAMILY (SPARGANIUM EURYCARPUM, SPARGANIUM ANDROCLADUM, SPARGANIUM AMERICANUM, SPARGANIUM CHLOROCARPUM, SPARGANIUM ANGUSTIFOLIUM, SPARGANIUM FLUCTUANS, SPARGANIUM MINIMUM), HORNED PONDWEED (ZANNICHELLIA PALUSTRIS), WATER-PLANTAIN (ALISMA TRIVIALE), ARROWHEAD (SAGISTTARIA SUBULATA, SAGITTARIA GRAMINEA, SAGITTARIA EATONI, SAGITTARIA ENGELMANNIANIA) WILD RICE (ZIZANIA AQUATICA), TUCKAHOE (PELTANDRA VIRGINICA), WATER-ARUM (CALLA PALUSTRIS), SKUNK CABBAGE (SYMPLOCARPUS FOETIDUS),

SWEET FLAG (ACORUS CALAMUS), PICKERELWEED (PONTEDERIA CORDATA), WATER STARGRASS (HETERANTHERA DUBIA) SOFT RUSH (JUNCUS EFFUSUS), FALSE HELLEBORE (VERATRUM VIRIDE), SLENDER BLUE FLAG (IRIS PRISMATICA PURSH), BLUE FLAG (IRIS VERSICOLOR), YELLOW IRIS (IRIS PSEUDACORUS), LIZARD'S TAIL (SAURURUS CERNUUS), SPECKLED ALDER (ALNUS RUGOSA), COMMON ALDER (ALNUS SERRULATA), ARROW-LEAVED TEARTHUMB (POLYGONUM SAGITTATUM), HALBERD-LEAVED TEARTHUMB (POLYGONUM ARIFOLIUM), SPATTER-DOCK (NUPHAR VARIEGATUM NUPHAR ADVENA), MARSH MARIGOLD (CALTHA PALUSTRIS), SWAMP ROSE (ROSA PALUSTRIS), POISON IVY (RHUS RADICANS), POISON SUMAC (RHUS VERNIX), RED MAPLE (ACER RUBRUM), JEWELWEED (IMPATIENS CAPENSIS), MARSHMALLOW (HIBISCUS PALUSTRIS), LOOSESTRIFE (LYTHRUM ALATUM, LYTHRUM SALICARIA), RED OSIER (CORNUS STOLONIFERA), RED WILLOW (CORNUS AMOMUM), SILKY DOGWOOD (CORNUS OBLIQUA), SWEET PEPPER-BUSH (CLETHRA ALNIFOLIA), SWAMP HONEYSUCKLE (RHODODENDRON VISCOSUM), HIGHBUSH BLUEBERRY (VACCINIUM CORYMBOSUM), CRANBERRY (VACCINIUM MACROCARPON), SEA LAVENDAR (LIMONIUM NASHII), CLIMBING HEMP-WEED (MIKANIA SCANDENS), JOE PYE WEED (EUPATORIUM PURPUREUM), JOE PYE WEED (EUPATORIUM MACULATUM), THOROUGHWORT (EUPATORIUM PERFOLIATUM); (3) "regulated activity" means any of the following: Draining, dredging, excavation, or removal of soil, mud, sand, gravel, aggregate of any kind or rubbish from any wetland or the dumping, filling or depositing thereon of any soil, stones, sand, gravel, mud, aggregate of any kind, rubbish or similar material, either directly or otherwise, and the erection of structures, driving of pilings, or placing of obstructions, whether or not changing the tidal ebb and flow. Notwithstanding the foregoing, "regulated activity" shall not include activities conducted by the mosquito control division of the state health department, conservation activities of the state department of environmental protection, the construction or maintenance of aids to navigation which are authorized by governmental authority and the emergency decrees of any duly appointed health

officer of a municipality acting to protect the public health; (4) "person" means any corporation, association or partnership, one or more individuals, and any unit of government or agency thereof.

Sec. 2. This act shall take effect from its passage.

Certified as correct by

_______________________________ *Legislative Commissioner.*

_______________________________ *Clerk of the Senate.*

_______________________________ *Clerk of the House.*

Approved ______ April 28 ______, 1972.

_______________________________ *Governor.*

Substitute House Bill No. 5257

PUBLIC ACT NO. 155

AN ACT CONCERNING INLAND WETLANDS AND WATER COURSES.

Be it enacted by the Senate and House of Representatives in General Assembly convened:

Section 1. The inland wetlands and water courses of the state of Connecticut are an indispensable and irreplaceable but fragile natural resource with which the citizens of the state have been endowed. The wetlands and water courses are an interrelated web of nature essential to an adequate supply of surface and underground water; to hydrological stability and control of flooding and erosion; to the recharging and purification of ground water; and to the existence of many forms of animal, aquatic and plant life. Many inland wetlands and water courses have been destroyed or are in danger of destruction because of unregulated use by reason of the deposition, filling or removal of material, the diversion or obstruction of water flow, the erection of structures and other uses, all of which have despoiled, polluted and eliminated wetlands and water courses. Such unregulated activity has had, and will continue to have, a significant, adverse impact on the environment and ecology of the state of Connecticut and has and will continue to imperil the quality of the environment thus adversely effecting the ecological, scenic, historic and recreational values and benefits of the state for its citizens now and forever more. The preservation and protection of the wetlands and water courses from random, unnecessary, undesirable and unregulated uses, disturbance or destruction is in the public interest and is essential to the health, welfare and safety of the citizens of the state. It is, therefore, the purpose of this act to protect the citizens of the state by making provisions for the protection, preservation, maintenance and use of the inland wetlands and water courses by minimizing their disturbance and pollution; maintaining and improving water quality in accordance with the highest standards set by federal, state or local authority; preventing damage from erosion, turbidity or siltation; preventing loss of fish and other beneficial aquatic organisms, wildlife and vegetation and the

destruction of the natural habitats thereof; deterring and inhibiting the danger of flood and pollution; protecting the quality of wetlands and water courses for their conservation, economic, aesthetic, recreational and other public and private uses and values; and protecting the state's potable fresh water supplies from the dangers of drought, overdraft, pollution, misuse and mismanagement by providing an orderly process to balance the need for the economic growth of the state and the use of its land with the need to protect its environment and ecology in order to forever guarantee to the people of the state, the safety of such natural resources for their benefit and enjoyment and for the benefit and enjoyment of generations yet unborn.

Sec. 2. This act shall be known and may be cited as "The Inland Wetlands and Water Courses Act."

Sec. 3. The following operations and uses shall be permitted in wetlands and water courses, as of right except as they involve regulated activities:

(a) Conservation of soil, vegetation, water, fish, shellfish and wildlife;

(b) Outdoor recreation including play and sporting areas, golf courses, field trials, nature study, hiking, horseback riding, swimming, skin diving, camping, boating, water skiing, trapping, hunting, fishing and shellfishing where otherwise legally permitted and regulated;

(c) Construction and operation of dams, reservoirs and other facilities necessary to the impounding, storage and withdrawal of water in connection with public water supplies or private dams and water control devices, including temporary authorization or diversion of water levels, or circulation for emergency maintenance, or aquaculture purposes;

(d) Grazing, farming, nurseries, gardening and harvesting of crops and farm ponds, three acres or less;

(e) Boat anchorage or mooring;

(f) Uses incidental for the enjoyment and maintenance of residential property, such property defined as the largest minimum lot site permitted by each municipality; and

(g) A residential home on a subdivision lot which subdivision has been approved as of the date of the promulgation of the municipal regulations.

Sec. 4. As used in this act:

(1) "Commissioner" means the commissioner of environmental protection;

(2) "Person" means any person, firm, partnership, association, corporation, company, organization or legal entity of any kind, including municipal corporations, governmental agencies or subdivisions thereof;

(3) "Municipality" means any metropolitan district, town, consolidated town and city, consolidated town and borough, city, borough, village, fire and sewer district, sewer district and each municipal organization having authority to levy and collect taxes or make charges for its authorized functions;

(4) "Conservation commission" means a municipal conservation commission established pursuant to and acting under section 7-131a of the general statutes, as amended;

(5) "Soil scientist" means an individual duly qualified in accordance with standards set by the United States civil service commission;

(6) "Material" means any substance, solid or liquid, organic or inorganic, including, but not limited to soil, sediment, aggregate, land, gravel, clay, bog, mud, debris, sand, refuse or waste;

(7) "Waste" means sewage or any substance, liquid, gaseous, solid or radioactive, which may pollute or tend to pollute any of the waters of the state;

(8) "Pollution" means harmful thermal effect or the contamination or rendering unclean or impure of any waters of the state by reason of any waste or other materials discharged or deposited therein by any public or private sewer or otherwise so as directly or indirectly to come in contact with any waters;

(9) "Rendering unclean or impure" means any alteration of the physical, chemical or biological properties of any of the waters of the state, including, but not limited to change in odor, color, turbidity or taste;

(10) "Discharge" means the emission of any water, substance or material into waters of the state whether or not such substance causes pollution;

(11) "Remove" includes, but shall not be limited to drain, excavate, mine, dig, dredge, suck, bulldoze, dragline or blast;

(12) "Deposit" includes, but shall not be limited to fill, grade, dump, place, discharge or emit;

(13) "Regulated activity" means any operation within or use of a wetland or water course involving removal or deposition of material, or any obstruction, construction, alteration or pollution, of such wetlands or water courses, but shall not include the specified activities in section 3 of this act.

(14) "License" means the whole or any part of any permit, certificate approval or similar form of permission which may be required of any person by the provisions of this act;

(15) "Wetlands" means land, including submerged land, not regulated pursuant to sections 22-7h to 22-7o, inclusive, of the 1969 supplement to the general statutes, as amended, which consists of any of the soil types designated as poorly drained, very poorly drained, alluvial and flood plain by the National Cooperative Soils Survey, as may be amended from time to time, of the Soil Conservation Service of the United States Department of Agriculture;

(16) "Water courses" means rivers, streams, brooks, waterways, lakes, ponds, marshes, swamps, bogs and all other bodies of water, natural or artificial, public or private, which are contained within flow through or border upon this state or any portion thereof, not regulated pursuant to sections 22-7h to 22-7o, inclusive, of the 1969 supplement to the general statutes, as amended.

Sec. 5. The commissioner shall:

(a) Exercise general supervision of the administration and enforcement of this act;

(b) Develop comprehensive programs in furtherance of the purposes of this act;

(c) Advise, consult and cooperate with other agencies of the state, the federal government, other states and with persons and municipalities in furtherance of the purposes of this act;

(d) Encourage, participate in or conduct studies, investigations, research and demonstrations, and collect and disseminate information, relating to the purposes of this act;

(e) Retain and employ consultants and assistants on a contract or other basis for rendering legal, financial, technical or other assistance and advice in furtherance of any of its purposes, specifically including, but not limited to, soil scientists on a cost-sharing basis with

the United States soil conservation service for the purpose of (1) completing the state soils survey and (2) making on-site interpretations, evaluations and findings as to soil types;

(f) Promulgate such regulations as are necessary to protect the wetlands or water courses or any of them individually or collectively;

(g) Inventory or index the wetlands and water courses in such form, including pictorial representations, as the commissioner deems best suited to effectuate the purposes of this act; and

(h) Exercise all incidental powers necessary to enforce rules and regulations and to carry out the purposes of this act.

Sec. 6. In carrying out the purposes and policies of this act, including matters relating to regulating, licensing and enforcing of the provisions thereof, the commissioner shall take into consideration all relevant facts and circumstances, including but not limited to:

(a) The environmental impact of the proposed action;

(b) The alternatives to the proposed action;

(c) The relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity;

(d) Irreversible and irretrievable commitments of resources which would be involved in the proposed activity;

(e) The character and degree of injury to, or interference with, safety, health or the reasonable use of property which is caused or threatened; and

(f) The suitability or unsuitability of such activity to the area for which it is proposed.

Sec. 7. (a) To carry out and effectuate the purposes and policies of this act, it is hereby declared to be the public policy of the state to encourage municipal participation by means of acquisition of wetlands and water courses and regulation respecting regulated activities affecting the wetlands and water courses within the territorial limits of the various municipalities.

(b) Any municipality may acquire wetlands and water courses within its territorial limits by gift or purchase, in fee or lesser interest including, but not limited to, lease, easement or covenant, subject to such reservations and exceptions as it deems advisable.

(c) Any municipality, acting through its legislative body, may authorize the conservation commission or other boards or commissions, as they may be by law authorized to act, to promulgate such regulations, in conformity with the regulations promulgated by the commissioner pursuant to section 5, as are necessary to protect the wetlands and water courses within its territorial limits. For the purposes of this section, the municipality shall serve as the sole agent for the licensing of regulated activities.

(d) Any municipality, pursuant to ordinance, may act through its conservation commission or other duly established board or commission to join with any other municipalities in the formation of a district for the regulation of activities affecting the wetlands and water courses within such district.

(e) Municipal or district ordinances or regulations may embody any regulations promulgated hereunder, in whole or in part, or may consist of other ordinances or regulations in conformity with regulations promulgated hereunder. Any ordinances or regulations shall be for the purpose of effectuating the purposes of this act and, a municipality or district, in acting upon ordinances and regulations shall give due consideration to the standards set forth in section 5 of this act.

(f) In the event that a municipality, by January 1, 1974, does not exercise its regulatory authority pursuant to this section, the commissioner shall take such action, including but not limited to the licensing of regulated activities, as is necessary to protect the wetlands and water courses within the territorial limits of such municipality.

(g) Nothing contained in this section shall be construed to limit the existing authority of a municipality or any boards or commissions of the municipality.

Sec. 8. (a) Any person aggrieved by any regulation, order, decision or action made pursuant to this act by the commissioner, district or municipality may, in accordance with the provisions of sections 4-166 to 4-184, inclusive, of the 1971 supplement to the general statutes, appeal to the court of common pleas for the county where the land affected is located, and if located in more than one county, to the court of common pleas in any such county.

(b) If upon appeal the court determines that the action appealed from is a taking, the court shall proceed to assess damages as to the extent of the taking in accordance with sections 48-12 to 48-14, inclusive, of the general statutes. The court may authorize the payment of court costs and reasonable attorneys' fees to the appellant by the commissioner, district or municipality. The interest acquired by any such taking shall be a perpetual easement.

(c) To carry out the purposes of this act, the commissioner, district or municipality may at any time purchase land or an interest in land in fee simple or other acceptable title, or subject to acceptable restrictions or exceptions, and enter into covenants and agreements with landowners.

Sec. 9. Any person who commits, takes part in, or assists in any violation of any provision of this act, including regulations promulgated by the commissioner and ordinances and regulations promulgated by municipalities or districts pursuant to the grant of authority herein contained, shall be fined not more than one thousand dollars for each offense. Each violation of this act shall be a separate and distinct offense, and, in the case of a continuing violation, each day's continuance thereof shall be deemed to be a separate and distinct offense. The superior court, in an action brought by the commissioner, municipality, district or any person, shall have jurisdiction to restrain a continuing violation of this act and to issue orders directing that the violation be corrected or removed. All costs, fees and expenses in connection with such action shall be assessed as damages against the violator. The moneys collected pursuant to this section shall be used by the commissioner of environmental protection to restore the affected wetlands or water courses to its condition prior to the violation, wherever possible.

Sec. 10. Any owner of wetlands and water courses who may be denied a license in connection with a regulated activity affecting such wetlands and water courses, shall upon written application to the assessor, or board of assessors, of the municipality, be entitled to a revaluation of such property to reflect the fair market value thereof in light of the restriction placed upon it by the denial of such license or permit, effective with

respect to the next succeeding assessment list of such municipality, provided no such revaluation shall be effective retroactively and the municipality may require as a condition therefor the conveyance of a less than fee interest of it of such land pursuant to the provisions of sections 7-131b to 7-131k, inclusive, of the general statutes, as amended.

Sec. 11. This act shall take effect from its passage.

Certified as correct by

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Legislative Commissioner.

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Clerk of the Senate.

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Clerk of the House.

Approved May 19, 1972.

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Governor.

Substitute Senate Bill No. 2040

PUBLIC ACT NO. 73-590

AN ACT CONCERNING HEARINGS ON WETLAND PERMITS.

Be it enacted by the Senate and House of Representatives in General Assembly convened:

Section 1. Section 22-71 of the 1971 noncumulative supplement to the general statutes is repealed and the following is substituted in lieu thereof: No regulated activity shall be conducted upon any wetland without a permit. Any person proposing to conduct or cause to be conducted a regulated activity upon any wetland shall file an application for a permit with the commissioner, in such form and with such information as the commissioner may prescribe. Such application shall include a detailed description of the proposed work and a map showing the area of wetland directly affected, with the location of the proposed work thereon, together with the names of the owners of record of adjacent land and known claimants of water rights in or adjacent to the wetland of whom the applicant has notice. The commissioner shall cause a copy of such application to be mailed to the chief administrative officer in the town or towns where the proposed work, or any part thereof, is located, and the chairman of the conservation commission and shellfish commission of the town or towns where the proposed work, or any part thereof, is located. No sooner than thirty days and not later than sixty days of the receipt of such application, the commissioner or his duly designated hearing officer shall hold a public hearing on such application, PROVIDED, WHENEVER THE COMMISSIONER DETERMINES THAT THE REGULATED ACTIVITY FOR WHICH A PERMIT IS SOUGHT IS NOT LIKELY TO HAVE A SIGNIFICANT IMPACT ON THE WETLAND, HE MAY WAIVE THE REQUIREMENT FOR PUBLIC HEARING AFTER PUBLISHING NOTICE, IN A NEWSPAPER HAVING GENERAL CIRCULATION IN EACH TOWN WHEREVER THE PROPOSED WORK OR ANY PART THEREOF IS LOCATED, OF HIS INTENT TO WAIVE SAID REQUIREMENT, EXCEPT THAT THE COMMISSIONER SHALL HOLD A HEARING ON SUCH APPLICATION UPON RECEIPT OF A PETITION, SIGNED BY AT LEAST TWENTY-FIVE PERSONS, REQUESTING SUCH A HEARING. The following shall be notified of the hearing by mail not less than fifteen days prior to the date set for the hearing: All of those persons and agencies who are entitled to receive a copy of such application in accordance with the terms hereof and all owners of record of adjacent

land and known claimants to water rights in or adjacent to the the wetland of whom the applicant has notice. The commissioner shall cause notice of such hearing to be published at least once not more than thirty days and not fewer than ten days before the date set for the hearing in the newspaper having a general circulation in each town where the proposed work, or any part thereof, is located. All applications and maps and documents relating thereto shall be open for public inspection at the office of the commissioner. At such hearing any person or persons may appear and be heard.

Sec. 2. Section 25-4a of the 1971 noncumulative supplement to the general statutes is repealed and the following is substituted in lieu thereof: The commissioner shall establish, along any TIDAL OR INLAND waterway or flood-prone area considered for stream clearance, channel improvement or any form of flood control or flood alleviation measure, lines beyond which, in the direction of the waterway or flood-prone area, no obstruction or encroachment shall be placed by any person, firm or corporation, public or private, unless authorized by said commissioner. The commissioner shall issue or deny permits upon applications for establishing such encroachments based upon his findings of the effect of such proposed encroachments upon the flood-carrying AND WATER STORAGE capacity of the waterways AND FLOOD PLAINS, flood heights, [and] hazards to life and property, AND THE PROTECTION AND PRESERVATION OF THE NATURAL RESOURCES AND ECOSYSTEMS OF THE STATE, INCLUDING BUT NOT LIMITED TO GROUND AND SURFACE WATER, ANIMAL, PLANT AND AQUATIC LIFE, NUTRIENT

EXCHANGE, AND ENERGY FLOW, with due consideration given to the results of similar encroachments constructed along the reach of waterway.

Sec. 3. This act shall take effect from its passage.

Certified as correct by

_______________ *Legislative Commissioner.*

_______________ *Clerk of the Senate.*

_______________ *Clerk of the House.*

Approved June 11, 1973.

_______________ *Governor.*

Substitute House Bill No. 9078

PUBLIC ACT NO. 73-571

AN ACT CONCERNING REVISION OF THE INLAND WETLANDS ACT.

Be it enacted by the Senate and House of Representatives in General Assembly convened:

Section 1. Section 3 of number 155 of the public acts of 1972 is repealed and the following is substituted in lieu thereof: (a) The following operations and uses shall be permitted in wetlands and water courses, as of right [except as they involve regulated activities]:

(1) GRAZING, FARMING, NURSERIES, GARDENING AND HARVESTING OF CROPS AND FARM PONDS OF THREE ACRES OR LESS;

(2) A RESIDENTIAL HOME (i) FOR WHICH A BUILDING PERMIT HAS BEEN ISSUED OR (ii) ON A SUBDIVISION LOT, PROVIDED THE PERMIT HAS BEEN ISSUED OR THE SUBDIVISION HAS BEEN APPROVED AS OF THE EFFECTIVE DATE OF PROMULGATION OF THE MUNICIPAL REGULATIONS PURSUANT TO SUBSECTION (b) OF SECTION 4 OF THIS ACT;

(3) BOAT ANCHORAGE OR MOORING;

(4) USES INCIDENTAL FOR THE ENJOYMENT AND MAINTENANCE OF RESIDENTIAL PROPERTY, SUCH PROPERTY DEFINED AS THE LARGEST MINIMUM RESIDENTIAL LOT SITE PERMITTED ANYWHERE IN THE MUNICIPALITY, PROVIDED IN ANY TOWN, WHERE THERE ARE NO ZONING REGULATIONS ESTABLISHING MINIMUM RESIDENTIAL LOT SITES, THE LARGEST MINIMUM LOT SITE SHALL BE TWO ACRES; AND

(5) CONSTRUCTION AND OPERATION, BY WATER COMPANIES AS DEFINED IN SECTION 16-1 OR BY MUNICIPAL WATER SUPPLY SYSTEMS AS PROVIDED FOR IN CHAPTER 102, OF DAMS, RESERVOIRS AND OTHER FACILITIES NECESSARY TO THE IMPOUNDING, STORAGE AND WITHDRAWAL OF WATER IN CONNECTION WITH PUBLIC WATER SUPPLIES EXCEPT AS PROVIDED IN SECTIONS 7 AND 8 OF THIS ACT.

(b) THE FOLLOWING OPERATIONS AND USES SHALL BE PERMITTED, AS A NONREGULATED USE IN WETLANDS AND WATER COURSES, PROVIDED THEY DO NOT DISTURB THE NATURAL AND INDIGENOUS CHARACTER OF THE LAND:

[(a)] (1) Conservation of soil, vegetation, water, fish, shellfish and wildlife [;] AND

[(b)] (2) Outdoor recreation including play and sporting areas, golf courses, field trails, nature study, hiking, horseback riding, swimming, skin diving, camping, boating, water skiing, trapping, hunting, fishing and shellfishing where otherwise legally permitted and regulated [;].

[(c) Construction and operation of dams, reservoirs and other facilities necessary to the impounding, storage and withdrawal of water in connection with public water supplies or private dams and water control devices, including temporary authorization or diversion of water levels, or circulation for emergency maintenance, or aquaculture purposes;

(d) Grazing, farming, nurseries, gardening and harvesting of crops and farm ponds, three acres or less;

(e) Boat anchorage or mooring;

(f) Uses incidental for the enjoyment and maintenance of residential property, such property defined as the largest minimum lot site permitted by each municipality; and

(g) A residential home on a subdivision lot which subdivision has been approved as of the date of the promulgation of the municipal regulations.]

Sec. 2. Subsections 4 and 15 of section 4 of number 155 of the public acts of 1972 are repealed and the following is substituted in lieu thereof:

(4) ["Conservation commission"] "INLAND WETLANDS AGENCY" means a municipal [conservation commission] BOARD OR COMMISSION established pursuant to and acting under section [7-131a] 3 of [the general statutes, as amended] THIS ACT;

(15) "Wetlands" means land, including submerged land, not regulated pursuant to sections 22-7h to 22-7o, inclusive, of the 1969 supplement to the general statutes, as amended, which consists of any of the soil types designated as poorly drained, very poorly drained, alluvial, and flood plain by the National Cooperative Soils Survey, as may be amended from time to time, of the Soil Conservation Service of the United States Department of Agriculture.

Sec. 3. Section 7 of number 155 of the public acts of 1972 is repealed and the following is substituted in lieu thereof: (a) To carry out and effectuate the purposes and policies of number 155 of the public acts of 1972, it is hereby declared to be the public policy of the state to encourage municipal participation by means of [acquisition of wetlands and water courses and regulation respecting regulated] REGULATION OF activities affecting the wetlands and water courses within the territorial limits of the various municipalities OR DISTRICTS.

(b) Any municipality may acquire wetlands and water courses within its territorial limits by

gift or purchase, in fee or lesser interest including, but not limited to, lease, easement or covenant, subject to such reservations and exceptions as it deems advisable.

(c) Any municipality, acting through its legislative body, may authorize [the conservation commission or other boards or commissions] ANY BOARD OR COMMISSION, as [they] may be by law authorized to act, OR MAY ESTABLISH A NEW BOARD OR COMMISSION to promulgate such regulations, in conformity with the regulations promulgated by the commissioner pursuant to section 5 of number 155 of the public acts of 1972, as are necessary to protect the wetlands and water courses within its territorial limits. THE ORDINANCE ESTABLISHING THE NEW BOARD OR COMMISSION SHALL DETERMINE THE NUMBER OF MEMBERS, THE LENGTH OF THEIR TERMS, THE METHOD OF SELECTION AND REMOVAL AND THE MANNER FOR FILLING VACANCIES IN THE NEW BOARD OR COMMISSION. For the purposes of this section, THE BOARD OR COMMISSION AUTHORIZED BY the municipality OR DISTRICT, AS THE CASE MAY BE, shall serve as the sole agent for the licensing of regulated activities.

(d) Any municipality, pursuant to ordinance, may act through [its conservation commission or other duly established] THE board or commission AUTHORIZED IN SUBSECTION (c) OF THIS SECTION to join with any other municipalities in the formation of a district for the regulation of activities affecting the wetlands and water courses within such district.

(e) Municipal or district ordinances or regulations may embody any regulations promulgated hereunder, in whole or in part, or may consist of other ordinances or regulations in conformity with regulations promulgated hereunder. Any ordinances or regulations shall be for the purpose of effectuating the purposes of number 155 of the public acts of 1972 AND THIS ACT and, a municipality or district, in acting upon ordinances and regulations shall give due consideration to the standards set forth in section [5] <u>6</u> of number 155 of the public acts of 1972.

(f) <u>(1)</u> In the event that a municipality, by January 1, 1974, does not exercise its regulatory authority pursuant to this section, the commissioner [shall] MAY take such action, including but not limited to the licensing of regulated activities, as is necessary to protect

the wetlands and water courses within the territorial limits of such municipality. (2) IN THE EVENT THAT A MUNICIPALITY, BY JUNE 30, 1974, DOES NOT EXERCISE ITS REGULATORY AUTHORITY PURSUANT TO THIS SECTION, THE COMMISSIONER SHALL TAKE SUCH ACTION, INCLUDING BUT NOT LIMITED TO THE LICENSING OF REGULATED ACTIVITIES, AS IS NECESSARY TO PROTECT THE WETLANDS AND WATER COURSES WITHIN THE TERRITORIAL LIMITS OF SUCH MUNICIPALITY.

(g) Nothing contained in this section shall be construed to limit the existing authority of a municipality or any boards or commissions of the municipality.

Sec. 4. (NEW) (a) The inland wetlands agencies authorized in section 3 of this act, shall through regulation provide for the manner in which the boundaries of inland wetland areas in their respective municipalities shall be established and amended or changed.

(b) No regulations of an inland wetlands agency including boundaries of inland wetland areas shall become effective or be established until after a public hearing in relation thereto is held by the inland wetlands agency, at which parties in interest and citizens shall have an opportunity to be heard. Notice of the time and place of such hearing shall be published in the form of a legal advertisement, appearing in a newspaper having a substantial circulation in the municipality at least twice at intervals of not less than two days, the first not more than twenty-five days nor less than fifteen days, and the last not less than two days, before such hearing, and a copy of such proposed regulation or boundary shall be filed in the office of the town, city or borough clerk as the case may be, in such municipality, for public inspection at least ten days before such hearing, and may be published in full in such paper. Such regulations and inland wetland boundaries may be from time to time, amended, changed or repealed, by majority vote of the inland wetlands agency. Regulations or boundaries or changes therein shall become effective at such time as is fixed by the inland wetlands agency, provided a copy of such regulation, boundary or change shall be filed in the office of the town, city or borough clerk, as the case may be. Whenever an inland wetland agency makes a change in regulations or boundaries it shall state upon its records the reason why the change was made. All petitions submitted in

writing and in a form prescribed by the inland wetland agency, requesting a change in the regulations or the boundaries of inland wetland area shall be considered at a public hearing in the manner provided for establishment of inland wetlands regulations and boundaries within ninety days after receipt of such petition. The inland wetland agency shall act upon the changes requested in such petition within sixty days after the hearing. The petitioner may consent to extension of the periods provided for in hearing and for adoption or denial or may withdraw such petition. The inland wetlands agency may require a filing fee to be deposited with the agency to defray the cost of publication of the notice required for a hearing.

(c) On and after the effective date of the municipal regulations promulgated pursuant to subsection (b) of this section, no regulated activity shall be conducted upon any inland wetland without a permit. Any person proposing to conduct or cause to be conducted a regulated activity upon an inland wetland shall file an application with the inland wetlands agency of the town or towns wherein the wetland in question is located. The application shall be in such form and contain such information as the inland wetlands agency may prescribe. No sooner than thirty and not later than sixty days after the receipt of such application, the inland wetlands agency may hold a public hearing on such application. Notice of the hearing shall be published at least once not more than thirty days and not fewer than ten days before the date set for the hearing in a newspaper having a general circulation in each town where the affected wetland or any part thereof, is located. All applications and maps and documents relating thereto shall be open for public inspection. At such hearing any person or persons may appear and be heard. Action shall be taken on applications within forty-five days after the completion of a public hearing or in the absence of a public hearing within sixty days from the date of receipt of the application.

(d) In granting, denying or limiting any permit for a regulated activity the inland wetlands agency shall consider the factors set forth in section 6 of number 155 of the public acts of 1972. In granting a permit the inland wetlands agency may impose conditions or

limitations designed to carry out the policy of the inland wetlands and water courses act. The agency may suspend or revoke a permit if it finds after giving notice to the permittee of the facts or conduct which warrant the intended action and after a hearing at which the permittee is given an opportunity to show compliance with the requirements for retention of the permit, that the applicant has not complied with the conditions or limitations set forth in the permit or has exceeded the scope of the work as set forth in the application. The applicant shall be notified of the agency's decision by certified mail within five days of the date of the decision and the agency shall cause notice of their order in issuance, denial, revocation or suspension of a permit to be published in a daily newspaper having a general circulation in the town wherein the wetland lies.

Sec. 5. Section 8 of number 155 of the public acts of 1972 is repealed and the following is substituted in lieu thereof: [(a)] Any person aggrieved by any regulation, order, decision or action made pursuant to number 155 of the public acts of 1972, by the commissioner, district or municipality may, [in accordance with the provisions of sections 4-166 to 4-184, inclusive, of the 1971 supplement to the general statutes,] WITHIN FIFTEEN DAYS AFTER PUBLICATION OF SUCH REGULATION, ORDER, DECISION OR ACTION appeal to the court of common pleas for the county where the land affected is located, and if located in more than one county, to the court of common pleas in any such county. SUCH APPEAL SHALL BE MADE RETURNABLE TO SAID COURT IN THE SAME MANNER AS THAT PRESCRIBED FOR CIVIL ACTIONS BROUGHT TO SAID COURT. NOTICE OF SUCH APPEAL SHALL BE SERVED UPON THE INLAND WETLANDS AGENCY. THE APPEAL SHALL STATE THE REASONS UPON WHICH IT IS PREDICATED AND SHALL NOT STAY PROCEEDINGS ON THE REGULATION, ORDER, DECISION OR ACTION, BUT THE COURT MAY ON APPLICATION AND AFTER NOTICE GRANT A RESTRAINING ORDER. SUCH APPEAL SHALL HAVE PRECEDENCE IN THE ORDER OF TRIAL.

[(b) If upon appeal the court determines that the action appealed from is a taking, the court shall proceed to assess damages as to the extent of the taking in accordance with sections 48-12 to 48-14, inclusive, of the 1971 noncumulative supplement to the general statutes. The court may authorize the payment of court costs

and reasonable attorneys' fees to the appellant by the commissioner, district or municipality. The interest acquired by any such taking shall be a perpetual easement.

(c) To carry out the purposes of this act, the commissioner, district or municipality may at any time purchase land or an interest in land in fee simple or other acceptable title, or subject to acceptable restrictions or exceptions, and enter into covenants and agreements with landowners.]

Sec. 6. (NEW) (a) If upon appeal pursuant to section 5 of this act, the court finds that the action appealed from constitutes the equivalent of a taking without compensation, it shall set aside the action or it may modify the action so that it does not constitute a taking. In both instances the court shall remand the order to the inland wetland agency for action not inconsistent with its decision.

(b) To carry out the purposes of this act, the commissioner, district or municipality may at any time purchase land or an interest in land in fee simple or other acceptable title, or subject to acceptable restrictions or exceptions, and enter into covenants and agreements with landowners.

Sec. 7. Section 25-110 of the 1971 noncumulative supplement to the general statutes is repealed and the following is substituted in lieu thereof: All dams, dikes, reservoirs and other similar structures, with their appurtenances, without exception and without further definition or enumeration herein, which, by breaking away or otherwise, might endanger life or property, shall be subject to the jurisdiction conferred by this chapter. The commissioner of environmental protection shall formulate all rules, definitions and regulations necessary to carry out the provisions of this chapter and not inconsistent therewith. The commissioner or his authorized representatives may enter upon private property to make such investigations and gather such data concerning dams, watersheds, sites, structures and general conditions as may be necessary in the public interest for a proper inspection, review and study of the design and construction of such structures AND OF THE ENVIRONMENTAL IMPACT OF SUCH STRUCTURES ON THE INLAND WETLANDS OF THE STATE. The commissioner may, when necessary, employ or make such

agreements with geologists, other engineers, expert consultants and such assistants as may be reasonably necessary to carry out the provisions of this chapter.

Sec. 8. Section 25-112 of said supplement to the general statutes is repealed and the following is substituted in lieu thereof: Before any person, firm or corporation constructs, alters, adds to, replaces or removes any such structure, such person, firm or corporation shall apply to the commissioner for a permit to undertake such work. The application for such permit shall be in duplicate, the original of which, with necessary drawings, plans, specifications and other data, shall be submitted to the commissioner, in the form and to the extent required by him. The commissioner or his representative, engineer or consultant shall DETERMINE THE ENVIRONMENTAL IMPACT OF THE CONSTRUCTION WORK ON THE INLAND WETLANDS OF THE STATE, IN ACCORDANCE WITH THE PROVISIONS OF NUMBER 155 OF THE PUBLIC ACTS OF 1972, AS AMENDED BY THIS ACT AND examine the documents and inspect the site, and, upon approval thereof, the commissioner shall issue a permit authorizing the proposed construction work under such conditions as the commissioner may direct. A copy of the permit shall be sent to the town clerk. The commissioner may require a fee of not less than one dollar nor more than ten dollars.

Sec. 9. This act shall take effect from its passage.

Certified as correct by

_______________ *Legislative Commissioner.*

_______________ *Clerk of the Senate.*

_______________ *Clerk of the House.*

Approved June 20, 1973.

_______________ *Governor.*

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