Herbst

WATER RESOURCE AND WILDLIFE STUDY
OF THE

PROPOSED HAM LAKE AIRPORT SITE
ANOKA COUNTY

MINNESOTA CONSERVATION DEPARTMENT

Division of Waters, Soils and Minerals
Division of Game and Fish

OCTOBER 1968

A Study of Water Resources and Wildlife Aspects of the Proposed Ham Lake Airport Site

INTRODUCTION

The Metropolitan Airports Commission has proposed construction of a major airport facility in Ham Lake Township, Anoka County, generally referred to as the "Ham Lake Site". Subsequently, Governor Harold LeVander requested that the State Planning Agency collect the factual data from concerned state agencies for submission to the Metropolitan Council for determination of the feasibility of the site. The Division of Waters, Soils and Minerals and the Division of Game and Fish of the Minnesota Conservation Department were asked to study the water resource and wildlife aspects relative to the proposed Ham Lake airport site and report its findings. The following information is based on the facts gained from special investigations and competent opinions and experience of professional personnel. Meetings were held with other agencies to exchange information and to delineate the problems.

I GAME MANAGEMENT PROBLEMS

Detailed information on the effects of the Ham Lake Airport site on the Carlos Avery Wildlife Management Area is found in the appendix. The following information summarizes the effects of the proposed Ham Lake Airport on the 23,000 acre Carlos Avery Wildlife Management Area.

The present and primary management program for the Carlos Avery Wildlife Management Area is designed to improve aquatic habitat for waterfowl and furbearing animals through the creation of water areas by impoundments, dugouts, diversion channels, water control devices and sedge mat removal. Losses of either surface or underground water resulting from the drainage project needed to construct the proposed airport as originally proposed would therefore seriously reduce water management capabilities within the Carlos Avery Wildlife Management Area and prohibit additional improvements planned for that area.

Water impoundment needs with reference to the available water supply are often critical over a large portion of the Carlos Avery Wildlife Management Area at the present time. This is especially true for the area lying immediately adjacent to the proposed Ham Lake Airport site. This shortage of a readily available water supply is quite understandable in view of the fact that the pools in this area lie at the top of the Coon Creek Watershed.

Aside from the physical alteration of the environment resulting in an attempt to eliminate habitat conditions favorable to wildlife which present a hazard to aircraft (see Wildlife Leaflet #429, Bureau of Sport Fisheries and Wildlife, Bird

Hazard to Aircraft included in the appendix), the aesthetic values, tranquility and naturalness of the area would be destroyed by jet noise, sighting of low flying jets and the exhaust caused by jets over a portion of this area. The reaction of a duck hunter sitting in his blind, the birdwatcher, the wildlife photographer, nature students, scouts, and other outdoor recreation users to the noise from large jet airliners flying overhead at low altitudes, needless to say, would be extremely distracting, unnatural and unwanted.

Mr. C. E. Faulkner, a specialist on bird strikes with the U.S. Bureau of Sport Fisheries and Wildlife Office in Minneapolis, stated at a meeting of the North Suburban Residents that the Ham Lake site is a poor site from the standpoint of bird hazards to aircraft and that the alternative, in the case where airports were established in similar situations, is to get rid of the bird life by destroying the habitat. A copy of the news release quoting Mr. C. E. Faulkner in the St. Paul Pioneer Press, October 23, 1968 is included in the appendix.

There can be no adequate minimization of environmental change if the airport is constructed at the Ham Lake site. Because of the uniqueness of the area it would be impossible to replace. There are no other areas or sites similar to the present Carlos Avery Wildlife Management Area within the proximity of this large metropolitan area.

Another problem that has to be considered is the possible loss of Federal Aid in Wildlife Restoration funds. The following is an excerpt from a letter to the State Conservation Department from the Federal Aid Section of the Bureau of Sport Fisheries and Wildlife: "Federal Aid in Wildlife Restoration has a substantial investment in land acquisition and wildlife habitat development at Carlos Avery. As we have previously discussed, loss of wildlife restoration benefits at this area will be viewed as a diversion of Federal Aid funds, and Secretary's Rule 80.5 (Federal Aid Manual, Revised 1967) will apply. Application of this rule means that your Department must replace the area lost with a property of equal value at current market prices and with commensurate benefits. Failure to accomplish this replacement in kind will make Minnesota ineligible to continue receiving Federal Aid in Wildlife Restoration funds."

If this replacement is not accomplished - and we doubt that it could be accomplished because we know of no other land of commensurate benefits available within the metropolitan area - Minnesota will be ineligible to continue receiving Federal Aid in Wildlife Restoration funds which amounts to approximately $400,000 to $500,000 annually. A copy of Mr. Springer's letter concerning the diversion of Federal Aid funds is found in the appendix.

II WATER RESOURCES OF THE HAM LAKE AIRPORT SITE

A study of the ground and surface water relationships and possible hydrologic problems was conducted in the vicinity of the Ham Lake airport site in Anoka County. The study

area encompassed approximately 48 square miles in parts of Linwood, Columbus, and Ham Lake Townships. This study consisted of an analysis of the bedrock geology, glacial history, aerial photographs, topographic maps and field investigations including 85 representative test borings. Because of time limitations on completion of the report, the study was limited to obtaining information on the regional configuration of the water table. Due to the technical nature of the study, the technical results of the study are contained in the appendix and this section provides a brief summary and conclusions derived from the technical data.

The study area is located within the Anoka sand plain which covers much of east central Minnesota. The area is generally level at elevations of 900 to 905 feet above sea level. It is covered by an extensive plain of uniform fine-grained sand containing numerous depressions generally filled with peaty soils. The maximum land surface elevation in the area of study is about 920 feet along the northern edge of Coon Lake and the lowest elevation is about 893 feet in a few low places along the western border of the study area.

Coon, Netta, Ham and Little Coon Lakes are the largest lakes within the study area. At the time of the study, the lake elevations ranged from 904 feet at Coon Lake to 898 feet at Ham and Little Coon Lakes. These lakes are water table lakes which fluctuate with changes in elevation of the water table. As can be noted from Figure 8, (appendix) water table contours immediately adjacent to these lakes closely correspond to the water level of these lakes.

A map of the area was prepared based on topographic maps and aerial photographs. This showed the sandy and peaty areas, and was used to spot the location of test holes. Using Highway Department equipment, 65 holes were drilled in August, 1968. Measurements were made of the water table at the time of drilling and 24 hours later. Lines of levels were run to all test holes so that the water table elevation could be reduced to sea level datum. On September 24, 1968, 31 additional holes were drilled, and several of the original holes were redrilled and remeasured in order to determine the effects of the rainfall which had occurred in the interim.

Several holes were drilled deeper (up to 56 feet) in order to sample the subsoil conditions. Records of soil borings taken by the Highway Department in the planning of I-35 and TH-65 and soil data obtained in a study for a proposed military airport near Bethel were also obtained for analysis. Well logs for several deep wells in the area

are available showing the materials and water conditions encountered in drilling. All available geologic studies and maps were collected and studied. The water table elevations obtained from the auger holes were plotted on the map, Figure 8 (appendix) and the contour lines showing the configuration of the water table were drawn.

Bedrock topography greatly influenced the movement of glacial ice through the area and the subsequent deposition of the surface sands. The basement rocks in this area contain three faults, or fractured zones, which have caused a displacement of the several overlying rock types. This faulting has had an effect on the surface geology and hydrology in the area.

The water table contours, or points of equal water table elevation, shown in Figure 8 reflect the influence of the bedrock structure and the faulting. These contours indicate that the water table slopes toward a major water table depression which is oriented in a general northeast-southwest direction. The location of the fault shown on Figure 5 coincides with the water table depression area shown in Figure 8.

The widespread spacing of the water table contours along the southwestern part of the water table depression area indicates that this is probably an area of major vertical recharge to deeper water bearing formations. Other local areas of probable major recharge are in the vicinity of Coon Lake along the northwest border of the study area and throughout much of the Carlos Avery Wildlife Management Area along the eastern edge of the study area.

The configuration of the water table contours just south of Little Coon Lake which is at elevation 898, indicates that there is a partial water table divide which transects the northeastern corner of the study area. This indicates that there is a small increment of ground water discharge northward from the upper part of the Carlos Avery Wildlife Management Area.

The effect of the drainage ditches in the area on the water table is most apparent near the center of the study area where the water table contours reflect the general alignment of the artificial ditch system.

CONCLUSIONS

If extensive drainage is utilized in the construction of the airport, the water table would be lowered within the area and produce the following effects:

1) Lower surface water levels in wetland areas within Carlos Avery Game Refuge and adjacent areas;
2) Reduce the amount of recharge of water into the artesian aquifers for the metropolitan area;
3) Lower lake levels within the immediate vicinity, particularly Ham Lake;
4) Lower water levels within local shallow ground water wells; and
5) Decrease the flow in Coon Creek.

The extent of these effects would be dependent upon the final design adopted for construction of the airport.

Careful design of the airport facilities could minimize the effects on the water resources. If the Ham Lake site should be selected, it is recommended that the following conditions be placed on the construction of the airport:

1) Construct the runways above the existing ground surface to preclude the necessity of lowering the water table within the area;
2) Maintain the surface and ground water at the site to the maximum extent possible to allow maximum infiltration of water into the ground; and
3) Construct no large deep open channels for drainage which would cause a lowering of the water table within the region. Any conduits which are constructed should be closed conduits with adequate provisions to minimize ground water flow adjacent to the conduit.

Present development at the Ham Lake site consists of widely spaced residential areas on the sandy uplands, interspersed with sod and truck farming on the peatlands. Construction of a major airport facility as proposed will inevitably result in rapid and concentrated development of the adjacent areas for commercial, residential, and industrial uses. There is no way of assuming that private development in this area will

abide by the conditions recommended above for the airport construction. Development of this type would cause further damage to the water resources of the region. Minimum damage to these water resources would be assured if a substantial portion of the area were preserved as "open space."

The airport would have the following adverse effects on the Carlos Avery Wildlife Management Area:

1) Aquatic habitat vital to the production of waterfowl, furbearers and other indigenous species would be destroyed and hunting, trapping, observing wildlife and other public values would be substantially reduced or eliminated if extensive drainage is utilized.
2) There will be high danger of aircraft-bird collisions. When this occurs, the recommended procedure is to eliminate the habitat which contributes to the problem. This will also result in further loss of wildlife habitat.
3) There will be a depreciation of aesthetic values associated with a wild, natural area by noise and air pollution and a loss of open space. Development of adjacent areas for commercial, residential and industrial uses will also contribute to the loss of these values.
4) There will be a depreciation of educational values to boy and girl scouts, wildlife photographers, birdwatchers and nature students.
5) There will be real danger of hunters shooting aircraft which will result in the closing of areas to public hunting.
6) Although the effect of airplane noise and vibrations on the Carlos Avery Game Farm is not known, there may be a potential danger in loss of bird production at the game farm.
7) Aircraft flying under 1000 feet have a definite scaring effect on waterfowl, particularly geese. This will reduce or eliminate the opportunities for waterfowl hunting and non-consumptive uses.
8) Loss of wildlife benefits will be considered as a diversion of Federal Aid funds unless replaced with property of equal value and commensurate benefits. Failure to accomplish this replacement in kind will make Minnesota ineligible to continue receiving Federal Aid in Wildlife Restoration Funds.

In conclusion, the Department of Conservation recommends that the proposed airport be relocated to some other area where hydrological problems and wildlife problems are less critical.

APPENDIX

Minnesota Conservation Department Statement, June 6, 1968

Bird - Plane Conflict - C. E. Faulkner, October 23, 1968

Letter from L. M. Springer - Federal Aid Funds, October 9, 1968

Wildlife Leaflet #429 - Bird Hazard to Aircraft - Bureau of Sport Fisheries and Wildlife, January 1961

Ground Water Conditions at the Ham Lake Airport Site, Anoka County, Division of Soils, Waters and Minerals, Minnesota Conservation Department

EFFECTS OF HAM LAKE AIRPORT SITE

ON THE

CARLOS AVERY WILDLIFE MANAGEMENT AREA

DESCRIPTION OF CARLOS AVERY WILDLIFE MANAGEMENT AREA AND GAME FARM

The Division of Game and Fish, Minnesota Conservation Department, has statutory responsibility for the protection, propagation and wise use of our fish and wildlife resources. Because of this responsibility, the Division annually spends millions of dollars for the acquisition, development and management of fish and wildlife lands.

Thirty-five years ago a small group of men in the Conservation Department had the foresight to initiate the establishment of a large wildlife management area for the public's enjoyment, close to Minnesota's populous metropolitan center. This area, acquired and developed by the state, provides sportsmen with good hunting - "right in their own backyard". It is also available to nature lovers, bird-watchers, hikers, school children, etc., and gives them the opportunity of seeing and enjoying the outdoors and nature in natural surroundings. This is the Carlos Avery Wildlife Management Area.

Plans show that the Ham Lake Airport site abuts the south and west sides of the Carlos Avery Wildlife Management Area for a distance of approximately 4.4 miles in Sections 18, 19, 29, & 30, Township 32 North, Range 22 West, Anoka County.

The Carlos Avery Wildlife Management Area is located 30 miles north of the Twin Cities in Anoka and Chisago Counties. It is bisected by U. S. Highway No. 61. The portion located east of the highway is known as the Sunrise River Addition to the Carlos Avery. The area lies within one-half hour's driving time from the Twin City Metropolitan Area of 1.5 million people. The project encompasses two wildlife sanctuaries and a large public hunting grounds. The state game farm, tree nursery and game research station are located on the project.

Originally, much of the land in the Carlos Avery project was owned by a local company which used it to raise wire grass for use in rug manufacturing. When the company failed and the abandoned land became tax delinquent, the Minnesota Conservation Department in 1933 purchased 8,478 acres at a cost of $42,190. This tract of land was to become the nucleus of the Carlos Avery Wildlife Management Area and

Public Hunting Grounds. As the years passed and more money was appropriated, additional land was purchased until now, 35 years later, the area totals 22,900 acres in size. The sportsmen of Minnesota paid $418,037.00 for acquisition of the Carlos Avery land. These lands, together with roads, trails, buildings, dikes, water control structures and other improvements exclusive of the game farm and research center, would have a current market value of $5 - $6,000,000.

This large wildlife management area sprawling over parts of Chisago and Anoka Counties, stands as a tribute to Carlos Avery, the first Commissioner of Conservation for whom the area was named.

The Carlos Avery Wildlife Management Area is 18 miles long and varies in width from one to four miles. It is approximately 36 square miles in size (over-all) and runs diagonally in northeast-southwest directions.

Topography

The topography of the original Carlos Avery is quite flat and poorly drained. Most of the area lies within the Sunrise River Watershed and is drained by the West Branch of the Sunrise River, a tributary of the St. Croix River. The remaining area, which lies south of County Road No. 18 and south of the Carlos Avery Game Farm, is in the Coon Creek Watershed. Coon Creek is a tributary of the Mississippi River.

The original Carlos Avery is about 60 percent wetland and 40 percent upland. Much of the wetland consists of shallow peat filled areas supporting dense stands of sedge and cattail. Overlying the peat in some areas is a few inches to several feet of muck. Underlying the peat is Zimmerman and Isanti fine loamy sand.

The upland areas consist of sand or loamy sand ridges supporting oak, brush and grasses with some Class IV tillable land present. The sand underlying the Carlos Avery Wildlife Management Area was deposited as part of an outwash plain by the Grantsburg Lobe of the Wisconsin age of glaciation.

The Sunrise River Addition has a more rolling topography than the original Carlos Avery and has fairly good drainage. The Sunrise River has a relatively large flood

plain ranging from several hundred feet to a mile in width. It is 10 to 30 feet below the general land level and has well defined banks. Much of the flood plain is covered with sandy peat up to 8 feet deep.

The moderately rolling uplands of the Sunrise River Addition have sandy clay and sandy loam topsoil, overlying sand and yellow gravel. The predominant tree species on these uplands are oak, elm and pole-sized aspen with some natural stands of Norway, white and jackpine also occurring.

In summary, the acreages and percentages of the major cover types in the Carlos Avery Wildlife Management Area are given in Table 1.

Table 1. Major cover types in the Carlos Avery Wildlife Management Area

Cover Type	No. of Acres	% of Total
Open water	3,590	16
Marshland	9,560	42
Brush	2,900	13
Timber	4,700	20
Cropland	2,150	9
	22,900	100

With 58 percent, or 13,150 acres, of open water and marshland being the predominant cover type, it is only natural that emphasis be placed on the production and hunting of waterfowl. This is the primary management objective.

History

After the original survey of the Carlos Avery area was completed in 1933, an Emergency Conservation Work (E.C.W.) camp moved in. They improved the area in various ways.

The Carlos Avery Game Farm is located in Section 6, Township 32 North, Range 22 West. It was built in 1935 as a Works Project Administration (W.P.A.) project. Quail, Hungarian partridge and chukar partridge were raised here in early years. The 50,000 day-old chicks per year now produced here are distributed to sportsmen's

clubs, 4-H Groups and FFA Chapters. Over one hundred wild geese are raised annually at the farm. About 20 species of wild animals are held here for educational display purposes. Research is carried out at the Game Farm by state personnel and in co-operation with the University of Minnesota. More emphasis is now being placed on the raising of Giant Canada geese for distribution to the state-owned management areas in the hope of establishing free-flying goose flocks.

In 1938, 120 acres of land within the Carlos Avery area was designated as a wildlife nursery site for the production of wildlife food and cover trees and shrubs. The nursery was completed and dedicated on October 16, 1938. It is now operated by the Division of Forestry for the production of forest seedlings and wildlife plants.

Prior to World War II, predator control, establishment of closed areas and artificial stocking were the primary management techniques employed. After the war, predator control and artificial stocking were relegated with the main emphasis placed on habitat improvement. Land acquisition was carried out during the period from 1933 to 1966. Habitat development measures were applied to the land after it was acquired.

Wildlife Utilization

The first spring waterfowl migrants usually arrive at Carlos Avery during the last week in March. Mallards arrive first and blue-winged teal a few days later. Ringneck, scaup and goldeneye ducks usually do not arrive until about 10 days after the first mallards. Four species of ducks are common as breeders at Carlos Avery. They are, in order of abundance, blue-winged teal, mallard, wood duck and ringneck. Several pairs of Canada geese are now nesting on the area.

The fall build-up of ducks begins about the middle of August. About 85 percent are mallards and blue-winged teal; the remainder are ringnecks and wood ducks. Scaup begin to arrive in early October, and by late October the build-up usually reaches a peak of about 25,000 of which about one-half are mallards, 40 percent divers (mostly ringnecks), and the remainder predominantly blue-winged teal. Hunters harvested an estimated 18,360 ducks during the 1967 season.

The ringneck pheasant began moving into the Carlos Avery area in about 1934. The population reached a peak during the late thirties, then declined somewhat and has since remained at a fairly constant level.

From the early 1930's to the fall of 1955, deer numbers increased from an occasional animal to a peak of about 700 head, and have since leveled off to about 400 animals. The most important furbearers common to the area are mink, muskrat, beaver, skunk and raccoon. Mink are the most widely sought furbearer with about $2,000 worth harvested annually.

Recreation

The number of hunters using the original Carlos Avery Wildlife Management Area has increased greatly during the past 15 years. About 4,000 man-days of hunting were provided in 1946 and 7,000 in 1950. In 1955 it reached about 10,000 and remained at about this figure until completion of the two pools in the Sunrise Addition. An estimated 18,250 duck hunter visits occurred during 1967. Estimates of visitor use during 1967 for the entire area including the Sunrise Addition are given in Table 2.

Table 2. Estimated number of visitors using the Carlos Avery Wildlife Management Area during 1967.

Recreational Use	Number of Visitor Days
Hunting	23,900
Fishing	3,000
Canoeing & Boating	300
General Camping	400
Birdwatchers	2,000
Scouts (Boy & Girl)	6,000
Picnickers	1,200
Photographers	400
Students	5,000
Horseback riders	700
Sightseers, etc.*	24,000
TOTAL	66,900

* Includes 6,000 estimated visitors at Carlos Avery Game Farm.

It is obvious that the Carlos Avery Wildlife Management Area and Carlos Avery Game Farm provide an enormous amount of recreation to people other then hunters. It is not unlikely that the figure will reach 100,000 visitor days within the next five years.

Management and Development

The Carlos Avery Wildlife Management Area was established primarily as a public hunting area for waterfowl and upland game. More than half of the area is wetland and three-fourths of the hunting trips to the area are made to hunt waterfowl. It is evident that to provide the maximum amount of desirable recreation possible, the area must be intensively managed primarily for waterfowl hunting.

Along with providing waterfowl hunting opportunities, this area must be developed to its fullest potential as a waterfowl production area. To make the area more attractive to breeding waterfowl, as well as to transient ducks and geese, more open water areas must be provided and more food plots established. This would also provide more huntable area. The development of waterfowl production habitat and waterfowl hunting areas by means of water impoundments was the primary objective on the Sunrise River Addition and the other 16 waterfowl pools which have been constructed. Additional water impoundments are planned including a new pool in the south end of the project.

Management measures which have been carried out for the waterfowl resource include the clearing of timber, establishing food plots and nesting sites, and saving nest trees. Hunter facilities have been improved. Management and development measures for upland game, big game and furbearers receive secondary consideration. About half of the 10,000 acres of wetlands in the original Carlos Avery Wildlife Management Area is open water. Most of the remaining marsh area is a floating peat mat covered with sedge, cattail or willow.

Two new control structures have recently been completed on the Sunrise Addition providing a total of approximately 2,500 acres of open water and marsh water.

Other major types of construction completed on the Carlos Avery Wildlife Management Area includes dikes, roads, stoplog and metal culvert water control structures and firebreaks.

In addition, a considerable amount of sedge mat removal, water drawdown work, food and cover planting, and nesting cover development has been done.

EFFECTS OF PROPOSED MAJOR AIRPORT IN HAM LAKE TOWNSHIP ON THE CARLOS AVERY WILDLIFE MANAGEMENT AREA AND GAME FARM.

It is our contention that construction of the proposed second major airport at the Ham Lake site will create numerous intolerable conditions which, in the future, will lead to severe restrictions being placed upon the operation and management of the Carlos Avery Wildlife Management Area and Carlos Avery Game Farm in order to protect airport property and human lives. Our major immediate concern includes the following items.

1. Danger of aircraft - bird collisions.
2. Depreciation of aesthetic values associated with a wild, natural area by noise, and a loss of "open space".
3. Lowered water tables both in the Carlos Avery Wildlife Management Area, and adjacent public lakes.

We are also concerned with the possible adverse effects of aircraft disturbance on the game farm operations as well as on locally reared, wild waterfowl and probable future demands to close a portion or all of the area to hunting with firearms. These items of concern will be discussed further under the heading of disturbance factors.

Collisions between aircraft and birds

Plans for the Ham Lake site show that the runways in a NE-SW direction will bring aircraft directly over the Carlos Avery Wildlife Management Area on landing approaches. We have been informed that use of these runways can be expected to occur

on the average approximately 10% of the time. It is logical to assume, however, that during certain months, especially spring, summer and fall months, use of these runways will increase substantially over the 10% average since the prevailing winds are from the SW more often during this time than during the winter months.

Aircraft approaching the airport on these runways will be directly over waterfowl and bird concentration areas, especially during periods of spring and fall migrations. The first spring waterfowl migrants normally arrive in late March and the migration may extend well into May, depending upon weather conditions. The first fall migrants are blue-winged teal beginning in mid-August. The fall migration extends into freeze-up, usually the month of November.

Geese, both resident and migrant, use the area in late summer and early fall. There is a continuous movement of Canada geese, Branta canadensis maxima (the giant Canada goose) between the Carlos Avery Game Farm and other private flocks, notably the Bell flock near Afton, Hill flock at North Oaks and Hennepin County Park Reserve flock near Waconia. Most of the metropolitan area is closed to the hunting of Canada geese by Commissioner's Order in an effort to increase their numbers. The giant Canada goose is huge, weighting up to 16 lbs. or more, and is noted for its low flight. The effect of such a large goose colliding with a jet airplane could be disastrous.

In a paper presented at the recent North American Wildlife and Natural Resources Conference, Houston, Texas, Mr. Victor Solman of the Canadian Wildlife Service stated that the calculated force of a 4 lb. bird (such as a small goose) colliding with an aircraft traveling at 300 MPH is equivalent to an impact force of 14 tons. What then would the effect be of a 16 lb. goose striking an airliner at 160 MPH during approach and/or take-off? The answer is obvious!

The crash of a turbo-prop Electra at Logan Airport, Boston, in October, 1960, with the loss of 62 lives was believed to have been caused, at least in part, by the aircraft flying through a large flock of starlings.

An article in Newsweek Magazine dated September 25, 1967, notes that the Federal Aviation Administration reported 526 separate collisions between U. S. commercial aircraft and birds during the first 8½ months of 1967. The birds ranged in size from sparrow to swan.

Another article in the January 7, 1967 issue of Science News notes that the U. S. Air Force spends $10 million annually on bird problems, of which $4-5 million is the cost of replacing and repairing engines. It also quotes the Air Force as saying, "bird/aircraft collisions are far more common than the public suspects or than pilots care to admit."

Gunn and Solman (1967) have reviewed some of the problems relative to reducing the number of aircraft - bird strikes. In their paper which was presented in London, England on September 28, 1967, at the Symposium on the Problems of Birds as Pests, the greatest threat from birds was judged to be those in which a multiple strike may damage more than one engine and/or those in which the bird struck is large enough to do serious damage to such vital parts of the air frame as the wind screens and stabilizer. They considered the prime hazards as being small birds (shore birds) in dense flocks, medium sized birds (gulls and terns) in relatively dense flocks, and large birds such as geese and swans. All of these potential hazards, including the presence of large numbers of black birds and other marsh birds, exist at Carlos Avery. A list of birds known to nest in and migrate through the Carlos Avery is shown in the appendix. Eighty-nine individual species of birds nest on the Carlos Avery area and an additional 81 species use the area during migration.

Wildlife Leaflet No. 429 prepared under the Federal Aviation Agency Bureau of Research and Development contract FFA/BRD-A-90 titled Bird Hazard to Aircraft clearly indicates the time of year in which the greatest hazard exists, the elevation at which to expect problems, and means to remedy the problem. Conditions, as described in this leaflet, which are attractive to birds at or near airports include food, roosting sites, resting or loafing areas, nesting, and migration.

If it is determined that a potential hazard does exist, the leaflet outlines three basic steps to follow:

(1) identify the species involved and the factors that attract these birds to the airport, (2) determine whether a particular bird problem is temporary in nature or whether it will persist or recur and (3) decide which remedial measures are most practical.

The following remedial steps are recommended in Wildlife Leaflet No. 429 where it has been decided that a permanent reduction of birds is necessary:

1. Potential roosting sites for flocking birds should be destroyed. Tall reeds, weeds, or brush may attract thousands of starlings and blackbirds, especially in fall and winter. Such cover may serve as roost sites for blackbirds and starlings, as well as for rodents and rabbits, which in turn attract birds of prey.
2. Berry or seed-producing shrubs and weeds that are attractive to wildlife should either be removed altogether or replaced by less attractive species. If a line of shrubs is needed for a snow fence or a windbreak, it should be kept free of weeds. Use of shrubs which produce abundant fruits or seeds of known value as wildlife foods should be avoided insofar as possible.
3. Ponds and other bodies of water should be drained or otherwise eliminated. Shallow impoundments in the immediate vicinity of runways should be well drained and the depressions filled to reduce even temporary rain pools to a minimum. Many species of birds are attracted to water for drinking and bathing purposes.

It is obvious to us that these solutions to bird problems are completely opposed to good wildlife management practices which we as professional people are encouraging and developing at the Carlos Avery Wildlife Management Area.

What then would the Metropolitan Airports Commission propose to do to all or part of the Carlos Avery Wildlife Management Area should the bird hazard become serious? Would they follow the recommendations of this booklet?

We feel that such a problem is indeed imminent, as more intensive management of our wildlife habitat is underway and planned at the Carlos Avery Wildlife Management Area. Add to this the proposed goal of 100,000 ducks and 25,000 geese at the Sherburne National Wildlife Refuge only 25-30 miles away, plus the metropolitan goose flock, and we can forsee very serious conflicts arising!

PRESERVATION OF OPEN SPACE AND NATURAL AREAS

Report #2, titled 4,000,000 by 2000!, prepared in December 1964 for The Joint Program, an inter-agency land use-transportation planning program for the Twin Cities Metropolitan Area, discusses the following problems and policies concerning "open space" for the future anticipated population growth of the seven county metropolitan area:

1. An adequate and convenient supply of "open space" to serve the recreation needs of the Area's population. (Note - the commonly used standard is 10 acres of major park and recreational land for every 1,000 residents. Many consider this standard too low due to an increasing amount of leisure time. The Area today has only 30% of the land it needs for this purpose.)
2. Protection and preservation of wildlife, historic sites, scenic areas, watersheds and drainage ways.
3. An open-space pattern that serves the greatest variety of public needs with the least conflict with related or competing functions.

The report further states on page 41 that future governmental action should be based on the following proposals:

1. Protect existing recreation, conservation, historic or scenic sites through zoning and avoid them when locating new highways or public buildings.

2. Keep drainage ways in their natural state to provide protected rights-of-way and impounding areas for storm run-off and to keep storage areas such as marshes and depressions open. (Note - on page 43 the report further states ---, "discharge the Area's storm water run-off into natural impounding reservoirs such as lakes, marshes, or other depressions to help recharge the Area's diminishing ground-water supplies".)

It is obvious that a major airport at the Ham Lake site would be contrary to the recommendations and goals as stated in the report, 4,000,000 by 2000!, on the following points:

1. The Carlos Avery Wildlife Management Area would lose its present "protection" as a conservation, recreation and scenic area by the construction of public airport facilities adjacent to the wildlife management area. That this loss would be real is evidenced by the site selection report which states, "another 3,000 acres of land would have to be acquired for approach protection in the northeast direction if it were not for the Carlos Avery Game Refuge which abuts the Ham Lake Site."
2. Construction of artificial drainage ditches, storm sewers, etc. needed to develop the airport would not maintain drainage ways in a natural condition. Natural water storage areas and ground-water recharge areas would not be preserved and protected unless special safety measures are incorporated into the drainage plan.

The question then arises as to why the need for spending approximately 1.8 million dollars to prepare such a report as this when the recommendations, policies, goals, etc. are being ignored? Has the Metropolitan Airports Commission referred to this report in making its recommendations?

Considerable time and expense is being put into the completion of a one-half mile nature trail south of the Carlos Avery Game Farm headquarters. The primary

purpose of this nature trail is to provide the thousands of school children which visit the area each year with an educational and interpretive look at various species of plants, trees, shrubs, and wildlife native to the area. The constant noise and disturbance from overhead aircraft will not only detract from the aesthetic values of this trail, but it will also make it extremely difficult to discuss and communicate to the children the ecology and conservation education associated with the nature trail.

DISTURBANCE FACTORS

Experience at the Lac Qui Parle Wildlife Management Area, Lac Qui Parle, Chippewa and Big Stone Counties and other projects has shown us that aircraft flying under 1,000' have a definite scaring effect on waterfowl, particularly geese. The approach of such aircraft causes the geese to mill around and because of this there is the likelyhood of scaring the geese out of the area. This, of course, eliminated the possibility of using the geese for both hunting and non-consumptive uses such as birdwatching and photography. This undoubtedly will occur at the Carlos Avery Wildlife Management Area also.

We are also concerned that the wild populations of waterfowl will suffer due to this disturbance. This is especially true at Carlos Avery Wildlife Management Area since most of the nesting birds are "pioneers", birds that were not raised in the area or nested there in previous years. This is due to the heavy hunting pressure on locally raised birds and the subsequent "burning-out" of these birds. It is true that some waterfowl do not react violently to aircraft, as experienced at other airports. However, how many other major airports are adjacent to a public area similar to Carlos Avery Wildlife Management Area and Public Hunting Grounds?

The presence of some waterfowl in the Minnesota River bottoms at Wold-Chamberlain Airport is not analogous as that area is not a major production or concentration area

such as the Carlos Avery Wildlife Management Area is. The majority of the waterfowl concentrate at the NSP Company Blackdog power plant located 5 miles southwest of the airport which is a considerable distance from the main approach area and, therefore, does not pose a serious potential hazard to aircraft in the vicinity.

The Carlos Avery Game Farm is located directly underneath the NE-SW runway at a distance of 3 - 4 miles from the proposed airport boundary. This means that the aircraft will be at an altitude of only 900 - 1,200' above the game farm on approaching the airport.

What effect will the noise and vibrations caused by approaching and circling aircraft have on game farm production of pheasant chicks and goslings is open to questions, as the literature is lacking on this subject.

Although it is known that incubating chickens are not adversely affected by the noise, this does not necessarily mean that pheasant chicks and goslings won't be affected.

Does the Metropolitan Airports Commission have sufficient data to guarantee that lowered egg production by adult pheasants and geese, and lowered incubation rates of pheasant eggs will not occur? Should the need arise to relocate the game farm as a result of disturbances caused by aircraft, the replacement cost could be expected to exceed $1,000,000. We believe it essential that this information be obtained prior to approval of the Ham Lake site.

That portion of the Carlos Avery Wildlife Management Area abutting the proposed airport is open to the hunting and trapping of all game birds and animals during the legally established season. This includes the hunting of deer with rifled slugs and bow and arrow; squirrels, rabbits, raccoon with 22 caliber rifles and shotguns; upland game birds and waterfowl with shotguns. It should also be noted that the hunting of unprotected birds and animals such as fox, woodchuck and crows is also permitted during the time on which there is an open season on protected game species. Many of these "varmint shooters" use hi-powered rifles in pursuit of these animals.

Since the Carlos Avery Wildlife Management Area is within only a one-half hour's drive of 1.5 million people, it is not unrealistic to expect that certain hunters might become careless or take an occasional pot-shot at approaching aircraft. Past experiences of wildlife management area personnel leave little doubt in our mind that such a problem will arise.

A shotgun slug is quite accurate up to 100 yards, and will carry a considerable longer distance. It should be noted that a 12 gauge slug weighs 450 grains, or 1 oz. The 22 caliber slug, although weighing less than 50 grains, will carry a considerable distance also. The hi-powered rifles, needless to say, carry considerably farther and have a much greater impact force then do either the shotgun or 22 caliber slugs.

Assuming that an occasional airplane was hit by gunfire from someone within the Carlos Avery Wildlife Management Area, what course of action would the Metropolitan Airports Commission take to remedy the problem? We believe that any specific action taken would result in the closing of a large portion of the area to hunting. It is quite possible that we would be expected to close a portion of the wildlife management area prior to the start of airport operations in order to prevent such an occurrence.

S U M M A R Y

The Division of Game and Fish has statutory responsibility for protection, propagation, and wise use of our fish and wildlife resources. We are very much concerned with the proposal to develop a major Metropolitan Airport at the Ham Lake site in Anoka County which abuts the southwest corner of the important 22,900 acre Carlos Avery Wildlife Management Area. This state area was acquired and developed for wildlife production, public hunting and recreation by the State of Minnesota at a cost of approximately one million dollars. The current market value of all lands and improvements is estimated at $5 - 6,000,000. During 1967 there were 67,000 visitor-days of use on this project, and it is anticipated that this figure will increase annually at a marked rate. It is not unlikely that the figure will reach 100,000 days within the next five years. The Carlos Avery Wildlife Management Area is a major recreational center, wild in character, and the only one of its type located so conveniently for the 1.5 million people in the Twin Cities area. Because of the uniqueness of the area, it would be impossible to replace.

The Department of Conservation feels that it is desirable for the State of Minnesota to have another major Metropolitan Airport but we are opposed to the Ham Lake site because of the adverse effects which it will have on the irreplaceable Carlos Avery Wildlife Management Area. It is our contention that construction of this airport at the Ham Lake site will create numerous intolerable conditions which, in the future, will lead to severe restrictions being placed upon the operation and management of the Carlos Avery Wildlife Management Area and Carlos Avery Game Farm in order to protect airport property and human lives. Our major concerns are:

1. Danger of aircraft - bird collisions.

2. Depreciation of aesthetic values associated with a wild, natural area by noise, and a loss of "open space".

3. Lowered water tables both in the Carlos Avery Wildlife Management Area and adjacent public lakes.

We are also concerned with the possible adverse effects of aircraft disturbance on the game farm operations as well as on locally reared and migrating wild waterfowl and probable future demands to close a portion or all of the area to hunting with firearms.

Many questions remain unanswered as to the ultimate effects which the proposed airport may or will have on the Carlos Avery Wildlife Management Area and Game Farm. We feel that it is not too late to move the airport from the proposed site, but it is too late to move the Carlos Avery Wildlife Management Area and Game Farm. The ultimate loss of this wildlife area is imminent if the proposed airport is constructed at the Ham Lake site.

We urge that M.A.C. give consideration to the location of the proposed airport on a site which would minimize loss to long established natural resource and public recreational areas.

Division of Game and Fish
Minnesota Department of Conservation

Species of Birds Nesting on the Carlos Avery Wildlife Management Area

Common Loon
Pied-billed Grebe
Green Heron
American Bittern
Canada Goose

Mallard
Blue-winged Teal
Wood Duck
Ring-necked Duck
Cooper's Hawk

Red-tailed Hawk
Red-shouldered Hawk
Broad-winged Hawk
Marsh Hawk
Sparrow Hawk

Ruffed Grouse
Ring-necked Pheasant
Sandhill Crane
Virginia Rail
Sora

American Coot
Killdeer
Woodcock
Wilson's Snipe
Spotted Sandpiper

Black Tern
Mourning Dove
Yellow-billed Cuckoo
Black-billed Cuckoo
Great Horned Owl

Barred Owl
Belted Kingfisher
Flicker
Pileated Woodpecker
Red-headed Woodpecker

Hairy Woodpecker
Downy Woodpecker
Kingbird
Crested Flycatcher
Phoebe

Alder Flycatcher
Least Flycatcher
Wood Pewee
Tree Swallow
Bank Swallow

Barn Swallow
Purple Martin
Blue Jay
Crow
Black-capped Chickadee

White-breasted Nuthatch
House Wren
Long-billed Marsh Wren
Short-billed Marsh Wren
Catbird

Brown Thrasher
Robin
Willow Thrush
Eastern Bluebird
Cedar Waxwing

Migrant Shrike
Starling
Yellow-throated Vireo
Red-eyed Vireo
Warbling Vireo

Yellow Warbler
Oven-bird
Yellow-throat
Redstart
Eastern Meadowlark

Yellow-headed Blackbird
Red-winged Blackbird
Baltimore Oriole
Brewer's Blackbird
Common Grackle

Cowbird
Scarlet Tanager
Cardinal
Rose-breasted Grosbeak
Indigo Bunting

Dickcissel
Goldfinch
Savannah Sparrow
Vesper Sparrow
Chipping Sparrow

Clay-colored Sparrow
Field Sparrow
Swamp Sparrow
Song Sparrow

Species of Birds Occurring on the Carlos Avery Wildlife Management Area
as Migrants or Visitors

Great Blue Heron
Black-crowned Night Heron
Whistling Swan
Snow Goose
Blue Goose

12 Species of Ducks
Goshawk
Sharp-shinned Hawk
Rough-legged Hawk
Bald Eagle

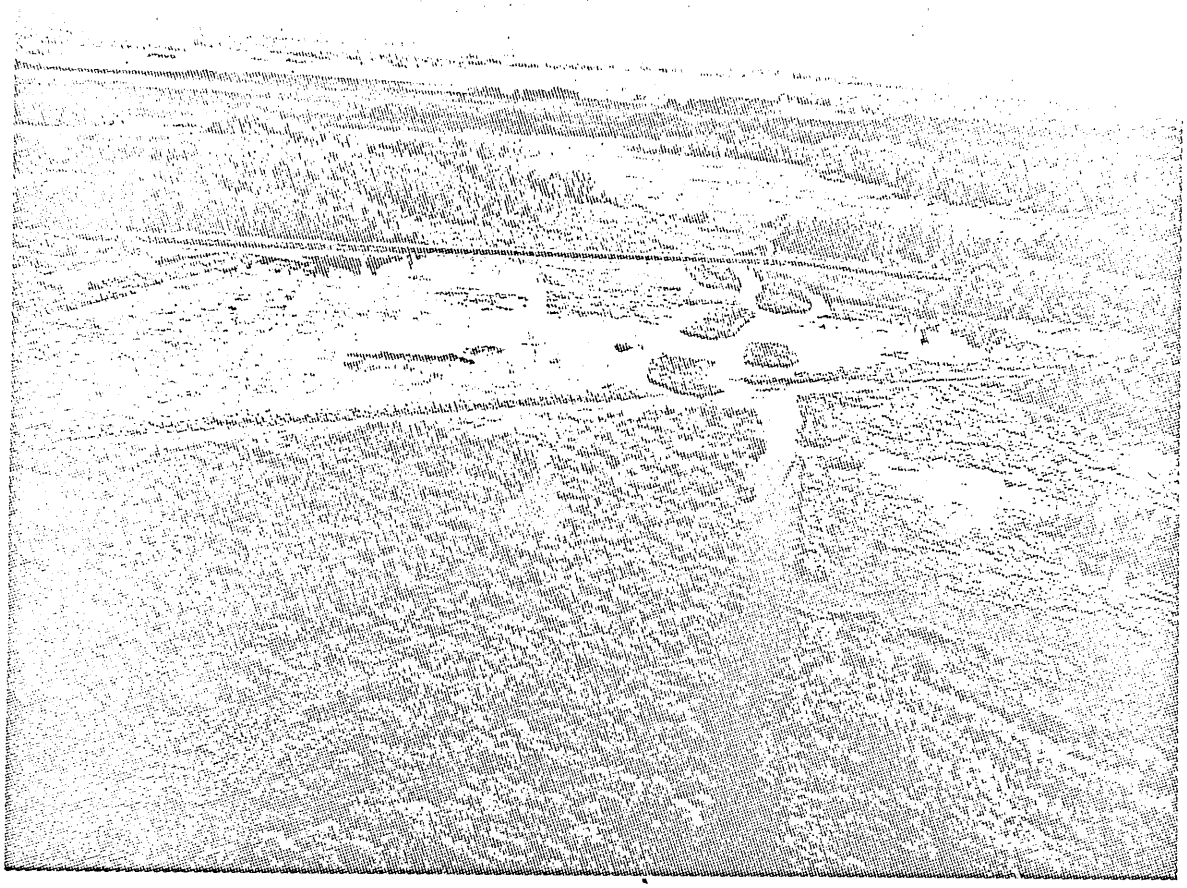
Osprey
Herring Gull
Ring-billed Gull
10 Species of Shore-birds
Whip-poor-will

Nighthawk
Red-bellied Woodpecker
Yellow-bellied Sapsucker
Brown Creeper
Olive-backed Thrash

Gray-checked Thrush
Golden-crowned Kinglet
Ruby-crowned Kinglet
Northern Shrike
Solitary Vireo

Philadelphia Vireo
21 Species of Warblers
Yellow-headed Blackbird
Rusty Blackbird
Purple Finch

Redpoll
10 Species of Sparrows



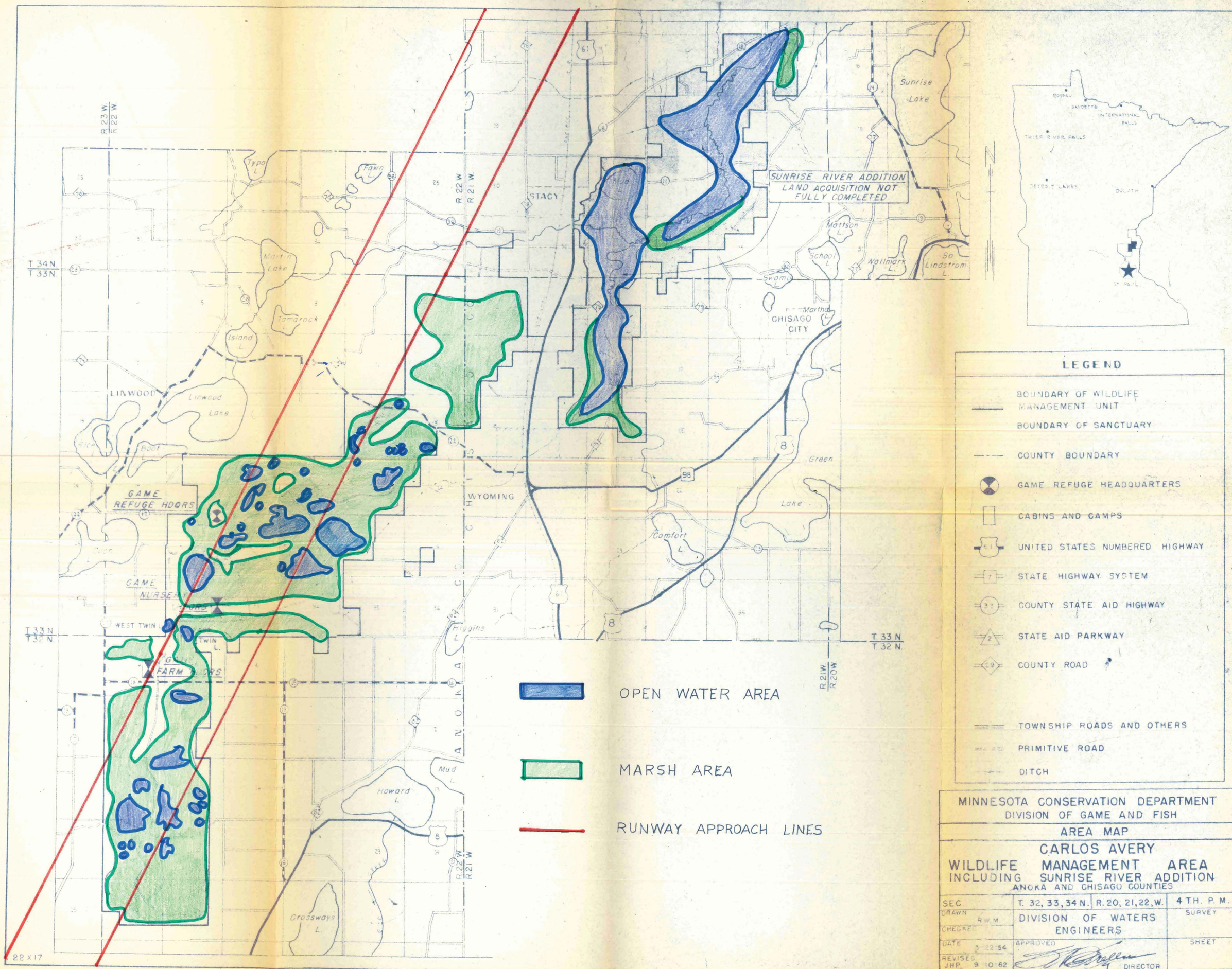
Pool 16 - Aquatic habitat typical of the Carlos Avery Wildlife Management Area. This pool is within 1.5 miles of the runways of the proposed airport.

Scenes such as this are typical at the Carlos Avery Wildlife Management Area during spring and fall waterfowl migrations.

Over 18,000 duck hunters used the Carlos Avery Wildlife Management Area in 1967.

Many deer hunters use the Carlos Avery Wildlife Management Area during the season.

Trapping of furbearers at the Carlos Avery Wildlife Management Area provides income and recreation to local residents.



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MINNESOTA CONSERVATION DEPARTMENT
DIVISION OF GAME AND FISH

AREA MAP

CARLOS AVERY WILDLIFE MANAGEMENT AREA INCLUDING SUNRISE RIVER ADDITION

ANOKA AND CHISAGO COUNTIES

SEC.	T. 32, 33, 34 N.	R. 20, 21, 22, W.
DRAWN R.W.M.	DIVISION OF WATERS ENGINEERS	4 TH. P. M. SURVEY
CHECKED		
DATE 3-22-54	APPROVED [signature] DIRECTOR	SHEET
REVISED J.H.P. 9-10-62	REQ. 54-106	SHEET 1 OF 1

FILE G-154 & G-349-X

BIRD-PLANE CONFLICT

Star 10/23/68

Ham Lake Site Termed Unsafe

By LEWIS PATTERSON
Staff Writer

From the standpoint of human safety the Ham Lake site for a second major metropolitan airport is not a good selection, a federal expert on bird and aircraft compatibility said Tuesday.

C. E. Faulkner, specialist with the U.S. Fish and Wildlife Service, said that "in a nutshell, the site selection should be made where there is not as much attraction for birds as there is at Carlos Avery Game Refuge" which borders the Ham Lake site in Anoka County.

The alternative, Faulkner indicated, is virtually to destroy the game refuge.

Faulkner answered questions for an hour at a meeting called by the Association of Northern Suburban Residents at which he was invited for the specific purpose of answering questions. The meeting was held at 1312 Lake St., Minneapolis.

To make the Ham Lake site unattractive to birds — in order to provide for human safety — the area would have to be drained, hunting would have to be halted, constant spraying would be required to eliminate insects, and other bird food would have to be killed, he said.

Faulkner noted that up to 18,000 ducks a year are shot annually at and near the Ham Lake site and many thousands more live or visit there, plus many thousands of other birds.

"Hunting would have to be eliminated because it puts thousands of birds into the air and this, of course, compounds danger to air flights, especially with more and faster jets and more take-offs," he said.

In the course of answering several questions Faulkner brought out the nature of the problem involved.

"Suppose you mow all the wild hay in order to discourage the presence of seed-eating birds," he said. "At once you have created a second problem because the short cropped grass attracts a variety of insects and then the insect-eating birds move in.

"And when you eliminate water by drainage the variety of gulls that now loaf on the water will be attracted to the runways as a loafing place."

Faulkner said the federal Fish and Wildlife Service has not been asked to make a study of the Ham Lake site and it cannot do so without invitation by a governmental agency. Such studies take time.

"You just don't select a major airport site in a hurry," he said. "The site should be observed four times a year — during the northern and southern migration periods and during the winter and in the summer resident period."

"Man should be more concerned with safety and should be willing to pay the cost of destroying the attractiveness of an area for birds or be willing to pay the cost to select an area that is not attractive to birds," Faulkner said.

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
1006 WEST LAKE STREET
MINNEAPOLIS, MINNESOTA 55408

In reply refer to:
FA-Minnesota
W-6-L
W-21-D

October 9, 1968

Mr. Richard D. Wettersten, Director
Division of Game and Fish
Department of Conservation
St. Paul, Minnesota 55101

Attention: Mr. Donald W. Burcalow, Federal Aid Coordinator

Dear Mr. Wettersten:

This letter is prompted by recent speculation that the Ham Lake site probably will be selected for constructing another metropolitan airport. You have stated that construction and operation at this site will result in serious losses for the Carlos Avery Wildlife Management Area.

Federal Aid in Wildlife Restoration has a substantial investment in land acquisition and wildlife habitat development at Carlos Avery. As we have previously discussed, loss of wildlife restoration benefits at this area will be viewed as a diversion of Federal Aid funds, and Secretary's Rule 80.5 (Federal Aid Manual, Revised 1967) will apply. Application of this rule means that your Department must replace the area lost with a property of equal value at current market prices and with commensurate benefits. Failure to accomplish this replacement in kind will make Minnesota ineligible to continue receiving Federal Aid in Wildlife Restoration funds.

Sincerely yours,

L. M. Springer
Regional Supervisor
Division of Federal Aid

ROUTING SCHEDULE
GAME & FISH - 390 CENTENNIAL BLDG.
F. A. COORD. — SEC. RES. & PLANNING —
LANDS DEV. — GAME RESEARCH —
WETLANDS ACQ. — FISH RESEARCH —
SEC. GAME — SURVEYS & INV —
SEC. FISHERIES — BIOL. SURVEYS —
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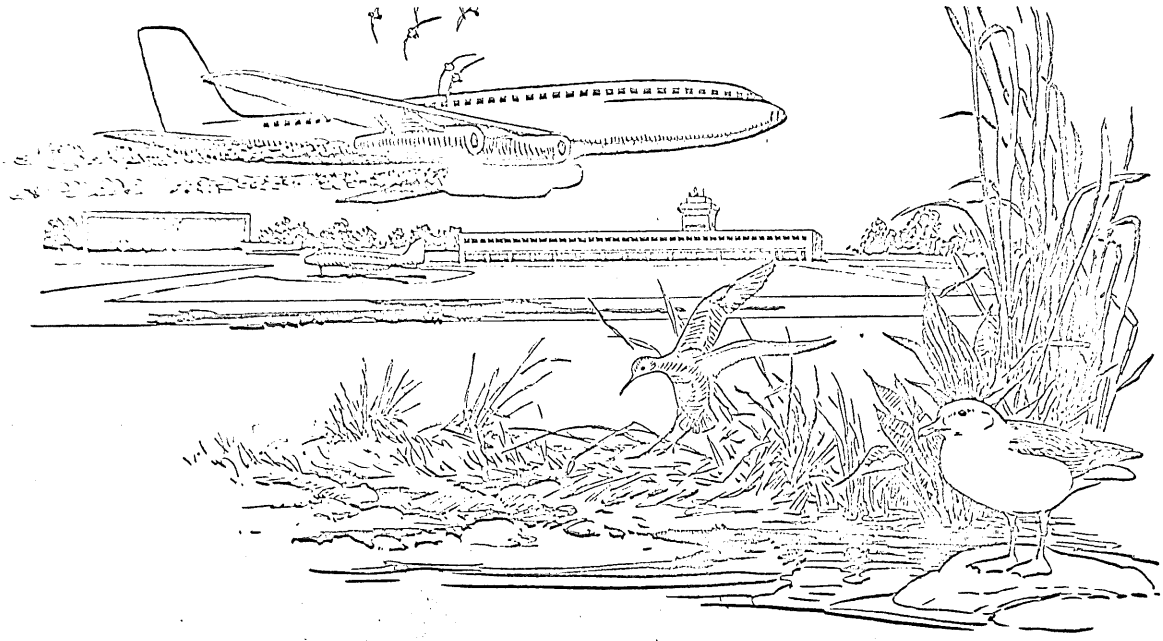
BIRD HAZARD TO AIRCRAFT



UNITED STATES DEPARTMENT OF THE INTERIOR

FISH AND WILDLIFE SERVICE

BUREAU OF SPORT FISHERIES AND WILDLIFE

Wildlife Leaflet 429

THIS LEAFLET PREPARED UNDER FEDERAL AVIATION AGENCY
BUREAU OF RESEARCH AND DEVELOPMENT CONTRACT FAA/BRD-A-90

United States Department of the Interior
Fish and Wildlife Service
Bureau of Sport Fisheries and Wildlife
Branch of Wildlife Research
Washington 25, D. C.

Wildlife Leaflet 429 January 1961

BIRD HAZARD TO AIRCRAFT

By

John W. Aldrich, Chandler S. Robbins, and Walter W. Dykstra
Biologists, Branch of Wildlife Research

Contents

Birds have long been recognized as a potential hazard to aircraft. During the early days of aviation when airplane speeds were relatively slow, damage from bird strikes usually was minor and largely confined to broken windshields and occasional damage to the fuselage. However, since World War II and the introduction of jet aircraft the problem has become more serious. In addition to greater damage resulting from impact with birds at high speeds, the ingestion of birds in jet and prop-jet engines has become a hazard.

During the past decade many birds became accustomed to the noise and speed of piston-driven aircraft and formed the habit of using airports without danger to themselves or to aircraft. With the advent

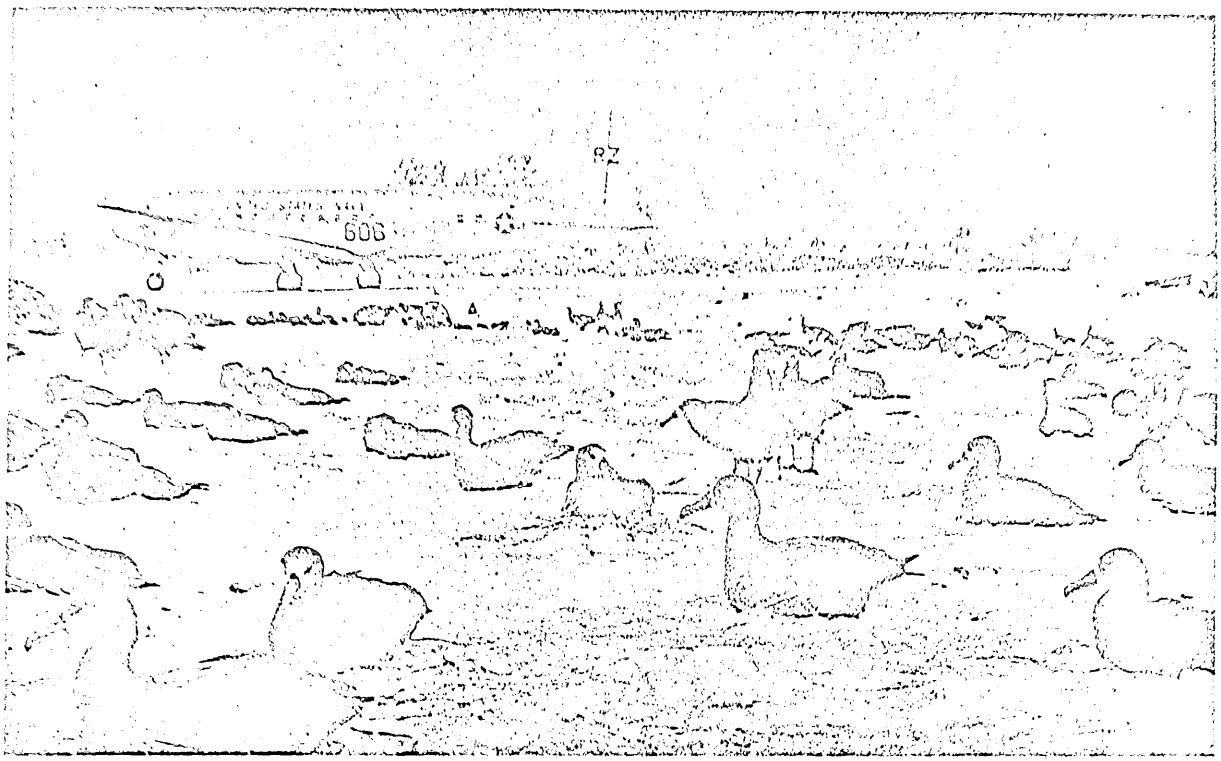
of jet and turbo-jet engines, however, the tremendous suction into air intakes has become an added factor. Furthermore, some birds have acquired the habit of resting on portions of runways not normally used by piston-driven aircraft. The longer runways and more complete use of runways required for jet planes thus pose a new problem; birds have not developed the ability to avoid a jet-powered aircraft.

The Bureau of Sport Fisheries and Wildlife is undertaking a study of this problem in cooperation with the Federal Aviation Agency, the Air Transport Association, and local airport management personnel. It is anticipated that the investigation will provide data on the nature and extent of bird strikes and that new measures will be developed which can be used to minimize such hazards. Meanwhile, airport managers are urged to make observations on the occurrence of birds in the vicinity of airfields under their jurisdiction. Such observations should be reported to the Bureau of Sport Fisheries and Wildlife, Fish and Wildlife Service, U. S. Department of the Interior, Washington 25, D. C.

The information in this leaflet has been compiled with the help of representatives of the Federal Aviation Agency, the Department of Defense, the Air Transport Association, local Audubon societies, and airport management. Their cooperation and assistance are gratefully acknowledged.

HISTORY OF THE PROBLEM

Records of bird strikes during the early days of aviation are fragmentary. During World War II military agencies recognized that sea birds constituted a hazard at bases on oceanic islands, notably at Midway Atoll in the North Pacific and Ascension Island in the South Atlantic. Sooty terns and albatrosses were the principal trouble makers. The problem still exists although corrective measures have decreased the hazards appreciably. For example, land leveling operations at Midway have reduced perceptibly albatross soaring activities over the runway at that airfield. A number of incidents have also occurred in the United States where the presence of gulls was associated with the close proximity of dumps to airfields and where small birds were attracted by weed growths adjacent to runways. Similar problems have been encountered in Great Britain involving plovers, pigeons, and crows. In the States, most of the recent strikes have involved sea gulls. A few included swallows, hawks, pigeons, ducks, geese, and starlings. The largest number of bird strikes have occurred during the summer and fall months, as expected, since these are the times of year when bird populations are at their peak. The greater number of strikes in the fall further reflects the autumnal bird migration.



Black-footed albatrosses at U. S. Naval Station, Midway Islands.

BIRDS IN FLIGHT

Much remains to be learned about the altitudes at which birds fly under various weather conditions at different seasons of the year. The following is a general summary of bird flight information as known at present. Although primary emphasis is given here to coastal areas and major water courses, heavy concentrations of waterfowl and other large birds also occur over a number of wildlife refuges in various parts of the United States. Persons interested in potential hazard areas in specific States should contact the Bureau of Sport Fisheries and Wildlife and State conservation departments for details relating to local bird concentration areas.

Songbirds generally fly within 5,000 feet of the ground. At night these small birds commonly fly as widely scattered individuals rather than in dense flocks; at times, however, concentrations may build up at night over shorelines when prevailing winds have a tendency to drift the birds toward the ocean or the Great Lakes. During daylight hours some species of songbirds fly in dense flocks.

Concentrations of large-sized birds are more frequent in coastal than in inland localities. Unfortunately, many major airports have been constructed in tidal locations -- even on reclaimed land partially surrounded by tidewater. This automatically creates serious and complex problems because of the variety of birds and the heavy transient populations that pass through coastal areas even when the airport itself offers no particular attraction.

From what is known of the geography of bird abundance in the United States, the Atlantic, Pacific, and gulf coasts and adjacent marshes would be potential hazard areas below 6,000 feet, day and night, from late August through late April. The hazard would continue locally through the summer on the coasts of Maine, New Hampshire, and Massachusetts (gulls up to about 4,000 feet); Connecticut to North Carolina (terns, chiefly below 500 feet; gulls in some areas up to 4,000 feet); South Carolina to and including Texas (pelicans, terns, and herons, chiefly below 500 feet; gulls in some areas up to about 4,000 feet); and on the Pacific coast and offshore islands (gulls and cormorants up to about 4,000 feet). The majority of coastal birds are within 5 miles of shore, but tens of thousands of large, low-flying shearwaters (mostly below 500 feet) may be present, especially off the central and southern California coast, June through August.

Chesapeake Bay, the North Carolina sounds, San Francisco Bay, and Puget Sound have high concentrations of waterfowl and gulls from October to mid-April, and much lower numbers through the summer months.

The Great Lakes, especially their shores and islands, are used by waterfowl (particularly during August-November and March-April) and gulls (locally in June-July, widespread during rest of year but less common in northern half in December, January, and February) and may constitute a hazard up to about 4,000 feet.

The Mississippi, Missouri, and Ohio river valleys are used, day and night, by large numbers of waterfowl and gulls, especially during the migration seasons, March-April and September-November. The lower half of the Mississippi River and adjacent streams and marshes are used extensively by waterfowl throughout the winter months. The great majority of the birds are below 3,000 feet in winter and below 6,000 feet during migration.

CONDITIONS THAT ATTRACT BIRDS TO AIRPORTS

There is no habitat, either natural or man-made, that will not attract certain species of birds at some season of the year. For this reason, the

objective when planning to reduce a bird hazard is to render the airport and its vicinity less attractive to those species that are a potential hazard -- not to strive for the impossible goal of a birdless community.

Birds that occur on or over airfields probably are there for one of five reasons: (1) In search of food or water; (2) roosting; (3) resting or loafing; (4) nesting; or (5) passing by, which includes traveling between roosting, feeding, and resting areas as well as active migration.

Food. -- Most airport areas provide an abundance of food in the form of weed seeds, grass seeds, berry-producing shrubs, earthworms, grubs, and other insects. Many airports have inadequate refuse disposal systems, such as an active dump on their property, or there may be a large municipal dump, or sewage outlets nearby. Some have ponds or other permanent bodies of water near or even between active runways; many have temporary rain pools that at certain seasons of the year may persist for days at a time.

Roosting. -- Cover in the form of tall reeds, shrubs, trees, or weed patches may provide convenient roosting places. They may even attract birds such as starlings or blackbirds from many miles away. An infrequently used runway may serve as a night roosting place for a flock of gulls. Ponds may provide roosting places for waterfowl and other water birds at night. Almost any area that is free from disturbance may provide a suitable roosting site for one or more species of birds.

Resting or Loafing. -- Gulls stand around for hours at a time between flights to feeding areas. Most shore birds (sandpipers and plovers) feed primarily on exposed mud flats in tidal areas. At high tide they rest in large flocks on beaches, golf courses, spoil banks, or on other open areas such as those created by dredging operations. Blackbirds and starlings frequently rest in the tallest vegetation near their feeding areas.

Nesting. -- The species of birds nesting on an airport depend upon the habitat and the amount of disturbance present. Once nesting of a species has been established, the same individuals can be expected to return year after year. Some of their surviving offspring can be expected to return and nest in the same area. The nesting density that ultimately will be reached depends upon the particular species, the type of cover, location, and the amount of disturbance.

Migration. -- The annual migration of birds northward in spring and southward in fall brings a variety of birds past almost every airport in the country. The migration dates vary from species to species and from area to area. The abundance of a given species may vary from year to year,

depending upon weather conditions and other factors. On nights when a heavy migration coincides with low overcast, fog or drizzle, many small birds may be attracted to ceilometer beams. Some airports in the immediate vicinity of cities may have a late afternoon and early morning flight of many thousands of starlings passing over enroute between a city roost and a rural feeding area. Airports in tidal areas may have flocks of shore birds traveling back and forth over the runways in moving from one exposed flat to another.

REMEDIAL MEASURES

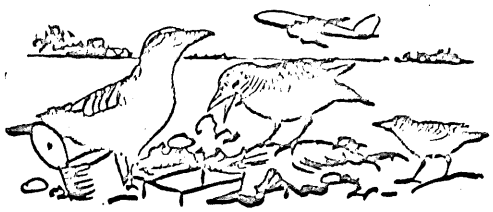
If it is determined that a potential hazard exists due to the presence of birds, the first step is to identify the species involved and the factors that attract these birds to the airport. The second step is to determine whether a particular bird problem is temporary in nature or whether it will persist or recur. Many situations involve migrating individuals that are readily dispersed from the area and will not return once they have been frightened away. In other cases, the birds may be resident species which feed, rest, or roost on the airport grounds. The third step is to decide which remedial measures are most practical.

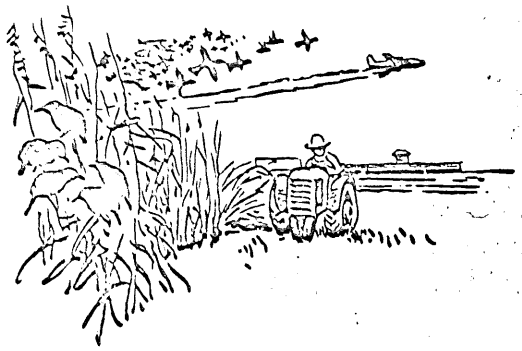
When a heavy concentration of a particular bird species constitutes a serious hazard, it may be necessary to give preference to immediate but temporary relief methods. On the other hand, if situations exist that currently or may in the future attract birds in dangerous numbers, steps should be taken to make the habitat on and in the vicinity of the airport less attractive to them.

Most concentrations of birds that occur during the spring and fall migration seasons are comprised of species that will be present for only a few days. Scaring devices generally are effective in these instances. On the other hand, summer or winter resident birds may gradually learn that scaring devices are relatively harmless, in which case other methods must be employed to reduce the hazard.

As long as attractive conditions exist on airports, birds will continue to take advantage of the situation. Much can be done to make such areas unattractive. The following are a few of the steps that can be taken toward a permanent rather than a temporary reduction of concentrations.

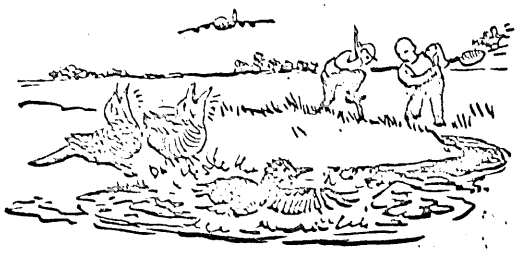
1. Elimination of dumps and other unsanitary conditions. Any dump or sewage disposal area in close proximity to the airport can be a definite hazard because of the large number of gulls, starlings, and other birds that are attracted to waste food. Even careless disposal of relatively clean trash may attract birds for short periods.





2. Potential roosting sites for flocking birds should be destroyed. Tall reeds, weeds, or brush may attract thousands of starlings and blackbirds, especially in fall and winter. Such cover may serve as roost sites for blackbirds and starlings, as well as for rodents and rabbits, which in turn attract birds of prey.

3. Berry-or seed-producing shrubs and weeds that are attractive to wildlife should either be removed altogether or replaced by less attractive species. If a line of shrubs is needed for a snow fence or a windbreak, it should be kept free of weeds. Use of shrubs which produce abundant fruits or seeds of known value as wildlife foods should be avoided insofar as possible.



4. Ponds and other bodies of water should be drained or otherwise eliminated. Shallow impoundments in the immediate vicinity of runways should be well drained and the depressions filled to reduce even temporary rain pools to a minimum. Many species of birds are attracted to water for drinking and bathing purposes.

SCARE DEVICES

Research on bird control, particularly in connection with agriculture, has resulted in the discovery and manufacture of a number of devices which, if used correctly and under the proper conditions, have proven successful in repelling temporarily a number of species of birds. The following types of devices and materials are on the market and should be considered for applicability to airport bird problems if conditions warrant. This list is incomplete and does not include all manufacturers of scare devices and materials, nor does it imply Government endorsement of the products mentioned.

Automatic Acetylene Exploders. -- Machines that ignite acetylene gas to produce loud explosions at regular intervals by dripping water on calcium carbide or from a tank of compressed acetylene gas. They are not injurious to birds, but the loud reports may be objectionable in residential areas.

Exide Thunderbird or Scare Away	-	Reed-Joseph Co. Highway 1 Greenville, Mississippi
Zon	-	B. M. Lawrence Co. 244 California Street San Francisco 11, California

Exploding Shotgun Shells. -- This is a 12-gauge shotgun shell containing, instead of pellets, a king-sized firecracker which is projected a distance of 100 yards or more before exploding.

B. M. Lawrence Co., 244 California St., San Francisco 11, California
K. K. Hori Co., Inc., 5833 Perry Drive, Culver City, California, or
100 West Chicago Avenue, Chicago 10, Illinois

Pyrotechnics: Fireworks. -- Firecrackers, inserted at intervals in slow-burning fuse ropes, have been useful in keeping birds away from agricultural crops. Dealers marked with an asterisk make and distribute completed ropes of firecrackers designed to explode at periodic intervals. The dealer marked with a number sign specializes in cotton fuse rope.

* Alpha Enterprises, Inc., P. O. Box 12242, Houston, Texas
\# J. E. Fricke Co., 40 N. Front St., Philadelphia 6, Pennsylvania
* Red Devil Fireworks Co., 5415 E. Century Blvd., Lynwood, California

Firecrackers, salutes, skyrockets, roman candles, and other devices have been used to drive birds from crops and to discourage roosting. These are standard items and may be purchased from regular firecracker manufacturers.

Birds gradually become accustomed to noise; therefore, it is best to move the exploders around occasionally and operate them only when necessary. They should not be operated during the dark of night but should be started at daybreak and dusk. Exploding shell crackers should be used occasionally in between explosions of the acetylene exploders. The number of exploders needed will depend upon the size of the airport and the severity of the bird problem.

Many States and cities have laws or ordinances prohibiting the use of fireworks. Investigate local city ordinances and State laws regulating the possession or use of fireworks or explosives, also local fire laws.

OTHER WILDLIFE

Rabbits, deer, and moose also have been involved in collisions with aircraft moving along runways. Specific information regarding their control or management is available through field offices of the Bureau of Sport Fisheries and Wildlife and State conservation agencies.

RESEARCH

Intensified studies are being initiated (1) to obtain more information on the extent and nature of the bird problem in all sections of the country; (2) to test commercial materials and devices marketed or proposed for use in bird control at airports; (3) to determine the potential usefulness of sterility-producing agents and selective lethal chemicals; (4) to investigate sonic, ultrasonic, and electronic media as bird deterrents; and (5) to observe bird behavior and responses in problem areas. It is

anticipated that these long-range studies will bring about the discovery and development of new and improved control techniques.

TECHNICAL ASSISTANCE

Technical consultation regarding bird control may be obtained from regional offices of the Bureau of Sport Fisheries and Wildlife. These are listed below:

Region 1 (Cal., Idaho, Mont., Nev., Ore., Wash.); Interior Bldg., 1001 N.E. Lloyd Blvd., Portland 14, Ore. (BElmont 4-3361)

Region 2 (Ariz., Colo., Kans., N. M., Okla., Tex., Utah, Wyo.); Federal Office Bldg., 517 Gold St., S.W., Box 1306, Albuquerque, N. M. (CHapel 7-0311)

Region 3 (Ill., Ind., Iowa, Mich., Minn., Mo., Nebr., N. D., Ohio, S.D., Wis.); 1006 W. Lake St., Minneapolis 8, Minn. (FEderal 9-3612)

Region 4 (Ala., Ark., Fla., Ga., Ky., La., Md., Miss., N. C., S. C., Tenn., Va.); 620 Peachtree-7th Bldg., Atlanta 23, Ga. (TRinity 6-3311)

Region 5 (Conn., Del., Me., Mass., N. H., N. J., N. Y., Pa., R. I., Vt., W. Va.); 1105 Blake Bldg., 59 Temple Pl., Boston 11, Mass. (CApitol 3-2961)

Region 6 (Alaska); Box 2021, Juneau (Phone: 6-3546)

Remains of birds involved in aircraft strikes, including fragments removed from jet engines may be sent to the Bird and Mammal Laboratories, Bureau of Sport Fisheries and Wildlife, Room 61, U.S. National Museum, Washington 25, D.C., for identification. Fleshy remains should be frozen or preserved in formalin or alcohol before shipping. Dry remains require no special treatment.

Many species of birds frequenting airports are protected by Federal or State laws. Their legal status should be determined before any lethal controls are attempted. In some cases the laws contain provisions to obtain permits to destroy those individual birds which are causing depredations or are injurious to the best interests of society.

WATER RESOURCE EVALUATION

AT THE

PROPOSED HAM LAKE AIRPORT SITE

"Ground Water Conditions at the Ham Lake Airport Site - Anoka County"

A Reconnaissance Study

Introduction

In order to determine the effects of the proposed airport at the Ham Lake site on water resources of the area, it is necessary to understand certain aspects of the bedrock geology, glacial geology, and hydrology of the surficial deposits.

Bedrock Geology

The dominant geological rock structure affecting this area is the Keweenawan Basin which represents a southwesterly extension of the Lake Superior syncline which extends as far south as Iowa. The Keweenawan Basin refers to the surficial configuration of the paleogeologic basement rocks which underlie the area at great depth, and consists mainly of extrusive rocks and lava flows of Keweenawan age. A thick succession of sedimentary rocks, principally of sandstones and shales of Precambrian, Cambrian, and Ordovician age, have been deposited in this basin over the basement rocks.

Recent aereomagnetic studies conducted by P.K. Sims and Isadore Zietz in 1967, established that several continuous faults are present in the basement rocks extending parallel to each other along the northeast-southwest axis of the Lake Superior Syncline, and pass directly under the Anoka sand plain. One fault passes directly under the proposed Ham Lake airport site and the Carlos Avery Game Refuge. Another known as the Pine fault follows the same northeast-southwest direction approximately one mile east of Ham Lake. A third fault, the Douglas fault, is located a short distance northwest of the study area and is oriented in the same direction.

Although younger sedimentary rocks have been deposited over

these faulted areas, it is expected that concentrated erosion and valley cutting would occur through geologic time along these weakened zones in the earth's crust. A typical geologic section in the Minneapolis-St. Paul area illustrates the presence of block faulting through the younger sedimentary rocks (Figure 3 Stone 1966). These rocks display deep erosional valleys with butte-shaped divides. Similar conditions are believed to exist at the Ham Lake site.

Glacial History

The proposed airport site lies within and near the southeastern limits of the Anoka sand plain which covers an area of about 850 square miles. It was deposited as a result of geological events that occurred at the close of the Pleistocene Ice Age.

During the last Wisconsin Ice Stage, two separate ice lobes originating from different ice centers invaded the area on separate occasions. Red sandy drift was first deposited in the area by an ice lobe originating from the Patrician Ice Center located northeast of Lake Superior. Later, after the Patrician ice had receded, the Des Moines lobe invaded Minnesota from the northwest and traveled southeast from the Red River valley across the south half of the state. This lobe originated from the Keewatin Ice Center in Canada west of Hudson's Bay. It deposited a discontinuous cover of gray calcareous drift over the previously deposited red drift. Red drift remnants are still exposed on the surface at several locations in the Anoka sand plain.

Although the main flow of ice of the Des Moines lobe was toward the southeast, a divergent off-shoot known as the Grantsburg sublobe suddenly developed west of the Twin Cities and followed a course that was almost at a right angle to the southeast direction of the parent Des Moines lobe (Figure 1). According to theories on

glacial regimen, it is an accepted fact that glacial ice will usually flow along the path of least resistance and can be expected to show a close relationship to the underlying bedrock topography. The unusual angle of divergence (about 90°) taken by the Grantsburg sublobe from the Des Moines lobe indicates that it encountered a low bedrock depression oriented northeast-southwest and responded to this lower gradient by diverging to the northeast along the axis of the pre-glacial lowland. Figures 1 and 2 illustrate the extent of the Des Moines lobe and Grantsburg Sublobe and the subsequent deposition involved in its recession.

The diversion of the drainage of the Mississippi River by the Grantsburg Sublobe is thought to be directly responsible for the formation of the Anoka sand plain (Cooper 1932). It is theorized that the river was detoured around the ice lobe into Lake Grantsburg and then eventually into the St. Croix River drainage. As the ice stagnated, the river then followed the receding ice, depositing sands until it attained its present location through the Twin Cities (Figure 2).

In order to emphasize the relationship of bedrock control on determining the direction of glacial flow, the Douglas fault, Pine fault, and a third unnamed fault were superimposed over the glacial map (Figure 2). It quickly becomes apparent that the inferred fault lines correspond very closely with the central axis of the Grantsburg Sublobe, giving credence to the probability of buried pre-glacial valley along that zone. This implies that the younger sedimentary rock formations deposited over the faulted basement rocks have been affected by continual shifting in this zone of crustal weakness, resulting in concentrated erosion of valleys through these formations. If such is the case, one would expect escarpments of Ordovician and Cambrian rock formations exposed in the valley walls.

A schematic cross section of rock formations (Figure 6) was compiled from available well logs as indicated along line A-A from Figure 5. It shows the presence of a pre-glacial valley over 300 feet deep, with steep northwest facing slopes. Of special note is the fact that several major bedrock aquifers such as the Shakopee-Oneota, Jordan sandstone, and the Dresbach formations that crop out along the escarpment of the southern valley wall are all favorably oriented and open to recharge from the overlying valley fill and glacial drift. These aquifers are the principle source of ground water for the metropolitan area. Figure 7 illustrates the structural contours of the Jordan sandstone artesian aquifer.

Investigation of the Water Table Aquifer

Arrangements were made with the Minnesota Highway Department to hire a mobile power auger and a two man crew for drilling the holes and sampling the soils. The soils specialist in charge of the auger crew did all of the sampling and measuring of water levels. Four inch diameter augers were used in drilling all of the test holes. Boring sites were selected prior to drilling by the Division of Waters, Soils and Minerals from a reconnaissance map compiled through the interpretation of aerial photographs. This afforded detailed outlines of landforms and general soils types in the area.

Most of the test holes were dug along the right of way of public roads and usually placed in the sandy uplands. A few holes that encountered peaty soils were drilled through these organic soils into the sand below. It was reasoned the fine sands are interconnected beneath the relatively shallow peat deposits, and would give more accurate data on the regional water table than if the holes were placed indiscriminately. Studies of water levels in peat bogs by Roger Bay of the North Central Experiment Station, U.S. Forest Service, 1966,

indicate water levels in peat bogs could vary considerably from the water table in surrounding mineral soils at certain seasons of the year.

All water levels in the test holes were tape measured at the time of drilling, and again after 24 hours. Detailed surveys were made by the staff of the Division of Waters, Soils and Minerals to obtain land surface elevations at the test hole sites.

Several deep holes were augered in an attempt to locate the extent and depth to the impervious layer of gray till, often refered to as the "gray mantle" which forms an aquitard approximately 25-65 feet below land surface in this area. The intention was to determine whether the gray mantle aquitard is continuous or broken, and to determine the saturated thickness of the fine sand aquifer above it. A comparison of the deeper borings with existing well logs, along with Minnesota Highway Department boring data, indicates that the gray mantle aquitard is missing in some locations over the suspected bedrock valleys. Three borings (T-3, T-27, and T-53) were drilled to depths ranging from 52-56 feet below land surface over the inferred fault lines and each failed to encounter the gray till. Others drilled farther east (test hole #10) encountered gray till at 28 feet below land surface, indicating a gradual shallowing of the sand in that direction. Farther southeast, soil borings taken by the Minnesota Highway Department in the construction of I-35W SP. 0280, established the presence of the gray mantle at still shallower depths.

Other borings were made by the Minnesota Highway Department in the construction of Highway 65, and many holes were augered in a search for construction material northwest of the Ham Lake site near Bethel. Soils data was also reviewed from the proposed military airport study (1956-57) near Bethel. All of these borings indicate the gray mantle

increases in depth, and the sand plain increases in thickness from southern Isanti County towards the southeast, in the direction of the airport. This information further confirms the contentions that the surface of the gray mantle has a regional slope inclined from the northwest to the southeast into the collapsed zone of the sand plain which is located directly over the suspected buried pre-glacial valleys. The possibility that the gray mantle aquitard is missing at this point is significant in that it affords a direct connection for recharge into underlying rock aquifers which supply ground water to the St. Paul and Minneapolis area.

The contour map (Figure 8) showing the configuration of the water table at the proposed Ham Lake airport site in Anoka County was prepared from the boring data and shows:

1. The water table is sloping from several directions into a low elongated depression oriented in a northeast-southwest direction and then slopes due west along Coon Creek. The contour pattern reveals the strong influence to the local geology described previously.
2. The steepest slope of the water table occurs on the northwest side where the contours descend from elevation 904 at Coon Lake, to elevation 888.2 at Coon Creek, or a total fall of 15.8 feet over a distance of less than 4 miles. The magnitude of the ground water discharge in this area is reflected by the close spacing of the contours.
3. Flattened, widely spaced contours within the depression may indicate a local area of recharge to lower aquifers. Evidence of this vertical movement of water to recharge lower aquifers can be shown by comparing the ground water levels at several of the same sites for different periods

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3. Flattened, widely spaced contours within the depression may indicate a local area of recharge to lower aquifers. Evidence of this vertical movement of water to recharge lower aquifers can be shown by comparing the ground water levels at several of the same sites for different periods

of time. For example, borings T-51 and T-52 located in Section 24, Township 32N, Range 23W, were made and checked on August 26-29 and again on September 24 and showed no change in water levels although approximately 6 inches of rainfall had occurred during the intervening time.

4. The effects of ditching on the water table can be seen in Section 24 and 25, Township 32N, Range 23, where the channel of Coon Creek has been straightened and improved. It is believed that if the transverse storm sewer of the proposed airport drainage system is located near the southeast corner of the Carlos Avery Refuge, as planned, it would shift the contour pattern between the 892-898 contours on the east side of Coon Creek farther eastward into the Carlos Avery Refuge.

5. If Coon Creek is relocated to the north of the airport as planned, much of the ground water inflow to the creek will still be maintained. However, there will be some loss of ground water and surface water runoff to Coon Creek because of a decrease in drainage area.

6. The water table divide east of the Carlos Avery Refuge shows there is no water table connection in the area north of Main Street to the Rice Creek drainage. There may be a minor connection out of the study area towards the southeast through Sections 7 and 8, Township 31N, Range 22W.

Recently (1965) Dr. G.M. Schwartz, Professor Emeritus, of the University of Minnesota made a water table investigation in the area located just north of Coon Lake, between Cedar Creek and the Sunrise River drainage. Water table contours compiled from his study are oriented in a northeast-southwest direction and show a

gradual declining slope of the water table towards the southeast from elevation 916 near Cedar Creek to elevation 888 at the Sunrise River east of Martin Lake. This pattern complements the regional contours of the water table configuration at the Ham Lake site (Figure 8) except for the general lower level of the regional water table at that time.

It is believed that the difference of a few feet between the high water and low water positions of the water table will have little or no effect on regional flow patterns, and the relative configuration of the water table will remain the same throughout the cycle of fluctuation. Accordingly, Dr. Schwartz's configuration of the water table taken several years ago in the area mentioned above can be considered to be representative of the regional water table today, except that the elevations are now slightly higher.

Of special interest is the fact that not all of the test holes were augered during the same period of time. The first 64 holes were dug between August 26-29, 1968, and the final group of holes were drilled on September 24, 1968. During that interval of time, approximately 6 inches of rainfall occurred in the study area.

In order to correlate the water levels of the second group of holes with the first group, nine of the previously drilled holes were redrilled and water levels remeasured. Interestingly, some of the holes rose from .7 to 2.6 feet above previous water levels (T-57, T-55, and T-60), while other holes showed little or no rise over previous water levels (T-52 and T-27). It should be noted those holes rechecked showing no change in water level are probably located in an area where recharge is occurring to aquifiers at greater depth. The immediate response of the water table to precipitation

demonstrates the high permeability of the sand plain. This flashy character, and high seasonal fluctuations affecting the water table, was the prime factor that forced the Minnesota Highway Department to raise the finished grade for I-35W SP.0280 two to three feet above the original grade design between Circle Pines and Highway 8.

It is assumed these unusual fluctuations may not have been taken into consideration, and the proposed airport construction would probably be faced with similar problems. If this problem were to occur, it would be necessary to lower the proposed storm sewers located close to the southeast corner of the Carlos Avery Game Refuge, below the elevations shown on the preliminary ditch plans. This would tend to lower the water table in the Carlos Avery Game Refuge much more than presently anticipated. It would perhaps result in lowering the water levels from three to five feet in parts of Sections 19 and 30, Township 32N, and Range 22W.

Summary

All information gathered to date in the ground water study tends to support the concept that ground water in the upper fine sand aquifer from over a large area of the Anoka sand plain is being focused and discharged into a narrow trough-shaped depression that represents a surficial expression of buried pre-glacial valleys. Evidence from geological reports, well logs of deeper wells, auger borings, and the resulting water table map, strongly indicates that ground water from the upper sand plain aquifer may be in turn recharging the major lower bedrock aquifers through gaps in the gray mantle and through the glacial and alluvial fill in the buried valleys. This would afford a direct connection with the Shakopee-Oneota dolomite, the Jordan sandstone and other rock formations which are supplying most of the ground water for the Twin Cities.

A general lowering of the water table in this area would reduce the rate of recharge to these artesian aquifers. Because of the limited amount of data available at this time it is not possible to estimate the amount of this reduction.

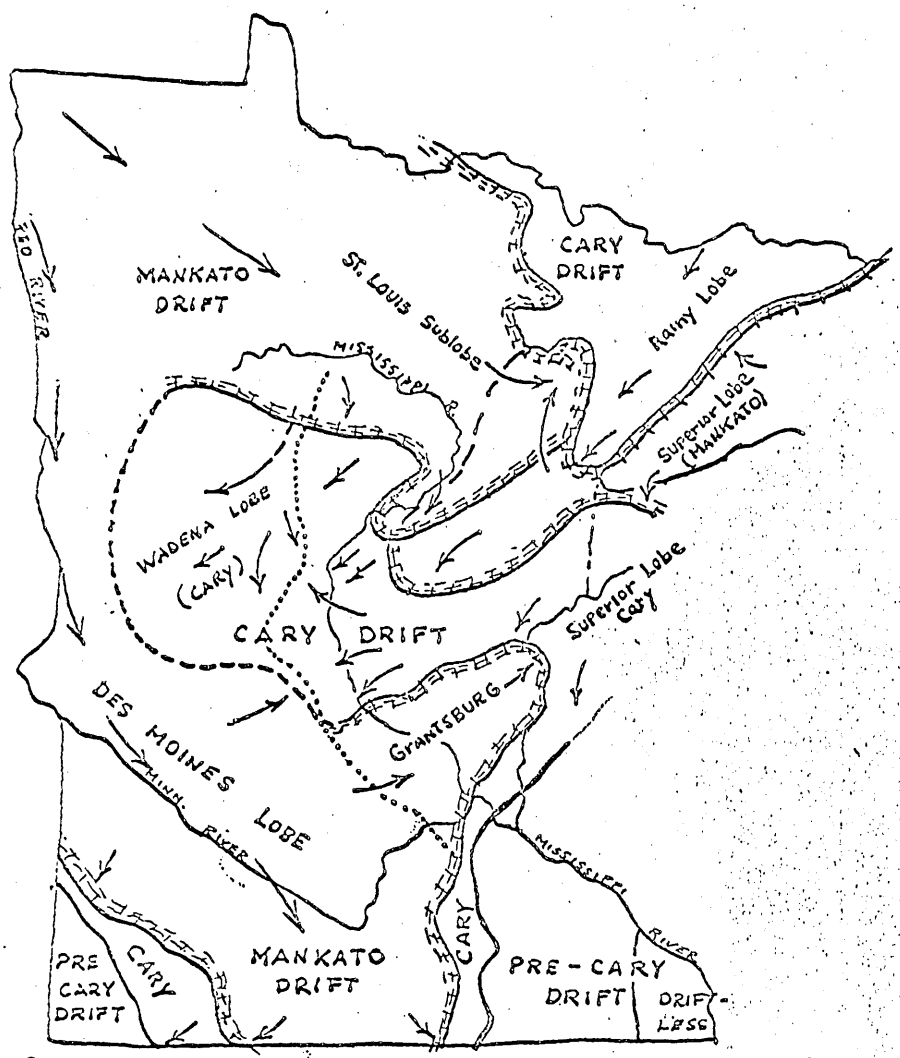
If the plan for extensive ditching is followed, the effect would be a lowering of the water table by several feet in the extreme south part of the Carlos Avery Game Refuge. The total effect would depend upon the finished depth of the ditches used.

It is believed that water levels on Lake Netta and Coon Lake would not be greatly affected by the airport drainage because of their location beyond the steep discharge slope of the water table. Ham Lake, on the other hand, is located directly over the steep water table slope which probably accounts for its past history of severe fluctuation. Any further steepening of the ground water discharge slope towards Ham Lake will probably lower the lake level.

Regardless of what drainage plan is used for the airport, it seems the greatest damage to the natural water and recreational resources in the area will not be accomplished by the airport itself, but by the intensive industrial and commercial developments which will be drawn to the airport complex.

It seems the present trend of development of widely spaced residential areas on the uplands, interspersed with sod and truck farming on the peatlands is a type of development which is compatible with the natural character of this area.

Morris T. Eng, Ground Water Hydrologist
Division of Waters, Soils and Minerals
Minnesota Department of Conservation

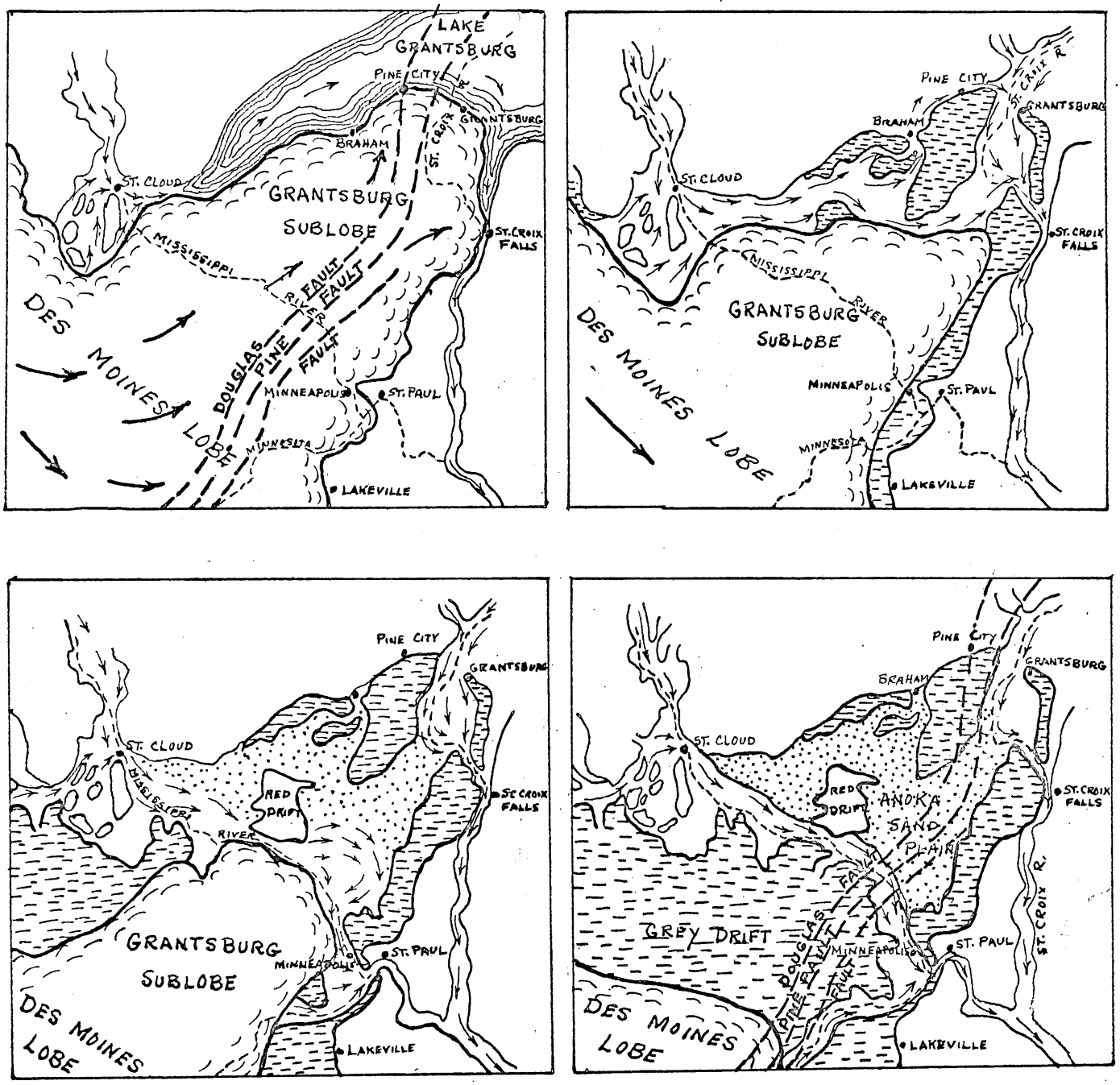


GLACIATION DURING THE WISCONSIN ICE STAGE

MANKATO, CARY AND PRE-CARY DRIFTS IN MINN.

(GEOL. of MPLS. - ST. PAUL REGION - UNIV. MINN)
BUL. 27 MINN. GEOL. SURVEY

FIGURE 1



STAGES IN THE FORMATION OF THE ANOKA SAND PLAIN

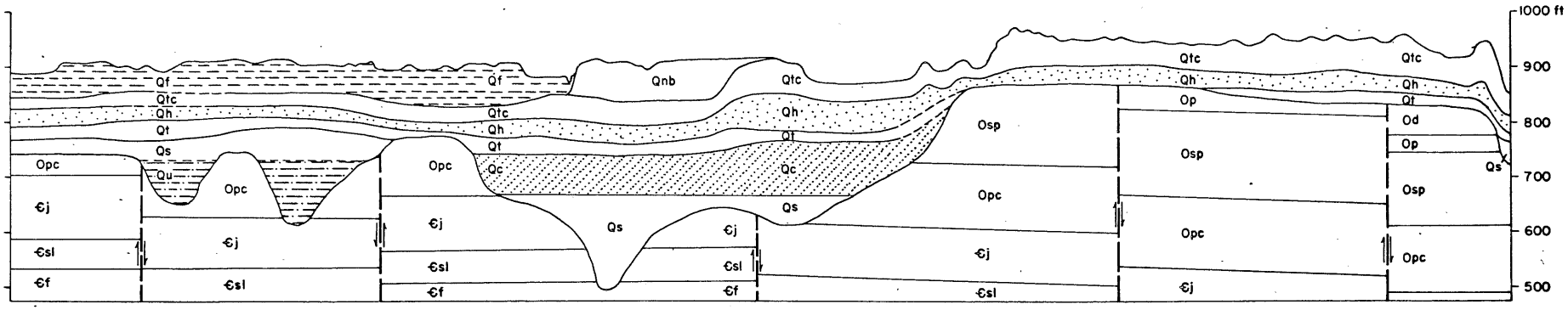
(R.S. FARNHAM-MPLS. GUIDEBOOK SERIES - GEOL. SOC. AM. 1956)

(FROM COOPER (1935)

FAULT LINES ADDED TO ILLUSTRATE POSSIBLE INFLUENCE OF PREGLACIAL VALLEYS ON ICE FLOW AND DEPOSITION OF THE ANOKA SAND PLAIN.

FIGURE 2

FIGURE 3



EXPLANATION

QUATERNARY

Qf	Fridley formation
Qnb	New Brighton formation
Qtc	Twin Cities formation
Qh	Hillside sand
Qt	Unnamed till
Qc	Clay
Qs	Sand
Qu	Undifferentiated glacial drift

PALEOZOIC

Ordovician

Od	Decorah formation
Op	Platteville formation
Osp	St. Peter sandstone
Opc	Prairie du Chien formation

Cambrian

€j	Jordan sandstone
€sl	St. Lawrence formation
€f	Franconia formation

Contact

Inferred fault, showing direction of movement

Figure 4.- GEOLOGIC SECTION SHOWING TYPICAL RELATIONSHIPS OF GLACIAL AND BEDROCK UNITS IN MINNEAPOLIS - ST. PAUL AREA. TAKEN FROM Plate 3, (STONE, 1966 a).

TABLE 1.- GEOLOGIC UNITS AND AQUIFERS OF THE MINNEAPOLIS-ST. PAUL AREA.

SYSTEM	FORMATION AND MEMBER	APPROX. THICKNESS (in feet)	DESCRIPTION	GRAPHIC COLUMN*	AQUIFERS AND AQUITARDS
QUATERNARY	Undifferentiated glacial drift	0-500	Glacial till, outwash sand and gravel, valley-train sand and gravel, lake deposits, and alluvium of several ages and several provenances; vertical and horizontal distribution of units is complex.		Distribution of aquifers and aquitards is poorly known. Sand and gravel aquifers containing moderate to large amounts of water appear to be common in buried bedrock valleys.
ORDOVICIAN	Decorah Fm.	90	Shale, bluish-green to bluish-gray; blocky; thin, discontinuous beds of fossiliferous limestone throughout formation.		Aquifer zone (in bedrock). Small quantities of water available from fractures and solution cavities.
	Platteville Fm.	Up to 35	Dolomitic limestone and dolomite, dark-gray, hard, thin-bedded to medium-bedded; some shale partings; can be divided into five members.		
	Glenwood Fm.	Up to 5	Shale, bluish-gray to bluish-green; generally soft but becomes dolomitic and harder toward east.		Aquitard zone (in bedrock).
	St. Peter Ss.	150	Sandstone, white, fine- to medium-grained, well sorted, quartzose; locally iron-stained and well-cemented; rounding and frosting of grains is common; 5-50 feet of siltstone and shale near bottom of formation.		Aquifer zone (in bedrock). Small to moderate amounts of water available.
					Aquitard (in bedrock).
	Prairie du Chien Fm. — Shakopee Member	50	Dolomite, light-brown to buff, thin- to thick-bedded cherty; shale partings; commonly sandy and oolitic.		Aquifer zone (in bedrock). Large quantities of water available. The most widely used source of ground water in the area.
	Prairie du Chien Fm. — New Richmond Memb.	0-10	Sandstone and sandy dolomite, buff; often missing.		
	Prairie du Chien Fm. — Oneota Memb.	50-120	Dolomite, light-brownish-gray to buff, thin- to thick-bedded, vuggy.		
CAMBRIAN	Jordan Ss.	90	Sandstone, white to yellowish, fine- to coarse-grained, massive to bedded, cross-bedded in places, quartzose; commonly iron-stained.		
	St. Lawrence Fm.	50	Dolomitic siltstone and fine-grained dolomitic sandstone; glauconitic, in part.		Aquitard.
	Franconia Fm. — Reno Memb.	120	Sandstone, very fine-grained, moderately to highly glauconitic; worm-bored in places.		Aquifer zone. Small amounts of water available
	Franconia Fm. — Mazomanie Memb.	Missing			
	Franconia Fm. — Tomah Memb.	20	Interbedded very fine-grained sandstone and shale; mica flakes common.		Aquitard zone.
	Franconia Fm. — Birkmose Memb.	20	Glauconitic fine-grained sandstone and orange to buff silty fine-grained sandstone (often worm-bored).		Aquifer zone. Moderate amounts of water available.
	Franconia Fm. — Woodhill Memb.	30	Sandstone, medium- to coarse-grained, cross-bedded.		
	Dresbach Fm. — Galesville Memb.	35	Sandstone, yellow- to white, medium- to coarse-grained, poorly cemented.		
	Dresbach Fm. — Eau Claire Memb.	Up to 150	Sandstone, siltstone, and shale, gray to reddish-brown; very fossiliferous.		Aquitard.
	Dresbach Fm. — Mt. Simon Memb.	Up to 200	Sandstone, gray to pink, medium- to coarse-grained.		Aquifer zone. Moderate quantities of water available.
			Unconformity		
KEWEENAWAN	Hinckley Ss.	Up to 200	Sandstone, buff to reddish, coarse-grained.		
			Unconformity		
	"Red clastics"	Up to 4,000	Silty feldspathic sandstone and lithic sandstone, fine-grained; probably also includes red shale.		Aquiclude zone.
			Unconformity		
	Volcanic rocks	Up to 20,000	Mostly mafic lava flows but includes thin interlayers of tuff and breccia.		

*The unit thicknesses are approximately to scale except for the two lowermost units.

J. E. Stone, Minn. Geol. Survey, 1966

FIGURE 4

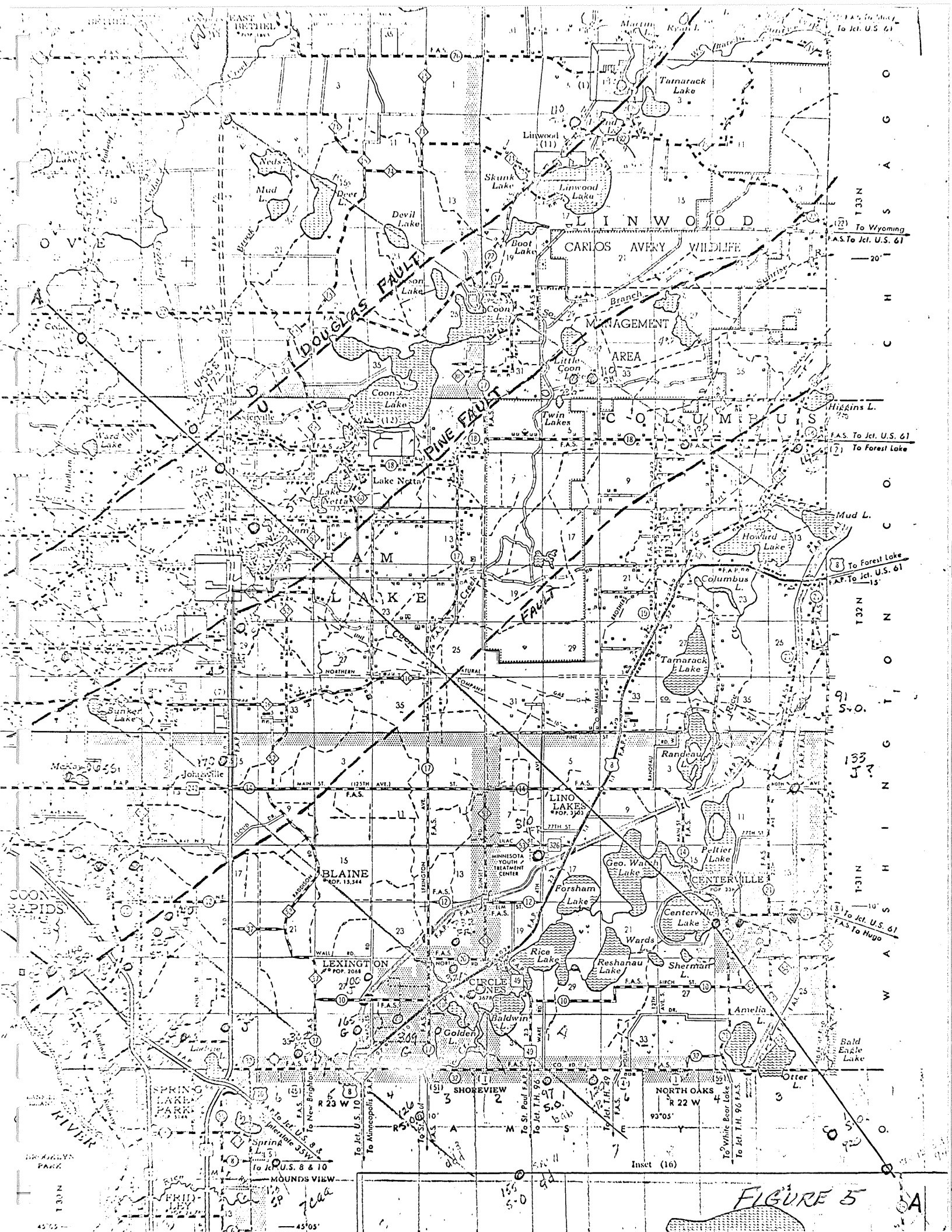
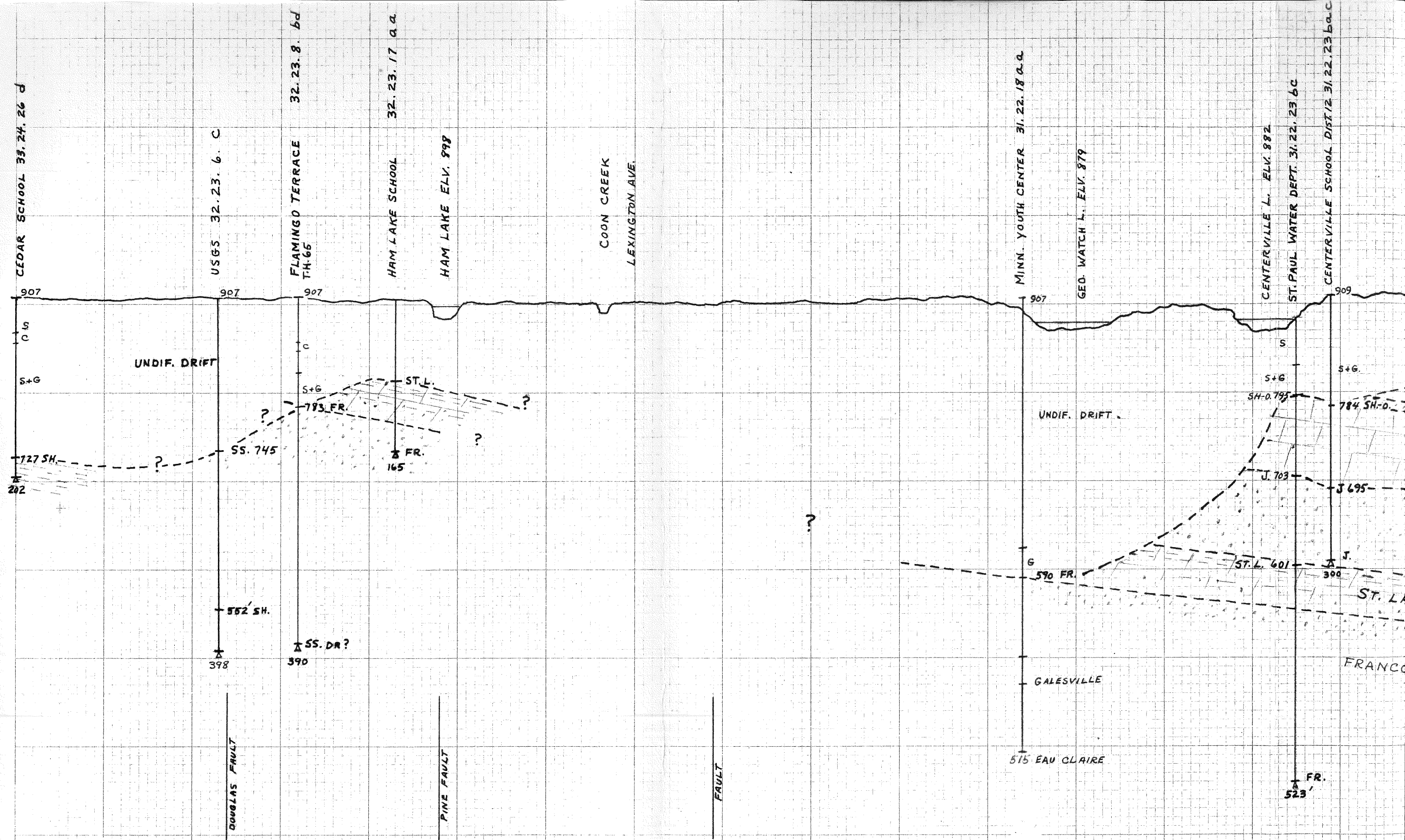

DOUGLAS FAULT
PINE FAULT
FAULT
CARLOS AVERY WILDLIFE MANAGEMENT AREA
LINWOOD
COLUMBUS
OAK GROVE
HAM LAKE
LINO LAKES POP. 3403
BLAINE POP. 15,544
LEXINGTON POP. 2088
CIRCLE PINES 3678
CENTERVILLE POP. 33
COON RAPIDS
SHOREVIEW
NORTH OAKS
SPRING LAKE PARK
MOUNDS VIEW
FRIDLEY
BROOKLYN PARK
Linwood (11)
Columbus (12)
Lake Netta
Coon Lake
Tamarack Lake
Howard Lake
Peltier Lake
Geo. Watch Lake
Forsham Lake
Centerville Lake
Rice Lake
Reshanau Lake
Wards L.
Sherman L.
Amelia L.
Baldwin L.
Golden L.
Bald Eagle Lake
Otter L.
Randeau L.
Johnsville
Inset (16)
To Jct. U.S. 61
To Wyoming
To Forest Lake
To Hugo
To New Brighton
To Minneapolis
To St. Paul
To White Bear Lake
Interstate 35W
To Jct. U.S. 8 & 10
R 23 W
R 22 W
T 33 N
T 32 N
T 31 N
WASHINGTON
CHISAGO

FIGURE 5



SCHEMATIC CROSS SECTION OF ROCK FORMATIONS THROUGH A–A

HORIZONTAL SCALE: 1 INCH = 1 MILE
VERTICAL SCALE: 1 INCH = 100 FEET

HAM LAKE SCHOOL 32.23.17 a a

HAM LAKE ELV. 898

COON CREEK

LEXINGTON AVE.

MINN. YOUTH CENTER 31.22.18 a a

GEO. WATCH L. ELV. 879

CENTERVILLE L. ELV. 882

ST. PAUL WATER DEPT. 31.22.23 b c

CENTERVILLE SCHOOL DIST 12 31.22.23 b a c

GLACIAL MORAINE

RAMSEY CO. LINE

BALD EAGLE LAKE ELV. 909

RAMSEY CO. NO. 15 30.22.11 a cd

RAMSEY CO. NO. 9 30.22.12 d d a

907

909

910

930

900

800

700

600

500

400

300

ST. L.

FR. 165

?

?

DRIFT

S

S+G

S+G

SH-0. 795

784 SH-0.

SHAKOPEE L.S.

OSP 836

ST. PETER S.S.

OP

UNDIF. DRIFT

ONEOTA DOLOMITE

J. 703

J 695

JORDAN S.S.

J

J

G

590 FR.

ST. L. 601

J. 300

ST. LAWRENCE FM.

ST. L.

FRANCONIA FM.

GALESVILLE

515 EAU CLAIRE

FR. 523'

FR.

DR. ?

616

627

PINE FAULT

FAULT

KEUFFEL & ESSER CO.
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SCHEMATIC CROSS SECTION OF ROCK FORMATIONS THROUGH A–A

HORIZONTAL SCALE: 1 INCH = 1 MILE
VERTICAL SCALE: 1 INCH = 100 FEET

FIGURE 6

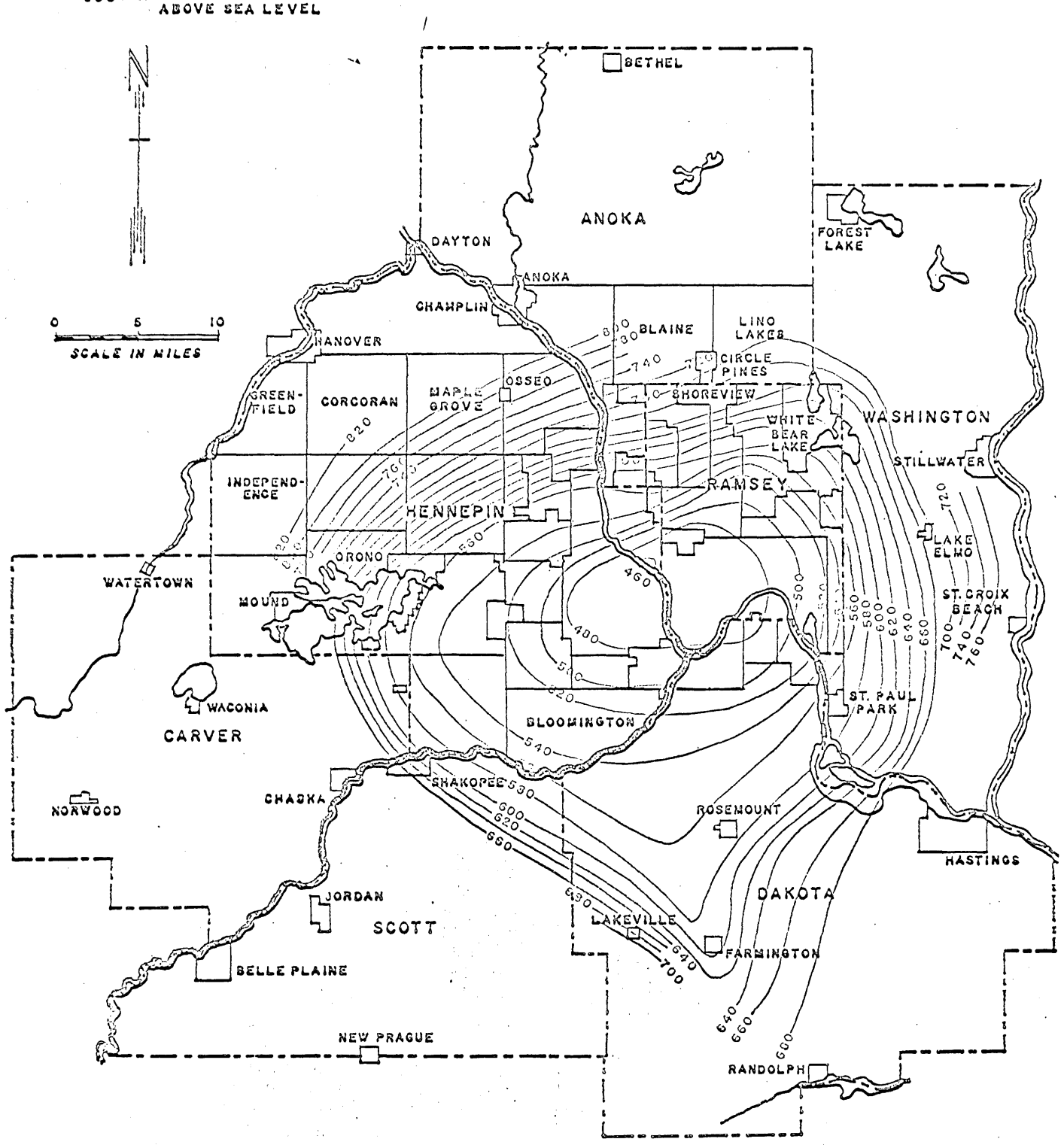

Figure 2.

MINNEAPOLIS - ST. PAUL METROPOLITAN AREA

STRUCTURAL CONTOURS ON THE JORDAN SANDSTONE

(MODIFIED AFTER SCHWARTZ, 1936)

MINNESOTA CONSERVATION DEPARTMENT
DIVISION OF WATERS

FIGURE 7

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U.S. Geological Survey, Topographic Maps, ($7\frac{1}{2}$ min) Circle Pines and Centerville Quadrangles, (15 min) Isanti Quadrangle.

CONFIGURATION OF THE WATER TABLE AT THE PROPOSED HAM LAKE AIRPORT SITE IN ANOKA COUNTY, MINNESOTA

FIGURE 8

EXPLANATION

- S — UPLANDS OF SANDY SOILS
- P — LOWLANDS COMPOSED OF PEATY SOILS
- D — DITCHES
- T-40 892.8 — AUGER HOLE AND ELEVATION OF WATER TABLE (AUG.-SEPT. 1968)
- 901 — WATER TABLE CONTOURS (LAND FORMS INTERPRETED FROM AERIAL PHOTOGRAPHS)

M.T. ENG 1968