Table 1

Environmental Characteristics of the Oklawaha River

Characteristics	Natural Stream	Barge Canal Impoundments
Sunlight	Subdued by forest	Intense energy input due to timber clearing and death of forest cover canopy
Water Temperature	Cool	Warmer due to impoundment and increased sunlight
Water Quality	Clean	Over-enriched
Flow Rate	Swift	Near stagnant—retention interval equals more than 14 days at Rodman and still longer in Eureka impoundment
Sedimentation	Low, subject to	High due to impoundment and canal dredging scouring
Bottom Type	Sand bottom stream	Organic sediments of a river plus sediments from dredging and decomposing aquatic vegetation
Vegetation	Rooted, swift	Water hyacinths and submerged weeds—ultimately algae water forms
Dissolved Oxygen	Adequate for game fish	Low, especially in summer months
Fishery	Sport fish	Rough fish predominate predominate

The water entering the lower Oklawaha River from the upper chain of lakes, in Lake and Orange Counties is rich in organic materials and other nutrients, and the discharge from Silver Springs provides an additional source of nutrients. Inputs from these two water sources, in association with the plant and animal community of the natural Oklawaha River ecosystem resulted in stable environmental conditions of considerable benefit to mankind. The organic materials and excess soluble nutrients were carried into the

St. Johns River where they were assimilated by organisms in the estuarine ecosystem; or they were dispersed over the surrounding lowland forest floor during inundation of the flood plain.

The inclusion of projected recreational benefits during the canal's 50-year project life made possible a benefit-to-cost ratio favorable enough to justify construction. Most of these benefits are expected to result from the impoundments created by the Rodman and Eureka dams, since the canal proper is of negligible recreational value. However, there now exists a wealth of data documenting the deterioration of Florida lakes, ecologically similar to these impoundments, following water-level management. These data demonstrate a decline in sport fishing and other recreational values five to seven years after reservoir construction. The impounded bodies of water created by the Cross-Florida Barge Canal are comparable to lakes managed for stabilization of water levels because major seasonal fluctuations cannot be permitted if the reservoirs are to fulfill their primary navigational function. Managed lakes and impoumdments of the Cross-Florida Barge Canal undergo a fantastic acceleration of eutrophication, a process constantly at work in all natural lakes. These bodies, in a decade or less, experience chemical and biological changes which require thousands of years in natural lakes.

Initially, natural lakes are relatively poor in nutrients and have low productivity. The input of nitrogen (nitrates) in rainfall, and additional nutrients and minerals carried into the basin by run-off

Table 2
Water Quality Deterioration as Reflected in Sport Fishing Success in Florida Reservoirs Following Impoundment

Impoundment	County	Impounded	Sport Fishing Declined
Dead River Lakes	Calhoun	1957	1965
Bear Lake	Santa Rosa	1961	1967
Deer Point	Bay	1961	1967
Lake Talquin	Leon and Gadsden	1957	1963

result in increased productivity. In many cases man's activities have accelerated the rate of nutrient addiion. Nutrient storage in these bodies of water increases with the decay of aquatic plants and animals, and with the very gradual accumulation of organic bottom muds. As the nutrient level increases, aquatic vegetation invades the shallow edges as water levels fluctuate between wet and dry periods. This vegetation normally does not adversely affect the quality of the environment, but "traps" some of the nutrients as plant biomass and provides a habitat for many animals. This natural water level fluctuation in an aquatic system, then, is the key to its long life as a useful body of water. Fluctuating water levels and wise land-use practices on the watershed will maintain this beneficial aquatic plant population for centuries.

Florida reservoirs, on the other hand, begin with nutrient rich water, a high productivity and a thick bottom layer of organic debris, particularly if the reservoir is located in a fertile river swamp forest as is the case with the Rodman and Eureka Pools. Because reservoir water levels are stabilized for specific purposes such as navigation, flood control, and irrigation, they lack the natural seasonal fluctuations which maintain high water quality. If impounded waters receive substantial nutrient inputs, they are destined for biological senility. The symptoms of this rapid aging include:

1. *Excessive aquatic plant growth*, which precludes access to the impoundments, impedes water flow and navigation and restricts its use by man.
2. *Development of algae* which replace higher plants as the dominant plant population; decimate the sports fish population, and render the waters unfit for recreational use.
3. *Build-up of organic mud and muck* on the bottom which eventually also destroys the sports fishery, and ultimately fills the lake and converts it to a swamp. The pool becomes unattractive for recreation; and a build-up of leeches and micro-organisms of potential health hazards is possible.
4. *Low levels of dissolved oxygen* because of plant and animal decay processes which leads to death of sport fish species requiring high-oxygen waters.

after year. The only solution to this dilemma is to drain the Rodman pool and never construct the Eureka pool.

It has been conclusively demonstrated in Lakes Trafford (Collier County), Hancock (Polk County), and Apopka (Lake and Orange Counties) that the accumulation of excessive quantities of unconsolidated muds foreshadowed their ecological death. It makes little difference how these muds are formed. The end result is the same whether it occurs naturally as in Lake Trafford; as a result of human alterations such as sewage discharge as in Lake Hancock, or from a combination of several sources as in Lake Apopka. The principal concern with water quality in the Rodman Pool and the proposed Eureka Pool is not one of poor-quality water entering the pools, but rather the effects of impounding the waters of a nutrient-rich natural ecosystem that already has a high accumulation of organic matter from the flood plain forest bottom. Water quality in Rodman Pool in 1969-70 was far below federal and state standards for recreational (class 3) waters.

The *rate* at which the harmful effects of impoundm5nt will appear depends on the amount of nutrients available since they result from the nutrient trap principle. In most aquatic ecosystems, phosphorus and nitrogen are usually the nutrients whose concentrations limit the rate of plant growth in surface waters. However, Florida waters, including the Oklawaha, its headwater lakes, and tributary streams, are very rich in phosphorus. The nutrient most likely to be limiting the the Rodman and Eureka pools is nitrogen. A determination of nitrogen input to these pools provides a basis for prediction of the rate of development of ecological changes.

Some of the major sources of nitrogen input to the Rodman and Eureka pools are listed in the following table. There will be some losses of soluble nitrogen in the waters leaving Rodman pool but it is expected that such losses will be relatively small during the eight-month growing season because the great extent of quiet water in these pools will provide excellent conditions for nitrogen-fixation in macro or micro plant material and will allow it to settle out. Losses of nutrients during a variety of river flow and plant growth conditions should be determined in order to make more refined predictions of future ecological changes.

5. *High turbidity* which usually accompanies this aquatic degradation.

In its simplest form a lake or impoundment functions as a nutrient trap. Organic materials transported by a natural stream usually settle out in the deeper pools in much the same manner as sewage solids settle in the quieter waters of a sewage treatment clarifier which acts as a gigantic settling pool.

These organic solids become a permanent part of the aquatic environment. The accumulation of excessive quantities of nutrient-binding unconsolidated muds significantly influence all other ecological forces and thus all aquatic plants and animals within the ecosystem. A discussion of the elaborate interrelationships of these unconsolidated muds and the rest of the ecosystem is beyond the scope of this report. However, the ultimate effect of these processes may be seen in several lakes in Florida.

The 6.5 million pounds of nitrogen poured into the impoundment annually by the rivers alone are more than twice that required to produce the enormous mass of water hyacinths which developed last year on the Rodman Pool. Significantly, there are additional major sources of nitrogen, some of which are:

...Springs on the lower Oklawaha would supply nutrients throughout the life of the project.

...Forest floor litter is high in organic debris, humus, and detritus; this will be an important source of nutrients only during the first year or two, supplying perhaps 200,000 pounds of nitrogen the first year.

...The gradual decay of drowned and destroyed forests will be a source of nutrients for many years.

...The persistence of nutrients in living and dead aquatic plants from previous years establishes a "bank" of nutrients steadily increasing with time.

Thus, there still is more than enough supplied year after year by the rivers alone to grow pest quantities of aquatic weeds in the reservoirs. This excessive growth, therefore, is emphatically NOT a transient phenomenon that will disappear in a year or two as has been suggested. The fundamental environmental changes (lower flow and greater illumination of the water) will persist and there will always be abundant nutrients to permit rampant plant growth year

Source	Pounds of Nitrogen* Per Year
Oklawaha River	2,700,000**
Silver River	3,000,000
Orange Creek	800,000
Total	6,500,000

*Total Nitrogen: From F.W.P.C.A. Pre-Impoundment Study, 1967.

**Expected to increase during Lake Apopka drawdown due to augmented flow.

The Cross-Florida Barge Canal project introduces two other major threats to water quality; siltation from dredging and pollution from barge accidents or operations. These factors have been largely overlooked by canal proponents. The cost of correcting these environmental hazards is not identified in any of the data presented on costs of the canal, although the Corps of Engineers is working on regulations to minimize pollution from adjacent property.

Sedimentation or siltation will be an extremely serious problem for years in the Rodman, Eureka and Inglis pools and downstream therefrom. Hydraulic dredging operations to dredge the 150 feet wide by 12 feet deep canal channel through these impoundments will suspend the finely divided sediments seen in many of the core borings taken by the Corps of Engineers. In a rather similar dredging operation on the Kissimmee River, a highly turbid band of water could be observed for the entire length of the river downstream from the dredge (approximately 35 miles) and thence well out into Lake Okeechobee. The ecological significance of sedimentation or siltation from dredging is outlined below:

1. Initial dredging will probably take several years to complete the channel. Maintenance dredging to offset erosion may continue for the life of the project.
2. Finely divided sediments will make the canal project water turbid during dredging and for a short time thereafter.

3. Turbidity can be expected to kill aquatic plant life by exclusion of light and to reduce recreational values of the impoundments.
4. Finely divided suspended material will eventually settle to the bottom, coating and smothering many forms of life including eggs and young of sport fish.
5. Temporary local turbidity can be expected to reoccur as storms or man's activities stir up bottom sediments.
6. Two federal agencies, the Federal Water Pollution Control Administration, and the Bureau of Sports Fisheries and one state agency, the Game and Fresh Water Fish Commission, recogni ed the problems associated with dredging and recommended that the spoil material excavated be deposited on the uplands to reduce the severity of effect. An examination of the latest plans for the reservoirs indicates that the Corps of Engineers has largely disregarded these recommendations.

The spectacular and costly oil spills of the past few months dramatically illustrate the pollution potential of barge and ship traffic to the waterways they traverse. When the barge canal project was conceived, it is possible there was not enough data to calculate the probability of pollution occurrence and the costs to society, but these costs must now be included in cost calculations.

§ 12.55 AQUATIC PLANT PROBLEMS

Aquatic plants have grown and will continue to grow to pest proportions in the impoundments on the Oklawaha River. Without control, the impoundments will have "wall to wall" water hyacinths. Chemical control of water hyacinths will make conditions ideal for development of Hydrilla, *believed to be the most difficult of all aquatic plants to effectively control. It would choke off recreational use, would interfere with navigation in the project, and would greatly accelerate the filling of the pools with organic debris. If expensive chemical control of* Hydrilla *were successful, algae would grow in fantastic abundance, destroying the sports fishery and fouling the water and air with noxious tastes and odors.*

Originally, the Oklawaha River had no serious aquatic weed problem. The degree of encroachment by aquatic weeds varied from year to year but they seldom reached pest proportions. The floodplain was covered by a luxuriant hardwood forest adapted to periodic flooding. This dense forest canopy shaded the river so effectively that much of the water surface received direct sunlight for a relatively short period each day. This diminution of direct light is a natural control which kept aquatic weeds from filling these otherwise suitable, nutrient-rich waters.

In addition, the swift current swept downstream the seeds and pieces of potentially large vegetative mats which, consequently, seldom developed. The natural system, by virtue of its physical and biological characteristics was thus relatively immune to invasion by the aquatic weeds that flourish in more open and static waters.

In its natural state, the Oklawaha River seldom had aquatic plant populations of pest proportions. Because the water was shielded from direct sunlight by the surrounding forest canopy, the light favorable to such vegetative growth was not available and the hyacinth growth which periodically developed was carried downstream by swift currents.

The construction of dams and concomitant destruction of forest cover during reservoir construction allowed direct sunlight to reach the nutrient-rich water which was further enriched by submerged decaying tree hulks and forest-floor litter. The abundance of sunlight and nutrients fosters an explosive growth of luxuriant and troublesome aquatic vegetation and the manyfold increase in flowthrough time (over 14 times greater at Rodman Pool) gives plants a longer period to assimilate nutrients into vegetative biomass.

Chemical control of the several aquatic plant pests will (1) repeat the nutrient cycle when dead plants decay again providing an abundance of nutrients and sunlight for renewed plant growth, and (2) contribute organic sediment to siltation of the open waterway. Mechanical control in reservoirs of this size and shoreline irregularity is economically and technically infeasible at this time.

If expensive chemical control is employed, the ecological repercussions would be so severe as to make barge traffic the only projected benefit of the canal to be realized. If chemical control is not attempted, such aquatic vegetation would soon fill the canal and NONE of the projected benefits would be realized. Possibly biological controls, which presently are unknown, could favorably resolve this dilemma.

§ 12.55.10 The Effect of the Construction of Dams on the Aquatic Weed Populations.

In the construction of the 13,000 acre Rodman Pool, 5,500 acres of hardwood forest were destroyed by crushing the trees into the mud. When the area was subsequently flooded, the enormous organic load of these submerged trees and the accompanying forest litter became available to aquatic plants. Also the flow time was slowed, allowing weeds more time to assimilate the nutrients and to build vegetative biomass. It now requires more than two weeks for water to flow through the Rodman Pool whereas water passed through that section of the original Oklawaha channel in less than one day. The increased access to direct sunlight resulting from the forest's destruction likewise favored prolific aquatic plant growth.

These fears were realized in the summer of 1969 when 3000 acres of Rodman Pool became choked with approximately 300,000 tons of luxuriant water hyacinths during a $2\frac{1}{2}$ month growing season. Prospects for recreational and aesthetic enjoyment, as well as land values, diminished proportionally.

Hyacinth cover can produce a virtually sterile aquatic ecosystem. The floating vegetative mat keeps sunlight from reaching the water surface thus preventing the establishment of submerged aquatic plants which release oxygen into the surrounding water. The near absence of dissolved oxygen, brought about indirectly by the hyacinth cover, creates an environment hostile to many fish and other aquatic animals which normally abound in similar, but oxygen-rich, environments.

The physical and biological changes inflicted on a portion of the Okalwaha River, a naturally balanced ecosystem, have produced conditions so favorable to a few species of aquatic plants that they have been and will be produced in such overwhelming amounts as to be detrimental to almost all other native organisms and to the projected benefits anticipated from construction of the canal.

§ 12.55.20 The Prospects for Effective Control of Aquatic Plants

A chemical method is known for hyacinth control but is has undesirable biological consequences.[1] Once chemically sprayed, water hyacinhs die and sink. As they rot, there may be a diastrous sag in dissolved oxygen content of the water. The partially decomposed hyacinths increase the already rich bottom deposit of organic sediment and permit sunlight to penetrate further into the water's surface. These conditions are extremely auspicious to the explosive growth of such even more difficult-to-control submerged aquatics as *Hydrilla verticillata* (Florida Elodea), *Myriophyllum spicatus* (Eurasian milfoil), *Egeria densa* (Brazilian waterweed), and algae (for which no suitable control is known) and to a renewed growth of hyacinths, *Eichornia crassipes*. Thus, chemical control of hyacinth is primarily "cosmetic" in nature. That is, it makes the water look better, but does not solve the fundamental problem and may even assist a worse problem, such as *Hydrilla* to develop.

Hydrilla verticillata is probably the fastest growing and most rapidly multiplying submerged aquatic flowering plant in the world. Growing stems may elongate 12 inches a day and the species reproduces by fragmentation of stems, by lateral stems (runners) in the bottom sediments, by rooting from lateral stems, and, most importantly, by the production of bulb-like tubers in the bottom sediments and along the stems. These tubers are highly resistant to chemicals and can survive many months of drying on land. The most effective chemical control[2] must be employed several times annually and involves the same disadvantages as hyacinth control, i.e., an increased organic load available for new vegetative growth. Chemical eradication appears impossible as dosages of over 400 ppm copper followed by 3 months of drying have not impaired the viability of *Hydrilla* tubers. Mechanical removal techniques have been developed, but the rapidregrowth of *Hydrilla* makes extensive operations of this type extremely costly.

Most aquatic weed specialists believe *Hydrilla* will ultimately be the most difficult of all aquatic plants to control in Florida. As this species is already present in the canal's Inglis Pool, it has been predicted that eventually *Hydrilla verticillata* will completely dominate the entire waterway (if hyacinths are controlled). If some biological control is not forthcoming, the entire canal and contiguous waters could be made useless for navigation, water control, and recreation.

The projected invasion of *Egeria densa* and *Myriophyllum spicatum* may be environmentally disastrous. Both species have been introduced into Florida waters; the former is known from the Oklawaha in Marion County and the latter from Citrus County localities less than 10 miles from the western end of the canal. It is possible that within 5 to 10 years, these species, if unchecked, will have reached such a density and extent that all projected canal uses except barge traffic will be negated. Mechanical controls for these species are economically prohibitive. Chemical controls are known[3] but are temporary, expensive, and produce organic pollution.

Siltation is another undesirable effect of rampant growth of aquatic plants, with or without chemical weed control. Controllled tests with water hyacinths from one growing season showed that they can produce an organic deposit 7 inches thick. Rodman Pool averages only about 6 feet in depth. It is reasonable, therefore, to expect that major parts of the pool will be filled to the surface with organic sediments well before the end of the project's 50-year life span. These loose, unconsolidated sediments already have ruined sports fisheries in nearby upstream lakes of the Oklawaha system, most notably Lakes Apopka, Dora, Beauclair, and Eustis.

§ 12.55.30 Alternatives to Chemical Control of Aquatic Plants

The only currently feasible alternative to chemical control of water hyacinths is mechanical removal. This method avoids the problems of siltation and bottom enrichment but nonetheless provides direct sunlight to water which is naturally rich in nutrients. It has been pointed out that, even after the unknown number of years required for the abatement of the unnatural nutrient problem (wood and litter on the bottom), there still would be abundant nutrients for an aquatic weed problem still to persist. Given the shoreline irregularities, flooded standing trees, size of the reservoirs, *Eichornia's* growth rate,[4] no economically feasible mechanical methos of hyacinth removal are now known, and, if available they would necessitate a vigilant continuous operation and areas for dumping or composting.

Thus, the only economically feasible method of aquatic weed control produces disastrous ecological results and, if employed, it would make barge transit the only one of the many projected benefits of the canal to be readily realized. If such chemical control is not used, lush aquatic vegetation will soon fill the canal and all contiguous waterways and none of the projected benefits will be realized. It is the drastic ecological alteration of this naturally-balanced system which imposes this unpalatable choice.

12.55.40 Consequences of Chemical Control of Aquatic Plants—Algae.

Consequences of chemical control of aquatic plants would include the recycling of nutrients, added organic muds on the bottom, and increased organic load in the water—all factors making it more probable that algae will develop to enormous proportions in the impoundments. If the pools of the canal project are taken over by algae, this would spell their doom for recreational or land-enhancement purposes. The algae would shade out other plants and would soon destroy the sports fishery. Waters loaded with algae develop unpleasant tastes and often give off noxious odors.

There is no known chemical or biological control for algae that would be feasible in bodies of water of the size and characteristics of the Rodman and Eureka pools of the Cross-Florida Barge Canal project.

References

1. One potential danger of this chemical, 2,4-D, lies in its very close chemical similarity to 2,4,5-T, another spray chemical which is believed to produce birth defects and other undesirable effects.
42. 1 ppm Diquat and 4 ppm copper sulfate per acre foot applied from surface vessel. Cost of chemicals only is $30.50 per acre foot. Rodman Pool alone contains approximately 78,000 acre feet of water.
3. For *Egeria densa*, 1 ppm Diquat (in static waters) applied underwater 2 to 3 times annually is suitable. The cost of the chemical alone (current prices to governmental agencies) is $27.50 per acre foot. Acrolein and Hydrothol are also effective but more costly and their effects are less persistent. *Myriophyllum spicatum* is more difficult to control satisfactorily than *Eichornia*, *Egeria*, or *Hydrilla*. The most economical chemical control is 2,4-D. The cost of the chemical only (20 pounds per acre applied by aircraft or boat) is $32.00 per surface acre and, in flowing water treatments must be repeated every 2 or 3 months.
4. Under normal Florida growing conditions, the offspring of 20 adult hyacinths will, in 8 months, cover 20 acres of water surface.

§ 12.56 VEGETATION

The immediate consequence of the construction of the Cross-Florida Barge Canal is the destruction of a thirty mile-long segment of the Oklawaha River and its adjacent hardwood forest. Indirect effects from *water level manipulation include changes in the bordering forest, water weed problems, and other extensive ecological changes. Subsequent cumulative effects due to increased human activity will result in the loss of a large, stable environmental area necessary for regulating the quality of life for large nearby human population centers.*

Foreseeable effects of the Cross-Florida Barge Canal on the Oklahawa Regional Ecosystem fall into three categories:

(1) immediate consequences of the construction;
(2) indirect effects resulting from changes in the water level; and
(3) subsequent cumulative effects spreading throughout the region as a result of the expected increase in human activity.

Construction of the canal will destroy over 27,350 acres of the unique hardwood forest of the Oklawaha River Valley and convert thirty miles of the free-flowing Oklawaha River into two shallow slow moving reservoirs.

The flooding of the large forested areas pre-empted for reservoirs will bring about changes in the remaining bordering forest. Because of the change in hydraulic balance, marked shifting of community boundaries will occur. A detailed forecast of these drastic ecologic changes is made in the following papers on wildlife, aquatic animals and water weeds.

As degrading as these effects will be, even more serious disruption will result from the operation of an industrial canal in the region. There are essentially only five sizeable areas of relative ecological stability remaining in the state: the Everglades National Park, the Okefenokee Swamp in the northeastern corner of the state; the west coast estuarine strip: the Aplachicola complex in the panhandle; and in the north-central peninsula, the Oklawaha Regional Ecosystem.

These areas are bordered by large human concentrations which depend directly and indirectly on the natural environment for survival. These ecosystems serve as buffer zones to human activity. They compensate and offset the effects of man's activities and thereby regulate the quality of the environment. These great natural areas modify the atmosphere with their tremendous oxygen production capacities. They help replenish our supply of clean water by their filtering ability, and, not least, they provide an aesthetic enhancement of our environment that enriches the quality of our life. When dissected and grossly modified, natural areas lose, to a large extent, their ameliorating capacities. Scattered small areas, although valuable for community recreation and beautification, do not have the wealth of species and variety of habitats that are necessary to maintain a healthy, stable regional environment.

§ 12.57 TERRESTRIAL WILDLIFE (BY JAMES N. LAYNE*)

Construction of the canal would eliminate the hydric hardwood forest association and its unique fauna, and would diminish the numbers of species that live primarily in other associations but depend on the hydric hardwoods and the river itself for some of their needs. Especially hard hit would be the larger, wider ranging species such as turkey, bear and panther which require large unbroken expanses of undisturbed habitat.

Because of the immense complexity of the natural system involved and the absence of adequately detailed and sufficiently long-term preliminary ecological studies, it is impossible to predict with complete accuracy the kinds and extent of the effects of the barge canal on the terrestrial fauna of the Oklawaha Regional Ecosystem. There can be absolutely no doubt, however, that this project and its ramifications will have a seriously deleterious effect on the biota of this region.

The animals of the hydric hardwoods association bordering the Oklawaha River itself will bear the brunt of the canal effects. This association, which is perhaps the most unique habitat of the Oklawaha region and the best example of its type to be found in Florida, will be destroyed along the entire stretch of river to be usurped by the canal. Any claim that remnants of the hydric hammock along meanders of the river cut off by the canal have been preserved is false. Flooding has already destroyed or will destroy the vegetation; and even if this were not the case, many species characteristic of the original community cannot survive continual high water and would disappear. The remaining elements of the original flora and fauna would no more be representative of the original community than a city park with its tame squirrels is of the original forest.

Those species of vertebrates that are most closely dependent upon the hydric hardwoods environment will of course be hardest hit.

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Such species include the Common Tree Frog, River-swamp Frog, Wood Duck, Prothonotary Warbler, Southeastern Shrew, and the Florida Long-tailed Weasel. A vastly greater number of invertebrate animals will undoubtedly similarly suffer.

The status of other species of land vertebrates found in the hydric hardwoods would be affected to the degree that they utilize this environment. Although the destruction of the habitat may not have as dramatic an impact on such forms, a detrimental effect on their overall populations in the region can confidently be predicted. This assumption is based on the ecological principle that each species in a habitat tends to fill the environment to its *carrying capacity* for that particular species. Therefore, destruction of a particular habitat results in a net reduction in the potential numbers of its contained species in the region as a whole, as the displaced individuals will for the most part not find available spaces in other habitats.

In addition to the species listed above, the Bull Frog, Green Frog, Alligator, Pileated Woodpecker, Red-bellied Woodpecker, Yellow-crowned Night Heron, Barred Owl, Red-shouldered Hawk, Turkey, and Otter are among the vertebrates that will be most affected by the destruction of the hydric hammock. Reduction in the populations of Bear, Deer, and Panther is also to be expected as a result of the decrease in overall cover diversity and area available to these wide-ranging species. For some species, the critical factor will not be the loss of the hydric hammock itself but rather the elimination of important *edge* cover between this environment and adjacent habitat types.

Another factor to be considered is that the zone of hydric hammock along the Oklawaha River also serves as a wintering ground and migratory route for many bird species that breed elsewhere in the United States and Canada and thus destruction of this environment would affect the status of species in widely removed areas of North America. Also, in late summer large numbers of water birds, including anhinga, Ibises, and Herons, congregate in the swamp along the river; the elimination of this forest might be detrimental to these species over a fairly wide area.

Some of the effects noted above have already become apparent in the part of the canal partially completed. In a survey of the undisturbed section of the river between Silver Springs and Eureka and of the flooded and partially cleared stretch below Eureka to the

Rodman Dam, the Common Tree Frog, Green Frog, and Bull Frog were recorded only in the natural area. The River-swamp Frog was more abundant in the undisturbed part, and dead tadpoles of this species were observed in the disturbed stretch. It appeared that except for Gray Squirrels terrestrial mammals had for the most part been driven from the forest and that the squirrels would follow as the trees died and food disappeared. More Alligators were seen in the natural river, and, according to a trained observer in the region, the initial clearing of the Rodman Pool had had a traumatic effect on these reptiles. The disturbance and destruction of habitat forced the animals to move to adjacent higher ground which is unsuitable for them. Even in a "stabilized" condition the flooded areas will probably not provide as satisfactory conditions for Alligators as the natural river, particularly from the standpoint of the availability of nesting sites protected from molestation by other animals and man.

The conditions created by construction of the canal will probably favor the increase of some species and attract new species into the area. In some cases, the effects will be temporary and in others may contribute further to the degradation of the total environment. An initial increase in shore-birds, attracted to bare earth areas along the water, and certain kinds of water birds is to be expected. Such an effect is already evident in the Rodman area. A survey in late summer of 1969 recorded 235 individuals of 33 species of birds along the natural river and 475 individuals of 44 species in the disturbed area of approximately equal length. The increase in the latter section was largely due to such aquatic types as the Ring-billed Gull, Common Gallinule, Coot, Pied-billed Grebe, Common Egret, and Little Blue Heron. These birds were concentrated around the masses of vegetation accumulated about crushed trees that had broken free of the bottom and floated to the surface and the extensive mats of emergent aquatic vegetation that flourished in the swath cut for the canal. Presumably when this vegetation has been removed and the canal is operational these species will decline in number. Water quality deterioration as the result of decaying vegetation, chemical sprays for water weed control. pollution from barges and other sources with its effects on food organisms will probably also be a factor in reducing water bird populations. In the meantime, any large concentrations of such birds speeds the process of eutrophication through the addition of their highly nitrogenous wastes to the system.

The completed canal and associated developments will increase the possibilities of introduction of undesirable species into the region and favor the build-up of certain native and non-native species which may create a nuisance problem or a potential threat to human health. Increased human development in the form of recreation areas, houses, etc. along the borders of the pools and canal proper will prove attractive to the introduced House Mouse Rats, and Armadillo and may also result in unnatural concentrations of such native species as the Opossum, Raccoon, and Striped Skunk. These animals may become a nuisance through gnawing, food contamination, molesting garbage cans, digging, predation on domestic animals, and so forth. In addition, some of these species serve as reservoirs and transmitters of diseases affecting man and domestic animals. The Raccoon and Skunk are among the important rabies vectors in this country, and concentrations of these animals in the vicinity of human populations can result in rapid spread of the disease through the wild species and increased probabilities of human infection. The Opossum is a known reservoir of encephalitis virus in Florida.

The canal would also serve as a potential route for the introduction of pest species, particularly insects, to the region.

Oil spills or the release of other toxic substances into the canal by transient barges would also pose a distinct threat to the semi-aquatic and terrestrial vertebrates and other animals of the region. Even species from upland environments relatively well insulated from the other effects of the canal but who travel to drink or forage for food along the water's edge would be threatened. Furthermore, oil spills in the St. Johns, which would presumably be more likely as the result of increased barge traffic for the canal, would endanger Florida Manatees living in the river, at least during certain times of the year, as well as other forms of animal and plant life.

In summary, it is believed that the canal will have a serious though not fully predictable effect on the terrestrial wildlife of the Oklawaha region. The important hydric hardwoods complex will be completely destroyed for the full length of the Oklawaha River to be used for the canal and the *shock wave* will be felt throughout the other major environments of the region. As a result, the *environmental quality* of this splendid region will be significantly diminished.

Although the degradation of the entire Oklawaha regional ecosystem is serious enough, the single most catastrophic result of the canal will be the loss of the hydric hardwoods community. A glance at the accompanying figures will show that, although most species of land vertebrates of the region do occur in more than one habitat type, each habitat has its own *unique* combination of species. Even this is a highly simplified representation. If all other kinds of animal life - worms, spiders, insects, snails, and so forth - together with vegetation, soil types, and physical environmental conditions such as temperature and humidity characteristic of each environment were added to the picture, the uniqueness of individuality of each ecosystem would be even more striking. Each of these systems involving interactions between the organisms and their environment far more complex than any computor yet conceived by man is the product of millions of years of evolution and represents a vast store of *genetic information.* It is the total hydric hardwoods ecosystem that is at stake. Even if the barge canal is constructed, the individual species will survive elsewhere in nature, though perhaps in diminished numbers; the ultimate tragedy will be the destruction of an entire ecosystem.

§ 12.58 AQUATIC ANIMALS

Converting the free-flowing Oklawaha River into shallow reservoirs will result in major changes in the aquatic fauna. While sport fishing may be productive for a few years the predicted long-range effect will be the replacement of the desirable sport fish by a population of trash fish—gars, bowfin, shad and bullheads.

As the flowing water of the Oklawaha becomes impounded as reservoirs, major changes in the fauna are certain to occur. The natural balance (stability) of the aquatic system will be impaired.

The first fish to be adversely affected will be the darters, true minnows and some sunfish which require moving water for their livelihood. It is impossible to say now whether any of the species will be completely eliminated by the population sizes of all of them will be markedly reduced.

In the early years of impoundment the general fish fauna will probably resemble that of nearby lakes. Sports fishing may be productive for a short period of time because of an increase in nutrients available for plant growth and subsequently more food for animals. The length of time that such favorable fishing conditions exist depends upon how rapidly the impoundment surface becomes covered by floating plants and/or how quickly submerged plants such as *Hydrilla, Myriophyllum,* and *Egeria* become established. In the absence of hyacinth cover, algae populations will become abundant. Such exposions are called "blooms" and are ecologically disastrous because algae populations often attain magnitudes which eventually exceed the available oxygen supply. The algae then die and sink. The oxygen depletions result in fish kills and only fish with air-breathing capabilities such as gars, bowfin, and bullheads, survive.

If rooted aquatic plants, instead of algae, are allowed to fill the reservoirs, the faunistic changes will be similar. As the plant biomass increases in magnitude, populations of game and other desirable species of fishes will diminish and be replaced by such trash fish as gars, bowfins, shad, and bullheads. The foraging activities of shad have adverse effects on nesting success of game fishes. Feeding shad grub along the bottom disrupting nests and eggs of other fish species.

As organic siltation proceeds the sandy bottom areas required for spawning by many species (especially game species) will disappear and populations of these fish will further diminish. Calm shallow water over mucky bottom will be conducive to production of many pest insects. such as midges and mosquitoes. Sludge worms will thrive, and attempts to control these pests by chemical means will result in the same undesirable conditions produced by chemical aquatic plant control efforts.

Dredging to maintain the barge channel, spillages, and dumpings from commercial and pleasure craft will further disrupt breeding sites of many shallow-water animals and shore inhabitants. Nutrients derived from decaying matter will be largely assimilated by nuisance plants and will further make the bottom and water qualities unsuitable for swimming, sailing and other recreational activities which were anticipated secondary benefits of the impoundments.

§ 12.59 **Man's Environment.** In the early part of the nineteenth century when a ship canal across Florida was first proposed, America was a young country in which the most serious hindrance to growth and development was lack of adequte transportation. Water transport was then relatively cheap, rapid, and efficient by comparison with all other available means for moving goods and people. Most of America and virtually all of Florida was wilderness. People were in short supply.

The linear descendant of the old ship canal is the Cross-Florida Barge Canal, a compromise proposal forced by the realization that the ship canal was not feasible. Now the barge canal is being constructed at a time when its value to a maturing nation is dubious and its detetrimental effects are obvious. Many alternate systems of transportation are available to move goods and people and new methods are being devised. People have reached all corners of America. Too rapid population growth is recognized by the President of the United States as a national problem. Wilderness encompassing a variety of habitats and plant communities is in short supply. Growth without plan, in the wrong places, for inadequate reasons, can threaten that quality of the environment which it is now our national policy to protect. The barge canal, if it were to be successfully completed and operated, would encourage just such unplanned growth, and virtually eliminate one of the few truly wild regions remaining in Florida.

In the state of Florida tourism is the major source of income. Over 20 million annual visitors spend billions of dollars for the privilege of enjoying the natural attractions of the state. The barge canal would destroy one of the state's most potentially valuable tourist assets in the wild Oklawaha River system. Admittedly the Oklawaha region has as yet been little developed as a recreational asset, but such development, if carried out in ways that would protect the wilderness quality of the area, would cost only a fraction of the amount of the proposed barge canal. It is difficult to believe that a barge canal with its problematical reservoirs will attract tourists to Florida. Such works of man can be seen in many places. The wild Oklawaha River system, once destroyed, will not be duplicated anywhere on earth again.

The imposition of a nineteenth-century transportation concept on late-twentieth century Florida will benefit a few people at the expense of the many. Those who will gain are a few land owners, some shippers of bulk cargo, those who build or operate commercial boats and barges, and a scattering of others. Those who lose will be all of those Americans, now and in the future, who will seek, but not be able to find, the wild country that has been a part of our national heritage.

It is difficult to understand why, when so many Federal agencies are engaged in efforts to improve and enhance the quality of life in America, one agency should be allowed massive amounts of money to impair and endanger that quality.

§ 12.60 Systems Analysis (By Ariel Lugo*)

Systems analysis is a tool for the analysis of ecosystems, and its techniques can be applied to situations created by the Cross-Florida Barge Canal project. Decisions regarding the future benefit/cost relationships of the Rodman reservoir, particularly as related to recreation and maintenance costs, are in part affected by the phosphorus budget and its exotic aquatic weeds, yet systems analysis techniques or other holistic studies of the Rodman reservoir apparently have never been undertaken. Lacking the predictive capabilities of an adequate systems analysis makes current estimates and future decisions ill founded.

The urgency of man's environmental problems warrants the application of the most sophisticated techniques of analysis available before any action regarding ecosystem use and management is taken. The ecosystem has been defined as a functional unit composed of living and non-living compartments through which matter and energy flows. As these compartments, like the ecosystem, obey the laws of thermodynamics, their behavior can be studied using such analytical techniques as systems analysis. This approach represents the most promising way of elucidating the complex interrelationships of ecosystem components.

In this section, systems analysis techniques are illustrated as they apply to a particular problem: the phosphorus budget of the Rodman Reservoir. Phosphorus and nitrogen are the two limiting nutrients of plant growth, and thus represent the two major water pollutants when found in large concentrations. Phosphorus has been

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Fig. 12.60-1. The phosphorus budget of the Rodman Reservoir. The first step in applying systems analysis to a problem is the identification of the compartments involved. In this figure, seven compartments are identified:

1. N_0, representing the phosphorus (P) concentration in the input to the reservoir, originating from agricultural runoff, and the industrial and city wastes.
2. N_1, representing the amount of P in the reservoir's waters.
3. N_2, representing the amount of P stored in water hyacinth, the expected dominant aquatic plant in the reservoir.
4. N_3, representing the stored P in other aquatic plants.
5. N_4, representing the amount of P stored in the sediments.
6. N_5, representing the amount of P stored in the aquifer.
7. N_6, representing the amount of P in the water man uses for drinking and other consumptive domestic requirements.

The pathways are represented by solid lines connecting the compartments. Arrows indicate the direction of flow. The reservoir water (N_1), due to its low turnover rate and large area, represents the largest storage of P. Inputs to this compartment are agricultural, technological, and human in origin (N_0), and from decomposition products in the sediments (N_4) and in the aquifer (N_5). The reservoir water loses P to the ocean through river flow and runoff, and to the aquatic vegetation (N_2 and N_3) via uptake attendent to photosynthesis. Phosphorus flows from compartments N_2 and N_3 to the bottom sediments (N_4) or is lost through plant harvest by man. Some P gets into the aquifer (N_5) from which it can move back to man in his drinking water (N_6), or into the reservoir via Silver Springs. Not shown in this diagram are the possible losses to the terrestrial ecosystem through littoral vegetation and terrestrial food chains, or the short term biological cycling in the reservoir through aquatic food chains and plant respiration. These pathways have been omitted to simplify the diagram.

selected for discussion since data on its abundance in the reservoir and its resulting effects on plant growth are available. Nitrogen is discussed under Water Quality (p. 73–79). It should be noted however, that the same treatment is applicable to any situation where a holistic approach is used. Thus, economic, hydrogological, and ecological problems pertinent to the Cross-Florida Barge Canal, are amenable to a systems analysis examination. The advantages of systems analysis are in its predictive capabilities and the laboratory manipulation of data in short time periods.

The second step, after all compartments have been identified, is to trace the movement of the material (P) through the various compartments.

The third step, following the description of pathways, is to write equations describing the behavior of each compartment. A passive storage tank charges and discharges in proportion to the amount of material stored and obeys the conservation of matter law. In Fig. 12:60-2 these principles are shown with mathematical notation. The *N*s represent the amount in the storage tank, and the *K*s the constants, or transfer coefficients, that describe the rate of exchange. From these expressions, differentials and integral equations are derived.

After the integral equations are derived, the next step is to feed the equations and the pertinent data to a computer (analog or digital). The computer solves the equations and determines the transfer coefficients (*K*s) for each pathway. With this information it

Fig. 12.60-2. Equations for a single compartment are derived and their simulation with an analog computer is illustrated.

is possible to experiment with the model by changing storage capacities of compartments, flow rates, substituting compartments, etc. This allows the researcher to predict the residence time of P in the various compartments, locate the compartments where it will accumulate, relate the growth of aquatic plants to reservoir conditions, study the effects of the canal on the aquifer, etc.

§ 12.70 Land Use Planning for the Oklawaha Regional Ecosystem

The Cross-Florida Barge Canal, designed primarily to serve navigational interests, has been presented by proponents as an economic and commercial asset to the nation, the state, and the local communities along its route. For this reason, it has appealed to those who feel that the future of North-central Florida will be secured by industrial growth. There is little reason to believe industrialization, with its attendant problems of slums, environmental destruction, and pollution, is truly in the best interests of a beautiful and natural rural area in a state whose primary industry is tourism.

Extensive recreational benefits have been projected as secondary assets resulting from the creation of new water surface and shoreline of the projected shallow reservoirs. It is true that reservoirs have more water surface than do wild rivers, but the critically important issue is the relative *quality* of recreational opportunity offered by the natural river and its adjacent valley forest compared with reservoirs in a region already richly endowed with natural lakes. Protective guidelines against pollution and encroachments are now being drafted by the Corps of Engineers, but it is unlikely that these will result in effective preventative or corrective measures in the long run.

Although construction of the Barge Canal is now 29% complete, no alternative proposal for land use was ever presented to local citizens for their consideration. However, preliminary investigations indicate that much greater economic benefits would accrue directly to local communities if the Oklawaha Regional Ecosystem were intelligently developed as a wilderness conservation/recreation area. It is not generally realized that the majority of the transportation benefits are predicted for areas beyond Florida, and yet state and local interests must share the consequences and legal responsibilities of environmental degradation.

If the thorough kind of planning that should have preceded this construction should now take place, three basic actions would be forthcoming, as follows:

1. Construction would be halted.
2. A regional environmental planning council, established in accordance with existing Florida statutes would be formed to draw up a master plan based on the needs of conservation, environmental protection, recreation, and development throughout the Oklawaha Regional Ecosystem.
3. An agency, perhaps patterned after such multi-county special-purpose governmental agencies as the Central and South Florida Flood Control District or the Southwest Florida Water Management District, would be created and given the authority to execute the land-use plan recommended by the Oklawaha regional environmental planning council.

It is essential to realize that there is now a unique opportunity to plan the future use of a significantly large ecosystem in peninsular Florida. The Cross-Florida Barge Canal controversy has exposed the lack of any valid plan for the wise use of a unique wilderness area in a section of the nation in which such original assets are rapidly being lost.

§ 12.80 Economic Evaluation of the Cross-Florida Barge Canal Project (By Paul E. Roberts, Jr.*)

The Cross-Florida Barge Canal project is a classic example of a long standing national disgrace—pork-barrel legislation. In the six years since construction began, the project has become a textbook example of what Robert G. Sherril, in his article "Corps of Engineers: The Pork-barrel Soldiers,"[1] describes as "the oldest established permanent floating boondoggle in American politics."

This Florida project is one of many water-resource projects, scattered throughout the nation, in which the taxpayers' natural and economic resources are recklessly wasted.

For decades economists have criticized the Alice-in-Wonderland economics of the most notorious of these public works projects, and political scientists have described the system that perpetuates the undemocratic process of "pork barrel" politics—but to no avail.

Today, however, there are signs that the public's mounting concern over the degradation of the environment, coupled with its growing impatience with federal programs that spend taxpayers money on programs that benefit only a few vested interests, will evoke corrective legislation by the United States Congress.

And it will take Congressional action to correct the miserable aberration of the boondoggle. Sherrill described the Corps-Congress relationship succinctly: "The boondoggle routine is perfectly balanced. The Corps justifies the projects and Congress appropriates the money. On one hand the Corps gets bigger and more influential—two conditions dearly prized by generals—and on the other hand public-works money is doled out to civilian contractors "back home" with Congress getting credit for spreading the happiness."

In all fairness it must be noted that the Corps of Engineers has, from time to time, recommended improvements in the economic

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guidelines that govern the evaluation of and economic justification for its projects, only to have the proposals nullified by the Congress.[2]

In these days, when great emphasis is placed on fiscal responsibility and the Congress has willingly cut federal spending on many domestic programs it is disconcerting to find Congress refusing to cut the appropriations for the enormous "pork-barrel" programs. The reason for this anomalous behavior may be found in the massive lobbying mechanism that supports the boondoggles.

In "Dam Outrage: The Story of the Engineers," Elizabeth B. Drew[3] has clearly described how the coalition of Corps, Congress and vested interests operate. In discussing the organized and undisguised pork-barrel lobbying groups she says:

> "The nationwide coalition of interested groups keeps momentum behind the public works program and gives the barge industry...the strength to continue to win federal largesse."

Some of these "interested groups" are:

> "the Mississippi Valley Association, the Tennessee-Tombigbee Association, the Arkansas Basin Development Association, and so on. The Florida Waterways Association, for example, boosters of the controversial Cross-Florida Barge Canal, has among its directors a realtor, representatives of a consulting engineering company, chambers of commerce, port authorities, newspapers, and a construction company. The associations meet and entertain and lobby. The Lower Mississippi Valley Association is noted for its days-long barge parties. Some twenty- to thirty-odd people from an association descend on Washington from time to time to testify and to see the right people in Congress and the Executive Branch."

The most powerful lobbying group is, of course, the National Rivers and Harbors Congress,

> "an unusual lobbying organization made up of politicians and private interests who support federal water projects. The chairman emeritus of the Rivers and Harbors Congress is Senator John McClellan. Among its directors are Senators Allen Ellender of Louisiana (chairman of the Public

> Works Appropriations Subcommittee) and Ralph Yarborough of Texas, and Congressman Hale Boggs of Louisiana and Robert Sikes of Florida."

Water resource projects normally follow a well defined series of steps from instigation of the project by "local interests," through Congressional authorization for the Corps to study the project, conduct public hearings, and compute the benefit-to-cost ratio of the project, to Congressional authorization of the project and finally Congressional appropriations of funds for construction. In his recent book, *The Diligent Destroyers*, George Laycock[4] has taken "a critical look at industries and agencies that are permanently defacing the American landscape." His many carefully documented case histories indicate how easily the public interest may be subverted in this process. He points out, the "public hearings" where only "interested parties" were notified; the deathlessness of project authorization—some authorized Corps projects are more than 20 years old, just waiting for an "interested" group and a favorable benefit-to-cost ratio to become active nightmares; the restudy gambit whereby the Corps recalculates over and over again until the all-important benefit-to-cost ratio of 1-to-1 is reached. The Cross-Florida Barge Canal is just one of the many projects the defects of which are revealed by Laycock's detailed analysis.

The ratio of benefit-to-cost of a project has come to be the foundation of every Corps project. The theoretical reason for its importance rests on the reasonable assumption that an expenditure of public funds is acceptable only if the benefits to the public equal, or exceed, the cost to the public when calculated for the projected life of the project. Theoretically, a benefit-to-cost analysis is an objective method of evaluating a project. In actuality a wide variety of subjective value-judgements enter into any benefit-to-cost analysis. Highly arbitrary choices as to what constitutes primary benefits and/or collateral benefits are made. Dollar values are assigned to both the assumed benefits and the estimated costs. It cannot be overemphasized that the final number emerging from a benefit-to-cost analysis has within it a multitude of subjective value judgements.

The Cross-Florida Barge Canal project, when authorized in 1942, had a benefit-to-cost ratio of only 0.18 to 1.0. In 1958, after the inclusion of the collateral benefits, flood control and land enhancement, the ratio rose from 1.01 to 1.0. Today, after the addition of recreation benefits the ratio is listed as 1.4 to 1.0. The past economic restudies have all been made by the Corps or by agencies selected by the Corps. It is high time that an economic analysis of the Cross-Florida Barge Canal project be carried out by an unbiased group of economists, specialists in the fields of economic theory, transportation economics, and environmental or resource economics.

Economists associated with the Florida Defenders of the Environment are investigating the economic justification of the project from several different angles. Some of their preliminary findings are reported below.

§ 12.80.10 Total Costs have been Underestimated

The Corps' report for Fiscal Year 1971 shows estimated fixed contractor and land costs to be $185,200,000. To this amount approximately $20,000,000[5] should be added to account for interest charges on capital costs during the period of construction. Total estimated costs, therefore, are now estimated to be $205,200,000. The $20,000,000 interest charge does not appear as a separate item in any of the Corps' reports although it is included in their calculations for annual charges. To calculate the interest charge on the capital costs, the Corps uses a rate of interest of 3.795 per cent. This rate is less than one per cent more than the present discount rate of 2.875 per cent used to discount benefits. It is unrealistic for the Corps to assume that interest rates for construction loans are this low. The Corps itself has recently increased land enhancement benefits by increasing the interest rate from six per cent to eight per cent because land values have gone up. Is it not reasonable to assume that increased land values would be accompanied by increased construction costs? If the Corps had calculated the interest charge on capital costs during construction at a rate of eight per cent, the total project costs would be much higher—and a great deal more realistic.

§ 12.80.11 The Discount Rate of 2.875% is Unrealistically Low

In an essay, "A Water Development Program for America's Future," U. S. Senator Stephen M. Young[6] clearly describes the rationale for discounting the projected benefits of a project as follows,

Table I

Cross-Florida Barge Canal; History of Benefit-Cost Ratio; 1958 Report to FY 70 Budget Request

Item	1958 Report	1962 Report	FY 63	FY 64	FY 65	FY 66 thru FY 68	FY 69	FY 70
Annual benefits:								
Transportation savings	$7,407,000	$7,016,000		$6,908,000			$6,908,000	$8,117,000
Commercial fishing benefits	49,000	70,000	No change in economic analysis	70,000	No change in benefits	No change in economic analysis	70,000	70,000
Benefits to contractors floating plant	20,000	30,000		30,000			30,000	30,000
Benefits to new vessel deliveries	155,000	115,000		115,000			115,000	127,000
Benefits to recreational boating	127,000	118,000		118,000			118,000	129,000
Flood control benefits	—	257,000		255,000			255,000	289,000
Land enhancement benefits	—	650,000		640,000			640,000	665,000
Recreation	—	—		—			3,142,000	3,142,000
Total annual benefits	7,758,000	8,256,000		8,136,000	8,136,000		11,278,000	12,569,000
Total annual charges	7,365,000	7,039,000		7,391,000	7,531,000		8,200,000	8,567,000
Benefit-cost ratio	1.05 to 1	1.17 to 1		1.1 to 1	1.1 to 1		1.4 to 1	1.5 to 1
	1.01 to 1**			1.10 to 1	1.08 to 1*		1.38 to 1*	1.46 to 1*

SOURCE: Jacksonville, Florida, District Engineer
SAJWN
August 1969

* Actual rates
** See House Appropriations Hearings 1962-63 Statement by General Morris, P. 744.

Table II
U.S. Army Corps of Engineers Figures for Expected Recreational Use of the Ross-Florida Barge Canal if Ompleted (August 1969).

Average annual use

Activity	Without project User days	Pct.	With project User days	Pct.	Difference (User days)
Fishing	271,700*	13.7	349,900*	5.8	78,200
Hunting	20,250*	1.0	2,100*	0.0	−18,150
Boating	497,000	25.0	1,620,000	27.0	1,123,000
Camping	298,200	15.0	900,000	15.0	801,800
Swimming	198,800	10.0	900,000	15.0	701,200
Picnicking	99,400	5.0	400,000	8.0	330,600
Sightseeing	404,160	20.3	1,449,600	24.2	1,045,440
Other	198,800	10.0	300,000	5.0	101,200
Total	1,988,310	100.0	6,001,600**	100.0	4,013,290***

* U. S. Fish and Wildlife Service estimates, 1963.

** About 70% of this is applied to the reservoirs in the Oklawaha River area for an estimate of about 11,510 users per day at those reservoir sites.

*** This difference is used to account for the annual recreational benefits listed in Table I.

> "As for the estimated benefits, they will be realized by society only in the future. For this reason, Federal practice 'discounts' these benefits to a lower-level present value. Obviously, the higher the rate of 'interest' assumed, the higher will be the estimated yearly 'cost' and the lower the present value of future benefits."

Then, a value judgement must be made as to what discount rate to use. The Water Resources Council of the Executive Branch of the federal government establishes guidelines as to the discount rate to be used at a given time. The present rate, established in 1968, is 4.625 per cent, and is based on the average yield of long-term U.S. government securities during the preceding year. It is interesting to note that the rate of interest used by the Army Corps of Engineers in this project from 1962 to 1965 was 2.625 per cent. This rate was increased to 2.875 per cent in 1965. The important points are that this project has had only one revision of the interest rate used to

§ 12.80.23 *Water weed control,* possibly one of the most important management problems is nowhere identified or estimated, although public statements by Corps spokesmen assert that this is only a minor item based on experiences with other bodies of water. However, these other waters do not possess the capabilities for water weed growth that the reservoirs would contain.

§ 12.80.24 *The "hold and save" clause* has not, at this time, been adequately defined as to the degree of liability the state of Florida has agreed to. Presumably, it means that the state is financially responsible for adverse effects due to the construction of the barge canal, including personal damages, property damages, and pollution damages which appear inevitable considering the nature of the barge canal and its massive impact as described elsewhere. Illustrative examples already apparent are:

§ 12.80.25 *The staggering cost of damage to Silver Springs.* In another report in this volume, the real danger of contamination of the Florida Aquifer and thus of Silver Springs is presented. The State of Florida may be directly liable in suits for damages to the Silver Springs attraction, as well as to all of the supporting private enterprises which depend on this attraction. Regardless of who actually pays, Florida faces the prospect of staggering damages not appearing as a cost of this project, nor even as risk provision in the discount rate.

§ 12.80.26 *Other lawsuits:* (a) drownings resulting from the canal project (Ward and Tullos v US Corps of Engineers); (b) a possible suit for damages on the lower reaches of the Withlacoochee River; (c) damages as a result of the inevitable oil spills.

§ 12.80.30 The Estimated Use of Barge Canal is Based on Inadequate Data

The Corps bases estimates of use of the barge canal on a limited number of variables. These variables are

(1) growth trends for population,
(2) value added by manufacturers,
(3) per capita consumption of selected commodities, and
(4) fertilizer consumption.

No attempt has been made to test these indices for statistical significance pertinent to waterways transportation. Furthermore, no attempt has been made to update these four variables for the intervening time between 1956 and 1970, although it is claimed by the Corps that they reevaluate the project annually.

§ 12.80.31 *Only 15% of barge traffic will stop in Florida.* The Chief of Engineers report in 1962 estimated that about 40% of the traffic will be local traffic when the project is completed and in operation. Recent statements from the Corps are to the effect that no more than 15% of the traffic can be described as local. That is, 85% of the transportation benefits will accrue to states other than Florida, according to Colonel Avery Fullerton, District Engineer, when speaking on March 16, 1970, to the Florida Senate Committee on Natural Resources and Conservation.

§ 12.80.32 *The barges will not pay user fee or state fuel tax.* No user fee is levied on commercial users of waterways built at federal expense although most United States presidents have favored such a charge. This constitutes a subsidy which competing forms of transportation do not enjoy—a long standing gross inequity. Barges are exempt from state fuel tax, another subsidy not extended to other waterways users.

§ 12.80.33 *It is erroneous to assume that barge rates will remain low in comparison to competing modes of transportation for the 50-year life of the project.* Original traffic estimates were made on a differential between barge and rail rates assumed to be in effect from the first year of the operation of the canal through to the last year of operation. The assumption was that barge rates were, and will continue to be, lower than competing modes of transportation such as rail roads.[7] Resources of the Future, Inc. conducted a study of inland waterway transportation during the years 1956-1963.[8] Some of their results are given below:

> "Over the period of time covered by this study, barge rates have generally increased in response to increased demand for barge services and increased costs. At the same time, improvements in barge service and general economic expansion have led to continued gains in the volume of goods shipped by barge.

Simultaneously, the demand for rail transportation has been affected by increased competition from air freight, motor transportation, and barge lines. As a result of these competitive changes and technological improvements, rail rates in the years covered by the study have generally been falling. Thus, increasing barge flows have been accompanied by increased barge rates and decreased rail rates."

§ 12.80.34 *Advancing the 50-year life span of the project from 1970-2020 to 1975-2025 is not valid justification for increasing transportation benefits.* The only basis for the big change in transportation savings from FY 1969 to FY 1970 is a change in the base for the time period for this project. Prior to FY 1970, the relevant time period for the purpose of discounting benefits was 1970 to 2020 (the original dates were 1965 to 2015). However, in FY 1970, the base was moved from 1970 to 1975. Thus, the relevant time period now for discounting transportation benefits is the 50 year period from 1975 to 2025. The results of moving the time period up by five years is simply to apply larger growth figures at the end of the project. This accounts for the additional $1,209,000 increase in this annual benefit figure. This method hardly represents an actual change in transportation savings. By 1975 the original estimates will be about 20 years old, and will not have been changed to reflect relevant transportation conditions. In other words, the actual estimates are not for 50 years, but are for 70 years. Furthermore, as the rate of construction of this project continues to lag behind schedule, the claimed transportation benefits will automatically be increased by this base-advancing technique. If this really presented a true picture of the project's benefits, then it would be reasonable to decrease project funding in order to increase the benefits.

§ 12.80.40 Areas to profit from flood control benefits are not specified.

The Corps of Engineers' claims of $289,000 per year for flood control benefits are divided between $121,000 for preventing flood damages and $168,000 for increased land use. The areas to be protected are difficult to locate and assess because maps or descriptions of the precise areas have apparently not been made public. Canal proponents suggest that the "hydraulically inefficient" natural Oklawaha River must be channelized if only for the benefit of flood control. In the light of the relatively small flood control benefits of $121,000 per year, it is doubtful if the expenditure to channelize the Oklawaha would be justified by accepted economic standards. Ecologists find the channelization proposal intolerable because of the damage that it would cause to the Oklawaha River. They contend that the meandering river with its existing flood plain and surrounding forest acting as a nutrient trap is naturally adapted to periodic flooding. They place a high value on the river's natural flood control qualities.

§ 12.80.50 The recreational benefits are at total variance with biological facts.

The reserviors will not be useful or desirable for recreation on a sustained basis. This statement is supported by the papers in this report dealing with water weeds, water quality, aquatic life, and wildlife and vegetation. This statement is also supported in the Florida Game and Fresh Water Fish Commission report (March 16, 1970) and the Federal Water Pollution Control Administration report, "Pre-impoundment Studies of 1967."[9]

An illustration of the economic effects due to ecological degredation is found in Lake Apopka, one of the lakes in the headwaters of the Oklawaha River. What was extimated as a $1,000,000 per year sport fishing industry is almost non-existent today. The assumption that lakes in Florida with stable water levels, nutrient-rich water, and constant re-supply of nutrients will produce high quality recreation for many years is grossly in error. Therefore, the claim of $3,142,000 annual benefits for recreation associated with the Cross-Florida Barge Canal is grossly inflated.

§ 12.80.60 The land enhancement value is inflated.

Between FY 1970 and FY 1971 the average annual value of land enhancement changed from $665,000 to $881,000, an addition of $216,000 per year. The only reason for this addition is attributed to inflation in real estate values associated with land enhancement benefits. The 6 per cent interest rate used to determine the value in FY 1970 was increased to 8 per cent in FY 1971. This is another example where the analysis has been "updated" only to reflect additional benefits, but in turn such "updating" has not been applied to other costs or interest rates.

§ 12.80.70 No value was assigned to the Oklawaha Regional Ecosystem.

No cost has been assigned for the destruction of the Oklawaha Regional Ecosystem. This is in direct conflict with existing government policy. The subcommittee on Evaluation Standards has stated:

> "A part of the value of any reduction in recreational use or fish and wildlife production may be measured in the same manner described above for increases in use or production. In addition, there may be other adverse effects which are important from a resource conservation standpoint and are not fully measureable under the procedure described above. Examples of such intangible effects would be the elimination of the last elk herd in a particular state, the destruction of any unusually scenic area, such as a portion of a national or other public park; or the destruction of an historically important site."[10]

The Oklawaha ecosystem is an irreplaceable economic resource. It derives its value by its very existence. The argument that non-commercial use of such natural resources represents no economic value is simply an erroneous assumption. Much re-thinking concerning how such resources are valued seems in order.

On the basis of the preliminary investigations in this paper, it is strongly recommended that a thorough re-study of the economic justifications for the Cross-Florida Barge Canal project be conducted by a neutral group of professional economists.

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§ 12.81 Observations on Cross-Florida Barge Canal Lock Design Much has happened to cargo transportation since 1941 to render the current canal lock design specifications obsolete. Technologically improved barges and tugs have resulted in increased bargetow size. Trends in barge transportation are encouraging construction of huge new barge carriers (*Lash*, or lighter-aboard ship carriers) that are capable of trans-Atlantic oceanic travel and have drafts of 16 to 18 feet. Other modern barges exceed the Cross-Florida Barge Canal depth of 12 feet by even greater margins. These new giant barge transports obviously dwarf the existing barges for which the Cross-Florida Barge Canal was designed. Furthermore, a variety of speciality barges soon to start operating in Gulf waters are too large to pass through the canal.

The lock design specifications in the Corp's 1942 report called for the construction of five locks, each 75 feet wide and 600 feet long. Subsequent design modifications increased the lock dimensions to their current size of 84 feet wide by 600 feet long. Three of the five locks planned for the canal have been completed to date and no changes have been announced for the construction of the other two locks despite the apparent barge transport industry trend toward their probable obsolescence. The barge transport industry itself as well as the Corps has recognized the problem of lock-inadequacy in several recent publications. On most of the major waterways, including those which the Cross-Florida Barge Canal is supposed to complement, such as the Ohio, 600-foot locks have been found to be inadequate. In its summer 1969 publication of *Water Spectrum*, the Corps of Engineers states,

> "With their added horsepower the new boats handle loads twice as long as the 600-foot locks, resulting in tows having to be broken and put through the locks in two sections. This double-locking, taking up to two hours, threatened to strangle further development in the Ohio Valley."

U. S. Senator Steven M. Young speaking for the 1969 National Waterways Conference and subsequently published by that body cited lock-size obsolescence as justification for further waterways expenditures. Senator Young, Chairman of the Subcommittee of Flood Control—Rivers and Harbors of the Senate Committee on Public Works, said,

> "Meanwhile, however, the navigation works and channels of our rivers and canals remain at obsolete, pre-war dimensions. The navigation system of the Ohio River, now only partially modernized, was completed in 1929. Its structure and dimensions are woefully out of date. Most of the system of the Upper Mississippi River, between Minneapolis and St. Louis, was completed some 30 years ago, and that of the Illinois River in the same period. Barge tows a quarter of a mile long have to be repeatedly broken up to get through 600-foot (or smaller) locks of these major rivers. Many hours are lost waiting for access to one-way lock installations. Moving modern vessel units through the antiquated passages is like compressing superhighway traffic into an old fashioned two-lane country road—with occasional one-way traffic."

Serious question exists concerning the future utility of the now-completed canal locks. It remains to be seen whether the project "costs" will feel the impact of yet another increase should the project be continued—this time for renovation of locks that are woefully obsolete and inadequate before the first barge navigates from Inglis to the St. Johns.

§ 12.90 In Conclusion (By Martin Mifflin*)

A fundamental characteristic of most water resource projects is that they are irreversible once the choice of resource alllocation has

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been made. This is true for the Cross-Florida Barge Canal. In other words, once the project is implemented, more than hydrology changes. Socio-economic changes are induced, as well as legal constraints surrounding the new activities in the region. Further, whether or not the project proves to be beneficial, it usually demands continued efforts in the same general direction. For example, when we build one segment of a navigation system it becomes an argument for the completion of missing links. We believe, therefore, that it behooves the scientific community as well as the action agencies of the Federal Government to evaluate new projects very carefully well in advance of their actual implementation. This evaluation must include *all* aspects, not just engineering concerns and piecemeal economics. The failure to make comprehensive evaluations is the underlying reason for this report and associated studies.

Large water resource projects became common in the United States in the first half of the 20th Century. Initially, most were conceived as single purpose endeavors to accomplish a basic objective such as providing irrigation water, generating power, or reducing flood losses. With time and experience, it became apparent that most large-scale manipulations of water resources had broader effects than accomplishing the primary objective. They usually served other purposes as well and often became more attractive to a broad spectrum of the public because of such unplanned functions. Thus, there developed the concept of the multipurpose project, where each anticipated benefit was identified and contributed to the justification of the project.

It was also recognized early in the history of their development that water resource projects entail certain costs beyond the obvious expenses of construction, maintenance and operation. These "costs" are the environmental trade-offs necessitated by the projects. These also have generated public interest in many projects, but even to the present day these environmental trade-offs, or opportunity costs, usually are not evaluated nor even discussed publicly by the action agencies charged with the projects. The fact remains that once the water resource is allocated to the project, little can be done about these undesirable environmental costs. Action agencies are quite aware that it matters very little how valuable the original environment and water resources were once they have been physically changed by resource manipulation. Thus, if an entire salmon run is have been very carefully evaluated not only in terms of benefit/cost ratio (which is designed only to determine the most desirable of several projects with respect to apparent, but arbitrary, economics), but also with respect to long-term social needs. It is our contention that such an analysis has never been attempted in the case of the Cross-Florida Barge Canal and that it cannot be performed in an unbiased manner by federal agencies whose business is constructing water control structures. By nature, the Corps of Engineers believes that conservation of water resources requires man-made structures. This has proved false in so many cases that the reputations of such agencies as the Corps and the Bureau of Reclamation have suffered greatly, both in the academic world and in the eyes of the general public. The Cross-Florida Barge Canal seems to be a prime example of how such a reputation is earned.

destroyed by a high dam, if thousands of acres prove unsuitable for the irrigation that was originally planned, if flood damage continues or increases, or if ground-water conditions are markedly changed, it really makes little difference. Even gross failure of a project often need not be recognized or admitted, because it cannnot be reversed. In other words, we are stuck with the project, because it is irreversible, and there is generally some benefit stemming from the project upon which public attention can be focused.

These benefits, however, do not necessarily equal the long-term benefits foregone because of the very costly nature of the "feedback problems" and the changing needs of the society that the water resources must serve. For example, at the time a project is conceived, the need of the region might be recognized as navigational development. However, 30 years later the economy of the region and the nation may have changed so materially that unhampered, pristine water resources are much more valuable than navigation. This appears to be the case with the Cross-Florida Barge Canal. Tourism has become the state's leading industry, and with this shift in economy has come an unprecedented demand for a quality environment. The scarcity of unpolluted and unmodified rivers within the state demands the preservation of the water courses which so far have escaped "development."

This discussion would be incomplete without a brief consideration of the philosophy of federally sponsored water resource projects. Our democratic society requires that welfare criteria be met as equitably as possible when federal funds and resources are expended on water resource projects. Briefly stated, this principle requires that resources be put to the best possible use for all the people. This requirement is best evaluated by examining the well-being of the public as a whole. Ideally, all the people should benefit from the project. Practically, this is generally impossible to establish, so we look to see if some segment of society benefits without another segment of society incurring damage. We might say that the project is good and desirable if it meets these demands. However, if some segment of society benefits at the expense of another segment of society, then the project must be very carefully evaluated to insure that a basic mistake in resource allocation is not made. It is no secret that the Cross-Florida Barge Canal has been opposed vigorously from its earliest inception. Thus, it seems that it should