Dykelands

Demise of the Garden of Acadia

by David Patriquin

There are 80,000 acres of dykeland in New Brunswick and Nova Scotia. Can they survive tidal-power barrages? Dalhousie University biologist David Patriquin describes why some of the Annapolis River dykeland farmers are concerned.

"The coast of the Bay of Fundy", wrote John Young referring to the dykelands in AGRICOLA'S LETTERS, "is unquestionably the garden of Acadia." Today the dykelands continue to produce two to four tons per acre of hay with nary a grain of fertilizer, and where special drainage structures are installed, produce amongst the highest yields in the province of corn and certain grains with half or less of the conventional fertilizer use. In spite of assurances to the contrary, dykeland farmers on the Annapolis River are becoming increasingly concerned that this productivity may not be maintained after the Annapolis River Tidal Power Project (TPP) goes into operation in 1983.

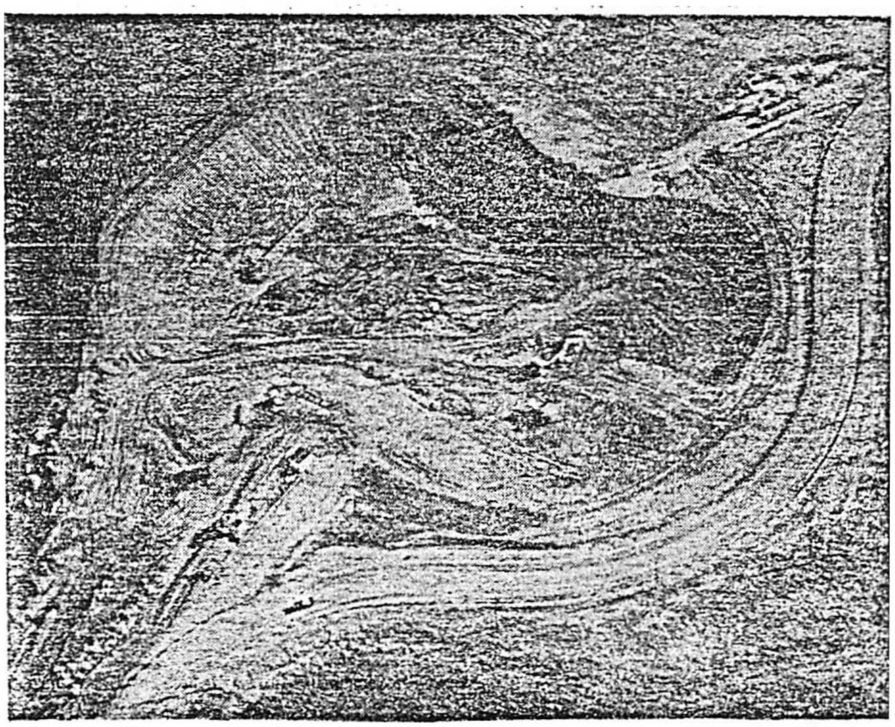
Dykeland fertility

The dykelands are the most fertile and potentially, the most productive lands in Nova Scotia. The first settlers recognized this; the dykelands WERE Nova Scotian agriculture in the 1600s and early 1700s, producing 50 bushels of wheat to the acre, flax, vegetables, and providing pasture for cattle. Agricola (John Young) recognized this in the last century: "There is thus a natural order of fertility dependent on the laws of the universe ... At the head of this order stands confessedly SEA MARSH, next FRESH WATER INTERVAL, then LOAM, and towards the foot CLAY and SAND." A local soil specialist remarked in 1976, "These (dykeland) areas now a part of the agricultural land base, can, when developed to their potential, play a key role in agricultural food production in this province. After all, 30,000 acres producing a ton and a half of wheat would provide more than double our present total grain production with a very small increase over present fertilizer use."

This fertility is due to the presence of silts reclaimed from the sea. Nutrients leached from the uplands by incessant rains are washed to sea where a kind of reverse weathering occurs and mineral rich deposits formed. Said Agricola, "SEA MARSH is a compound prepared by the laws of Nature of the insoluble and fine particles of sand, limestone and clay carried by the rivers from the dry land; mixed up with the calcareous earth of shells, and enriched by the putrescent remains of the vegetables and animals which lived and decayed on it. It is so fat, that in many parts of this Province marsh mud is employed as a manure, and is experienced to be highly beneficial on many of our uplands." A recent report cites values of "available" potassium, phosphorous, calcium and magnesium which are two to eight times the typical values of upland soils; the total reserves in the mineral rich silts are much greater still.

Removing the limitations

The Fundy marshes occur in the upper third of the intertidal zone; dykes are built to hold out the sea water. The first dykes were made of sods which sprouted and stabilized sea walls built



An engineers' dream could create a farmers' nightmare, warns Dalhousie University biologist David Patriquin. Above, work proceeds on the Fundy Tidal Power project dam at Annapolis Royal, N.S. When completed, the dam will hold water higher than normal against hundreds of acres of quality farm land protected by modest dykes along the Annapolis River.

Photo and map reproduced from Professional Engineer of the Association of Professional Engineers in Nova Scotia, Vol. 21, No. 2

around a few acres at a time; the sea walls held back the rising tides, while a clapper or sluice gate built across the main creek opened on the falling tide permitting fresh water to drain. In time barrages were built across larger creeks and finally across river mouths as at Annapolis today, permitting protection of large areas by a single gate, but the principle remained the same: hold back the sea water on the rising tide, and permit fresh water to drain on the falling tide. Within a few years of reclaiming marshes by such means, salts are washed out of the surface horizons sufficiently to permit growing of salt-sensitive species.

The second factor to be ameliorated is water saturation of the soils. Dykeland soils have a shallow water table and drainage tends to be slow.

About 50% of the volume of a soil is normally taken up by pores. The larger "gravitational pores", which range in size from invisible to visible, drain by downward gravitational movement of water. It is important that these drain quickly because then they are filled with air which the plants need to breathe; if they remain filled with water, oxygen is depleted within a few hours and damage to the crop can ensue. Water in the smaller "capillary pores" does not drain by gravitation, but stays there held by capillary forces in much the same way that water is held in a paper towel or face cloth against gravity. This water is the "plant available water" that is drawn upon by plants long after the rain has stopped and the gravitational pores have emptied. Since plants need both water and air, you want water-filled and air-filled pores in about equal proportions. The dykeland soils, because of their fine, uniform texture and lack of much structural aggregation are better than average for holding water, but worse than average for aeration.

In the traditional "daled" marsh, drainage of gravitational water was enhanced by provision of closely spaced (15 to 23 meters) open ditches. In the modern "landforming" systems, ditches are more widely spaced (38 to 110 meters), and there is some crowning of the intervening land. This results in rapid removal of surface water, but the water table tends to rise, and drainage of gravitational water becomes poorer towards the center, and generally subsurface drainage is not fast enough to allow growth of crops requiring well-aerated soils.

Rob Warren was the first farmer in the Maritimes to employ subsurface drainage in the dykelands. On the Belleisle marsh (Annapolis River) he constructed a system of the sort in use in England, consisting of mole drains at two to three feet depth, leading into tile drains which in turn empty into ditches. This arrangement allows a large expanse of uninterrupted field, tempers rise in the water table, and most importantly, provides for rapid drainage of gravitational pores.

Warren constructs steep-sided, narrow ditches to permit installation of the tile drains. These take up less space and encourage more rapid movement of water than do the gently sloped, broad ditches of the landforming systems. The latter, Warren maintains, belong in the uplands where you want to slow water movement to reduce erosion; in the lowlands, you want to increase water movement.

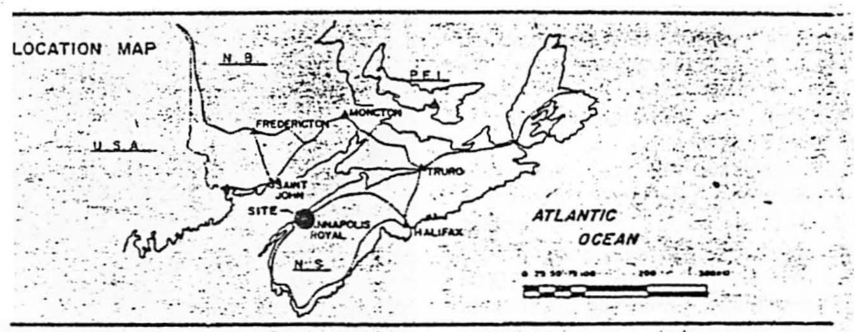
A remarkable property of this system is that not only is the drainage rapid enough to render the soil suitably aerated for cultivated crops, but the water table remains shallow enough (as it must also in the landforming systems) to subirrigate crops. Water rises above the water table by capillary movement up the smaller pores in the same way liquid moves up a wick. The combination of effective drainage and subsurface irrigation results in quick drainage in the spring (giving higher soil temperatures, and permitting working of the soil in April), good aeration, efficient use of fertilizer, and always adequate water. Warren's land is unquestionably some of the most productive in the province. He produces all of the feed for his dairy operation, including corn, cereals and faba beans, and this now saves him more than $5000 a month, a commendable achievement in a province where 80 percent of feed grains are imported. Even without the sorts of improvements that Warren has made, which do require considerable expenditure and care, the dykelands are a valuable resource yielding as they do, two to four tons per acre of hay year after year, generation after generation without use of fertilizer. The dykeland farmers are understandably reluctant to give this up.

How will the Tidal Power Project affect dykeland agriculture?

It is most important to recognize that the function of the Annapolis barrage will be fundamentally different: presently the sluice gate closes on the rising tide, and opens on the falling tide, but with operation of the TPP, it will do just the reverse.

That is, it will open on the rising tide to let sea water in, and then close on the falling tide so that a hydrostatic head is maintained to operate the generator which will operate when the water is flowing out, not in. This will result in a higher maximum water level behind the barrage, at least three to four feet above the current maximum; in increased duration of high water levels in the river; and in a much greater salt loading of the river.

The consultants responsible for considering the potential impacts of such changes on the dykelands concluded, "increasing the maximum levels to 1.83 meters (six ft.) should not have a detrimental effect on the present moisture regime and chemistry of the marsh soils provided that the maximum elevation in the ditches will not be less than one meter below the land surface during the growing season and that the surface will not be flooded with brackish water." It would be comforting if that statement were based on precedent or on detailed study, but it is not. The assessment did not include consideration of the increased duration of high water, increased salt loading, the types of crops grown, depth of well aerated soil, evaporative movement of salts, effects of water content on the thermal regime, or of variation in such factors through the year. Apparently the only consideration was that of drainage of surface water.



The lack of consideration of these other factors is remarkable, as questions relating to aeration and salinization are normally of primary concern in design of drainage systems for low lying land, even where the inundating water is not saline!

In a subirrigated situation the depth of well-aerated soil is less than the depth of the water table because a "capillary fringe" extends above the water table (see diagram). The lack of trees on the dykelands is evidence of the limitation of plant growth brought about by the shallowness of aerated soil. As well as limiting depth of aeration, capillary movement of water above the water table and evaporation of this water result in a seasonal accumulation of salts in the upper horizons. Even the oldest of reclaimed marshes exhibit an efflorescence of salts after dry weather in summer. Fortunately, under the present operating regime, river discharge and water tables are lowest in mid to late summer when rooting depth is greatest and the creek water saltiest. But with operation of the TPP, high river levels will be maintained throughout the season, and in summer those will be achieved by letting more seawater into the river — precisely when the crops are most susceptible.

The consultants reported creek water salinities of up to 0.1 percent. Creek water samples taken by Rob Warren in the summer of 1980 had values going over one percent, or one-third the strength of sea water — 10 times those measured by the consultants, and 20 times the level (0.05 percent) at which most crops begin to be affected. With operation of the TPP, they will be higher still, and only one meter below the surface. How deep should the water table be? Conventional recommendations indicate one to two meters when the water is not saline, and two to four meters (six to 12 feet) when the water is at all saline!

Why have these concerns not been recognized?

Certainly, the nature of the problem was not anticipated. Federally-funded projects are subject to a federal "environmental assessment review" but only if it is suspected that there will be significant impacts. In this case, a bureaucratic judgment was made that there would not be significant impacts, thus allowing federal monies to be forwarded without a rigorous federal review, and the assessment was restricted to a 3-month, largely theoretical study in the fall of 1979.

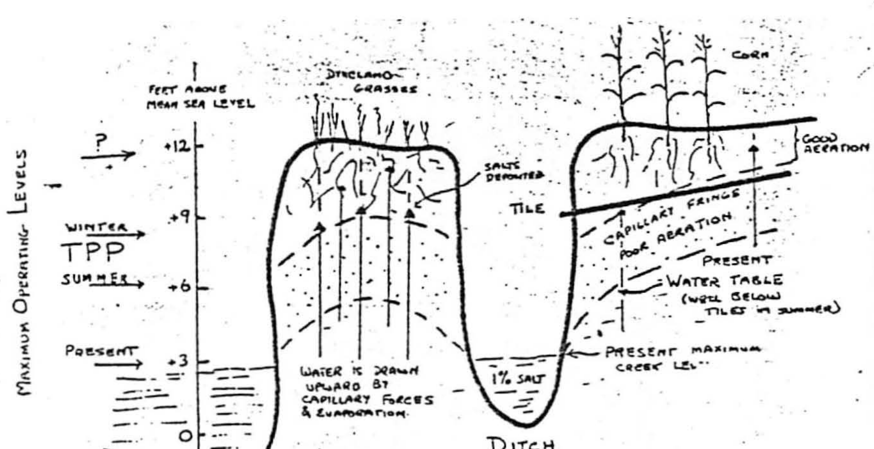
The terms of reference for the project, as they have been variously stated, left little room for consideration of the possibility that there would be serious impacts because if there were, the project would be scotched: "acceptance of the project is conditional upon, amongst other things, determination that the proposed project will not have unacceptable effects on the present biophysical or social environments (and establishment that) a tidal power project can be built in harmony with the environment." In other words, it was to be an all or nothing approach, and that it was to be "all" was evident from the beginning ... turbines were ordered before the assessment, such as it was, was released.

The consultants' preliminary conclusions, made public at Annapolis on December 19, 1979, indicated a total unawareness of potential impacts: "there are indications the project's impacts on agriculture, marshlands, erosion and wildlife will not be significant ... studies showed that present agricultural use will be compatible with the tidal power project if water elevations are properly managed, and salt water intrusions will not occur." Following public objections to that conclusion and to the experimental raising of the river to determine elevations, the viewpoint changed from one of "no impacts" to admission that lowest lying lands (those whose surfaces would be less than one meter above the maximum operating level) would be affected and would require special protective structures (as yet undefined). The affected area, according to the consultants, is only 186 acres but if areas lying higher than one meter above maximum operating level are affected, a much larger area will be involved (a small increase in height corresponds to a large increase in surface area affected). Certainly impact will not be restricted to the tiled lands of Rob Warren.

In allowing construction of the project to proceed, the Minister of Agriculture (N.S.) directed that "it must be physically demonstrated that damage to agricultural lands will not occur as a result of the tidal power project." What is particularly worrisome is the apparent lack of any effort so far to obtain appropriate baseline data against which to assess potential impacts. The environmental assessment was released, and the project officially begun, in April of 1980. No baseline studies were conducted in 1980, and as yet, the consultants responsible for carrying out the baseline studies have not been seen on the dykelands. Climatic and soil conditions, and consequently crop yields, vary tremendously from year to year and place to place. Large numbers of crop samples are required to assess change in productivity, and many environmental observations would be required over several entire years to determine the parameters of those changes to determine how the still theoretical protective structures would have to be operated to protect threatened land.

Will it be up to the farmers, as they have already been told by one elected official, to prove damage? The Environmental Advisory Committee responsible for approving (or not) the baseline studies and associated recommendations, does not include a marsh owner, and there is no means for presenting conflicting views to this committee. Only the Tidal Power Corporation has direct input to this committee, and their interest is in seeing the maximum power generated, which means operating at the maximum possible levels, perhaps even higher than those cited now.

The lack of objectivity with respect to



D. Patriquin

DIAGRAMMATIC ILLUSTRATION OF SOIL AERATION, UPWARD MOVEMENT OF WATER AND SALTS, AND ROOTING OF CROPS ON THE DYKELAND IN MID TO LATE SUMMER. The depth of well aerated soil is limited because of the shallow water table, and because the fine textured soil draws water above the water table in a "capillary fringe" (stippled); this water is not removed by tiles. Salts are deposited at the upper edge of the fringe where water evaporates. When the tidal power project goes into operation, the water level will be at least 3 to 4 feet higher, and the water saltier, resulting in reduced depth of well aerated soil, and in increased salinization of surface horizons.

potential agricultural problems is worrisome, but what about tidal power itself? Will barrage work? What will happen to all that suspended sediment that the Fundy tides carry with them when they make their way up the basins? Now most of it goes back on the outgoing tide. But put in a barrage, let the water in and then stop it dead, what will happen? I have not been able to find a geologist or sedimentologist who will give a reassuring answer. The mudflats by the Avon River Causeway are awesome evidence of the ability of the tides to transport mud, and to lay it down where they were not expected to. The only large tidal barrage scheme in existence — the French system on the River Rance — is reported to be showing premature wear; installed in 1966 and expected to last for 30 years, it is now expected to be good for only 15, and plans for larger schemes are reported to have been suspended.

In any case, the Federal Government is not spending $50 million to develop tidal power. The turbine at Annapolis is being tested for its application in low-head rivers (that's why it works in only one direction) — not tidal barrages, but rivers — and if it is successful a plant to manufacture these turbines will be built in Quebec, not Nova Scotia. The Annapolis barrage is simply a convenient place to do the test.

The Annapolis River Tidal Power Project is not a demonstration as it is often called, but an experiment; we do not have precedent upon which to base our optimism that it will be compatible with dykeland agriculture, and common sense argues against it. In the final analysis, we must recognize that the dykes were constructed to keep salt water out, and to permit drainage of water and leaching of salts on the falling tide. The operations of the TPP are designed to do the reverse, that is to keep salt water in. If we are to insist on attempting to maintain agricultural productivity in the face of this fundamental fact, then let us be objective and open in our deliberations, and not leave either the burden of proving failure, or of bearing that failure, on the dykeland farmers. If the project IS a success, then it will likewise be clear to all.

There is no question that tidal power will ultimately be harnessed and that it can be done without environmental repercussions; but the harness would better be a submerged windmill than a barrage, and the product hydrogen, rather than electricity ... We can be blue eyed Arabs, and walk into the 21st century with our 17th century heritage intact — but it will require imaginative technology, not the brute force approach of tidal barrages.

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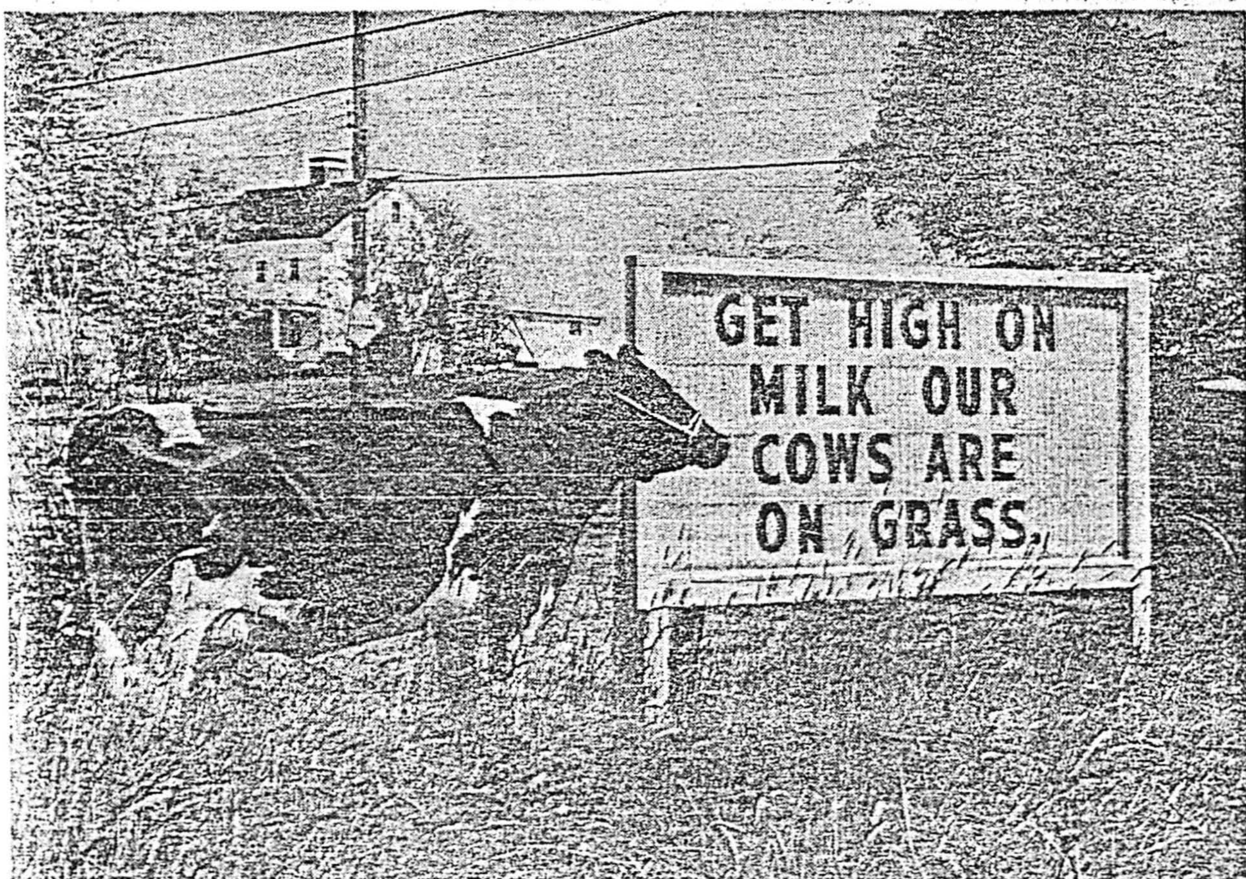
CAN DYKELANDS SURVIVE TIDAL POWER?... GIVE PANTYHOSE LONGER LIFE... BUILDING A STONE CHIMNEY
GROW YOUR OWN SEEDS...JUPITER, SATURN, BOOTES THE BEAR DRIVER...WHEAT GERM MUFFINS
PROLIFIC CHINESE PORKERS...MUSHROOM FORAGER'S BOOKSHELF...LOBSTERING...COUNTRY CLASSIFIEDS



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