# BLACK HAWK LAKE INLET STUDY

## SAC COUNTY, IOWA

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Des Moines, Iowa

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Black Hawk Lake -- Sac County, Iowa

## Purpose and Scope

The purpose of this study is to respond to a request for information about the characteristics of surface water flows through Black Hawk Marsh and the inlet channel to Black Hawk Lake.

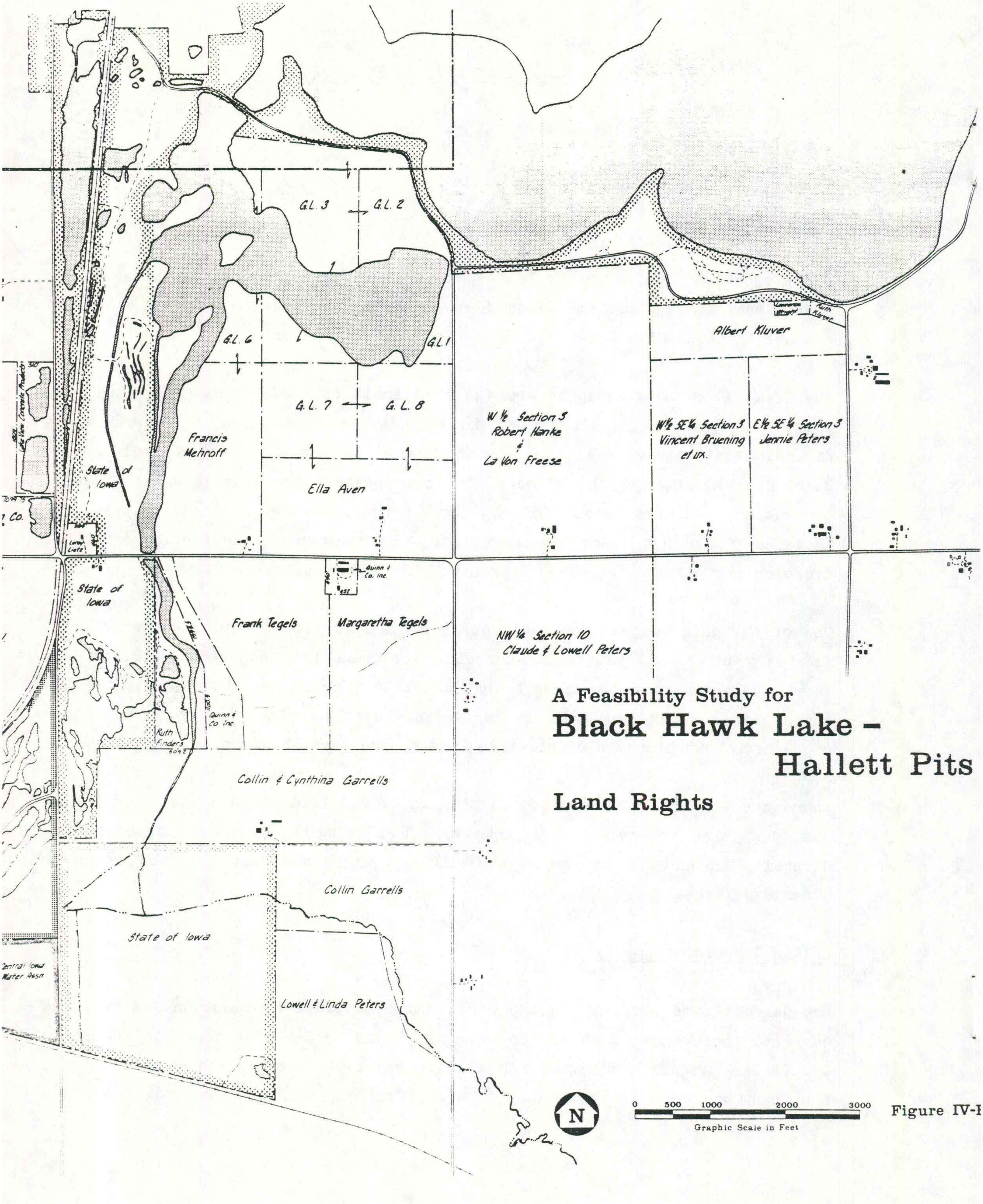
Specific items of discussion are (1) the feasibility of cleaning out the lake inlet channel through Black Hawk Marsh, (2) the feasibility of installing a diversion structure near the point where the lake inlet channel enters Black Hawk Marsh, (3) the effects of the proposed Black Hawk Lake/Hallett Pits connection, (4) the need for a comprehensive water management plan for Black Hawk Lake and Black Hawk Marsh, and (5) recommendations for improving the hydrologic conditions at Black Hawk Lake and Black Hawk Marsh.

One of the main reasons for the request for information about the inlet channel is for replying to Mr. Collin Garrels, who owns land adjacent to Black Hawk Marsh, regarding some concerns he has about whether or not the operation of the marsh and/or Black Hawk Lake is impounding water on his property. He also is concerned about blockage of his tile line(s) due to silt deposits.

There are also other interested parties who would like to know whether cleaning out the inlet channel to the lake and/or placing a diversion structure and diversion channel in the marsh would direct increased quantities of water to Black Hawk Lake.

## Collin Garrels' Property

Mr. Garrels owns property on the north and east sides of Black Hawk Marsh. He currently has concerns about the wetness of his property adjacent to the marsh and feels that the Conservation Commission can take steps to reduce or eliminate the problem. His explanation of the situation, and the Commission staff's




A Feasibility Study for

# Black Hawk Lake – Hallett Pits

## Land Rights

Figure IV-I

answers to his questions about the problem can be found in Appendices D, E, G, and J (Pages 93-96). Surveys of the area are included in Appendix P. Aerial photographs of Black Hawk Lake and the inlet area can be found in Appendix L.

The following appear to the Commission staff to be some of the concerns that Mr. Garrels has had at various times in the past:

1. The Conservation Commission staff supposedly improperly operates and maintains the Black Hawk Lake inlet channel on Commission property,

2. The Commission supposedly is responsible for the periodic flooding of Mr. Garrels' pastureland and the subsequent closure of field tile outlets on his property because the Commission allows silt and vegetation to build up in the inlet ditch below his property and in the channel that crosses Black Hawk Marsh,

3. The Commission is responsible for maintaining the Black Hawk Lake inlet ditch; therefore, it should presumedly be required to clean this ditch of any silt and vegetation restricting drainage,

4. For the past several years, Mr. Garrels has been experiencing flooding of a portion of his farmland seemingly due in part to changes in the channelization of the creek from its natural course through Black Hawk Marsh, and supposedly the presumed rechannelization was the result of efforts of the Conservation Commission.

5. A land survey that Mr. Garrels paid for reportedly indicates that an alternate channel can be dug through Black Hawk Marsh which would at least partially relieve the flooding of his property,

6. Mr. Garrels would like the Commission to clean out the channel, rechannelize the stream, or possibly allow him to do one of these,

7. It was presumed that the Commission staff had cut trees for damming up the stream at least two years in a row,

8. The Commission operations reputedly have backed water onto several other private properties as well,

9. In past years, water was backed onto private land for only "36 to 48 hours", but now stands on private property "for two to three months and even longer" and the water problem is worsening every year.

10. It has been claimed that in the past, before trees and other vegetation blocked the flow, Carnarvon Creek flowed freely and naturally kept its channel clean through higher velocity water flows, keeping Mr. Garrels' tile outlets free of silt.

11. The poor maintenance of the channel and the cutting of trees to dam the channel presumedly account for "90 percent of (the) drainage problem" on Mr. Garrels' property.

12. There are many others who supposedly also want to see the inlet channel cleaned out, but the Commission is preventing this course of action.

13. The blockage of field tiles by silt has been blamed for creating wet spots in Mr. Garrels' row crop ground.

14. Water that has backed up onto the Garrels' property, because of the silted-in channel and blocked field tiles, "has to seep into the ground and the time that it takes depends on how high or low the water table is."

15. Mr. Garrels has indicated that he gets a better crop in drier drought years than he does in years of average rainfall when his crops are drowned out.

16. A new channel is presumably starting to cut through the northeast corner of the game refuge where there is the least amount of trees and grass.

17. Mr. Garrels' pasture land along the inlet channel supposedly "is turning into a marsh ground."

18. The property of Mr. Garrels in question was described by him as "valuable farmland."

19. According to quotes of Mr. Garrels in a newspaper article, he has talked to federal, state, and county officials about the problem for over a three-year period, but has become frustrated in his attempts to get something done. "Everybody passes the buck," he said, adding that "nobody seems to want to do anything." (See Appendix G, newspaper article, "Collin Garrels Fights Flooding as Black Hawk Lake Recedes".)

20. Also in the newspaper article, it appeared that Mr. Garrels believed that the low water level problem in Black Hawk Lake could be eased if his flooding problem were taken care of. "Dredge this creek and the lake will get water," he said, pointing out that a 7,000-acre watershed supplies water to the creek (See Appendix G).

21. In the newspaper article, Mr. Garrels reportedly claimed that his efforts to dredge his property will not do any good if the Conservation Commission does not do more dredging. "The work should be done now while the creek bed is dry," he said, adding, "If we get a rain, we're done. It may be several years before we see the creek bed this dry again" (See Appendix G).

Conservation Commission staff members have taken several courses of action in response to Mr. Garrels' concerns, including the following:

1. After meeting and discussing the drainage problem with Mr. Garrels and his attorney, the staff agreed to remove an earth plug from the channel and to deepen the channel by one foot from the location of the plug, back approximately 1,200 feet, to where the channel enters state property. This work was agreed to because the staff wanted to be a good neighbor. It was pointed out at the time that the action was not to be interpreted as admission of any responsibility for the silting in of Mr. Garrels' tile

outlets. The staff presently maintains that this action did not significantly improve the natural flooding conditions that exist at the site.

2. The inlet area was surveyed by the Conservation Commission's Engineering Section survey crew.

3. A field investigation was done, the results of which are included on Page 29.

4. This study of the problem was conducted.

The Commission staff has made the following responses about Mr. Garrels' concerns:

1. Regarding the concern that the Commission has worsened flooding by changing the creek channel through the marsh, it has been pointed out that at the time of purchase of the Black Hawk Marsh property in 1966, the previously altered channel through the marsh was reestablished to near its original location from which it had been diverted by previous landowners in a futile attempt to farm the property.

2. The Conservation Commission wants to be a good neighbor and has no desire to cause any injury to his property. Although the Commission sympathizes with Mr. Garrels' problem, the operating staff has stated that the Commission does not appear to be responsible because the Commission owns and controls only a portion of the Black Hawk Lake inlet channel, the silt originates in the watershed above the marsh mostly from farming operations (including Mr. Garrels' farm), the topography of the property in question creates the marsh-type environment, and the Commission has done nothing to restrict the normal flow of water off of his property.

3. Mr. Garrels' proposed channel would have a detrimental effect on the water holding capabilities of Black Hawk Marsh by diverting its primary water source. The Commission should not arbitrarily grant him permission to excavate the channel or excavate an alternate channel.

4. Mr. Garrels' tile blockage problem had developed long before a temporary plug (now removed) had been placed in the channel to divert water into Black Hawk Marsh.

5. The portion of Mr. Garrels' property north of the marsh has historically been marsh land and is low enough in elevation in comparison to the lake that nothing can ever economically be done to prevent periodic inundation. Mr. Garrels has apparently agreed with this response at least once during one of the various meetings with our field staff.

6. If deepening the channel through the marsh improved drainage of Mr. Garrels' property, the effects would only be temporary.

7. The Conservation Commission is interested in purchasing the problem portions of Mr. Garrels' property at a fair price, comparable to the prices for other marsh land properties, but not at unreasonable "valuable farmland" prices.

8. One reason that Mr. Garrels' tile lines plug up is because they are set too low at their outlets.

As a result of reviewing past studies of and reports about this and related problems at the Black Hawk Lake inlet channel, and after reviewing surveys of the site as well as visiting the site first-hand, the following comments can be added to what has already been contributed by other Commission staff.

Because of the topography of Mr. Garrels' property, as indicated by U. S. Geological Survey maps and by on-site surveys, it appears that nothing can be economically done to prevent periodic inundation of his low-lying property adjacent to the lake inlet channel. The elevation of backwater from the lake depends on: (1) the effects of constrictions in the channel such as structures -- bridges, culverts, and the outlet structure beneath the county and park roads (see Appendix K) -- the cross-section of the channel, the vegetative growth, etc., (2) the amount and intensity of precipitation, (3) other climatic factors such as temperature, drought conditions, evaporation, and wind speed, (4) the storage potential of the groundwater aquifer, the nearby pits, and the lake, and (5) other factors which might affect runoff quantities (such as the moisture levels in the soil prior to precipitation or snowmelt). Estimating a reasonably accurate prediction about backwater effects would best be accomplished through computer modeling of the existing and proposed configurations of the inlet channel, lake, outlet structure, and groundwater aquifer, based on a complex collection of data and research. Such a detailed study, however, is beyond the scope of this study.

Mr. Garrels' concern about the recent "increasing" problem with poor drainage from his property seems to be based on his own personal experience with the property during the time that he has owned it. According to precipitation records and from discussions with field personnel, it appears that when Mr. Garrels first purchased the property in April of 1977, the Black Hawk Lake area was going through a period of statewide and localized dry or drought periods; he first began noticing the drainage problems when the climatic cycle returned to normal and/or wetter-than-normal conditions. Such subjective observations should not be the basis for a decision to take action that might be potentially damaging to the natural environment that is reestablishing at Black Hawk Marsh.

On September 6, 1984, the study area was investigated first-hand (see Page 29 of this report). Climatic conditions at that time were similar to those that existed at the time when Mr. Garrels wrote to the Attorney General in October of 1980, and when he was interviewed for an article that appeared in the September 16, 1981 edition of a newspaper that is published in Lake View, Iowa (see Appendix G). Observed water conditions at the site appeared to be nearly identical to those described by Mr. Garrels in his letter and to those pictured and described in the newspaper article. The conditions that Mr. Garrels attributed to the Commission staff -- water being backed onto his property by small log dams -- were more likely caused by beavers. He stated in his letter to the Attorney General: "In the last two years they (the state of Iowa) have even cut some trees to dam the stream up." "The poor maintenance of this ground and the cutting of trees to dam it up, we feel are 90 percent of our drainage problem."

Some of the physical characteristics of the Carnarvon Creek drainage basin are shown on Figures 1 and 2. The drainage slope decreases rapidly and begins to flatten out at approximately the location where the creek leaves Mr. Garrels' property and enters Black Hawk Marsh. The rapid reduction in drainage slope, accompanied by widening of the stream flow at this location, causes the water velocity in the stream to be reduced. With reduced water velocity, the stream tends to deposit silt at this location. Figure 3 shows that extensive alluvial deposits can be found in the entire inlet area of the lake. Due to the topography near the east side of the marsh, and also due to farming operations upstream, this area can be expected to have heavy silt deposits regardless of how deep the channel at this location might be.

The Commission does not appear to be obligated to change the channel from its present "natural" or near-natural location. In fact, the Commission would need to apply for a permit from the Iowa Department of Water, Air and Waste Management (IDWAWM) to change the channel or even to clean it out if the cross-sectional area of the channel is changed by more than 10 percent. According to a representative of the IDWAWM, they do not have a permit application -- and therefore no permit --on file from Mr. Garrels for the channel cleanout that he performed on his property.

The Commission not only is not obligated to clean out the channel or give permission for Mr. Garrels to clean out the channel, but should not allow the channel to be arbitrarily rechanneled or cleaned out in such a way that would be detrimental to Black Hawk Marsh.

The implication that cleaning out the inlet channel to Black Hawk Lake would be the answer to low lake levels in dry periods is incorrect. The more effective the channel is in draining the marsh areas, the more water would be lost during wet periods when runoff is discharged at the outlet structure. Then, during dry periods, there would be less water stored in the marsh area to recharge the groundwater aquifer that supplies the lake. During times of low precipitation, this aquifer has been shown, in engineering studies, to be the primary water source for the lake. During very dry periods, such as when the September 1984 field investigation was conducted, Carnarvon Creek has barely enough water to

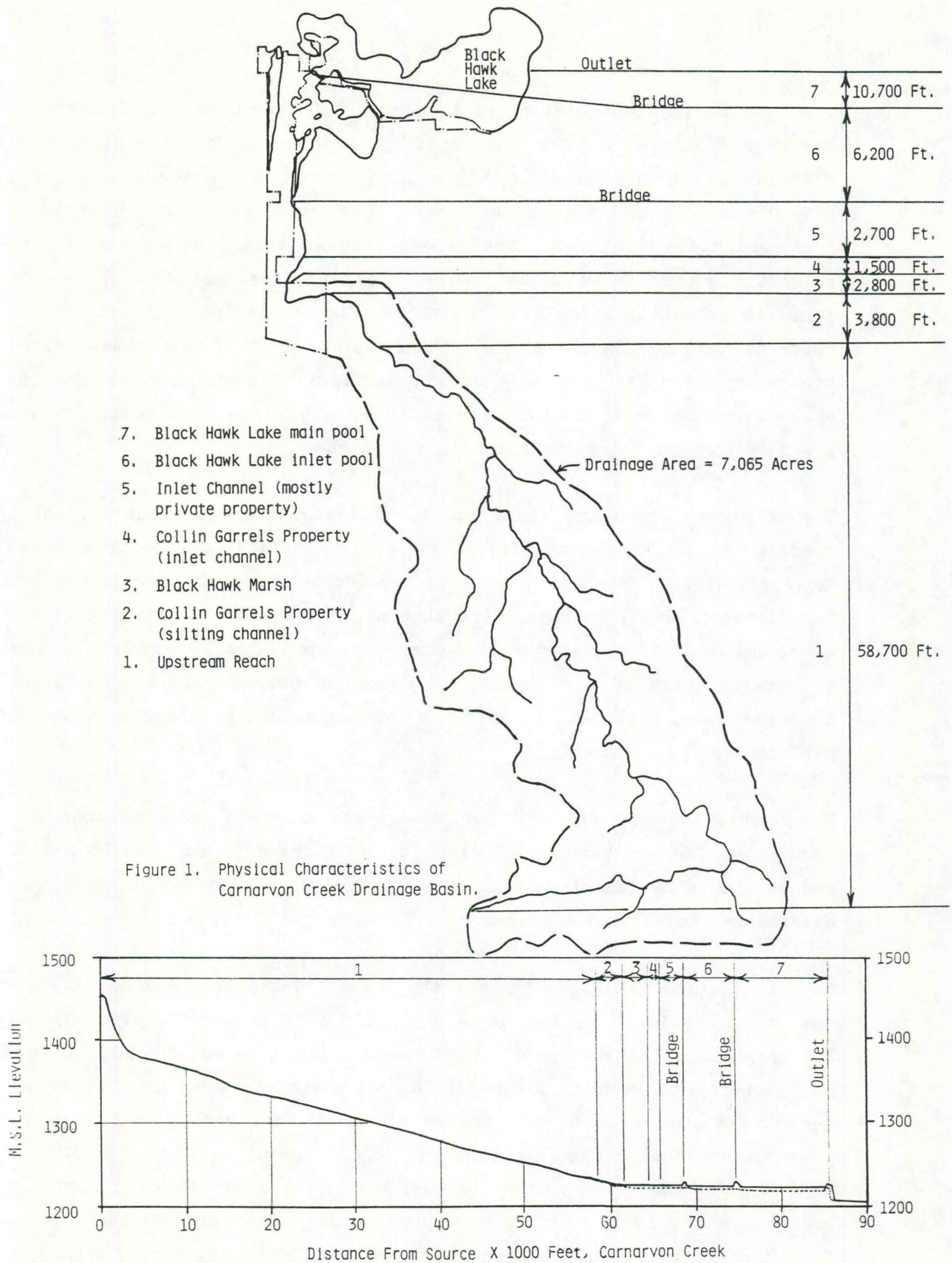



Figure 1. Physical Characteristics of Carnarvon Creek Drainage Basin.

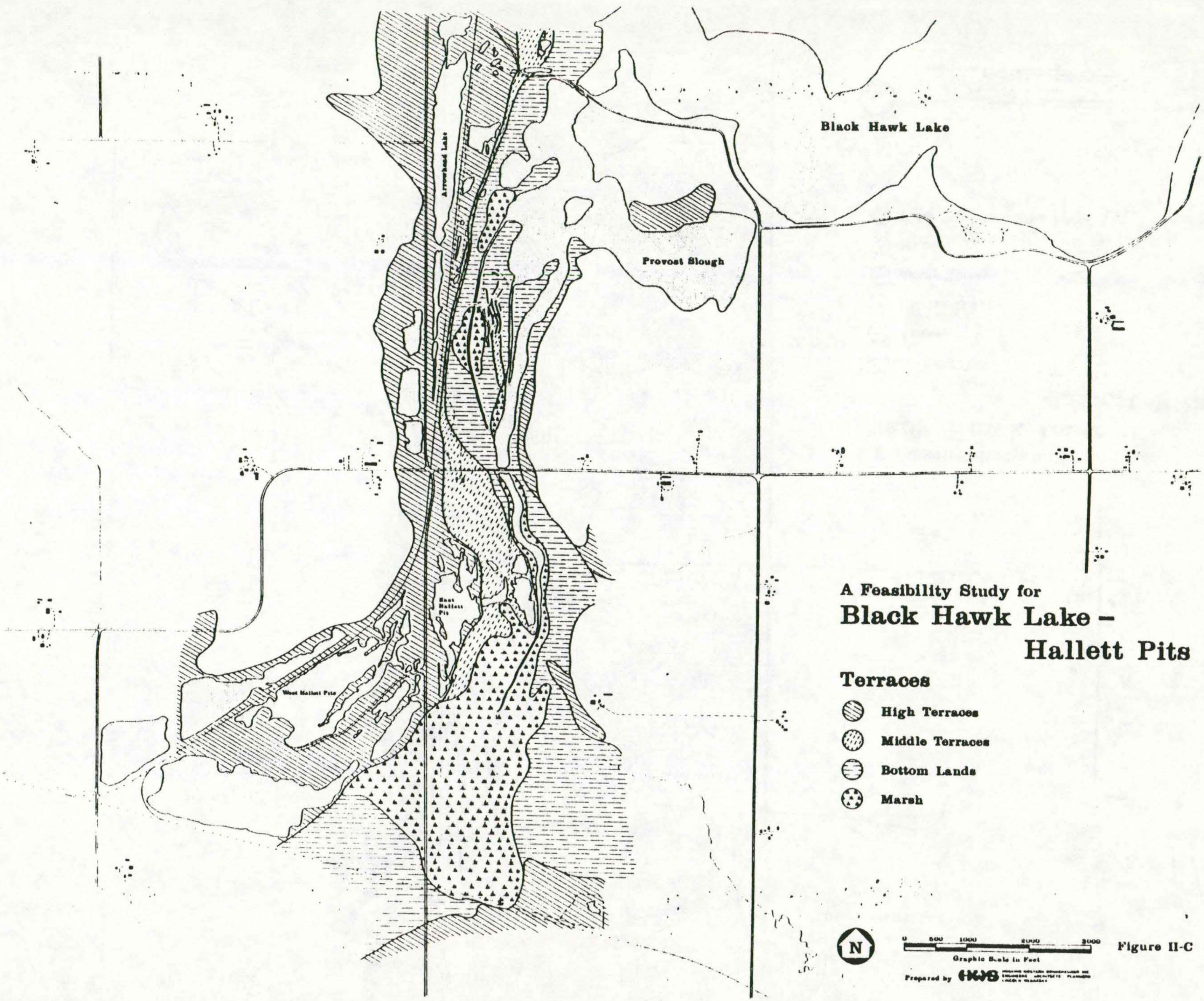

Black Hawk Lake
Arrowhead Lake
Provost Slough
West Hallett Pits
A Feasibility Study for
Black Hawk Lake - Hallett Pits
Terraces
High Terraces
Middle Terraces
Bottom Lands
Marsh
N
0 500 1000 2000 3000
Graphic Scale in Feet
Prepared by HWS
Figure II-C

Figure 2

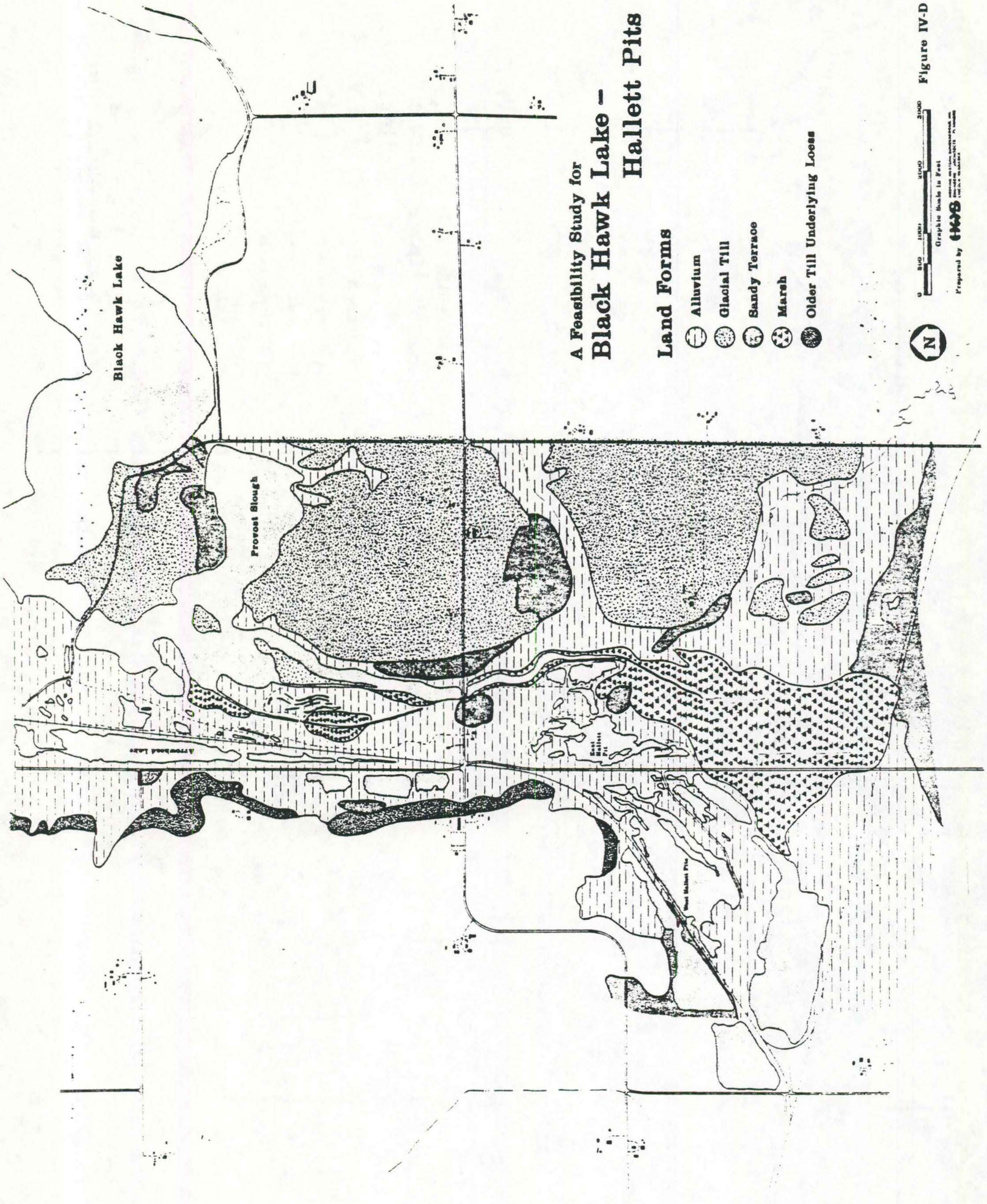

A Feasibility Study for
Black Hawk Lake –
Hallett Pits
Land Forms
Alluvium
Glacial Till
Sandy Terrace
Marsh
Older Till Underlying Loess
Figure IV-D
Black Hawk Lake
Provost Slough


Figure 3

supply the beaver impoundments in the channel on the east side of the marsh. The marsh, in September of 1984, was dried up and was not responsible for keeping water from flowing through the inlet channel to the lake. Based on observation, and examination of historical data, it appears that Mr. Garrels' concern -- that flooding of his property is due to improper operation and maintenance of that portion of the inlet channel on state property -- is unfounded.

Recommendations For Resolving The Collin Garrels Situation

If, to be a good neighbor, the Conservation Commission does anything to try to improve drainage from Mr. Garrels' property, this action should be limited to cleaning out the beaver dams and trapping out the beavers. This action may need to be repeated frequently to keep the beavers from reestablishing themselves.

The low-lying portions of Mr. Garrels' property, in particular those areas lower in elevation than approximately 1,230 ft. MSL, should be included in future purchase plans and development plans for the area. In various land acquisition proposals (which have not as yet ever been considered for adoption by the Conservation Commission), these areas, and other areas as well, have been recommended for purchase and development. Figure 4 shows portions of property that Mr. Garrels owns included in a preliminary comprehensive land acquisition proposal, submitted by Engineering for this report. If the properties were acquired as proposed, the area could be developed in a way that takes better advantage of the available land and water resources to improve wildlife management in the area as well as to improve the quality of Black Hawk Lake.

The acquisition of properties adjacent to Black Hawk Marsh should be done carefully so that the Commission purchases those areas that could be developed as marsh habitat, or might be affected by higher water levels as a result of the marsh development. The Commission may need to acquire the property that Mr. Garrels now has tile lines on, or compensation may be required for placing new tile lines at a higher elevation. Any solution that is adopted should absolve the Commission of the responsibility for keeping the tile lines open.

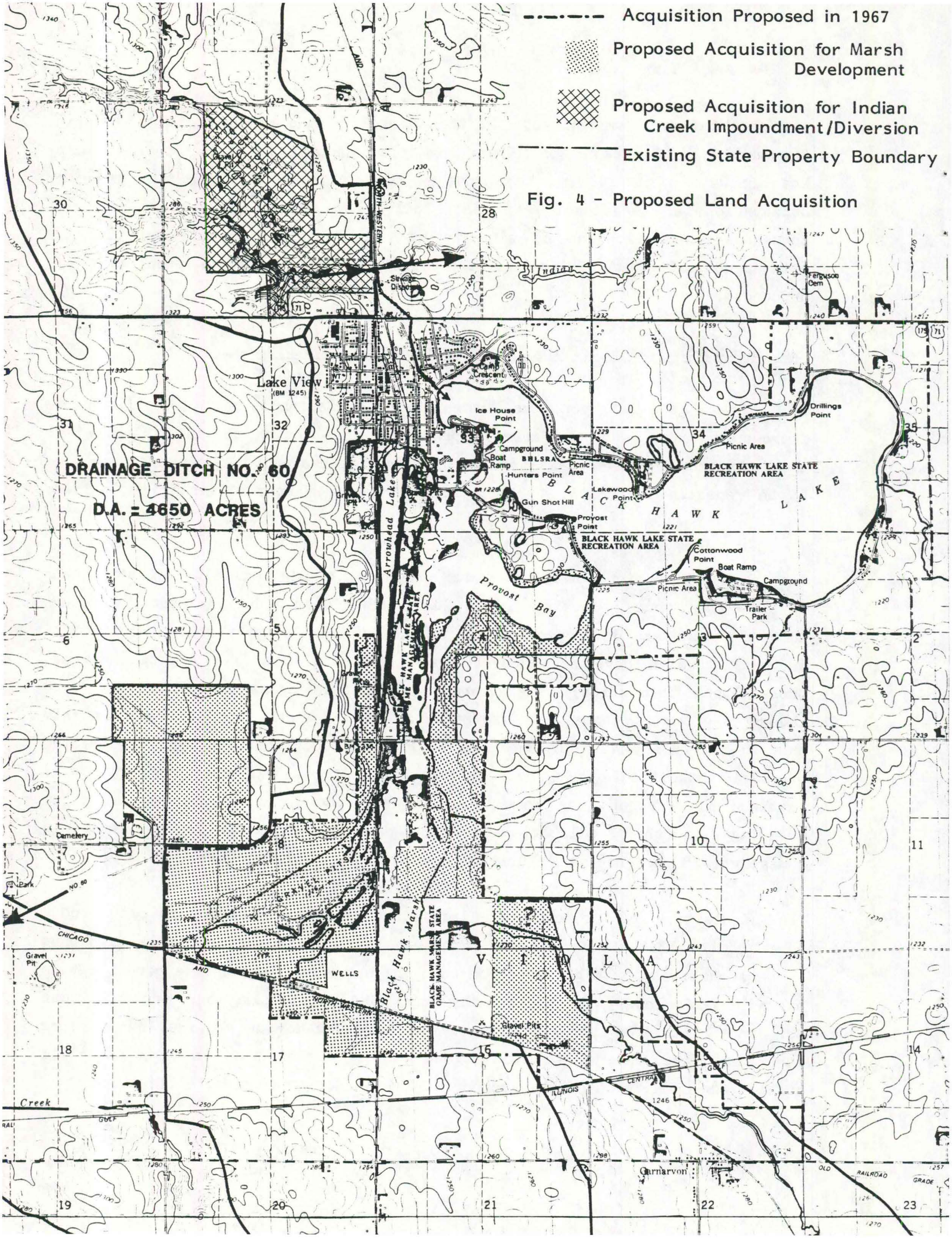


Fig. 4 - Proposed Land Acquisition

Black Hawk Marsh Diversion Structure

The second item of discussion concerns the feasibility of installing a diversion structure near the point where the lake inlet channel enters Black Hawk Marsh. The proposed method of operation would be to divert Carnarvon Creek around Black Hawk Marsh during dry periods when there is little rainfall and low creek levels, and then divert the flows into Black Hawk Marsh at wetter times when there are high flows in the creek. According to the June 14, 1983 project request in Appendix C, "There is feeling among the citizens in the Lake View community and Black Hawk Lake vicinity that, during times of low flow, the water goes into Black Hawk Marsh and the marsh acts like a giant sponge and water does not reach the lake. Therefore, lake levels fall. They feel that if there was some kind of a water control structure or bypass structure put in Carnarvon Creek at Black Hawk Marsh, the water could be shunted past the marsh or into the marsh. This would help maintain the water level of Black Hawk Lake during periods of low flow."

The opinion of the operating staff has been:

1. During times of low flow, there is not enough flow through the inlet channel to make any difference in the level of Black Hawk Lake.

2. Such a diversion structure does not appear to be feasible.

3. At times of high flow, such a diversion channel would not help speed the water on to Black Hawk Lake. "The land is so flat that what is really controlling the water level in Black Hawk Lake in periods of high flow is the outlet structure rather than any clogging or plugs in the inlet channel."

The construction of a diversion channel would require review by, and the approval of, the IDWAWM. Also, according to the Office of the Attorney General, "The state, of course, has no greater right to divert water from 'flowing in its natural course' than has any private person. If such diversion is necessary in the public interest, rights thereto must be acquired by the state, which may exercise its power of eminent domain to acquire the necessary rights"

(Appendix E). The Commission would also need to be able to compensate landowners, both upstream and downstream from the structure, in the event that there are any damages caused either by additional backwater or by increased water discharge. Even if such damages were not necessarily caused by the structure, it would probably be the burden of the state to prove otherwise.

The Commission operating staff might find it very difficult to always be able to change the diversion direction of the structure to accommodate sudden fluctuations in the weather. If the structure was diverting water past the marsh, landowners downstream from the structure might claim that additional water discharged during heavy precipitation and runoff had caused damage to their properties. Such damage claims might include increased erosion due to additional runoff, increased wave action erosion due to slightly higher lake levels, crop damage due to increased runoff, etc. Upstream landowners might claim reduced groundwater levels adjacent to the marsh, especially at the wells of the West Central Iowa Rural Water Association.

If the structure was diverting water into the marsh (this case most closely resembles present conditions), the landowner upstream from the structure (presently Collin Garrels) might claim that backwater from the marsh had caused damage to his property and/or crops. The landowner would claim that the damage could have been reduced by diverting the water past the marsh.

It appears that diverting water around the marsh would have very little benefit to the lake, and probably would have a detrimental effect. At present, the marsh area acts as a silt trap and as a water storage area. The water that leaves the marsh through seepage enters the groundwater acquifer and flows to several possible destinations, which include: (1) wells and subsequent withdrawal using well pumps, (2) gravel pits and subsequent outflow due to seepage, evapotranspiration, surface discharge, and withdrawals, and (3) Black Hawk Lake and subsequent outflow due to seepage, evapotranspiration, surface discharge, and withdrawals. Silt-laden water, diverted around the marsh during wet periods, would drop silt in the inlet channel and lake and then be discharged over the lake outlet structure. During dry periods, the water quantities in Carnarvon Creek are not enough to make a difference in the lake levels. Most of this water seeps into the ground and finds its way to the lake anyway, as shown by engineering studies which report that the main source of water for the lake is groundwater (Page 80, Appendix J).

A water diversion structure and diversion channel would not solve the backwater problems on Collin Garrels' property, would have little benefit to Black Hawk Lake, would at times have a detrimental effect on the lake, and would also have a detrimental effect on the marsh. It would require that the Commission acquire the low-lying portions of land above the structure (a portion of the Collin Garrels' property), and the low-lying areas below the structure, in particular those along the inlet channel. Otherwise, the state would be increasing its liability for any damage caused to property above and below the structure; the state would be altering the drainage pattern from natural flows (which the state cannot be held accountable for) to a Commission-controlled drainage pattern which adjacent landowners could claim as the reason for flood damage to their property. The state could also be held accountable for any flood damage downstream from the lake outlet structure if the diversion causes increased discharge rates.

Theoretically, discharges from the lake should only be increased during times when high flows are diverted around the marsh instead of into the marsh. However, there is no guarantee that the operating staff will always be able to respond to unexpected storms in time to change from diverting flows around the marsh to diverting them through the marsh.

Recommendations For Diversion Structure and Diversion Channel

A diversion channel and structure would (1) alter the natural drainage flow and place control of the drainage as the responsibility of the Conservation Commission, thereby increasing the liability of the state, (2) have little or no beneficial effects on the lake, (3) have detrimental effects on the marsh and probably, at times, on the lake as well.

Therefore, it is recommended that the diversion channel and diversion structure not be constructed.

Previous Studies Of Black Hawk Lake

Several studies have been done about Black Hawk Lake. These studies also contain information about the inlet to the lake and about Black Hawk Marsh.

One such study is "A Preliminary Study of Dredging Programs, Benefits, Costs, and Effects for Eight Iowa Lakes," prepared for the Conservation Commission in December of 1974 by Economic Research Associates and by Engineering Consultants, Inc. This study of costs, benefits, and impacts of dredging programs for eight Iowa lakes was commissioned by the Iowa General Assembly to assist in determining public policy with respect to dredging of the subject lakes, one of which was Black Hawk Lake. Excerpts from this study are included in Appendices H and N.

Another general study that includes information about Black Hawk Lake is the August of 1980 "Clean Lakes Classification Study of Iowa Lakes for Restoration" by the Iowa Cooperative Fisheries Research Unit and Department of Animal Ecology at Iowa State University. This study was carried out in response to the requirement that each state make a survey of their public lakes in need of restoration and/or protection and develop a priority ranking of the lakes for restoration projects in order to be eligible for Clean Lakes federal assistance after January 1, 1982. Excerpts from this study may be found in Appendices F and I.

A study that was done specifically about Black Hawk Lake is the "Black Hawk Lake/Hallett Pits Feasibility Study," completed in February of 1979. This study was prepared by Hoskins-Western-Sonderegger, Inc., a consultant from Lincoln, Nebraska, for the Iowa Conservation Commission. The study was conducted as a result of a strong local interest in providing a water connection between Black Hawk Lake and the gravel pits to the south of that lake. The study was authorized by the 1978 Legislature. The intent of the Joint Budget Subcommittee for that study was as follows: "Funds are appropriated . . . to accomplish a feasibility study of the costs and benefits of connecting Black Hawk Lake to the Hallett Quarry Pits. It is the intent of the Joint Budget Subcommittee that this study examine alternatives to accomplish this objective and propose a plan to the General Assembly no later than March 16, 1979. The plan should insure public access to the water areas."

Another study that was done specifically about Black Hawk Lake is the "Black Hawk Lake Restoration, Diagnostic/Feasibility Study" of January 1983, carried out by Iowa State University with funding from the U. S. Environmental Protection Agency and the Lake View Commercial Club. The purpose of this study was to come up with specific recommendations for a plan of action that would help restore the lake. Excerpts from that study are included in Appendix J.

A study of the potential for reestablishment of a marsh near the town of Wall Lake was conducted in 1944. This former marsh, which was connected to the same underground aquifer as Black Hawk Marsh and Black Hawk Lake, was drained away from the Black Hawk Lake area when a drainage ditch was installed in 1916. This study is included in Appendix M.

A group of proponents for the Black Hawk Lake/Hallett Pits connection have provided the Iowa Development Commission with some estimates on increased use and actual benefits to the lake which would supposedly accrue from the dredged connection. The Development Commission computed economic projections based on that information, and submitted a report (included in Appendix E). The report, however, is based on the false assumption that there will be no serious detrimental effects due to the proposed connection.

Aquifer Characteristics

A groundwater aquifer can be pictured as a great reservoir filled with water. The water in this reservoir moves from recharge areas of higher hydrostatic head to discharge areas of lower hydrostatic head. The hydraulic gradient is the slope of a line, usually measured in feet per mile, from the hydraulic head in the recharge area to the hydraulic head in the discharge area.

The amount of groundwater in storage and the rate of groundwater movement are governed in large measure by the character and structure of the rock in the aquifer. The floor of the valley where Black Hawk Marsh, Black Hawk Lake, and

Hallett Pits are located is underlain by large alluvial deposits of sand and gravel. Sand and gravel deposits, which have large, interconnected pore spaces or other openings, are capable of both storing and transmitting large quantities of water. The water table is that surface which coincides with the water levels in the lake, the marsh, the pits, and the wells that are all located in the water table aquifer.

As already mentioned, the water table aquifer functions as a reservoir. When the discharge exceeds the recharge, the amount of water in storage declines; when the recharge exceeds the discharge, the amount increases. Changes in the amount of water in storage are indicated by rises and declines of the water table. Periodic measurements of the lake levels or the water level in wells show whether a net gain or loss in storage has occurred in the aquifer.

The water table aquifers in Iowa are recharged principally by local precipitation. The most favorable periods for recharge are after the spring thaw before appreciable growth of vegetation, and again in the fall after the first killing frost but before the ground becomes frozen. Obviously, if precipitation is low during these periods, recharge will be low. Recharge is retarded, but not stopped, during the growing season by depletion of the soil water by evaporation and transpiration, and during the winter by frozen ground. Large amounts of precipitation during the summer months can be mostly consumed by vegetation and very little water reaches the water table, whereas smaller amounts of precipitation during March and April can cause a marked rise in the water table. Sometimes, however, during periods of extremely heavy precipitation in the summer months, excess water is available to recharge the water table aquifer. Also, if the ground is not completely frozen and the precipitation is in the form of rain instead of snow, recharge can occur during the early winter months.

Natural discharge from a water table aquifer is through springs and seeps and by evaporation and transpiration. The water table normally slopes more or less gently toward a point of discharge, such as a spring or stream, and the rate of groundwater movement is proportional to the gradient of the water table, among other factors. Therefore, as long as the water table has a gradient toward a discharge point, water is being continually discharged from the aquifer. This continual discharge explains the steady decline of the water table during periods of little or no recharge.

The three main processes involved in groundwater recharge are the infiltration of local precipitation, seepage, and subsurface inflow. Of these processes, the infiltration of local precipitation is the most important in the recharge of the aquifers in the Black Hawk Lake vicinity.

A large part of precipitation that reaches the ground runs off directly to streams, but some of the water enters the ground, and under favorable conditions reaches the groundwater table. The quantity of water that will enter the ground is governed by the quantity and intensity of rainfall, the infiltration capacity of the soil, the local topography, the amount and type of vegetation, and the rate of evaporation. Other than the topography, these factors are all variables and make an extremely complex problem. Close examination of the qualitative relation between quantity and intensity of precipitation and the amount of recharge indicates that an intensive rain of short duration results in less groundwater recharge than a more gentle rain of longer duration.

Recharge by seepage from surface waters is dependent largely on local precipitation although the effects are delayed. Streams and bodies of ponded water whose water surface is above that of the adjacent water table commonly lose water by seepage; these are known as influent streams and ponds. Some of the intermittent streams near Black Hawk Lake lie above the water table and water may seep downward to become groundwater in those reaches where the stream bed consists of permeable materials. Seepage from undrained depressions on the fields and pastures around the lake and the marsh also contribute to the recharge of the aquifer.

Although recharge to the aquifers near Black Hawk Lake is more-or-less continuous, the amount of water in storage within the aquifer is kept within relatively narrow limits by discharge over the outlet structure, subsurface outflow, transpiration and evaporation, and artificial discharge.

The amount of discharge that will occur is governed by the amount of groundwater in storage. During periods of greater recharge, discharge is greatly increased;

but even during periods of little recharge, discharge continues, although at progressively decreasing rates. The quantity of subsurface outflow is difficult to estimate.

Transpiration is the process whereby water is taken up by plants from the soil and rock materials and discharged to the atmosphere. For the most part, transpiration depletes soil moisture; but near the lake and the marsh, plant roots take water directly from the water table. The rate of transpiration is dependent upon temperature, sunlight, available moisture, relative humidity, and air movement as well as the type and stage of plant growth. Thus, transpiration is virtually restricted to daylight hours.

The depletion of soil moisture by the transpiration of field crops in the watershed is important because it greatly reduces potential recharge to the groundwater reservoir. It has been determined that, at times, as much as one-half of the potential recharge to the water table by local precipitation is lost by transpiration.

Except in clay soils where deep cracks form upon drying and permit evaporation from a considerable depth, groundwater discharge by evaporation occurs only where the water table is at, or very near, the land surface. Evaporation from the lake, the marsh, the pits, and from ponds and streams in the upper reaches of the Black Hawk Lake watershed is a significant variable in the water budget for the lake.

Artificial discharge presently occurs where water is pumped from wells or where fields have been artificially drained. Withdrawals of groundwater may exceed the recharge and thus cause a progressive lowering of the water table. Such a change in the ratio of discharge to recharge disrupts the previously established equilibrium, and groundwater is taken from storage. Equilibrium will be reestablished only if recharge and discharge are again brought into balance. A new balance may result if the steepened hydraulic gradient induces greater recharge or the lowered water table decreases the natural discharge.

Artificial discharge also occurs where fields have been artificially drained. Draining fields by tiling is limited mainly to the poorly drained low spots on tiled areas around the lake and the marsh. Tiling speeds the discharge of soil water, and possibly groundwater during wet seasons, but probably much of the water would have been discharged by natural means at a later time. The actual relation between tiling and groundwater storage is not fully understood, but the effect is considered to be minor. Tiles are most effective in the spring after the soil thaws and before vegetation develops, and this coincides with highest yearly water levels in shallow wells. Thus, tiling seems in large part to remove water that would be rejected by already full groundwater reservoirs or would soon be discharged naturally. The effects of tiling become increasingly important if the drainage is changed from one watershed to another. The main effect that tiling near Black Hawk Lake seems to have, however, is decreasing the detention time of water in the upper reaches of the watershed.

## Effects of the Proposed Black Hawk Lake/Hallett Pits Connection

The beneficial effects of a navigational channel connection between Black Hawk Lake and the nearby Hallett Gravel Pits would be minimal, as pointed out by the 1979 study of the proposal. However, the detrimental effects of the connection on the groundwater storage appear to be underestimated and understated in the study.

At present, the marsh, inlet, and pit areas act as flood and silt detention areas, or collectively as a floodplain. During periods of high surface runoff, backwater from the lake covers a much larger-than-normal area. When backwater has subsided and surface runoff has decreased, water that is stored in the pits, the marsh, and the groundwater aquifer recharges the lake as it moves from reservoir areas of higher hydrostatic head to areas of lower hydrostatic head. The amount of groundwater in storage, and the rate of groundwater movement (infiltration rate) from the recharge area to the discharge area, are controlled by the character of the aquifer. However, if a navigable channel was constructed through the area, the rate of water movement from the recharge area to the lake would be controlled mainly by the size of the channel (see Figure 5). Instead of having just the existing natural seepage from the pits to the lake, there would also be large surface runoff flows through the new navigational channel. The hydraulic gradient between the lake and the pits would, therefore, be diminished much more rapidly.

Figure IV-C

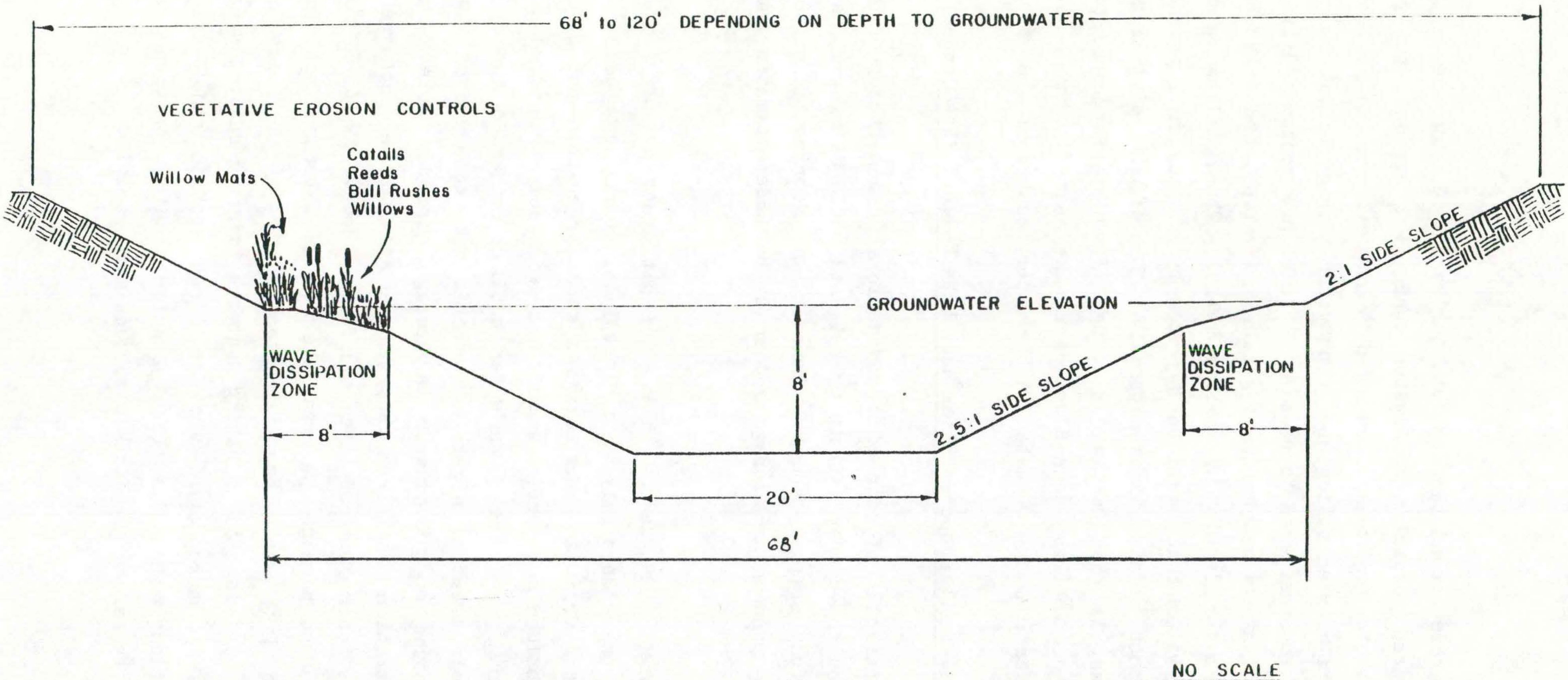



FIGURE 5.

CHANNEL TEMPLATE (Typical)

The 1979 study gives the false impression that the channel will have minimal or even no impact on water storage in the lake, the pits, and the groundwater aquifer. The additional water that could potentially be lost would be water that is higher in elevation than the outlet structure; much of this water would normally be stored as surface water in the pits or as groundwater in the aquifer and would not seep into the lake until after the lake had dropped below the outlet structure. With the new channel, however, this water would instead be lost through increased surface runoff through the channel and over the lake outlet structure. Because of the additional water losses by surface runoff--resulting in diminished storage and recharge capacity of the pits and aquifer--it appears likely that the level of Black Hawk Lake would drop sooner and to lower elevations, during dry periods, than it does now. Water that would normally be stored in the pits and aquifer, and would not seep into the lake until after the lake level had dropped below the level of the outlet structure, would be subject to early surface water flow into the lake and over the outlet structure.

The pits and adjacent aquifer should not be assumed to have unlimited recharge potential. Large withdrawals of groundwater in the area can eventually draw the groundwater table down enough to impact the lake level. Records show that the lake levels have previously been 3 1/2 to 4 feet below the outlet structure after extended droughts, and considerable time is needed for precipitation and runoff to recharge the aquifer and the lake. According to the 1983 I.S.U. diagnostic/feasibility study for the restoration of Black Hawk Lake, lake levels fluctuated considerably during each year that these levels were studied. The maximum distance of the lake elevation below spillway crest was recorded in 1981 when the level dropped nearly two feet below crest. Other than that, the maximum recorded distance below crest elevation was about one foot in 1971. Although there is no data, it has been reported that the lake fell as much as 42 inches below the spillway during the drought of 1976-77. Thus, it appears that although the lake has no great problem with water quantity, it does show considerable fluctuations in level in response to periods of varying precipitation. Further evidence that the lake is subject to rather large variations in lake level throughout its history is illustrated in Table 10.2 of the 1983 study where dates of various high and low levels were reported.

The 1979 feasibility study of the Black Hawk Lake/Hallett Pits connection was supposed to give general hydrologic implications of what the effects of the connection would be. However, it appears that some of the assumptions made in the study seem to be faulty, or inconsistent with other assumptions. For instance, the 1979 study states that flows in the navigable channel would be "on the order of 0.2 cubic feet per second flow through the connection with a 2.3 foot elevation difference" between the pits and the lake. Although actual flows through the channel would be very difficult to estimate, a flow rate of 0.2 cubic feet per second is well below the potential capacity of the navigable channel; with an elevational difference of 2.3 feet between the lake and the pits, it is estimated (without going into a very complex analysis) that the channel would likely have the potential for flows much higher than 50 or even 100 cubic feet per second. The only way that these large flows would decrease to as little as 0.2 cubic feet per second, would be if the elevational difference decreased to a very slight amount--a difference that would be maintained primarily due to seepage inflow into the pits and out through the channel.

The study also states that the flow from the pits would raise the lake level "about 0.1 feet." However, an additional 0.1 feet of head at the outlet structure would increase the discharge by as much as 22 cubic feet per second (based on the February 20, 1971, lake level), or more, depending on the depth of flow over the crest of the structure. Water flowed over the Black Hawk Lake outlet structure for a period of 117 days, in the spring and summer of 1975, at an average depth over the crest of 0.35 feet. Adding 0.1 feet of head to the average flow depth would increase the discharge by approximately 8.8 cubic feet per second.

The flow rate, estimated in the 1979 study, of 0.2 cubic feet per second, therefore, does not correspond with either the flow that would accompany a 2.3 foot elevational difference between the pits and the lake, nor with the increase in flow that would accompany a 0.1 foot increase in the lake elevation.

It is stated in the study that, "increases in well discharge in any part of the aquifer will affect the lake level. However, only large discharges need cause concern, in the order of 500 to 1,000 million gallons per year (an average rate of 2.1 to 4.2 cubic feet per second). The Rural Water District wells together are allowed to pump a maximum of 188 million gallons annually." This rate of withdrawal for the water district would be an average of 6 gallons per second, or 0.8 cubic feet per second. It was pointed out by the 1979 study that well discharges will "be replenished by precipitation recharge." This is especially true when water is withdrawn during high groundwater levels, since this water is replenished by water that would otherwise be discharged over the outlet structure. However, the study does not mention that once lake levels drop below the level of the outlet structure, well discharges will have a much greater short-term impact on lake levels.

The 1979 study also, "based on the subsurface data," assumes that "groundwater levels will not be significantly affected by physically connecting the West Hallett Pits to Black Hawk Lake." The assumption apparently was based on the assumed increase in discharge, due to the proposed channel, of "0.2 cubic feet per second." Instead, potential flow rates exceeding 50 to 100 cubic feet per second are more likely to occur, decreasing as the hydraulic gradient between the pits and the lake decreases. Whatever the actual flow rates would be, they would be much higher than the 2.1 to 4.2 cubic feet per second well discharge rates that the 1979 study says would cause concern. It is likely that any groundwater or surface water higher in elevation than the outlet structure will be discharged at a faster rate than it can be replenished. With increased artificial drainage due to the proposed channel, as long as the lake level, the pit levels, and the aquifer levels are higher in elevation than the outlet structure, the discharge will be higher than it would be without the additional drainage from the new channel.

It appears that creating additional artificial drainage by constructing the navigable channel would very effectively decrease runoff detention time and increase peak discharge quantities, increase overall discharge quantities at the overflow structure, lower the normal water table in the vicinity of the pits and the new channel, decrease storage of groundwater in the aquifer, reduce the capabilities of the aquifer to recharge the lake, and would probably result in lower lake and marsh levels at the end of the dry season. Lowering the water table by one or even two feet in a well generally has very little effect on the capabilities of the well to produce water. A similar drop in Black Hawk Lake levels, however, can be very detrimental to the recreational uses of the lake. Also, if the peak discharges at the overflow structure are increased as expected, the state will be liable for increased flood damage to lakeside properties (probably minimal) and to properties downstream from the lake (may be more substantial).

The quantity of equilibrium flow that would exist at any given time in the channel is unique for specific depth and channel conditions. Normally, the equilibrium discharge for the channel could be computed by a trial-and-error process when the channel shape, slope, roughness, and depth of flow are known. In this case, however, backwater from the lake into the channel would affect the discharge quantities. The water surface profile for the connecting channel would be determined assuming that discharge from multiple reservoirs (Hallett Pits) would flow through uniformly constructed segments of horizontal or mildly sloped channel into another reservoir (Black Hawk Lake) with discharges at the outlet structure. Constrictions of the channel, such as at bridges and culverts, would cause flow variations that would also need to be accounted for in the water surface profile.

Increases in yearly discharges over the outlet structure due to a navigable channel could easily be in the range of 280 acre-feet to 1,500 acre-feet, or even higher. Determining a better estimate of the average increased yearly discharge quantity would be a complex problem based on many variables, including the route of the proposed channel. Therefore, this study will not attempt to determine better estimates of the increased discharge. It is hoped, however, that the increased discharges will be considered a major cause for concern and will not be overlooked if the Black Hawk Lake/Hallett Pits connection is ever reconsidered.

The short-term effects of constructing the proposed navigable channel apparently would be: less detention time for surface runoffs, increased discharge amounts over the outlet structure, decreased ability of the groundwater table and precipitation to recharge the lake, lower lake levels and marsh levels at the end of dry periods, greater fluctuations in the groundwater table, and the accompanying detrimental effects on the marsh and the lake. The long-term effects would apparently be: the loss of a significant portion of the existing surface and groundwater storage, a lowered normal groundwater level, and a likely change in the successional development of the habitat surrounding the marsh and lake as a new equilibrium of the groundwater, lake, and pit surface water levels is reached.

A recent news article in the Des Moines Register was about establishing good marsh habitats in Iowa (see Appendix G). The article included an accurate, though nontechnical explanation of the effects of marshes and wetlands on the environment. According to the article:

> "Iowa lost more than wildlife habitat when wetlands were drained and farmed. Marshes once soaked up runoff and released it slowly, retarding floods in wet weather and boosting stream flows during drought. But rain water now rushes away in swollen rivers, leaving few reserves to temper dry spells.
>
> "A wetland also can function as nature's version of a sewage treatment plant, absorbing tremendous quantities of natural and man-made waste. Without wetland 'filters,' pollutants contaminate lakes, rivers and streams.
>
> "Unfortuantely, we've come to appreciate the value of these natural systems only after most of them are gone. Only 27,000 acres of Iowa's natural wetlands remain -- and even some of those face drainage."

The Hallet Pits/Black Hawk Lake connection proposal does not appear to give enough consideration to the economic and environmental losses that would be suffered if the connection had a detrimental effect on lake levels.

On the other hand, there are other proposals that would improve the lake water levels, lake water quality, and marsh habitat. These proposals, if implemented should also encourage private development along an improved Black Hawk Lake. The proposals, discussed more fully in the rest of this study, include: (1) the storage of excess water that is currently discharged at the outlet structure, (2) the construction of dikes and control structures for the storage of water and controlled release of the stored water during dry periods, (3) improvement of the existing marsh and the creation of additional marsh habitat, and (4) the diversion of additional water sources to Black Hawk Lake.

Recommendations On Black Hawk Lake/Hallett Pits Connection Proposal

It is recommended that, in any future consideration of the Black Hawk Lake/Hallett Pits connection proposal, the above-mentioned effects be incorporated into the list of potentially detrimental impacts on the lake environment. Although any study would probably have difficulty quantifying the effects of a navigable channel between Black Hawk Lake and Hallett Pits, the detrimental effects should not be considered negligible. Because of the detrimental effects on the lake, marsh, and designated wetland areas, it appears unlikely that the proposal will ever receive the necessary approvals of the U. S. Fish and Wildlife Service, the Corps of Engineers, IDWAWM, and the Conservation Commission. Also, costs for fish renovation in the pit areas should be included in the connection proposal. The costs would probably be between $100,000 and $200,000 with a high risk of failure.

Comprehensive Water Management Plan for Black Hawk Lake and Black Hawk Marsh

At first it would seem, with several studies conducted and with numerous man-hours spent in the attempt to come up with a plan for restoration of Black Hawk Lake, that every conceivable option would have been fully explored. However, there are still a few ideas that have not been studied in full. At one time, a proposal was made for establishing a comprehensive water management plan for Black Hawk Marsh that would provide some long-term solutions for several problems at the marsh. Apparently, however, the comprehensive water management plan was never completed.

Engineering studies have shown that a direct relationship exists between the Hallett Pits, Black Hawk Marsh, the Central Iowa Water Association wells, the groundwater aquifer, and Black Hawk Lake. Therefore, it would seem advisable that a comprehensive water management plan be established which includes details for the future operation of all of the above features.

Previous studies have done very little to explore the possibilities for increasing water supplies to the watershed of the lake, for increasing water storage capacity in the watershed, or for storing lake discharges that are presently lost during times when there is excess water. The lake presently is subject to seasonal changes in lake levels which currently cannot be controlled, resulting in complaints about flooding during wet periods and complaints about low lake levels during dry periods. The absence of any kind of control structure or additional storage capacity leaves the lake levels totally at the mercy of the weather. Reducing the storage of water detention areas, such as the marsh and the gravel pits, by constructing artificial drainage channels will only worsen the present situation. Increasing storage capacity and constructing a series of control structures, however, would allow flexibility in the operation of the lake/marsh/pits complex. Diverting new water sources to the area would further enhance the water storage potential.

Some of the proposals that have been submitted in the past supposedly would provide increased supplies of water, increased storage of water, or increased control of the water supplying Black Hawk Lake. In most instances, however, the proposals actually would be more detrimental, or potentially detrimental, than beneficial to the lake and the marsh.

The Black Hawk Lake/Hallett Pits connection, for instance, would have detrimental effects as previously described. This proposal, if enacted, would also eliminate consideration of other more beneficial proposals that conflict with the private development associated with a connection between Hallett Pits and Black Hawk Lake. The proposal to construct a diversion structure in Black Hawk Marsh -- unless additional land is acquired and dikes for water storage are constructed -- would be of little benefit, would increase the state's responsibility for any flood damages upstream and downstream from the structure, and might have some detrimental effects on the lake and the marsh. If effective, the proposal to clean out a drainage channel through the marsh to the lake would also have detrimental effects including lowered water levels in the marsh and increased silt loads on the lake.

The following is a summary of recommendations for restoring Black hawk Lake as proposed by Iowa State University in the 1983 <u>Black Hawk Lake Restoration</u>

Diagnostic/Feasibility Study:

"The possible restoration of Black Hawk Lake was studied as a part of the U.S. EPA Clean Lakes Program. Lake problems were determined with a diagnostic study. The shallowness of the lake leads to problems of high turbidity, poor transparency, heavy algal blooms, and winter fishkills. Soil erosion in the watershed is bringing sediments into the lake and further reducing its volume. At the present rate of siltation, the lake will lose most of its recreational value in about 60 years.

"Alternatives considered for lake restoration included lake aeration, soil erosion control, lake dredging, and dredging of the lake inlet. A plan is recommended that includes a combination of lake aeration, soil erosion control, and lake dredging. The lake inlet dredging was not considered to have significant benefits to the main lake. The total cost of this plan is $2,697,000."

In the 1983 study, the proposed soil erosion control measures included the intensification of soil conservation practices within the watershed to reduce the rate of inflow of sediments. The recommended practical methods of reducing soil erosion from the watershed included conservation tillage, no-till, and the construction of terraces and grassed waterways. The estimated cost of erosion control measures was $1,935,000 (1982 base cost).

An erosion control method that was not proposed in the 1983 study is the construction of dikes and water control structures in the Black Hawk Marsh area. This method would create improved marsh habitat, provide additional water storage for recharging Black Hawk Lake, give better control of the level of the lake, and trap a much greater amount of the silt that is presently entering the marsh and the lake. The creation of additional marshes and the improvement of Black Hawk Marsh would require additional land purchases (see Figure 4). Most of the property that needs to be acquired is presently marshy and undeveloped.

In the past, there have been proposals for increasing the water supply to Black Hawk Lake. In 1914, an engineer was hired to determine if water could be pumped into the lake from Indian Creek. In 1916, it was suggested that Lime Creek and Klitzke Creek (Drainage Ditch No. 60) be diverted into the inlet of Black Hawk Lake (never done). It has been proposed, possibly in the 1940's (see Appendix O), to divert water by gravity flow from Indian Creek through an underground pipe to Black Hawk Lake, similar to the way that water is presently diverted into Lake Manawa in Pottawattamie County.

The above-mentioned proposals for increasing the water supply would be possible, but may not be economically feasible. The diversion of Drainage Ditch No. 60 appears to be the most feasible. Lime Creek probably could not be diverted without seriously affecting at least two adjacent farms. The gravity diversion of Indian Creek might have potential, but would require additional study to determine its feasibility. The railroad tracks through Lake View have recently been abandoned, so the feasibility of the Indian Creek proposal has improved significantly from when it was first proposed. Should the Commission wish to consider diverting Indian Creek, the disposition of the right-of-way for the abandoned railroad tracks should be determined as soon as possible, before further development of Lake View precludes the proposal. Alternatives for diverting Indian Creek should consider: (1) whether to build a dam and control structure for impounding the creek, or a smaller diversion structure further upstream, (2) whether to divert water to Black Hawk Lake directly or to the lake via Arrowhead Lake, (3) the size of underground pipe needed to carry sufficient volume of water to improve lake levels, and (4) the cost/benefit ratios of the alternatives.

Before additional water could be diverted to Black Hawk Lake, the Commission would need to have the ability to store and control it. Adequate land would need to be acquired. The Commission would also need to be able to show that the modifications to the existing drainage would not have any offsetting detrimental impacts on upstream and downstream private properties.

The only previous proposal for increasing the storage capacity of Black Hawk Lake was the suggestion that the lake outlet structure be raised by 6 to 12 inches. This proposal was opposed by those property owners along the lake that did not want additional flood and erosion damage to their property.

The best method for increasing storage capacity of the lake appears to be the construction of dikes and control structures in the relatively undeveloped inlet area of the lake, and at Black Hawk Marsh. This water could then either recharge the lake by seepage, or be released through the control structures during dry seasons. This would also require the acquisition of affected private properties.

The 1944 proposal to reestablish Goose Pond (see Appendix M), near Wall Lake, still appears to have some merit. However, it may be more feasible to establish a marsh area where the West Hallett Pits are located, and direct excess flows through water control structures, fish traps, and Black Hawk Marsh, to the lake.

It is recommended that aerial photography and topography be done of state-owned land, and nearby potential acquisitions, in the vicinity of Black Hawk Lake and Black Hawk Marsh. This would greatly aid any further investigations of proposals for the operation of this area.

<u>Summary/Recommendations</u>

1. If it is decided to do anything to eliminate the late summer and fall season backwater on Collin Garrels' property, the beavers and beaver dams in Black Hawk Marsh should be removed. Such action should return the channel to normal flows. The Commission should not allow the inlet channel to be "cleaned out" through Black Hawk Marsh, or be diverted to a new location.

2. The low-lying, flood-prone areas of Mr. Garrels' property, as well as other properties in the area, should be acquired for wildlife management purposes, for providing a buffer zone around marshy areas in Black Hawk Marsh, and for providing adequate areas for backwater from the marsh and the lake. With these additional areas, water could be impounded for extended lengths of time on state-owned land.

3. Additional marsh impoundments, with control structures, should also be established which would retain silt, capture runoff that would otherwise be discharged at the lake outlet structure, and store water that could either

help recharge the groundwater aquifer, or be released directly into the lake. Some years there would be good marsh habitat and high lake levels, and other years, the marsh habitat could be sacrificed slightly to provide better lake levels. Even after small water releases, the marsh would probably still have higher average water levels than it presently does.

4. If Black Hawk Lake and Hallett Pits are ever connected, this should be done with control structures and fish traps between. This would allow controlled release, during dry periods, of water stored in proposed marsh impoundments.

5. In conjunction with increased storage capacity and water control capabilities in the marsh and pit areas, the Commission could consider increasing the water supply for the lake, not only by capturing excess runoff that is presently discharged, but also by diverting new sources of water to the lake via the gravel pits and the marsh (or series of marshes). New sources could include Drainage Ditch No. 60, Indian Creek, and Lime Creek. Further study and additional land acquisition would be required before any of these new sources could be utilized.

6. It is recommended that the Commission continue to oppose the proposed Hallett Pits/Black Hawk Lake connection because of the detrimental effects that the channel would have.

7. It is recommended that the Commission <u>not</u> construct a diversion structure and diversion channel through Black Hawk Marsh because of the limited benefit, the increased state liability, and the detrimental effects on the lake and the marsh.

8. A comprehensive water management plan would aid the Commission in making future decisions regarding operation and capital improvements associated with Black Hawk Lake and Black Hawk Marsh.

# FIELD INVESTIGATION OF BLACK HAWK LAKE AND BLACK HAWK MARSH -- Sac County, September 6, 1984

In conjunction with the Black Hawk Lake Inlet Study, the study area was investigated firsthand, much of it on foot. The day of the field investigation was cloudy with occasional light rain. Streams and creeks in the area had low flows. The lake level was approximately 0.5 feet below the top of the outlet structure.

The month of August, 1984 was a month of record or near record low rainfalls for the State of Iowa. Although climatological data for the month of August was not available at the time of this report, it is fairly safe to assume that rainfall amounts had, for at least one month prior to the field investigation, been much lower than average.

At the west side of Black Hawk Marsh, where Carnarvon Creek enters the marsh, water was impounded bank full in the channel that had been cleaned out on Collin Garrels' property. Following the channel about 150 to 200 feet into the marsh, no channel obstruction could be found. Because the dense vegetation made access extremely difficult and also limited the visibility of the channel, it was decided that the marsh be examined on the north side where water exits.

On the north side, the channel coming out of the marsh was essentially dried up. The channel was followed on foot into the interior of Black Hawk Marsh and was found to be dry and relatively free from obstructions. The marsh was also dried up. There was ample evidence of beaver activity and the remnants of the beginnings of beaver dams in the dried up channel. However, near the west side of the marsh where Carnarvon Creek was impounded, a series of recently constructed beaver dams was found. The water had dried up behind the first couple of dams in the series, but was effectively retained behind the dams that were closer to the water source.

The beavers had instinctively located the dams within an area of the marsh that had ample cover vegetation, trees for construction materials and food, a narrow channel, and a source of fresh surface water. The narrow channel could quickly and easily be blocked by the beavers as water receded in the main portion of the marsh.

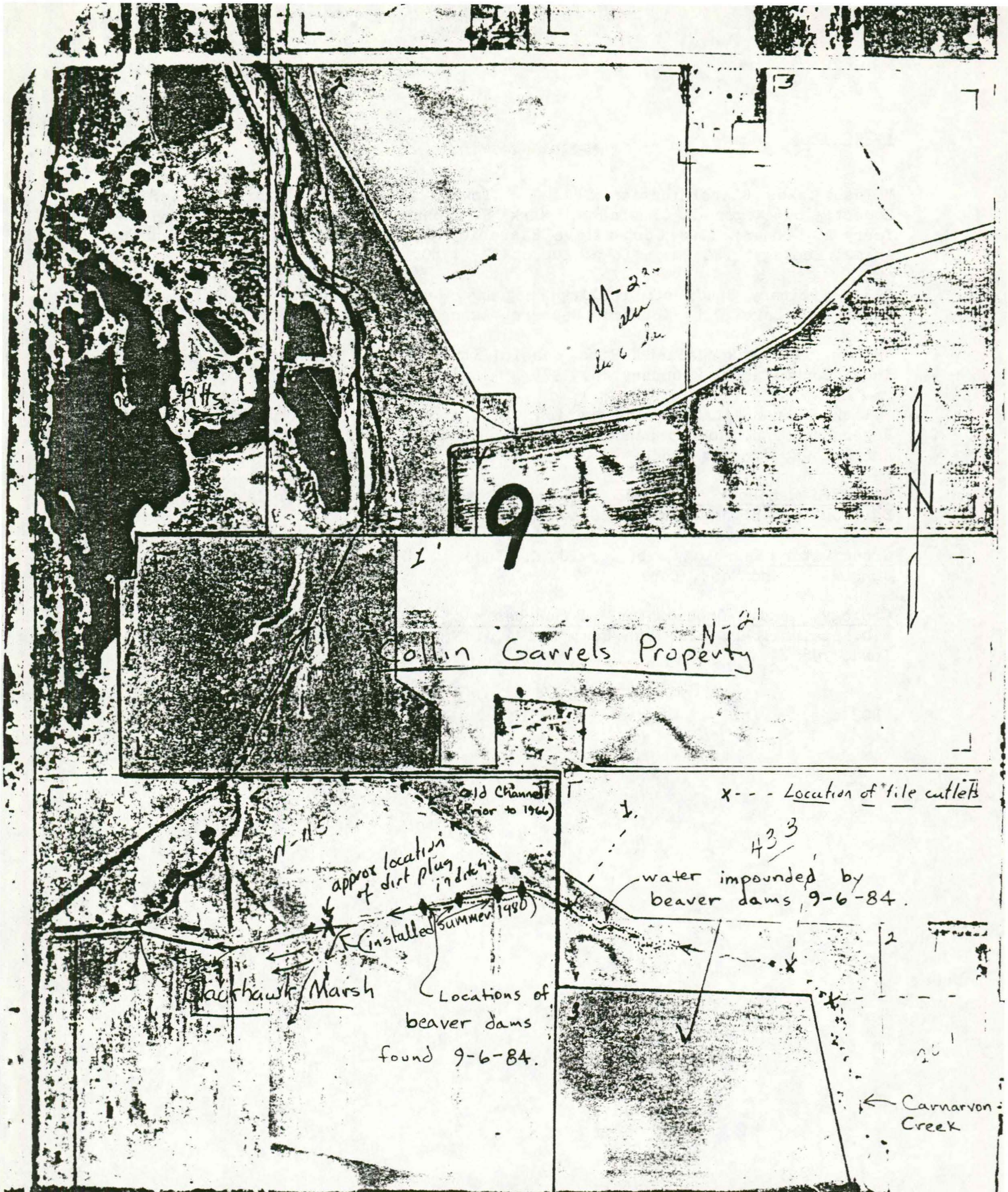
The channel from Black Hawk Marsh to the county bridge 4000 feet north of the marsh appeared to be clear, with only a small amount of standing water in the bottom of the channel. There was no surrounding wildlife cover along the channel through Collin Garrels' property, and very little along the channel between Mr. Garrels' property and the county bridge to the north. These areas have been heavily pastured and presently would not be suitable areas for beavers to establish themselves.

It appeared that if the beavers had not constructed dams in the channel, water would not have been impounded on Collin Garrels' property to the east of the marsh. The channel through the marsh, having been allowed to revert to its natural state, is of course more restrictive to the flow of water than the cleaned out channel through Mr. Garrels' property. However, cleaning out the channel through the marsh, except for the removal of the beaver dams, would not effectively improve the drainage upstream from the marsh.

CONCLUSIONS:

During high rainfall or snowmelt runoffs the main reason for poor drainage of the marsh and the property upstream from the marsh would appear to be because of backwater from the lake, which would be affected very little by cleaning out the channel through the marsh. The remnants of beaver dams in the channel, however, would hinder drainage of the area once backwater from the lake recedes. During the summer, beavers in the marsh area can be expected to repair their dams so that, even when the marsh is dried up, they will have a suitable habitat near the east end of Black Hawk Marsh.

The most effective method for improving the drainage upstream from the marsh appears to be the removal of the beaver dams and the trapping and removal of the beavers.




NOT TO SCALE Sac Crop Year 2N 50

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