DRAFT ENVIRONMENTAL IMPACT STATEMENT

MINNESOTA POWER & LIGHT COMPANY'S PROPOSED UNIT 4 CLAY BOSWELL STEAM ELECTRIC STATION

JULY, 1977

PREPARED BY

MINNESOTA POLLUTION CONTROL AGENCY

VOLUME II

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THIS DOCUMENT IS CONTAINED IN THREE VOLUMES.

VOLUME I

VOLUME II

VOLUME III

CHAPTER IV

ENVIRONMENTAL SETTING

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ENVIRONMENTAL SETTING

The description of the environmental setting focusses on those aspects of the environment that may be affected by MP&L's proposed addition of Unit 4 to the Clay Boswell Steam Electric Station. Chapter IV presents an environmental framework which provides a basis for understanding and evaluating the probable environmental impacts of the proposed action and alternatives. Both Chapter IV and Chapter V of the Draft EIS are organized into sections describing major environmental components. Chapter IV may be reviewed in its entirety prior to proceeding to the probable impacts in Chapter V, or corresponding subsections of Chapters IV and V may be reviewed separately prior to reviewing the chapters in their entirety.

GEOGRAPHICAL SETTING

Regional

The Clay Boswell Steam Electric Station is situated in the southwest corner of Itasca County in northeastern Minnesota as shown in Figure IV-1. Itasca County bordered by Koochiching, Beltrami, Cass, Aitkin, and St. Louis Counties is in the west central part of the 7 county Arrowhead Region. The Arrowhead Region includes major industrial and recreational areas. To the northeast of the Clay Boswell Station, the Mesabi Iron Range stretches 90 miles (145 km) to the community of Babbitt. This major taconite mining district served by MP&L includes the communities of Grand Rapids, Hibbing, Chisholm, Mountain Iron, Virginia, Eveleth, Hoyt Lakes, and Babbitt.

Eighty miles to the southeast of the plant is Duluth, the major city of northeastern Minnesota and a major port on Lake Superior. As a manufacturing and retail center, Duluth provides services for the northeastern part of the State. Approximately 80 miles (129 km) to the northeast is the inactive Vermilion Iron Range near Tower and Soudan. To the southwest approximately 50 miles (80 km) is situated the inactive Cuyuna Iron Range including the towns of Aitkin, Crosby, and Ironton.

The Clay Boswell Station is well situated for major access from the Iron Range and from the south of the State. U.S. 169, a 2-lane highway, links Grand Rapids with Minneapolis and St. Paul to the south and with the Mesabi Iron Range to the northeast. U.S. 2, a 2-lane highway, connects Grand Rapids with Duluth to the southeast and Grand Forks, North Dakota, to the northwest. Minnesota 38 connects Grand Rapids with International Falls to the north. Bus service in the area between population centers is provided by the Greyhound Bus Company and the Triangle Transportation Company. The Grand Rapids airport about 6 miles (9.6 km) from the Clay Boswell Station has regularly scheduled commuter flights between Grand Rapids, and Duluth, Eveleth, Virginia, and the Twin Cities. Rail transportation in the region is confined to freight service, with the Burlington Northern, Soo Line Railroad, and Duluth, Missabe & Iron Range Railway providing service.

As shown in Figure IV-2, power transmission lines form a network over the entire northeastern portion of the State, with some of the lines connecting with the Clay Boswell Station. One 250 kilovolt (kv) line runs from the Clay Boswell Station to Chisholm and Hibbing, another runs south to Crosby and Brainerd, while another runs north to International Falls. 115 kv lines connect the Clay Boswell Station with Duluth.

The Arrowhead Region is an important recreational area with its parks, forests, wildlife areas, rivers, and abundance of lakes. The Boundary Waters Canoe Area (BWCA) and the Voyageurs National Park are 2 major national recreational areas. The many forest lands in the Arrowhead Region are managed for both timber production and recreation. Among the large National Forests are Koochiching and Kabetogama. Other State Forests include George Washington, Big Fork, Cloquet Valley, and Finland. The area also supports several State Parks. The Nett Lake Indian Reservation lies in the north central part of the Arrowhead Region, and the Leech Lake Indian Reservation, which marks the western border of the MP&L service area, is situated just outside the western edge of the Arrowhead Region.

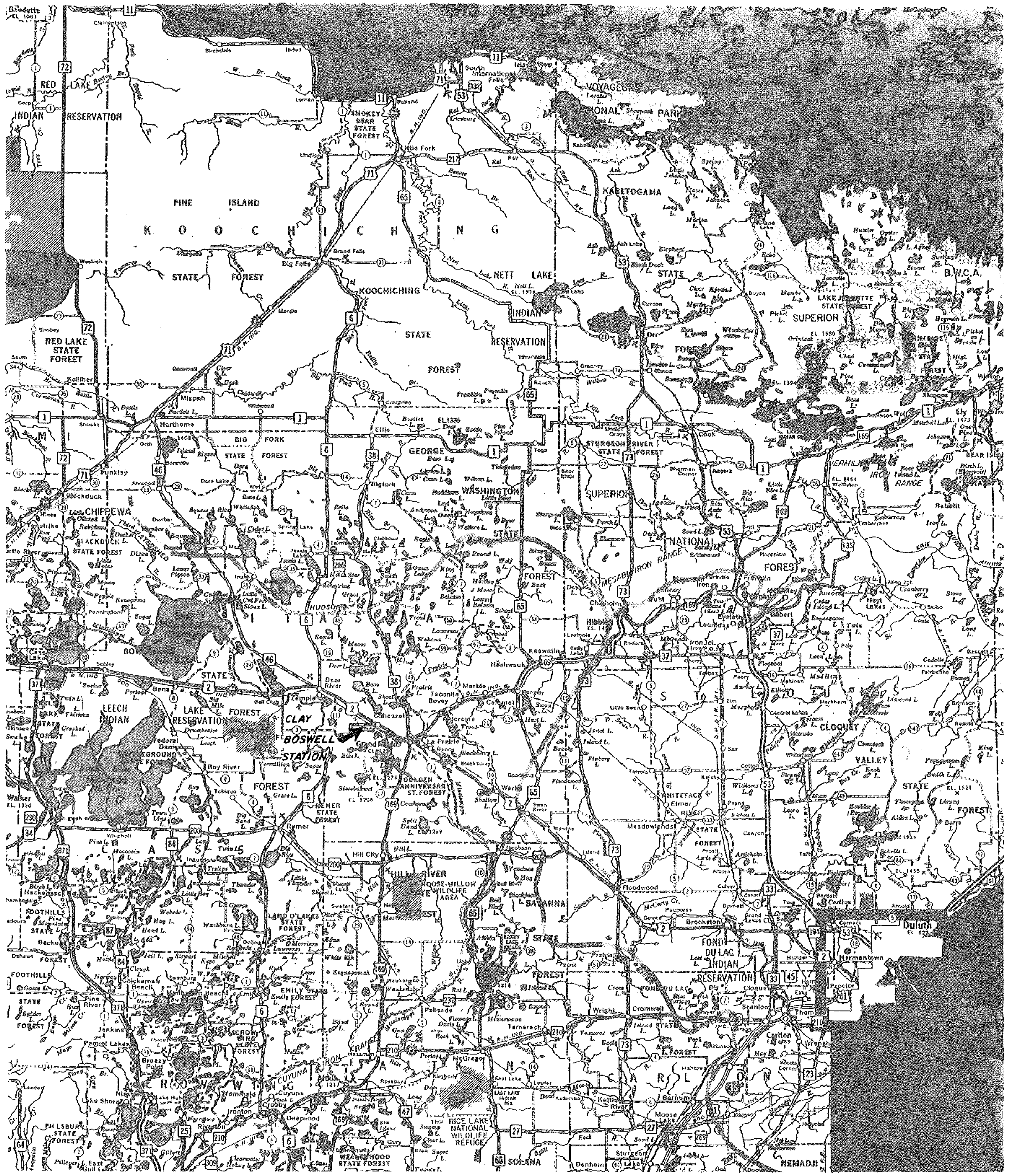
Local

The site of the Clay Boswell Steam Electric Station is 5 miles northwest of Grand Rapids, between the north shore of the Mississippi River at Blackwater Lake and the present 2-lane Minnesota Trunk Highway 6. A mile to the north of the Station is U.S. 2, a major east-west highway linking Duluth with North Dakota. The Burlington Northern Railroad, which transports MP&L's coal from Montana, runs parallel with U.S. 2 near the Clay Boswell Station, and a spur connects directly with the site. Oil and gas pipelines from Canada parallel U.S. 2 in the immediate vicinity of the plant.

Five miles southeast of the Clay Boswell Station is Grand Rapids, county seat of Itasca County and its largest city. The Clay Boswell Station is located at the western edge of the Grand Rapids suburban fringe, but the immediate area to the north and west of the Station is sparsely populated with only a few rural residences. However, around Bass Lake to the northeast and Pokegama Lake to the southwest of Grand Rapids are many year round and summer residences. The combined population of Grand Rapids and its surrounding townships of Bass Brook and La Prairie is 13,700.

Much of the area surrounding Grand Rapids and the Clay Boswell Station is wooded. Large areas of low lying marshlands flank the Mississippi River and the numerous lakes and streams, the legacy of the glacial activity thousands of years ago, drain into the river. Topographically, the area surrounding Grand Rapids and the Clay Boswell Station is gently rolling, becoming hilly to the south and to the northeast toward the Mesabi Iron Range. The elevation averages around 1,300 ft (396 m). One of the highest points in the area is the Sugar Hills Ski area, elevation 1,596 ft (486 m) located about 10 miles (16 km) southwest of Grand Rapids.

The area surrounding Grand Rapids and the Clay Boswell Station developed as the timber industry expanded during the last decade of the nineteenth century. The Village of Cohasset, now Bass Brook Township, was platted in 1893 and had 3



BASE MAP LEGEND

INTERSTATE
MULTILANE DIVIDED HIGHWAY
MULTILANE UNDIVIDED HIGHWAY
INTERMEDIATE TYPE
GRAVEL SURFACED
SECONDARY ROAD-HARD SURFACED
SECONDARY ROAD-GRAVEL
NATIONAL FOREST
STATE FOREST
WILDLIFE MANAGEMENT AREA

N

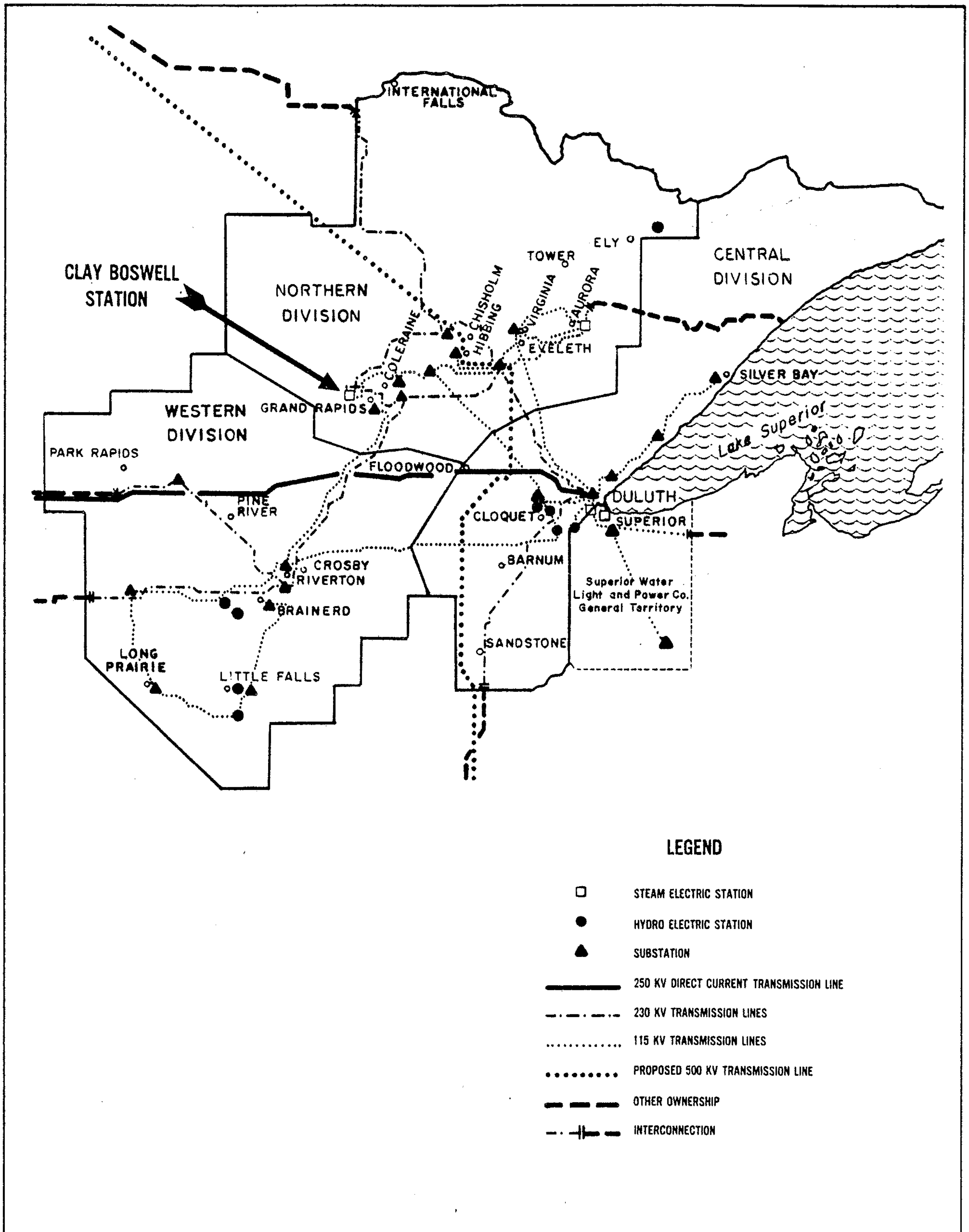
10 0 10 20
MILES

10 0 10 20
KILOMETERS

LOCATION OF CLAY BOSWELL STEAM ELECTRIC STATION - NORTHEASTERN MINNESOTA

SOURCE: STATE OF MINNESOTA HIGHWAY MAP, 1976

FIGURE IV-1



MP & L SERVICE AREA AND TRANSMISSION LINES

(ADAPTED FROM "MINNESOTA POWER AND LIGHT COMPANY REPORT TO SHAREHOLDERS", 1975, MINNESOTA POWER AND LIGHT COMPANY, DULUTH, MINNESOTA)

FIGURE IV-2

saw mills by 1900. Grand Rapids, a trading post, became an important lumber supply point. With the potential water power of the Pokegama Falls 1½ miles (4 km) upstream, Grand Rapids was obviously an ideal site for a paper mill. The Itasca Paper Mill, constructed in 1902, was bought by George Blandin, a St. Paul newspaper publisher in 1916. At the height of the depression, he modernized the plant so that paper production had increased from 10,000 tons (9,072 mt) in 1917 to 40,000 tons (36,287 mt) in 1939. The Blandin Paper Mill is now the major industry in Grand Rapids, employing over 1,100 people in the area.

While the lumber business boomed, the iron ore mining industry was developing. In 1906, an iron ore washing plant went into operation at Coleraine. Further growth came with the opening of rail routes between Grand Rapids and the Mesabi Iron Range. The mines nearest to Grand Rapids today are concentrated around the small communities of Coleraine and Bovey. The Clay Boswell Station itself lies near the southwest tip of the Mesabi Iron Range. It is the continued growth of mining on the Mesabi Iron Range which results in the forecasted need for Unit 4 at the Clay Boswell Steam Electric Station.

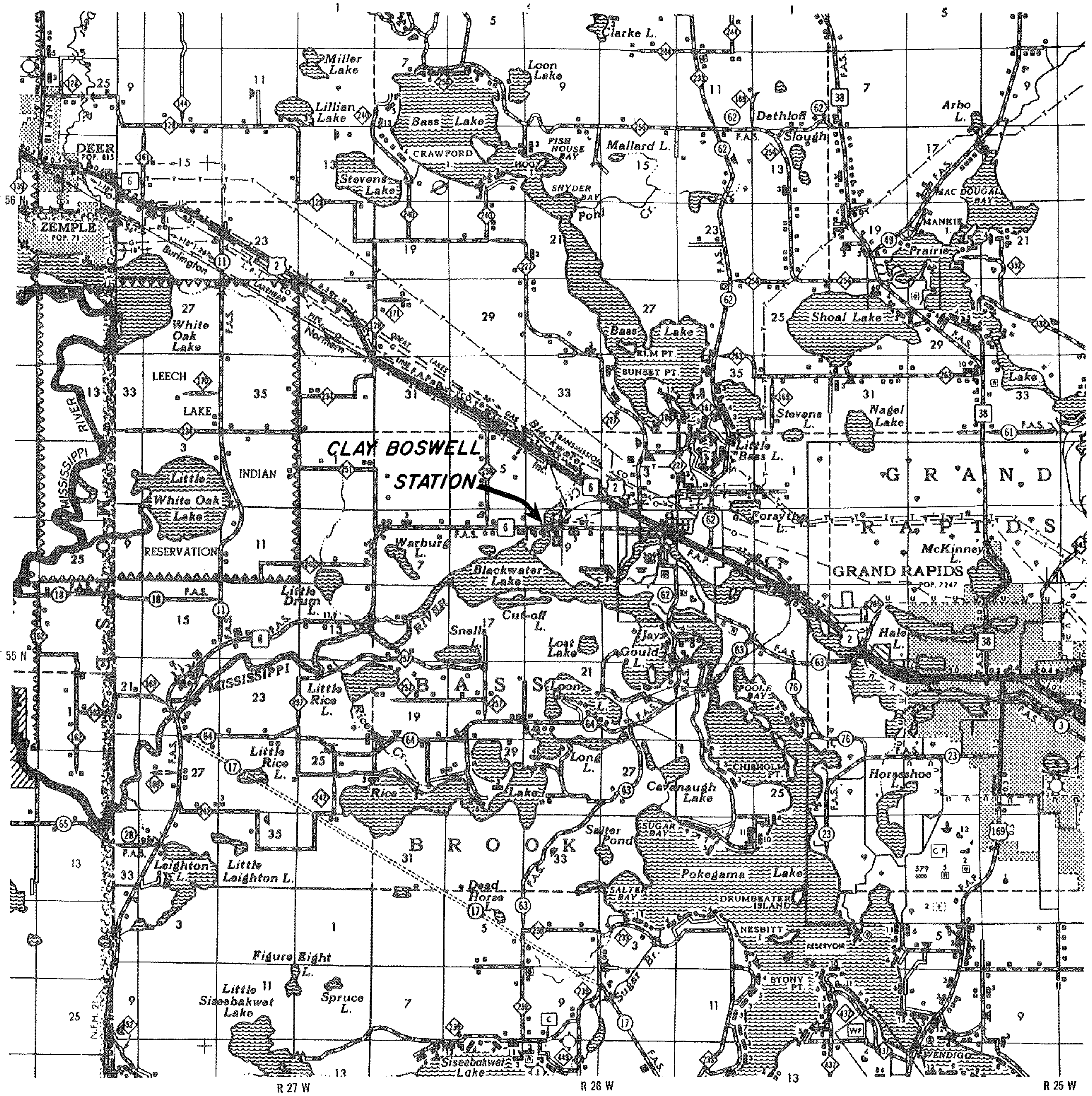
Site Specific

MP&L's existing Clay Boswell Steam Electric Station is located mostly in sections 8 and 9 of T.55N., R.26W (Figure IV-3). The existing Clay Boswell Station site abuts the Mississippi River on the south and State Highway 6 on the north. The east boundary of the existing Station site is a public street between sections 9 and 10. The western edge of the site extends slightly into section 7. Blackwater Lake, which is connected to the Mississippi River, bisects the site near the center in the northwestern portion of section 9.

The main power generating facilities are located near the center of section 9, just east of Blackwater Lake. The coal storage pile is south of the main power generating facilities and abuts the Mississippi River. Rail switch yards and a water cooling tower are located east of the main power generating facilities. Water for the power generating facilities is appropriated from Blackwater Lake and water is discharged into the Mississippi River in the southeast portion of section 9. The solid waste (bottom and fly ash) from the existing power generating facilities are deposited in ponds west of Blackwater Lake. These ponds are located in the northern portion of section 8 and the northeastern portion of section 7, between the Mississippi River and State Highway 6.

In addition to the lands in section 7, 8, and 9 already described, MP&L has now acquired substantial additional lands in sections 3, 4, 5, 6, 7, and 10 of T.55N., R.26W. These lands have been acquired by MP&L in anticipation of constructing Unit 4 at the Clay Boswell Station. MP&L plans to acquire additional land to consolidate its land holdings in sections 4, 5, 6, 7, and 10.

LEGEND



BASE MAP LEGEND

ROAD AND ROADWAY FEATURES

- PROJECTED ROAD
- GRADED AND DRAINED ROAD
- GRAVEL OR STONE ROAD
- BITUMINOUS ROAD
- PAVED ROAD

BOUNDARIES

- COUNTY
- CIVIL TOWNSHIP
- CONGRESSIONAL TOWNSHIP (U.S. LAND)
- SECTION LINE
- NATIONAL OR STATE PARK
- NATIONAL OR STATE FOREST
- NATIONAL INDIAN RESERVATION

DRAINAGE

- INTERMITTENT STREAM
- NARROW STREAM
- MARSH OR SWAMP LAND
- POND OR LAKE

PUBLIC SERVICE FACILITIES

- PIPE LINE, GAS
- PIPE LINE, OIL
- TRANSMISSION LINE (33 KV OR OVER)
- POWER PLANT

EDUCATIONAL AND CORRECTIONAL INSTITUTIONS

- SCHOOL HOUSE
- CONSOLIDATED OR LARGE SCHOOL

N

0 1 2 3
MILES

0 1 2 3
KILOMETERS

AREA IN VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION - ITASCA COUNTY, MINNESOTA

SOURCE: ITASCA COUNTY, MINNESOTA GENERAL HIGHWAY MAP, 1975

FIGURE IV-3

ENERGY

MP&L Service Area

Minnesota Power & Light Company (MP&L) is an investor-owned utility headquartered in Duluth, Minnesota, which serves 15 counties of northeastern Minnesota and 2 counties of northwestern Wisconsin. With its subsidiary, the Superior Water, Light and Power Company (SWL&P), MP&L provides electricity for approximately 330,000 customers, serving 98,000 homes in addition to businesses and factories in 144 communities. Duluth, with a population of approximately 100,000, is the largest city in the franchise area (1).

MP&L's service territory, shown in Figure IV-2, includes 3 of the nation's principal iron mining regions: the Mesabi Range, the Vermilion Range, and the Cuyuna Range. Its service area also includes a geological formation, the Duluth Gabbro, which contains significant deposits of copper and nickel (2).

MP&L Existing System

The MP&L system in Minnesota currently consists of 12 electric generating facilities. Of the 12 facilities, 9 are hydro-electric generating stations, while the remaining 4 are steam electric generating stations using coal, oil, or gas, or some combination of these fuels. It is interesting to note that the hydro-electric plants are among the oldest in MP&L's system. The newest among them are the Scanlon the Winton plants, built in 1923 and Thomson Unit 2 built in 1949; while the oldest hydro-electric plant is Unit 1 at the Thomson Station, built in 1907.

The Clay Boswell Steam Electric Station is the largest in MP&L's system. It consists of 3 coal-fired steam electric generating units with a combined capacity of approximately 500 megawatts (500 MW). The addition of proposed Unit 4 at the Clay Boswell Station would bring total capacity at that facility to nearly 1,000 MW.

In addition to the proposed expansion of the Clay Boswell Station, MP&L would like to build a coal-fired steam electric station at Floodwood, in St. Louis County, Minnesota. The first unit of the proposed Floodwood facility would have a generating capacity of 800 MW, with future units to produce a combined total of 3,400 MW(3). MP&L hopes to have the Floodwood facility operational by 1984. A complete list of MP&L's existing units, their type, location, age, size, and fuel source is presented in Table IV-1.

MP&L Interconnections and Pooling Arrangements

Since 1973, in an effort to meet current and anticipated energy demands, MP&L has purchased electrical energy from other regional sources. It is expected that it will be necessary to purchase additional energy through agreements with the Manitoba Hydro-Electric System and members of the Mid-Continent Area Power Pool (MAPP). Planning assistance will be provided through the Mid-Continent Area Reliability Coordination Agreement (MARCA).

TABLE IV-1
EXISTING UNITS - MINNESOTA POWER & LIGHT COMPANY

Plant	Type	Location	Size MW	Age	Fuel Type	Fuel Source
Blanchard	hydro	Mississippi River Morrison County	12	both units 52 years (1925)	water	run of the river
Clay Boswell	steam electric	Cohasset, Minnesota	490 Gross	Unit 1 19 years (1958) Unit 2 17 years (1960) Unit 3 4 years (1973)	sub-bituminous pulverized coal	Big Sky Mine Colstrip, Montana
Fond du Lac	hydro	St. Louis River St. Louis County and Carlton County	12	both units 53 years (1924)	water	storage
M. L. Hibbard	steam electric	Duluth, Minnesota	124.5 Gross	Unit 1 46 years (1931) Unit 2 34 years (1943) Unit 3 28 years (1949) Unit 4 26 years (1951)	no.6 oil and natural gas	Berg Oil Company Gustafson Oil Company Murphy Oil Company City of Duluth (Gas)
Knife Falls	hydro	St. Louis River Carlton County	1.9	56 years (est. 1921)	water	-
Syl Laskin	steam electric	Colby Lake Aurora, Minnesota	116 Gross	24 years (1953)	sub-bituminous pulverized coal no. 6 oil	Clay Boswell
Little Falls	hydro	Mississippi River Morrison County	2.4	57 years (1920)	water	run of the river
Pillager	hydro	Crow Wing River Cass County Morrison County	1.52	60 years (1917)	water	run of the river
Scanlon	hydro	St. Louis River Carlton County	1.6	54 years (1923)	water	run of the river
Sylvan	hydro	Crow Wing River Cass County Morrison County	1.8	64 years (1913)	water	run of the river
Thompson	hydro	St. Louis River Carlton County	67.53	Unit 1 70 years (1907) Unit 2 28 years (1949)	water	storage
Winslow	steam electric	Superior, Wisconsin	25	Unit 2 35 years (1942) Unit 3 (25 years) (1952)	no. 6 oil	Murphy Oil Company
Winton	hydro	Basswood Lake Lake County	4.0	54 years (1923)	water	storage

The Mid-Continent Area Power Pool (MAPP) is a consortium of 12 investor-owned utilities, 7 generation cooperatives, 2 public power districts, 11 municipalities, and a Federal hydro-electric system. Benefits of membership in MAPP include coordinated planning and participation in the development of power supply resources; availability of power supply services from other members, including reserve sharing, emergency, and scheduled outage service; surplus capacity purchases and sales; participation in energy purchases and sales; peaking energy purchases and sales; and transmission service (4).

MP&L is also a member of the Mid-Continent Area Reliability Coordination Agreement (MARCA), an organization which provides an overview of the planning and operating activities of its members with respect to reliability. The MARCA region is identical to the MAPP service area. It covers all of the states of Minnesota, Iowa, North Dakota, most of South Dakota and Nebraska, and portions of Wisconsin, Illinois, Michigan, and Montana. Organized in 1968, MARCA presently has 22 members including 11 investor-owned utilities, 8 generation and transmission cooperatives, 2 public power districts, and a Federal agency. The Manitoba Hydro-Electric Board is an associate member of MARCA. Of the 22 MARCA utilities, 21 (along with 12 smaller utilities) also are members of MAPP. The overview of regional planning is provided first by a specific channel reporting procedure to MARCA by each system on load forecasts, new facilities planned, and the resultant generating capacity and reserves. Periodic testing of the overall projected system is performed by computer modeling in accordance with criteria established for the interruption of load. These criteria contain sets of contingencies to minimize interruptions in service.

Coordination of MARCA with the Mid-American Interpool Network (MAIN) is effected through an Inter-Region Reliability Coordination Agreement, which establishes an Inter-Region Review Committee with responsibilities relating to bulk power supply planning and operating reliability. Additionally, a statement concerning inter-regional cooperation with the Southwest Power Pool (SPP) has been exchanged and a letter of agreement has been signed with the Western Systems Coordinating Council (WSCC), which provides for inter-regional planning and operating liaison, planning coordination committees as required, and an understanding that the coordination of operations relating to the East-West ties will be performed by the East-West Work Group of the WSCC Operations Committee (5). Figure IV-4 shows the relationship of MP&L to MAPP, MAIN, and MARCA.

In addition to the agreements with Manitoba Hydro-Electric System and MAPP, MP&L has arranged to purchase the entire 400 MW of electrical power generated at the Square Butte Plant near Center, North Dakota,, until 1984. At that time, MP&L will purchase a declining percentage of the plant's capacity, to a minimum of 49% of Square Butte's production. The power is to be transmitted through a 250 kv direct current line (6).

Projected Electrical Energy Consumption, and Power Demand

Based largely on commitments from the taconite industry, MP&L's electrical energy sales are projected to increase by more than 79% - from 4.4 billion to 7.8 billion kilowatt-hours (kw hr) - in the period 1975 to 1979. MP&L already has signed electric service agreements to provide electrical power for U.S.

LEGEND

✻ CLAY BOSWELL STATION

MINNESOTA POWER AND LIGHT COMPANY SERVICE AREA; MAPP AND MARCA HAVE THE SAME SERVICE AREA; MANITOBA IS AN ASSOCIATE MEMBER OF MARCA

MAIN — MID AMERICA INTERPOOL NETWORK

MARCA — MID-CONTINENT AREA RELIABILITY COORDINATION AGREEMENT

MP&L, MAPP, AND MARCA SERVICE AREAS

(ADAPTED FROM A REPORT BY MARCA TO THE FEDERAL POWER COMMISSION, APRIL 1, 1975, MIDWEST AREA RELIABILITY COORDINATION AGREEMENT, pp. A-5.)

FIGURE IV-4

Steel's expansion of its Minntac plant near Mountain Iron, to be completed by 1977; Inland Steel's Minorca Plant near Virginia, scheduled to begin operations in 1977; National Steel's expansion of operations at Keewatin, completed in early 1977; Hibbing Taconite's operations at Hibbing, scheduled to be fully operational by 1979; and Eveleth Taconite's expansion at the Fairlane Plant, which was in full operation by November, 1976.

MP&L's projected annual electrical energy consumption by ultimate consumers from 1976 through 1991 is presented in Table IV-2. In 1976, annual electrical energy consumption by the industrial and mining sector was 72% of the electrical energy consumed in MP&L's service area, while farm electrical energy use was less than 1% of that consumed. While electrical energy usage by farms is expected to increase by 1 million kw hr or 2.9% between 1976 and 1991, electrical energy usage by the industrial and mining sectors is expected to increase by 6,671 million kw hr or 186% between 1976 and 1991. Most of this increase will be caused by the expansion of the taconite mining industry as well as the expansion of the paper and pulp industries. These expansions will create employment which will cause people to move to the area. Increased population will result in new homes, schools, offices, and commercial areas, which will cause increased energy demand in the commercial and residential sectors in the MP&L service area. For instance, consumption of electrical power by the commercial sector is expected to be twice as great in 1991 as it was in 1976. Similarly, residential energy demand is expected to be 1.6 times as great in 1991 as it was in 1976.

TABLE IV-2

PROJECTED ANNUAL ELECTRICAL ENERGY CONSUMPTION BY ULTIMATE CONSUMERS - MINNESOTA POWER & LIGHT COMPANY (7)

	thousand kilowatt hour							
Year	Farm	Non-Farm Residential	Commerical	Mining	Industrial	Street and Highway Lighting	Other	Total[a]
1976	35,000	621,596	475,937	2,608,100	983,596	19,178	242,018	4,985,425
1977	35,000	641,300	499,600	4,167,000	1,037,650	20,100	243,100	6,643,750
1978	35,000	662,200	525,000	4,907,400	1,122,200	20,700	244,100	7,516,600
1979	35,000	684,400	552,300	5,157,800	1,139,750	21,300	245,100	7,835,650
1980	35,000	707,800	581,500	6,140,800	1,170,900	21,900	246,100	8,904,000
1981	36,000	731,100	612,300	7,069,800	1,252,050	22,500	247,100	9,970,850
1982	36,000	754,100	643,100	7,272,800	1,260,300	23,100	248,100	10,237,500
1983	36,000	777,800	675,400	7,371,800	1,570,300	23,700	249,100	10,704,100
1984	36,000	802,200	709,200	7,450,800	1,680,100	24,300	250,100	10,952,700
1985	36,000	827,400	745,300	7,565,800	1,675,600	24,900	251,100	11,126,100
1986	36,000	853,800	782,800	7,735,800	1,797,500	25,500	252,100	11,483,500
1987	36,000	881,000	822,500	7,735,800	1,941,500	26,100	253,100	11,696,000
1988	36,000	909,000	864,200	7,735,800	2,086,200	26,700	254,100	11,912,000
1989	36,000	937,900	908,000	7,735,800	2,232,900	27,300	255,100	12,133,000
1990	36,000	967,700	954,000	7,735,800	2,379,500	27,900	256,100	12,357,000
1991	36,000	998,400	1,002,500	7,735,800	2,526,700	28,500	257,100	12,585,000

[a] The numbers exclude sales for resale.

Figure IV-5 presents MP&L's projected maximum demand for electrical power in its service area from 1975 through 1985, and the system's net generating capabilities. These projections, which were made in 1975, have been revised by individually reviewing forecasts for large users, and including more historical data for the trending analyses. The revised projected maximum demand for electrical power also is presented in Figure IV-4. "Committed Generating Capability" is MP&L's present production capacity in addition to the capacity purchased from Square Butte. From 1977 to 1983, capacity is expected to remain at 1,260 MW. In 1984, this capacity will deline to 1,140 MW due to a reduction in energy purchased from Square Butte. "Uncommitted Generating Capability" is that electrical power which would be available by proposed additions to the MP&L system. "Net Purchase" is that power available because of purchases by MP&L through agreements with other power systems. "Additional Capacity Requirement" is the extra capacity necessary to maintain an adequate system reserve to meet peak demands or to provide uninterrupted service in the event of scheduled and emergency outages. It is apparent that MP&L anticipates that demand for electrical power in their service area will increase dramatically, from 762 MW in 1975 to 1,825 MW by 1985. This is a growth of 140%. Because of the disparity between the projected growth of demand for electrical power and MP&L's system generating capacity, MP&L plans to increase generating capacity by adding the proposed 500 MW Unit 4 at the Clay Boswell Steam Electric Station. Commercial operation of Unit 4 is scheduled to begin in May, 1980.

Required Certificates from the State of Minnesota

Certificate of Need

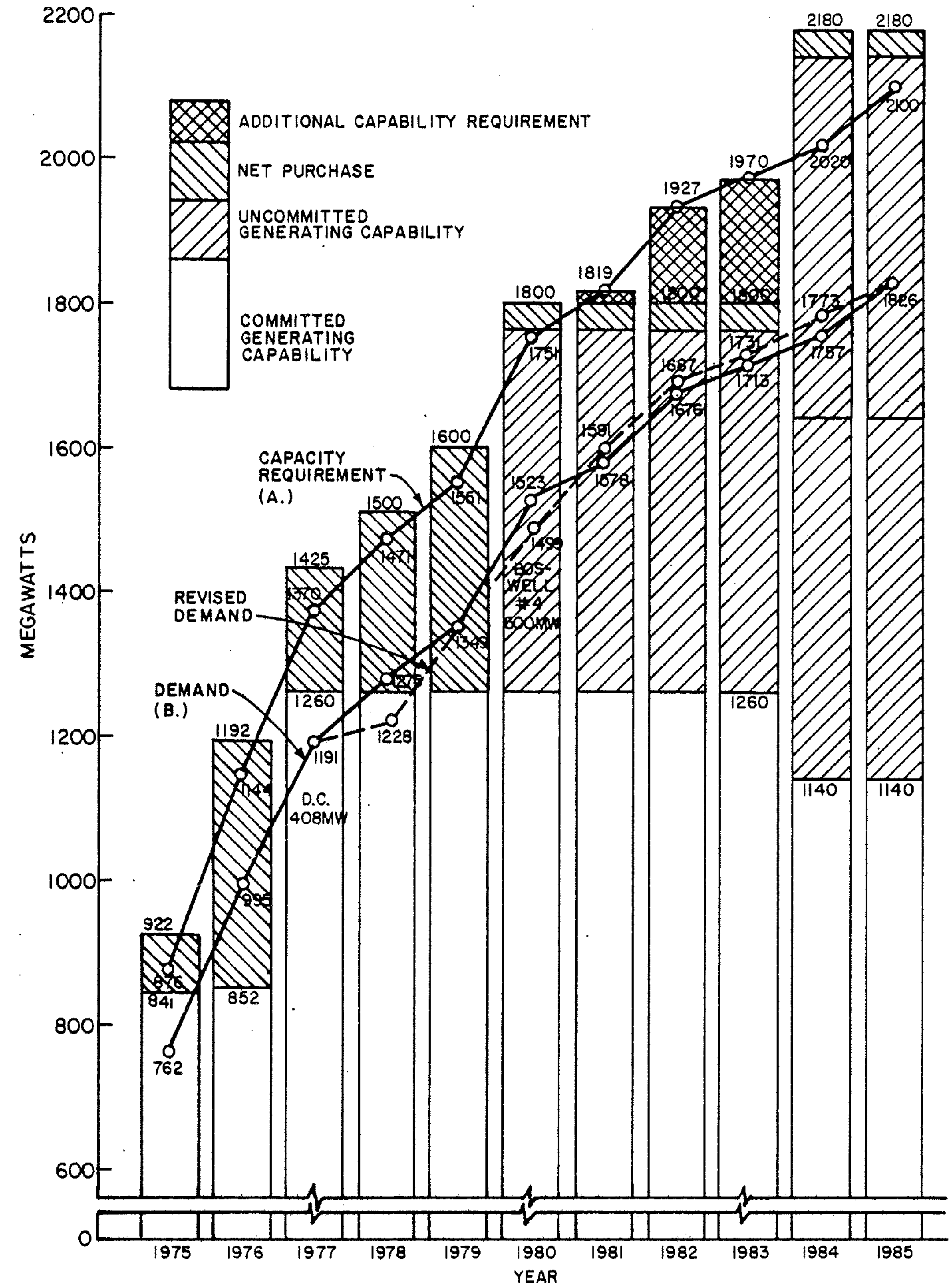
MP&L is required by the Minnesota Public Utilities Act (Laws 1974, Chapter 429) to act in the best interests of its customers. Specifically, Section 4 thereof provides in part that "Every public utility shall furnish safe, adequate, efficient, and reasonable service."

MP&L, therefore, applied for a Certificate of Need for a 500 MW electric generating facility in accordance with the Minnesota Energy Agency Act (Minn. Stat., §§ 116H.13 et seq.) and regulations promulgated thereto, on December 12, 1975. Subsequent to 2 days of public hearings held at the St. Louis County Courthouse in Duluth, Minnesota, on February 13 and 14, 1976, the Director of the Minnesota Energy Agency (MEA) granted a Certificate of Need on April 6, 1976, for a 500 MW coal-fired steam turbine electric generating facility to be sited at the Clay Boswell Steam Electric Station, near the community of Cohasset, Minnesota (8).

Minn. Reg. EA 611(a)(b)(1974) state that an application for a Certificate of Need shall be granted if:

(a)

> it is determined that the probable result of denial of the application will be an unacceptable level of reliability of electric service to ultimate consumers in Minnesota or in neighboring states.



(A.) CAPACITY REQUIREMENT (DEMAND PLUS 15% RESERVE)
(B.) ANNUAL MAXIMUM DEMAND (OCCURS IN WINTER)

REDUCTION IN COMMITTED GENERATING CAPACITY REFLECTS MP & L'S REDUCED CONTRACTUAL CAPACITY PURCHASED FROM SQUARE BUTTE
NO REQUIREMENTS ARE SCHEDULED

NET GENERATING CAPABILITIES AND
:FORECAST OF MAXIMUM DEMAND (MEGAWATTS) - MP&L

SOURCE: "APPLICATION FOR CERTIFICATE OF NEED", DECEMBER 1975 AND OCTOBER 1976

FIGURE IV-5

(b)

if a determination is made that the socially beneficial uses of the output of the proposed facility, including its uses to protect or enhance environmental quality, are deemed significant enough to justify the need for the facility.

Some of the reasons presented by MP&L to justify the need for a new generating facility were (9):

- Expansion of the taconite mining industry will increase demand for electric power in MP&L's service area by 1980;
- Conversion from gas and oil to electricity because of shortages of these fuels may increase demand for electric power in the area;
- There are no projected Federal or State conservation measures which significantly will reduce demand for electric power in MP&L's area;
- Only short term supplies of energy are available from outside the area; and
- An excess of 550 MW of electric power does not exist in the MAPP system.

The Findings of Fact issued by the MEA Dirèctor concluded that:

- MP&L's projections of electricity consumption have a high degree of accuracy through 1980 due to the significant mining load component, the growth of which is verified by existing commitment agreements and electric service contracts which are binding on the parties;
- Conservation is not likely to have a greater effect on electricity requirements than is considered by MP&L in its forecast;
- Current facilities and planned facilities not requiring a Certificate of Need cannot meet the future demand for electricity in MP&L's service area;
- There are no reasonable and prudent alternatives to the proposed facility that would allow MP&L to meet the demand for electricity imposed upon it;
- The size, type, and timing of the proposed facility are appropriate;
- The system reserve margin maintained by MP&L is appropriate; and
- The output of the proposed facility will be a socially beneficial addition to Minnesota's energy sources.

Certificate of Site Compatibility

Pursuant to the provisions of the Power Plant Siting Act [Minn. Stat. 116C.51 et seq. (1974)] and the Rules and Regulations promulgated thereunder [MEQC 71-75 (1976)], MP&L submitted a Site Designation Application (SDA) to the Minnesota Environmental Quality Council (MEQC), now the Minnesota Environmental Quality Board (MEQB), for the purpose of securing a Certificate of Site Compatibility for a generating unit at MP&L's Clay Boswell Station (10).

The MEQB on February 10, 1976, in the proceeding identified as Docket No. MP&L-P-1, issued a Certificate of Site Compatibility to MP&L pursuant to the provisions of Minnésota Power Plant Siting Act for a Large Electric Power Generating Plant (LEPGP) and associated facilities. The MEQB and a 21 member Site Evaluation Committee concluded that the Clay Boswell Station is a suitable site upon which to locate, construct, and operate an additional 500 MW coal-fired steam electric power generating unit for the following reasons (11):

- Grand Rapids could provide the service and personnel necessary to support an increased work force during plant construction;

- Expansion of the existing Clay Boswell Station would more fully utilize existing coal-handling facilities;

- Due to the developed nature of the Clay Boswell Station area, the destruction or major alternation of land forms, vegetative types or wildlife habitat which are rare, unique, or of unusual importance to the surrdounding area will not occur;

- The proposed addition would utilize water from the discharge canal of Units 1, 2, and 3, thereby making increased appropriations of water from the Mississippi River unnecessary; and

- Selection of the Clay Boswell Station would expedite construction of the new facility, and avoid increased costs to both company and consumers.

<u>Consequences of Delay</u>

As a result of the public hearing on MP&L's application for a Certificate of Need, the MEA Director issued Findings of Fact, addressing the consequences of delaying construction and operation of MP&L's proposed Unit 4 at the Clay Boswell Station. The Director concluded that delay would have several adverse consequences, among which are (12):

- MP&L's reserve margin would be eliminated, affecting the reliability and integrity of the MAPP System;

- MP&L's existing and planned transmission lines would be required for power purchases, leaving no reserve transmission capability for contingencies;

- Purchasing power would result in increased use of oil and natural gas in the MAPP region, with resultant higher operating costs;

- Construction costs of the proposed facility would increase; and

- Undesirable social and economic impacts to Minnesota and the iron mining industry could result.

If construction and commercial operation of the proposed Unit 4 at the Clay Boswell Station is delayed, the reliability of MP&L's system will depend on MP&L's ability to purchase additional base load electrical energy from other utilities. The purchase of this energy is contingent on adequate transmission capacity to carry the purchased energy and availability of sufficient saleable energy surpluses by other utilities (13).

Construction of MP&L's proposed Unit 4 has already begun under a limited work authorization (14), and commercial operation is scheduled to begin in May 1980.

Transmission Facilities

The transmission facilities required to support MP&L's proposed Unit 4 at the Clay Boswell Station will consist of two 230 kv lines in addition to the existing 230 kv system. Although MP&L has not applied to MEQB for transmission line corridors for the Clay Boswell Station, MP&L indicates that it intends to extend one 230 kv line 40 miles (64 km) northwest to the Shannon substation (15) and another 230 kv line 25 miles (40 km) east to the Blackberry substation (15) (16).

GEOLOGY

Regional

Physiography

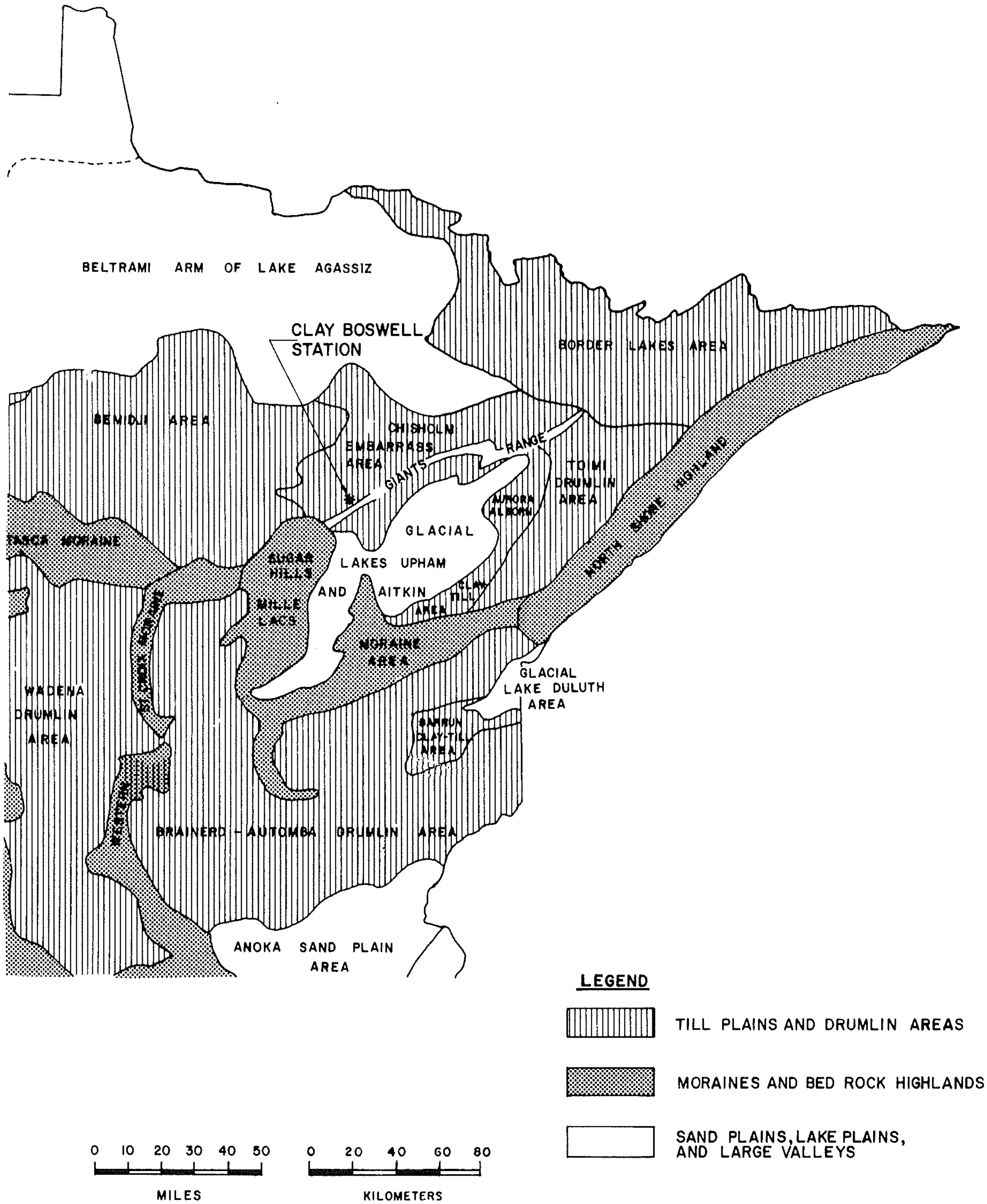
The Clay Boswell Steam Electric Station is situated on the Canadian Shield, in the Chisholm Embarrass area which lies between the Mesabi (Giants) Range and the eastern arm of glacial Lake Agassiz in northern Minnesota. Figure IV-6 shows the physiographic setting of the Clay Boswell Station. A few miles (km) southeast of the site, the Mesabi (Giants) Range, a granite highland, rises out of the plains of the Chisholm-Embarrass area. The Mesabi (Giants) Range marks the three-way divide among drainage systems to Hudson Bay, the Gulf of Mexico, and the Great Lakes (17).

The Clay Boswell Station site is situated in an area that reflects a complex geologic history (18). The bedrock geology in the Clay Boswell Station area is shown in Figure IV-7. Bedrock consists of a folded and faulted Precambrian (at least 600 million years old) terrain typical of the Canadian Shield (19). These sedimentary, meta-volcanic, metamorphic, and intrusive rocks crop out in northern Minnesota and in Canada. However, local outcrops of Precambrian rocks are primarily limited to the Mesabi Range because of a widespread mantle of glacial deposits (19). The Precambrian rocks are overlain by a mantle of Cretaceons (60 to 130 million years old) rock (18).

The major structural features of the area are bedrock faults (20) shown in Figure IV-7. Substantial left and right lateral displacements along these faults have juxtaposed rocks of strikingly different character in certain areas. The age of almost all of the faults is considered to be Lower Precambrian, formed during a mountain building and granite forming episode (the Algoman Orogeny) approximately 2.5 billion years ago. Many of the faults reactivated in Middle Precambrian (1.6 to 2.4 billion years ago) time. However, since then, they have been generally inactive (18).

Glacial History

The glacial landscape of the Chisholm Embarrass area is characterized by morainal, till plain, and glacial lake deposits left during the Quarternary Period (last million years) (21). Although ice sheets covered the State several times, landforms and surficial deposits generally reflect only the last glaciation, that of the Wisconsin Stage which began some 40,000 years ago and ended some 10,000 years ago (21). Wisconsin Stage drifts (soils) in Minnesota have a highly varied lithology and complex stratigraphy, which reflect the configuration of the several lobes that protruded from the ice sheet margin during various intervals of advance and retreat (21) (22). Four major Wisconsin age ice lobes - Superior, Rainy, Wadena, and Des Moines - are recognized for the glaciation of Minnesota (21 (22). Drift from 3 major glacial advances exists in northeast Minnesota. The earliest ice lobe (perhaps the Wadena lobe) originated northwest of Minnesota, moved into the Mesabi Iron Range from the southwest, probably was confined to the area south of the Mesabi (Giants) Range, and deposited a discontinuous drift termed basal till. The basal till is probably at least 36,000 years old and of early to mid-Wisconsin age, though it may be



REGIONAL PHYSIOGRAPHY OF NORTHEAST MINNESOTA

SOURCE: ADAPTED FROM MP&L, "ENVIRONMENTAL REPORT", EXHIBIT III-A-1

FIGURE IV-6

-N-

LEGEND

MESOZOIC

—K— INDICATES EASTERN EDGE OF CRETACEOUS OVERLAP

PRECAMBRIAN

VIRGINIA FORMATION

BIWABIK IRON-FORMATION

POKEGAMA QUARTZITE

GRAY MEDIUM-GRAINED FOLIATED BIOTITEQUARTZ TONALITE

PINK MEDIUM-GRAINED, FOLIATED BIOTITEHORNBLENDE GRANODIORITE, TONALITE, AND DIORITE

GRANITIC ROCKS, UNDIVIDED

AGE UNKNOWN

MIGMATITIC BIOTITE AND HORNBLENDE GNEISSES

METASEDIMENTARY ROCKS, UNDIVIDED

METAVOLCANIC ROCKS, UNDIVIDED

FAULT

0 1 2 3 4 5 6 7 8 9 10

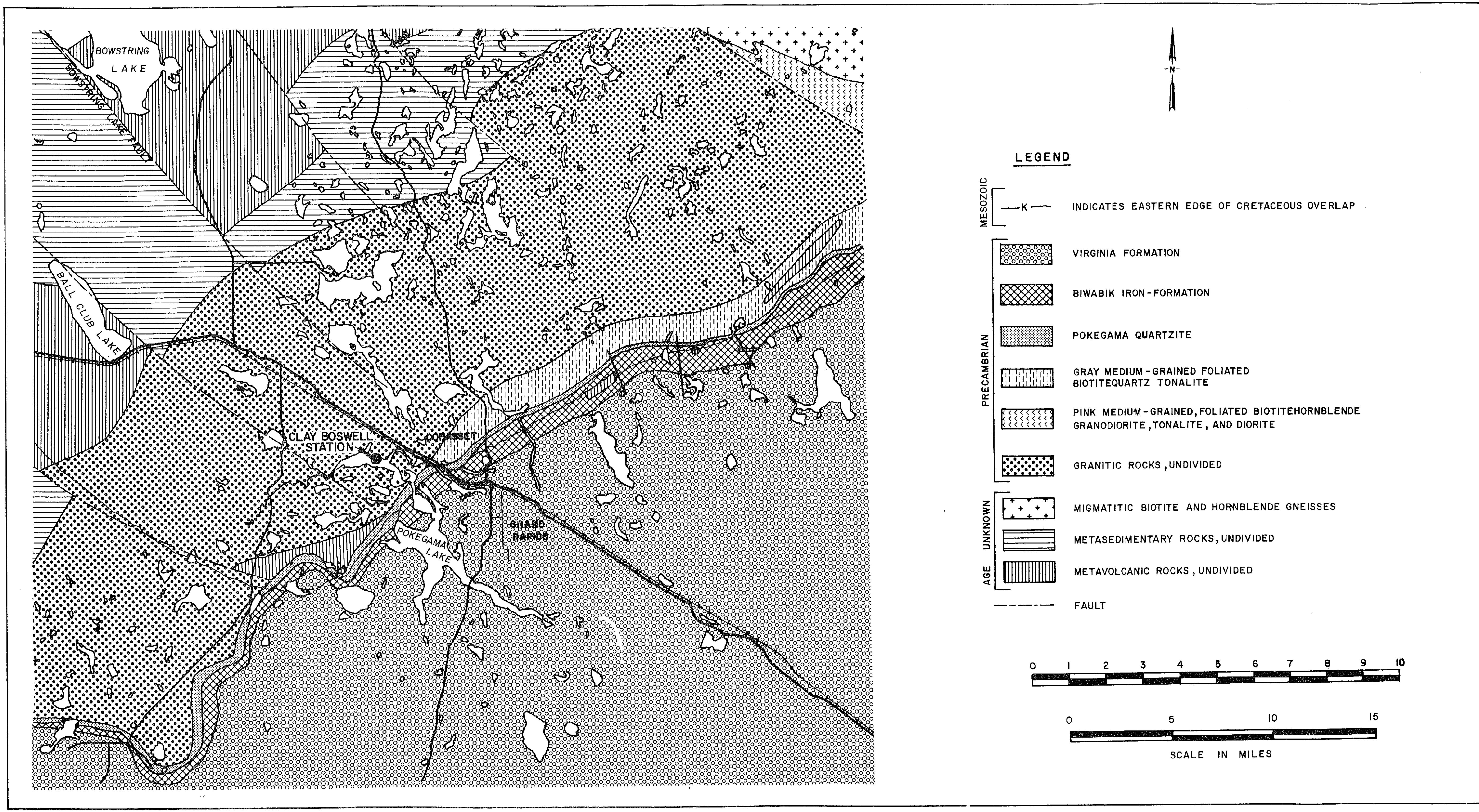
0 5 10 15

SCALE IN MILES

BEDROCK GEOLOGY - VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION

SOURCE: MP&L, "ENVIRONMENTAL REPORT", EXHIBIT III-A-3

FIGURE IV-7


BOWSTRING
LAKE
BOWSTRING LAKE FAULT
BALL CLUB LAKE
CLAY BOSWELL
STATION
COHASSET
POKEGAMA
LAKE
GRAND
RAPIDS
N
LEGEND
MESOZOIC
K
INDICATES EASTERN EDGE OF CRETACEOUS OVERLAP
PRECAMBRIAN
VIRGINIA FORMATION
BIWABIK IRON-FORMATION
POKEGAMA QUARTZITE
GRAY MEDIUM-GRAINED FOLIATED BIOTITEQUARTZ TONALITE
PINK MEDIUM-GRAINED, FOLIATED BIOTITEHORNBLENDE GRANODIORITE, TONALITE, AND DIORITE
GRANITIC ROCKS, UNDIVIDED
AGE UNKNOWN
MIGMATITIC BIOTITE AND HORNBLENDE GNEISSES
METASEDIMENTARY ROCKS, UNDIVIDED
METAVOLCANIC ROCKS, UNDIVIDED
FAULT
0 1 2 3 4 5 6 7 8 9 10
0 5 10 15
SCALE IN MILES

pre-Wisconsin in age (23 (24). Basal till thickness is typically 50 to 100 ft (15.2 to 30.5 m) and in most places it lies directly on bedrock (19). At some locations, e.g., near Grand Rapids, the basal till is underlain by glaciofluvial sediments (19). The basal till is generally overlain by substantial thicknesses of younger drift.

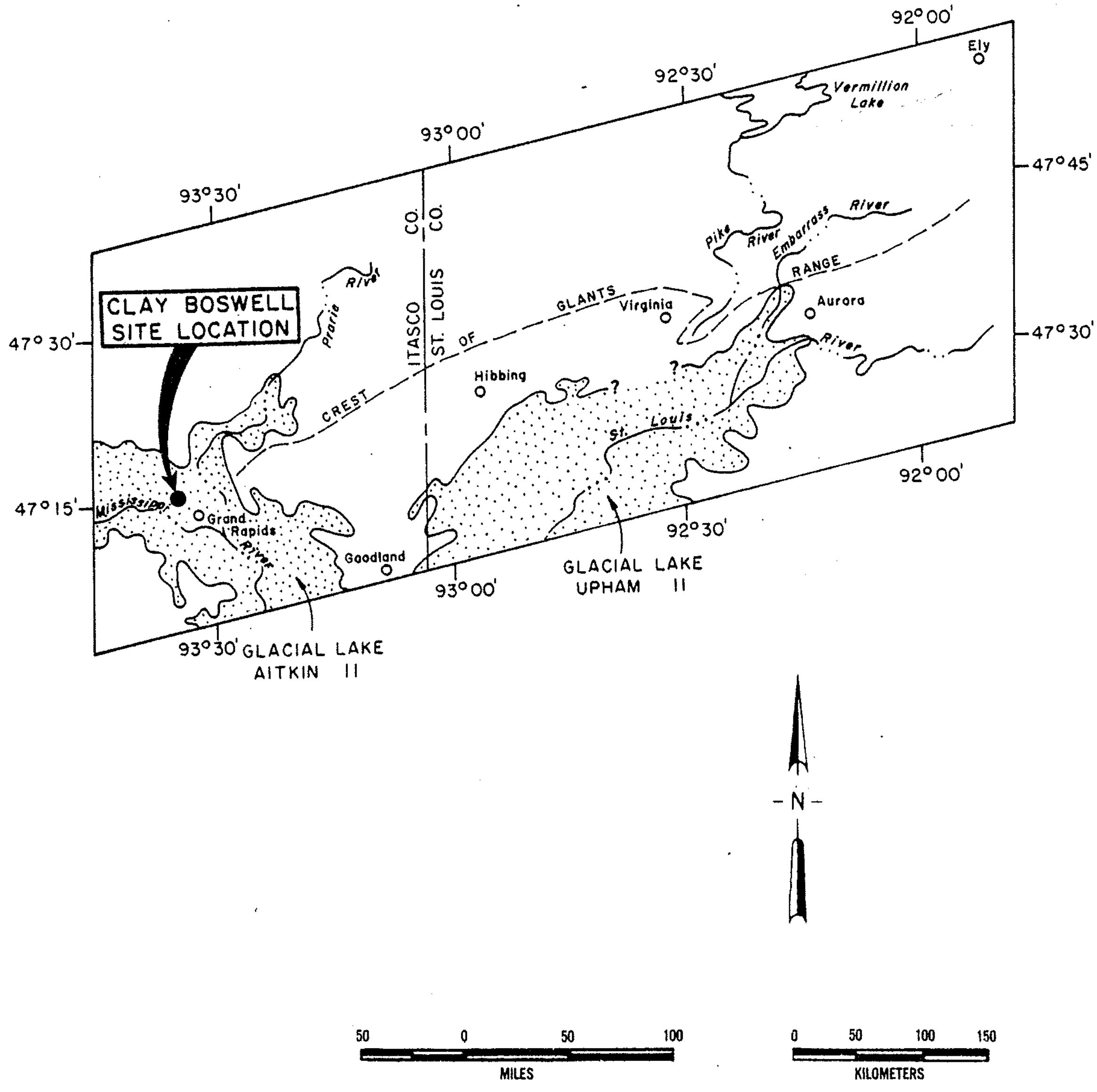
The second major ice advance was the Rainy lobe which moved into the Mesabi Iron Range from the northeast, and deposited a fairly continuous drift termed bouldery till (23) (19). The age of the bouldery till is uncertain and may be in the range of 15,000 to 35,000 years (23). Thickness of bouldery till is typically less than 50 ft (15.2 m). It is generally both underlain and overlain by glaciofluvial sediments (19). Glaciofluvial sediments underlying the bouldery till are typically less than 50 ft (15.2 m) thick; those overlying the bouldery till are typically more than 50 ft (15.2 m) thick and occasionally more than 100 ft (30.5 m) thick (19). These latter sediments were probably deposited some 14,000 to 16,000 years ago during retreat of the Rainy lobe when much of the present day topography was formed (23 (24).

The third major ice advance occurred about 12,000 years ago and involved the St. Louis sublobe of the Des Moines lobe (23 (24). This sublobe entered the area from the west-northwest, then split at the west end of the Mesabi (Giants) Range, Second order sublobes moved eastward, north, and south of the Mesabi Range (23). The St. Louis sublobe deposited a fairly thin, but continuous drift termed surficial till (23) (24) (25). The surficial till is generally less than 25 ft (7.6 m) thick (23) (24) and does not form conspicuous topographic features except in the morainal complex (including the vicinity of the Clay Boswell Station) at the western edge of the Mesabi Iron Range (23).

After retreat of the St. Louis sublobe, much of the area south and west of the Mesabi Iron Range was covered by glacial lakes, as shown in Figure IV-8. Glacial Lake Aitkin II extended northward along the present Mississippi and Prairie River valleys and covered most of the area around Clay Boswell Station (22) (23). Interbedded sands, silts, and clays were deposited in Lake Aitkin II (22) (24). Lacustrine soil deposits in the Mesabi Iron Range are generally less than 25 ft (7.6 m) thick. No date is readily available for the draining of Lake Aitkin II, but it was probably about 11,000 years ago (25).

Mineral Resources

Abundant mineral resources are present in northern Minnesota. The mineral deposits associated with Precambrian bedrock include iron, dimension stone, and gold resources. These occur in Precambrian rocks that crop out in the northeast Itasca County as well as on the Mesabi (Giants) Range. The Mesabi Iron Range has been the major iron ore source for our nation's steel industry. Since 1890, 3.0 billion long tons (3.1 billion mt) of iron ore and pellets have been shipped from the Mesabi Range. In the early years of the Mesabi Iron Range, most of the iron ore was high grade direct shipping ore. However, in recent years, most of the iron ore mined on the Mesabi Range has been low grade ore, requiring concentration to extract the iron from the ore. Low grade magnetic taconite ore is mined and concentrated to produce high grade iron pellets, with the first commercial taconite pellet shipments beginning in 1956.



EXTENT OF GLACIAL LAKES AITKIN II AND UPHAM II

(ADAPTED FROM WINTER, T.C., "SEQUENCE OF GLACIATION IN THE MESABI-VERMILLION IRON RANGE AREA, NORTHEASTERN MINNESOTA," PROFESSIONAL PAPER 750-C, U.S. GEOLOGICAL SURVEY, 1971, p. C87)

FIGURE IV-8

The iron mines of the Mesabi Iron Range are located mostly northeast of Grand Rapids. These include numerous active, inactive, and exhausted natural ore mines and 8 large magnetic taconite mines. In 1976, an estimated 52.5 million long tons (54.3 million mt) of iron ore and pellets were shipped from the Mesabi Range, including 11.0 million long tons (11.4 million mt) of natural ore (direct shipping and beneficiated products) and 41.5 million long tons (42.9 million mt) of pellets (25). Present taconite operations have mined about 3% of the estimated 45 billion long tons (46.5 billion mt) of taconite ore recoverable by open pit mining methods. Mining the 45 billion long tons (46.5 billion mt) of taconite ore will result in approximately 30 billion long tons (31.0 billion mt) of waste (tailings) and 15 billion long tons (15.5 billion mt) of iron pellets. The Mesabi Iron Range has substantial taconite resources which could be extracted in the future by underground mining methods. The Mesabi Range also has non-magnetic taconite resources which presently are not mined and processed commercially. Thus, taconite is a major iron ore resource for the future. Iron ore may also exist along major magnetic belts in northern Itasca and Cass Counties, but, although some prospects are known, proven reserves are too small to be mined economically.

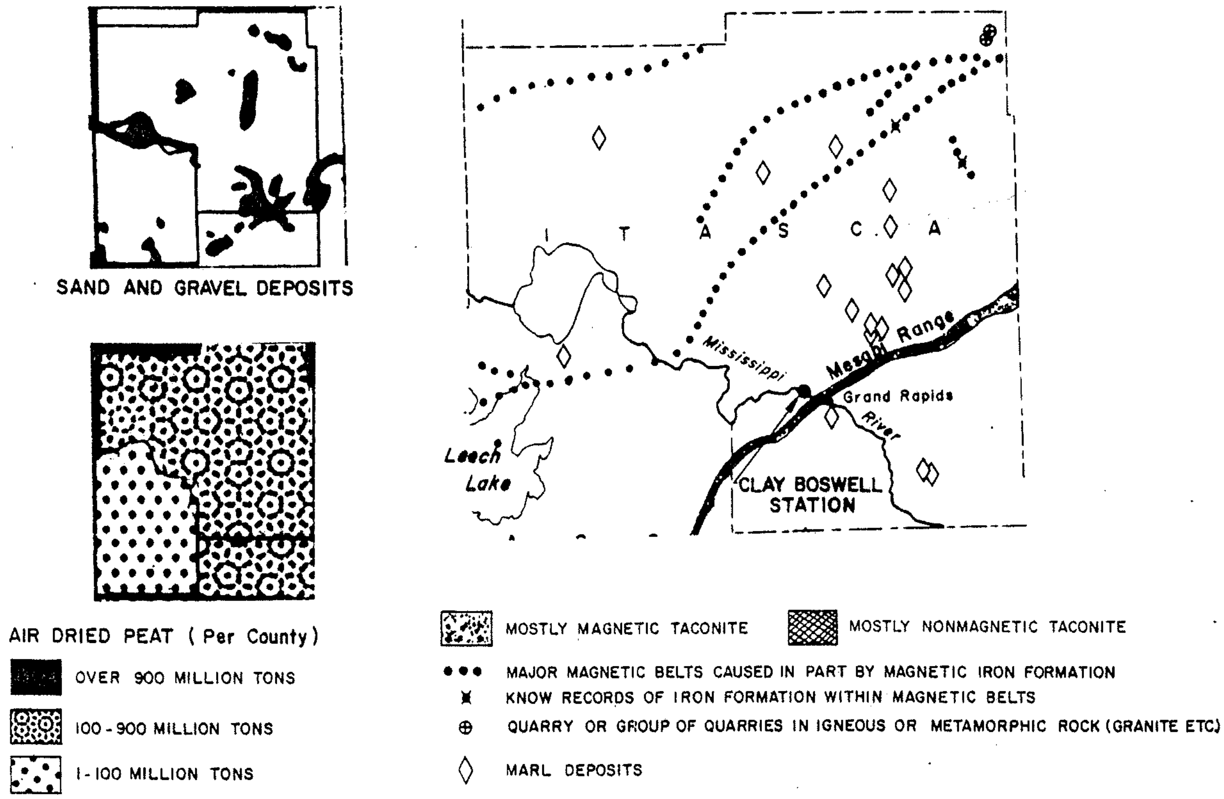
Butler Taconite, located at Cooley between Calumet and Nashwauk, is the only magnetic taconite operation in Itasca County. The other magnetic taconite operations on the Mesabi Range are located further northeast in St. Louis County. These taconite operations include National Steel Pellet Company, Butler Taconite, Hibbing Taconite, U.S. Steel's Minntac, Inland Steel's Minorca, Eveleth Taconite, Erie Mining, and Reserve Mining.

Meta-volcanic rocks (rocks originally volcanic but metamorphosed or changed by heat and pressure over geologic time) are quarried in extreme northeastern Itasca County and are used for decorative construction material or for road material. Gold, associated with Precambrian rocks, occurs throughout the area (26). However, no economically recoverable deposits of gold are known, and this resource has not been included in Figure IV-9.

Marl, sand, and gravel are surficial deposits associated mainly with glacial activity. All 3 deposits occur in northeastern Minnesota. Marl, a calcareous clay used primarily in the ceramics industry, was probably deposited in glacial lakes which remained after the retreat of Quaternary continental glaciers. Sand and gravel, used mostly in the construction industry, occur in glacial soil deposits and river flood plains. Peat deposits are not a direct result of glaciation, but they occur in poorly drained post-glacial depressions underlain by impervious material, such as clay, where organic matter accumulated and decayed anaerobically.

Seismology

The Clay Boswell Station is situated on the Canadian Shield (27) in the northern part of the Central Stable Region of the United States. Figure IV-10 shows that this area is characterized by a low frequency of seismic activity, and the earthquakes which have occurred in this zone have been of low intensities. Causes for past shocks in this area are not well understood, but according to Coffman and von Hake (28), are probably related to crustal rebound which has continued since continental ice sheets retreated about 10,000 years



MINERAL RESOURCES OF ITASCA, NE CASS, AND NEW AITKIN COUNTIES

SOURCE: MP&L "ENVIRONMENTAL REPORT", EXHIBIT III-A-4

FIGURE IV-9

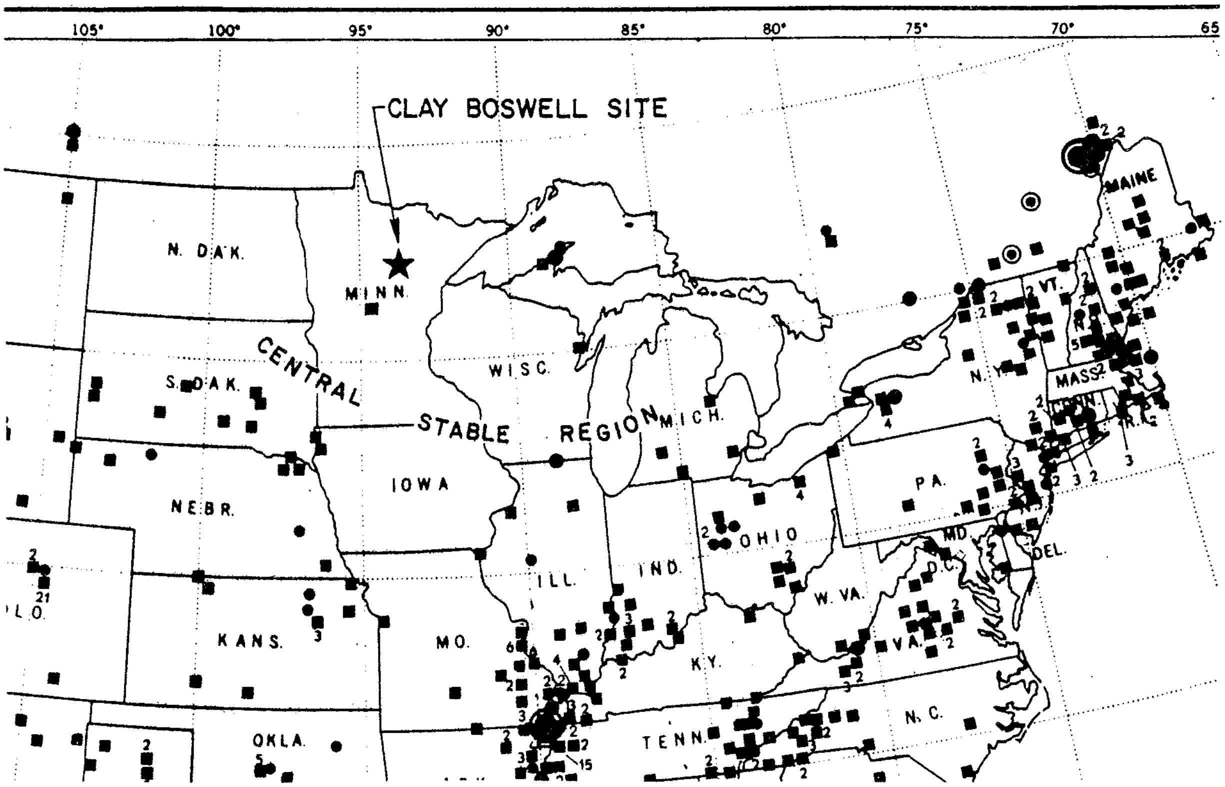
ago. (The weight of thousands of feet of glacial ice is thought to have depressed the earth's crust and the crust is now believed to be returning to its original position.)

In addition to earthquakes which occur in the Central Stable Region, the Clay Boswell Station may be affected by shocks which occur in the St. Lawrence River region and the upper Mississippi-lower Ohio River valleys region (Figure IV-10). These zones of major seismic activity have had earthquakes which were powerful enough to be felt at the Clay Boswell Station (28) (29).

Local and Site Specific Geological Description

Physiography

Topographic expression around the Clay Boswell Station is, like the surficial geology, almost exclusively the result of Wisconsin Stage glaciation. The area is quite flat at an average elevation of about 1,300 ft (396.2 m) above



LEGEND

- ■ Intensity V-VII (except California)
- • Intensity VII-VIII
- ● Intensity VIII-IX
- ◉ Intensity IX-X
- ⬤ Intensity X-XII

EPICENTERS OF EARTHQUAKES THROUGH 1970 - NORTH CENTRAL AND EASTERN UNITED STATES

SOURCE: MP&L, "ENVIRONMENTAL REPORT", EXHIBIT III-A-5

FIGURE IV-10

mean sea level (MSL), although elevations in the Mesabi (Giants) Range are about 200 to 400 ft (61.0 to 121.9 m) higher due to the erosion resistant granite which underlies the Mesabi (Giants) Range. Relief near the Clay Boswell Station is low (about 200 ft or 61.0 m), and elevations range from 1,275 to 1,450 ft (388.6 to 442.0 m) MSL. After grading, the Station site will be at an elevation of about 1,293 ft (394.1 m) MSL, 20 ft (6.1 m) above normal pool for Blackwater Lake.

Mineral Deposits

No economically recoverable mineral deposits are known to exist on the Clay Boswell Station site with the possible exception of sand and gravel in the northwest corner. Sand and gravel from this corner of the site will probably be used in the construction of Unit 4.

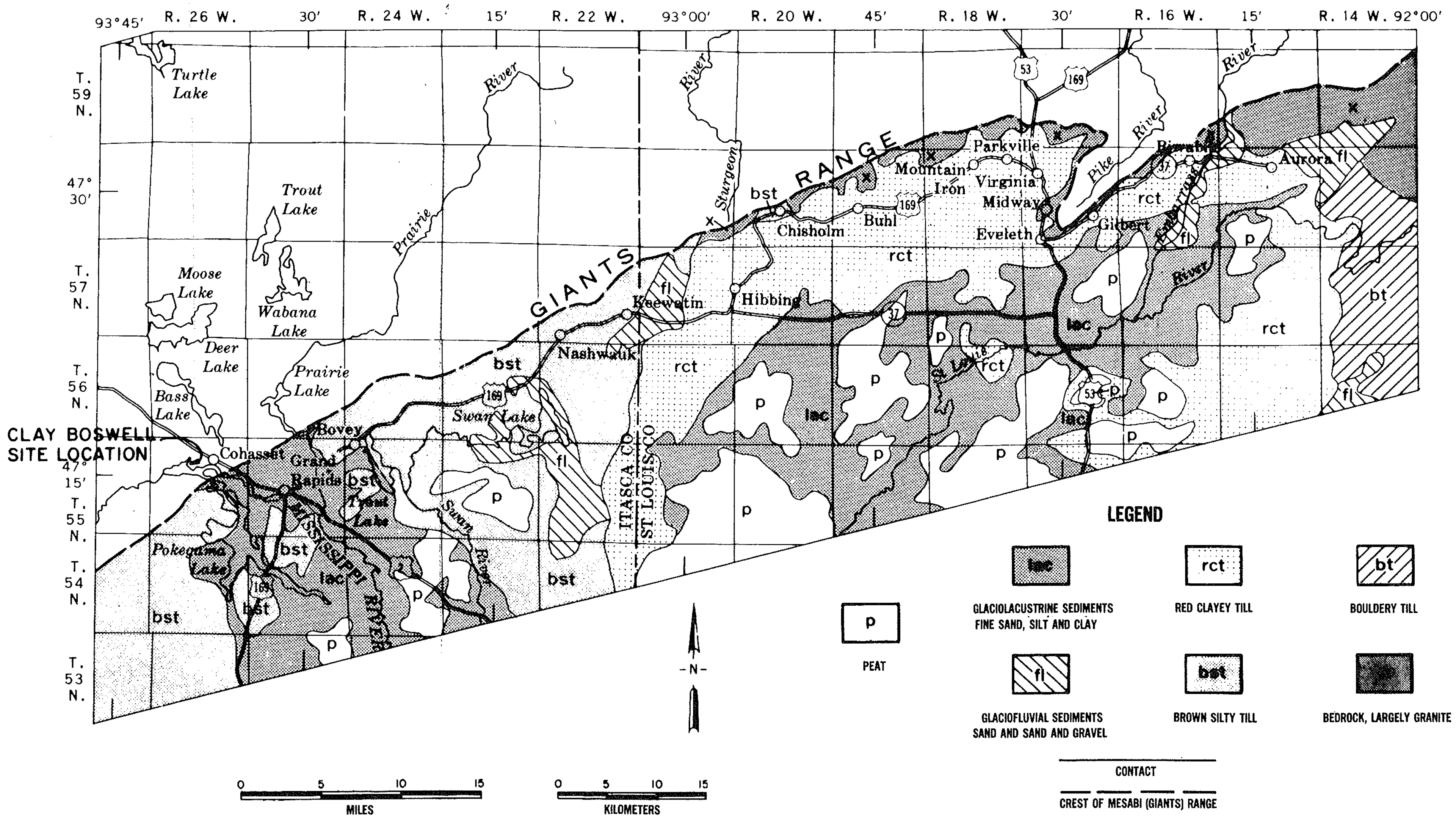
Glacial Landforms

Landforms and soil conditions at the western end of the Mesabi (Giants) Range in the vicinity of the Clay Boswell Station resulted primarily from the glacial advances during the Wisconsin stage of the Rainy lobe and St. Louis sublobe of the Des Moines lobe (21)(23). In the vicinity of the Clay Boswell Station, bedrock composed of granite associated with the Mesabi (Giants) Range batholith is covered, as shown in Figure IV-11, by more than 200 ft (61.0 m) of glacial drift (soils).

The Clay Boswell Station is located in a former arm of Lake Aitkin II, bounded by several end moraines (Figure IV-12) or brown silty till which extended above the inferred maximum lake water level of approximately 1,320 ft (402.3 m) MSL. The nearest portions of former lake shorelines are about 2 miles (3.2 km) northeast and southeast of the existing electric generating facility (Figure IV-12). Four "islands", apparently of brown silty till or similar morainal material also extended above the level of former Lake Aitkin II. The largest and southernmost of these "islands" is the hill located about 2 miles (3.2 km) northwest of the existing Clay Boswell Station and about 3,000 ft (914.4 m) west of the proposed Unit 4 ash pond. This hill has been proposed as a source of borrow material for construction of fills and ash pond dikes for MP&L's proposed Unit 4.

Ice contact and outwash deposits of various origins may exist around the edges of this hill and at other near-surface locations in the area. According to Figure IV-12, the shoreline of glacial Lake Aitkin II is located about 5 miles (8.0 km) north of the existing Clay Boswell Station and the area north of this shoreline is a complex of moraine, outwash, and ice contact deposits including eskers. Given the proximity of moraine, outwash, and ice contact deposits to the proposed Unit 4 ash and SO_2 sludge pond, the possibility of such deposits at or near the ground surface in the ash pond area should certainly not be dismissed. Ice contact and outwash deposits are frequently rather pervious, which may allow seepage from the ash pond.

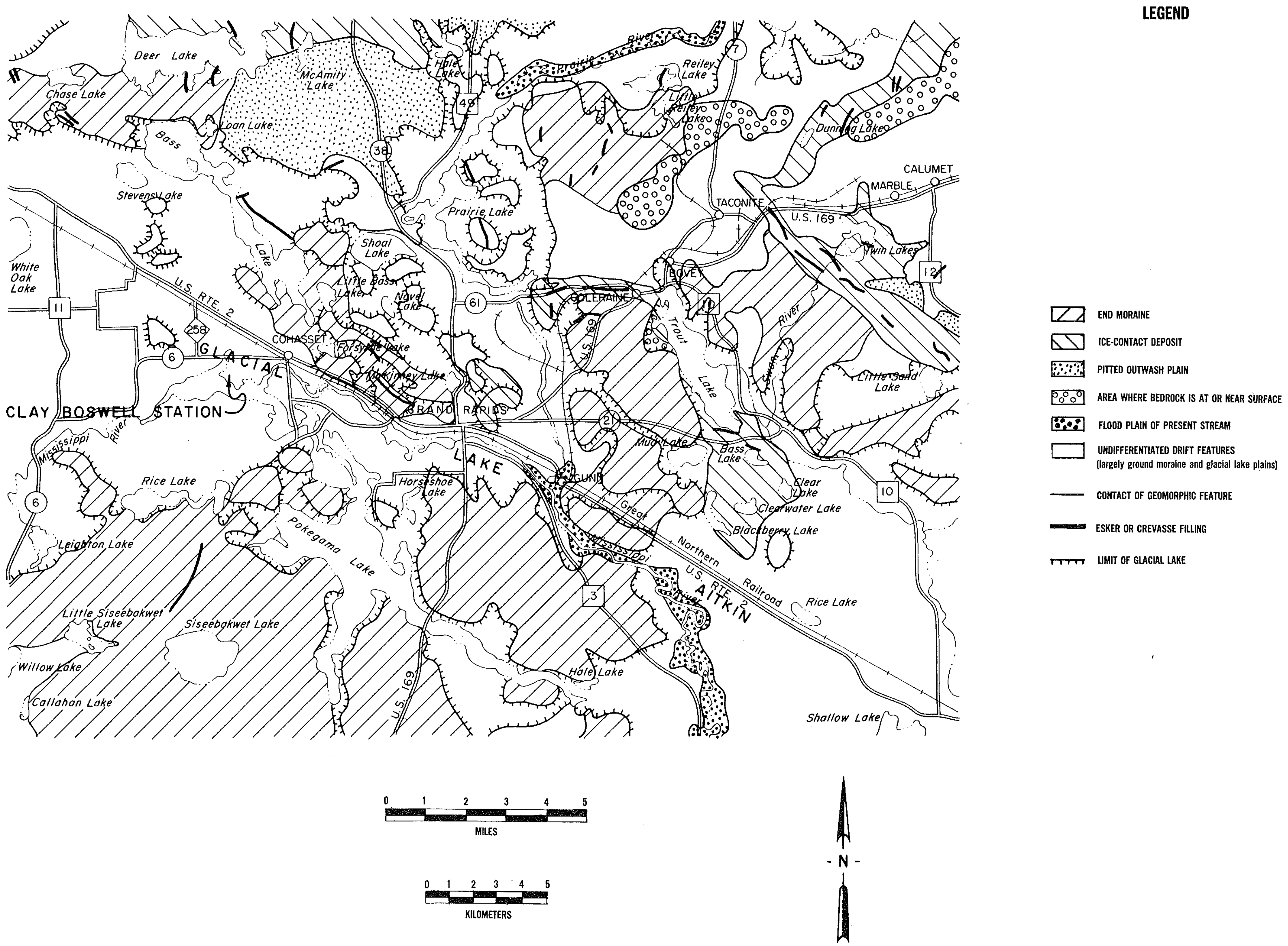
The Clay Boswell Station and existing ash disposal areas are located in the bed of former glacial Lake Aitkin II (Figure IV-12). Surficial soils on this lake plain are predominantly sand, though there are extensive peat deposits in low, poorly drained areas as well as brown silty till on high areas within a few



SURFICIAL GEOLOGY MAP, U.S. GEOLOGICAL SURVEY GLACIAL GEOLOGY AND GEOHYDROLOGY STUDY AREA SOUTH OF MESABI RANGE

(ADAPTED FROM WINTER, T.C., "HYDROGEOLOGY OF GLACIAL DRIFT, MESABI IRON RANGE, NORTHEASTERN MINNESOTA," WATER SUPPLY PAPER 2029-A, U.S. GEOLOGICAL SURVEY, 1973, pp. A10-A11.)

FIGURE IV-11



LANDFORMS - VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION

(ADAPTED FROM WINTER, T.C., COTTER, R.D., AND YOUNG, H. L. "PETROGRAPHY AND STRATIGRAPHY OF GLACIAL DRIFT, MESABI-VERMILLION IRON RANGE AREA, NORTHEASTERN MINNESOTA," BULLETIN 1331-C, U.S. GEOLOGICAL SURVEY, 1973, PLATE 1-A)

FIGURE IV-12

miles (km) of the Clay Boswell Station (Figure IV-13). It is important to recognize, however, that soil characterizations of the types shown in Figure IV-13 are highly generalized.

Surficial Soils

Description of surficial soils at the Clay Boswell Station is confined specifically to that area on the east side of Blackwater Lake and south of Minnesota Route 6 where the existing Units 1, 2, and 3, coal handling facilities and fly ash reclamation area are situated. Existing ash ponds for Units 1, 2, and 3 located south of Route 6 on the west side of Blackwater Lake have not been examined, as there are no plans for wastes from Unit 4 to be placed in these ponds. The glacial geology and soil conditions at the proposed Unit 4 ash and SO_2 sludge pond north of Route 6 are discussed separately.

At the Clay Boswell Station, borings and water wells extended to maximum depths of about 250 ft (76.2 m) below the average ground elevation of approximately 1,300 ft (396.2 m) MSL. None of these borings or wells reached bedrock (30) (31) (32). Thus, it appears that soil deposits at the site have a minimum thickness of 250 ft (76.2 m) and extend down to at least an elevation of 1,050 ft (320.0 m) MSL.

Except for localized, relatively thin, surficial zones of topsoil, man-made fill, stockpiled coal, and old fly ash (in fly ash reclamation area), all soils at the Clay Boswell Station are of glacial origin. The glacial soils can be divided into 2 main categories:

1. Lacustrine deposits
2. Outwash deposits

The lacustrine deposits overlie the outwash deposits and extend up to the ground surface except in those areas covered by topsoil, fill, coal, or fly ash.

The lacustrine soils, which range in thickness from about 40 to 90 ft (12.2 to 27.4 m), were deposited in former glacial Lake Aitkin II. These soils are interbedded clays, silts, and sands typical of lake bed and lake beach deposits. Patterns of stratification are quite erratic, indicating variable water depth, current, and sediment source conditions during deposition. Similarly, consistency of the finer grained (clay and silt) lacustrine soils and relative density of the coarser grained (sand) lacustrine soils are variable both horizontally and vertically at the Clay Boswell Station. The lacustrine clays are generally of medium stiff to stiff consistency and, based on laboratory test data (30) (31), are probably slightly to moderately overconsolidated due to desiccation. The lacustrine silts and clayey silts range from soft to stiff in consistency and are typically soft to medium stiff. The lacustrine sands, silty sands, and sandy silts are generally loose to medium dense. It is probable that some of the lacustrine sands are beach deposits corresponding to water level fluctuations in former Lake Aitkin II. The finer grained lacustrine soils are reported to contain lenses and seams of sand (30) (31). It is not clear from the available information whether the lacustrine clays and silts are truly varved, though this is a strong possibility, at least in certain locations.

Outwash soils underlie the lacustrine soils and extend to the maximum depths penetrated by borings and wells at the Clay Boswell Station. The outwash soils appear to be at least 100 ft (30.5 m) thick (31). They typically consist of medium dense to very dense, fine to medium grained sands becoming progressively denser with depth. These sands or outwash soils probably originated from deposition in an outwash plain by streams flowing from a melting glacier. It is recognized that the sands may have a non-glacial alluvial origin (30), but this possibility is considered remote.

The outwash sands at the Clay Boswell Station probably correspond to glaciofluvial sediments overlying the bouldery till. These glaciofluvial sediments were probably deposited some 14,000 to 16,000 years ago, during retreat of the Rainy lobe. No information is presently available regarding the existence of bouldery till or other underlying glacial soils at the site.

Unit 4 Ash and SO_2 Scrubber Sludge Pond Site

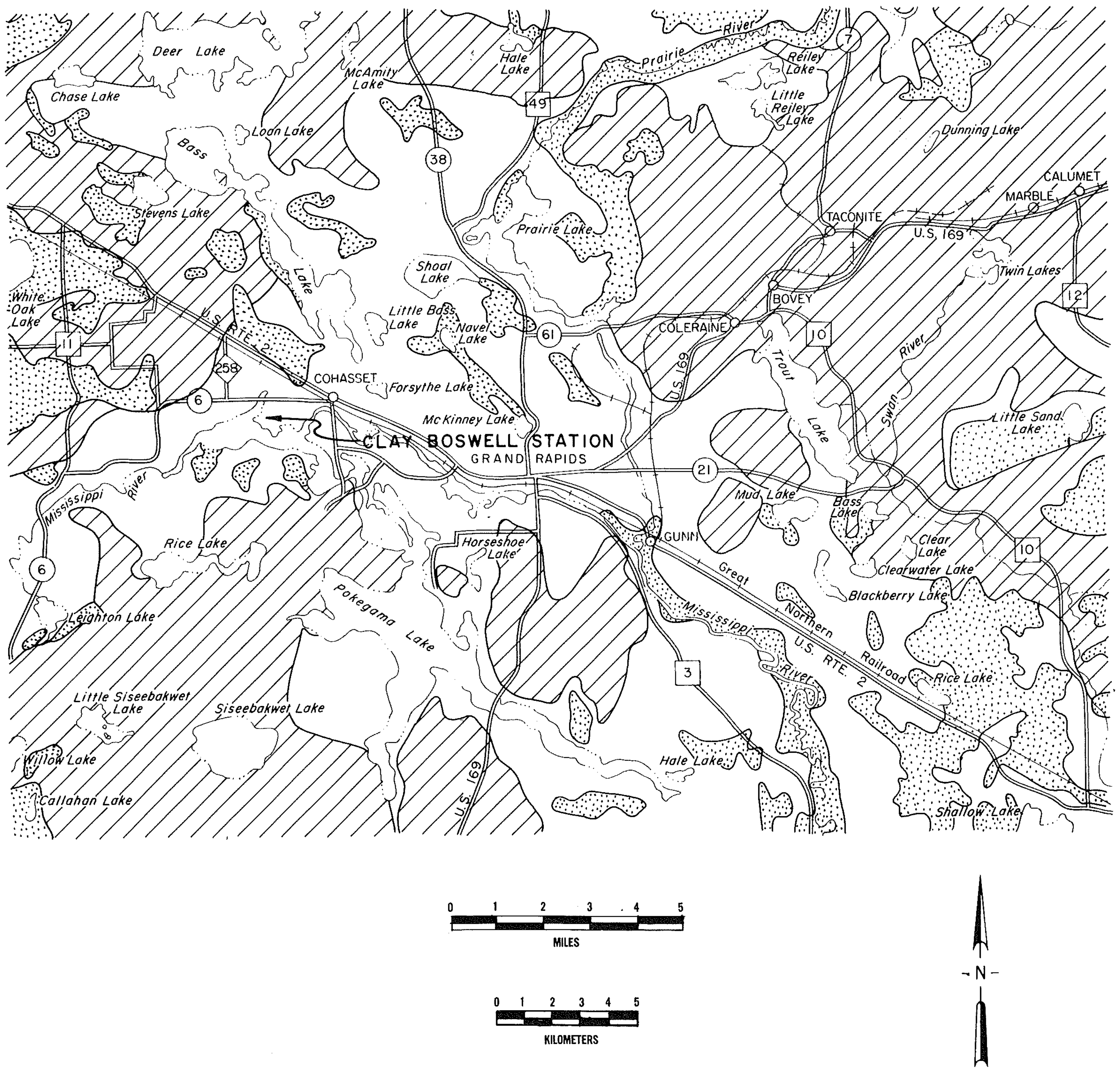
The Unit 4 ash and SO_2 scrubber sludge pond site is located west of Blackwater Creek and Blackwater Lake and north of Minnesota Route 6 in Sections 4, 5, and 6 of T55N, R26W, (Figure IV-3).

Information on the glacial geology of the site has been compiled from study of aerial photographs, and topographic maps, limited field reconnaissance work, and preparation of maps and cross sections from boring logs compiled by Ebasco Services Inc. in their report on the Unit 4 ash disposal pond (33).

Glacial Landforms. Figure IV-14, the top of till structure contour map, shows that the hill on the west side of the ash pond site is composed mainly of till, the surface of which slopes south and east from the hill in a plateau (or till plain) covered with other soils. Figure IV-14 also shows that the till beneath the west side of the proposed pond is rather shallow with an irregular surface containing several noses and valleys. The till is believed to be much deeper beneath the central and eastern portions of the pond (where it was not encountered in any of the borings). This latter area apparently corresponds to a deep arm of former glacial Lake Aitkin II.

Figure IV-15 is a plan showing 6 approximate zones of inferred glacial landforms and soil deposits. Zone 1, the hill top above approximately elevation 1,350 ft (411 m) MSL, consists of till with a few small local patches of ice contact and outwash soils. Zone 2, the sides of the hill from approximately elevation 1,350 to 1,310 ft (411 to 399 m) MSL, consists mainly of kame and kettle-type ice contact deposits underlain by till. Zone 2 contains numerous patches of outwash soils, especially on the east and west sides of the hill below approximately elevation 1,320 ft (402 m) MSL. Some of the sandy soils in this lower portion of Zone 2 may be beach deposits from former glacial Lake Aitkin II which had a maximum water level of about elevation 1,320 ft (402 m) MSL. The large kettle lake on the south end of the hill is included in Zone 2 even though its present water level is at elevation 1,200 ft (396 m) MSL. This kettle lake was probably occupied by a block of stagnant ice when glacial Lake Aitkin II had its maximum water level.

Zone 3 extends around the west, south, and east sides of the hill. This zone is fairly level with ground surface elevations on the order of 1,300 to



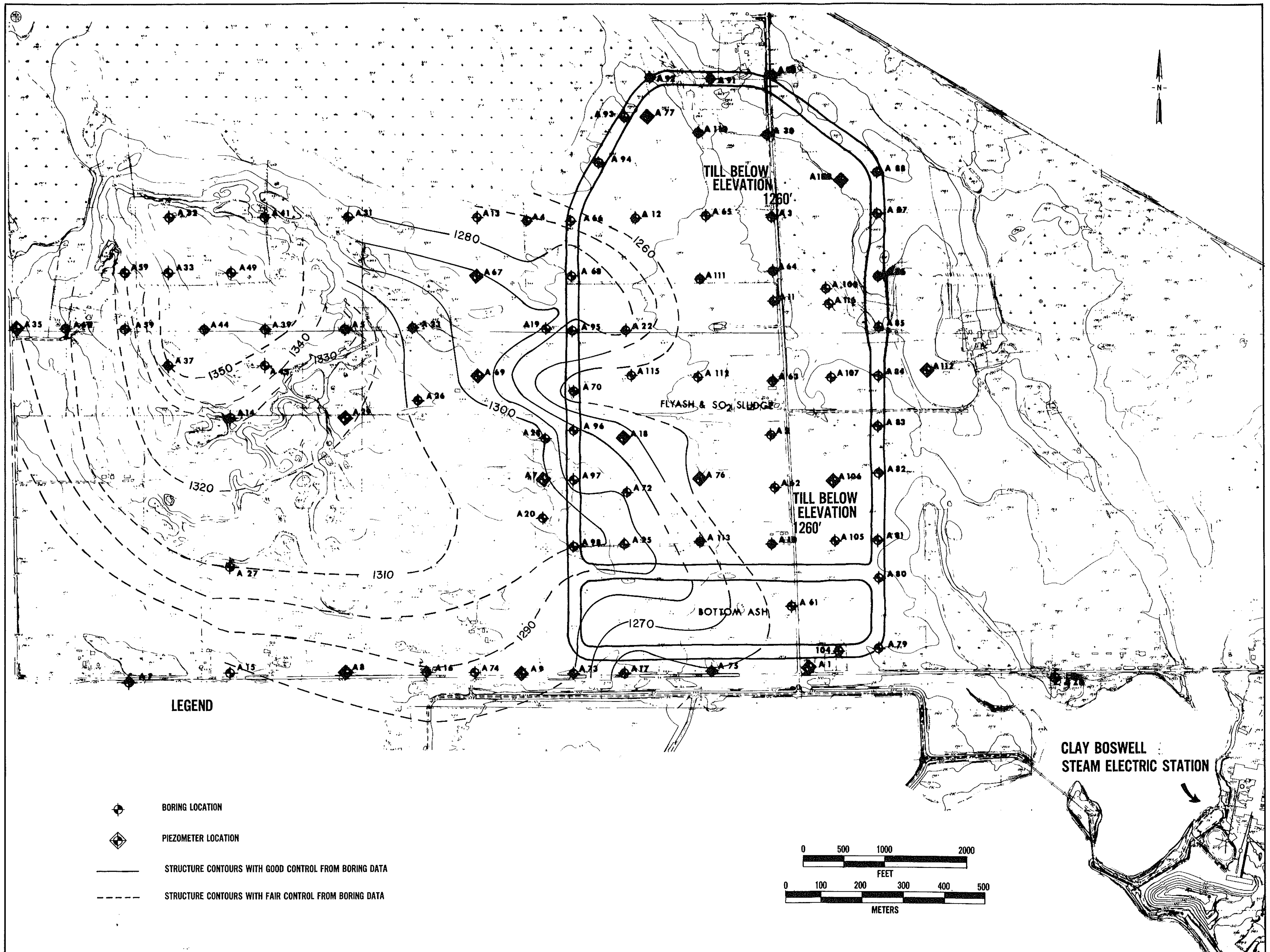
LEGEND

- PEAT
- SAND
- BROWN SILTY TILL
- CONTACT

SURFICIAL SOILS - VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION

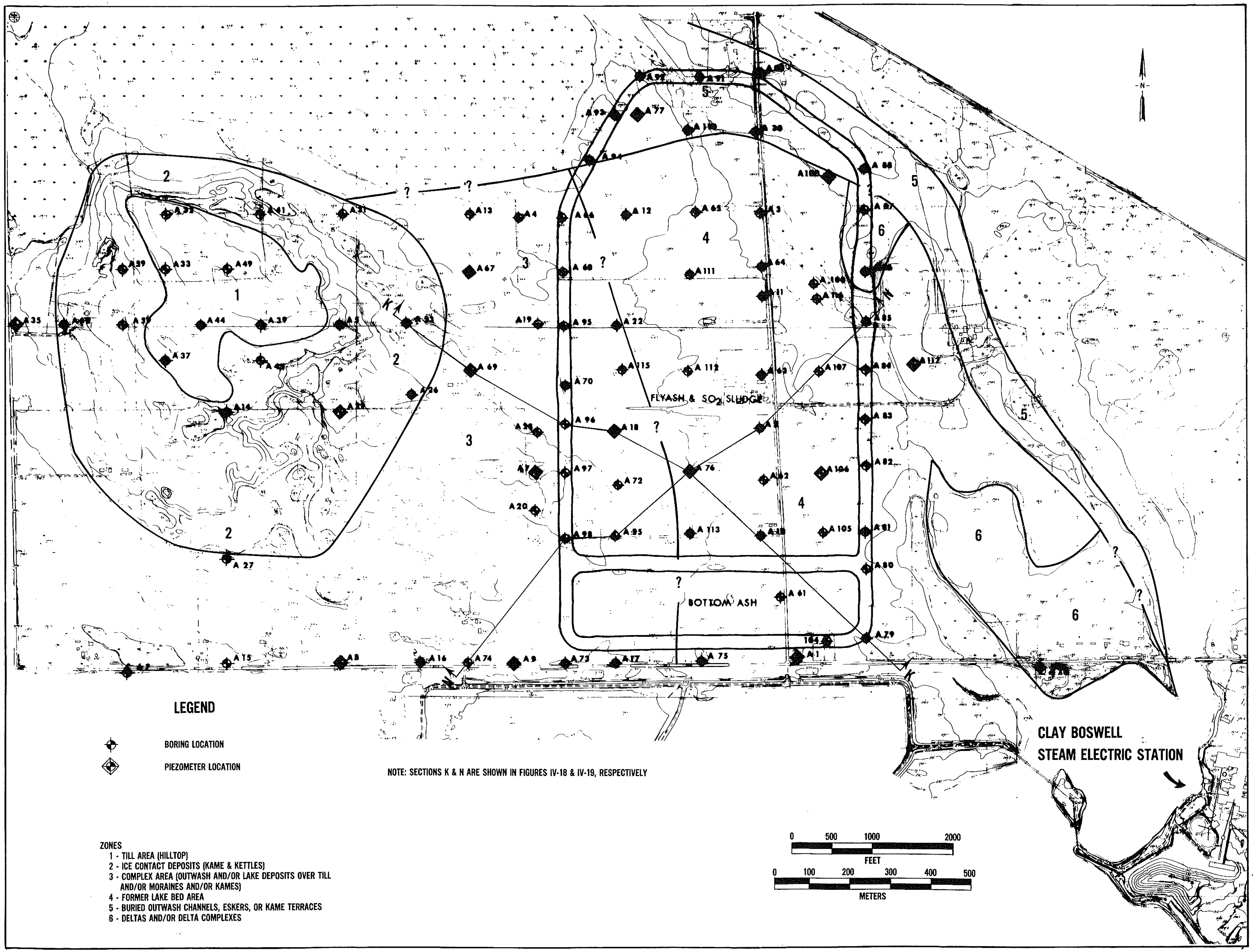
(ADAPTED FROM WINTER, T.C., COTTER, R.D., AND YOUNG, H.L., "PETROGRAPHY AND STRATIGRAPHY OF GLACIAL DRIFT, MESABI-VERMILLION IRON RANGE AREA, NORTHEASTERN MINNESOTA," BULLETIN 1331-C, U.S. GEOLOGICAL SURVEY, 1973, PLATE 1-B)

FIGURE IV-13



STRUCTURAL CONTOURS ON TOP OF TILL-VICINITY OF PROPOSED UNIT 4 ASH DISPOSAL POND SITE CLAY BOSWELL STEAM ELECTRIC STATION

FIGURE-IV-14



APPROXIMATE ZONES OF INFERRED GLACIAL LANDFORMS AND SOIL DEPOSITS VICINITY OF PROPOSED UNIT 4 ASH DISPOSAL POND SITE CLAY BOSWELL STEAM ELECTRIC STATION

FIGURE IV-15

1,310 ft (396 to 399 m) MSL. Zone 3, an area of very complex soil conditions, appears to be a till plain covered with a veneer of outwash (presumably derived from the hill). This till plain contains a number of moraine and kame features including a probably archipelago of end moraine and/or kame deposits extending southeasterly from the south end of the hill (Figure IV-15). Soil conditions are further complicated by lacustrine deposits from former glacial Lake Aitkin II along the east edge of Zone 3 (and perhaps elsewhere in the zone). Lacustrine deposits along the east edge of Zone 3 are quite erratic; this reflects irregular lake bed and lake shore topography (Figure IV-14) as well as variable sediment inflow from the hill to the west (Figures IV-14 and IV-15), and fluctuations in lake water level.

Zone 4, the former lake bed area with surface elevations on the order of 1,280 to 1,300 ft (390 to 396 m) MSL, contains thick deposits of lacustrine silts and clays beneath a surficial stratum of silty fine sand which is probably also of lacustrine origin. Zone 4 includes most of the Unit 4 ash SO_2 scrubber sludge pond and extends east of the pond where it covers portions of Zones 5 and 6. The east-central portion of Zone 4 which has the lowest present ground surface elevations and the thickest, softest clay deposits, probably corresponds to a deep embayment in this arm of former glacial Lake Aitkin II.

Zone 5 has surface elevations of about 1,290 to 1,300 ft (393 to 396 m) MSL and apparently consists of one or more buried outwash channels, eskers, and/or kame terraces. Zone 5 is composed of fairly loose granular material and appears to be an aquifer. It is probable that the outwash and/or ice contact deposits in Zone 3 formed during wasting of an ice front north or northeast of the pond site prior to the development of Lake Aitkin II. The portion of Zone 5 at the north end of the Unit 4 pond is overlain by lacustrine deposits. No borings were made in the portion of Zone 5 east of the Unit 4 pond but this portion of Zone 5 is probably also overlain, at least locally, by lacustrine deposits.

The center of the east side of Zone 5 is cut by the channel of the small unnamed stream that drains most of Zone 4. The stream channel may correspond to an outlet of former glacial Lake Aitkin II. It is possible that water impounded in Lake Aitkin II overtopped and breached the ridge of Zone 5 to make this outlet to the east, perhaps after melting of a stagnant ice block in what is now the swampy area north of Blackwater Lake, between Zone 5 and Blackwater Creek. An alternate and more probable explanation is that the stream channel across Zone 5 was eroded by melt water flowing westerly from stagnant glacial ice in what is now the swampy area along Blackwater Creek. If this latter explanation is correct, the present easterly flow of the stream reflects a subsequent reversal of drainage as the Zone 4 area of Lake Aitkin II filled with sediments. A more definitive explanation of the origin of this stream channel would require much more detailed study of the glacial history of adjacent areas to the north and east and is beyond the scope of this report.

Zone 6, with ground surface elevations similar to those of Zones 4 and 5, appears to consist of 2 separate deltas or delta complexes (perhaps including kame deltas) which extend from the west side of Zone 5 into the arm of former glacial Lake Aitkin II (Zone 4). It might be appropriate to consider these delta features as parts of Zone 5 because of the intimate generic relationship of the former to the latter. However, the delta features are considered here as a separate zone because of their conspicuous shapes and their somewhat different origins relative to the soil deposits of Zone 5. The Zone 6 delta at the northeast corner of the Unit 4 pond is overlain by lacustrine silt and clay deposits of considerable thickness. Only one boring (A-78) was made in the delta complex east of the southeast corner of the Unit 4 pond. The log of this single boring indicates that the south end of the southern part of Zone 6 is covered with thick lacustrine clay deposits. It is probable that the remainder of the southern part of Zone 6 is also covered with lacustrine silts and clays.

It is apparent that the glacial history and resultant soil conditions at the Unit 4 pond site are complex. Glacial soil deposits include lodgement and ablation tills, several types of ice contact deposits (moraines, kames, and related kame features, possible eskers), glacio-fluvial deposits (outwash), and glacio-lacustrine deposits (lake bed sediments, beaches, and deltas). Each of these types of soil deposits in itself is quite heterogeneous and erratic in composition and physical properties. Intermingling of these soils in a depositional environment like that of the Unit 4 pond site further complicates an evaluation of their engineering and environmental behavior.

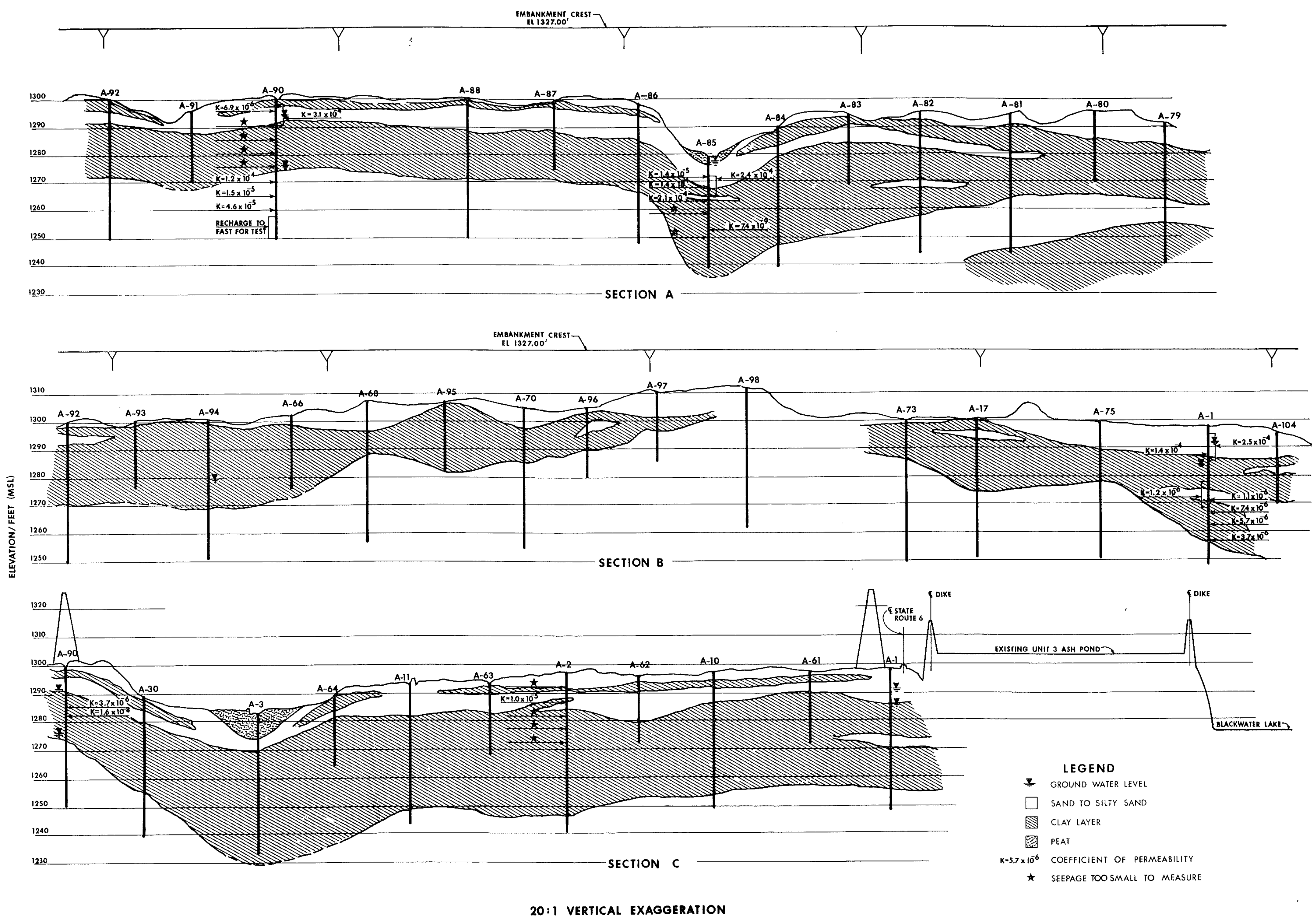
Soils. Several north-south and east-west subsurface cross-sections through the Unit 4 ash and SO_2 scrubber sludge pond are provided in Figures IV-16 and IV-17. These cross-sections, give a general idea of the thickness and continuity of soils in the basin of former glacial Lake Aitkin II. Also, 2 illustrative (though not necessarily typical) subsurface cross-sections in northwest-southeast and northeast-southwest directions across the southern part of the Unit 4 pond site are included in Figures IV-18 and IV19. The location of these cross-sections are shown in Figure IV-15. Section K in Figure IV-18 illustrates the inferred transition of materials in Zones 2, 3, and 4 of Figure IV-15. Section N in Figure IV-19 illustrates inferred soil conditions in the southwest corner of the Unit 4 ash pond (Zones 3 and 4 of Figure IV-15).

Seismology

Earthquake information for the north-central area of Minnesota has been recorded only since about 1850 (34). There are very few direct reports of earthquakes felt in the vicinity of the Clay Boswell Station. If a general area (such as "eastern Minnesota") was reported as the "felt area", it is assumed that the Clay Boswell Station also experienced the disturbance. Table IV-3 shows recorded earthquakes at the Clay Boswell Station site.

The Modified Mercalli Scale given in Table IV-4 is used to estimate the effects of earthquakes on people and structures. Earthquake "intensity" is subjectively rated on a non-linear scale from I to XII depending upon the severity of damage caused by the shock.

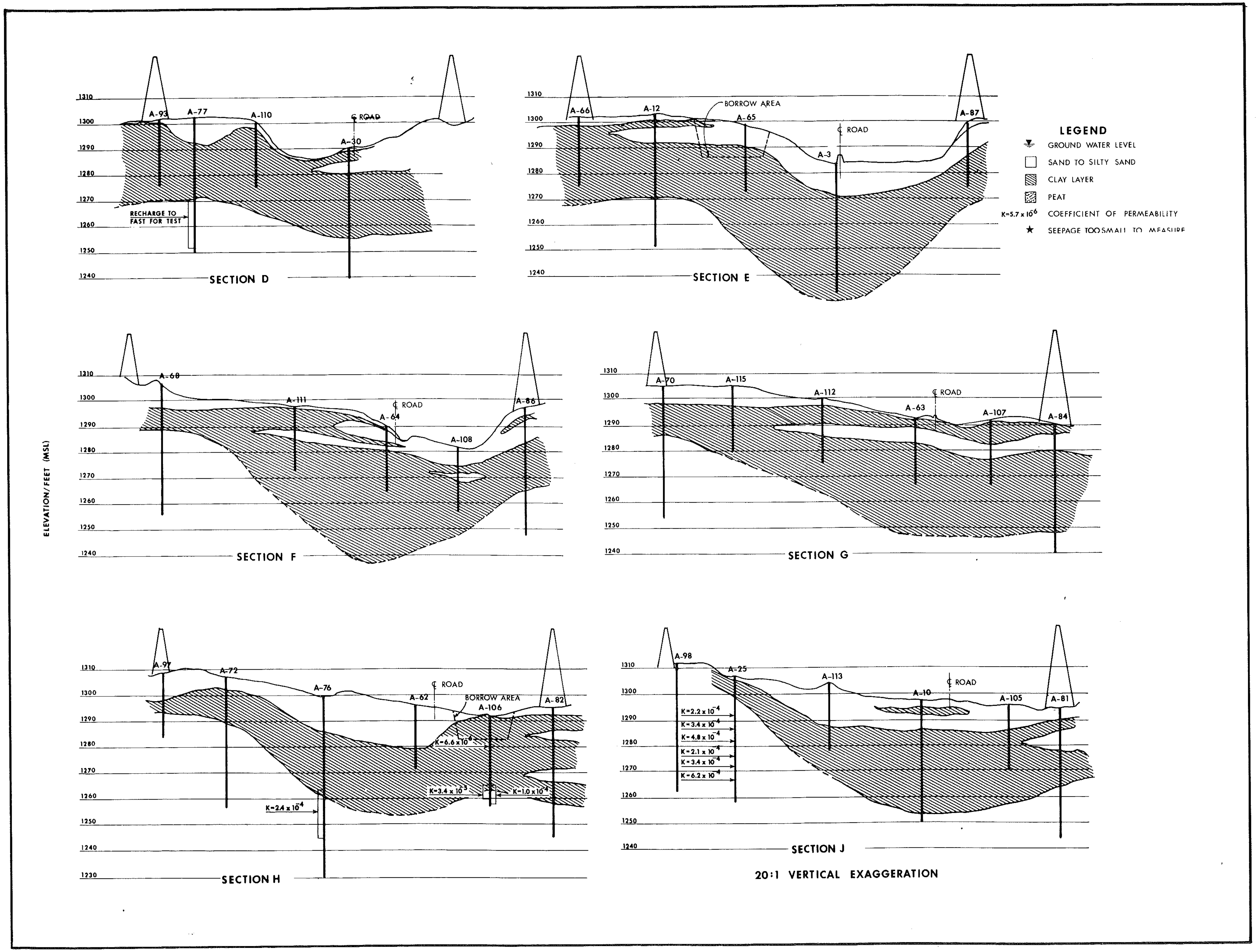
Only 7 earthquakes have probably been felt at the Clay Boswell Station site zonce 1850 (Table IV-3), and none of these has been felt with an intensity greater than VI (the intensity at which damage begins to be sustained) on the Modified Mercalli Scale. A minor earthquake with an intensity of III to IV on the Modified Mercalli Scale did occur on December 23, 1928, and was apparently associated with the Bowstring Lake Fault which is located 3 to 5 miles (4.8 to 8.0 km) northwest of the Clay Boswell Station (37). Some shocks, such as those in the St. Lawrence River region (February 28, 1925) and in Illinois (June 26, 1909 and November 9, 1968), were powerful enough to cause damage near their



BORING PROFILE SECTIONS A, B, AND C - PROPOSED UNIT 4 ASH DISPOSAL POND SITE CLAY BOSWELL STEAM ELECTRIC STATION

SOURCE: "MP&L CLAY BOSWELL STEAM ELECTRIC STATION, UNIT NO. 4, ASH DISPOSAL POND DIKE AND FOUNDATION STUDIES - ENGINEERING REPORT", APRIL 1977, FIGURE 5

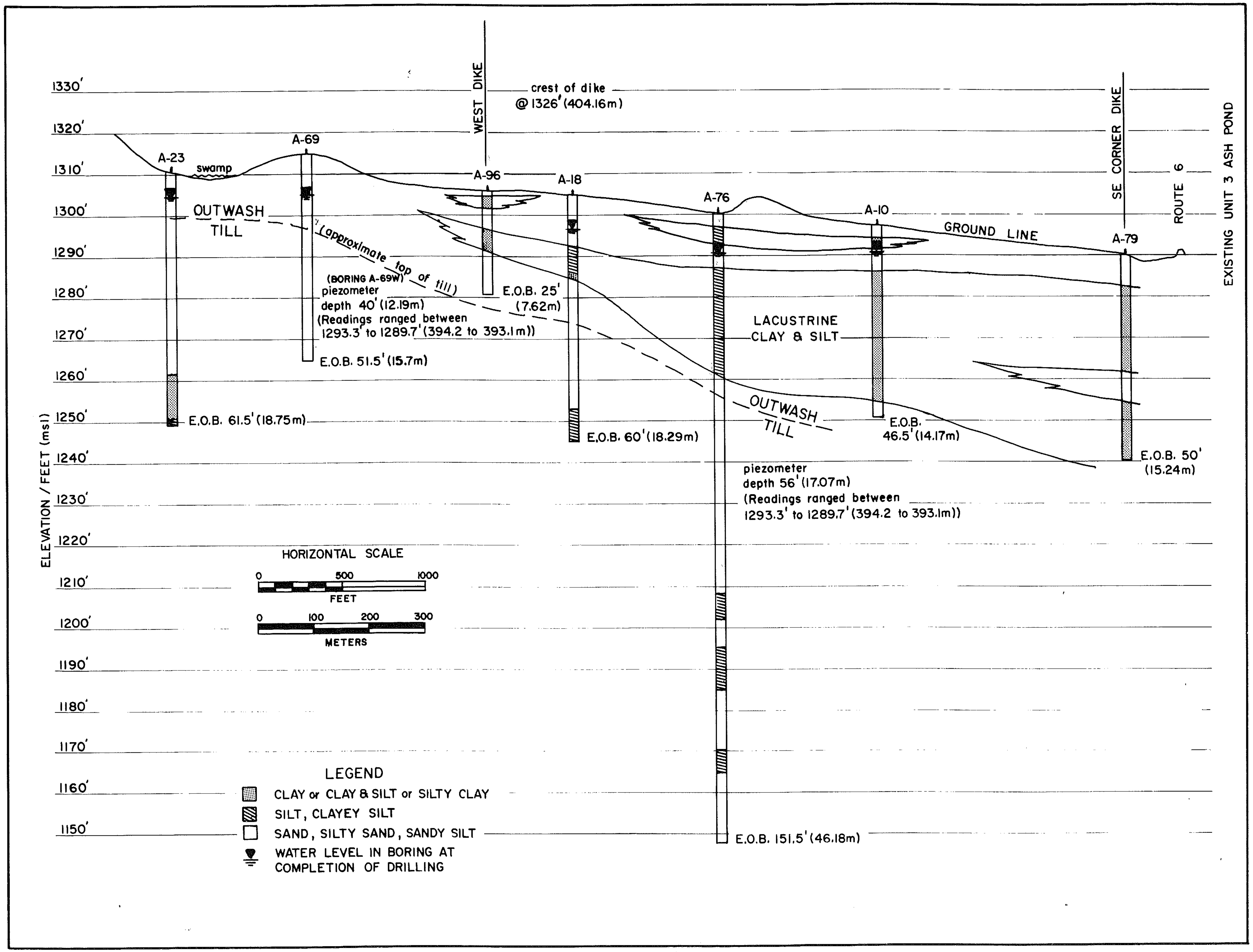
FIGURE IV-16



BORING PROFILE SECTIONS D THROUGH H AND J - PROPOSED UNIT 4 ASH DISPOSAL POND SITE CLAY BOSWELL STEAM ELECTRIC STATION

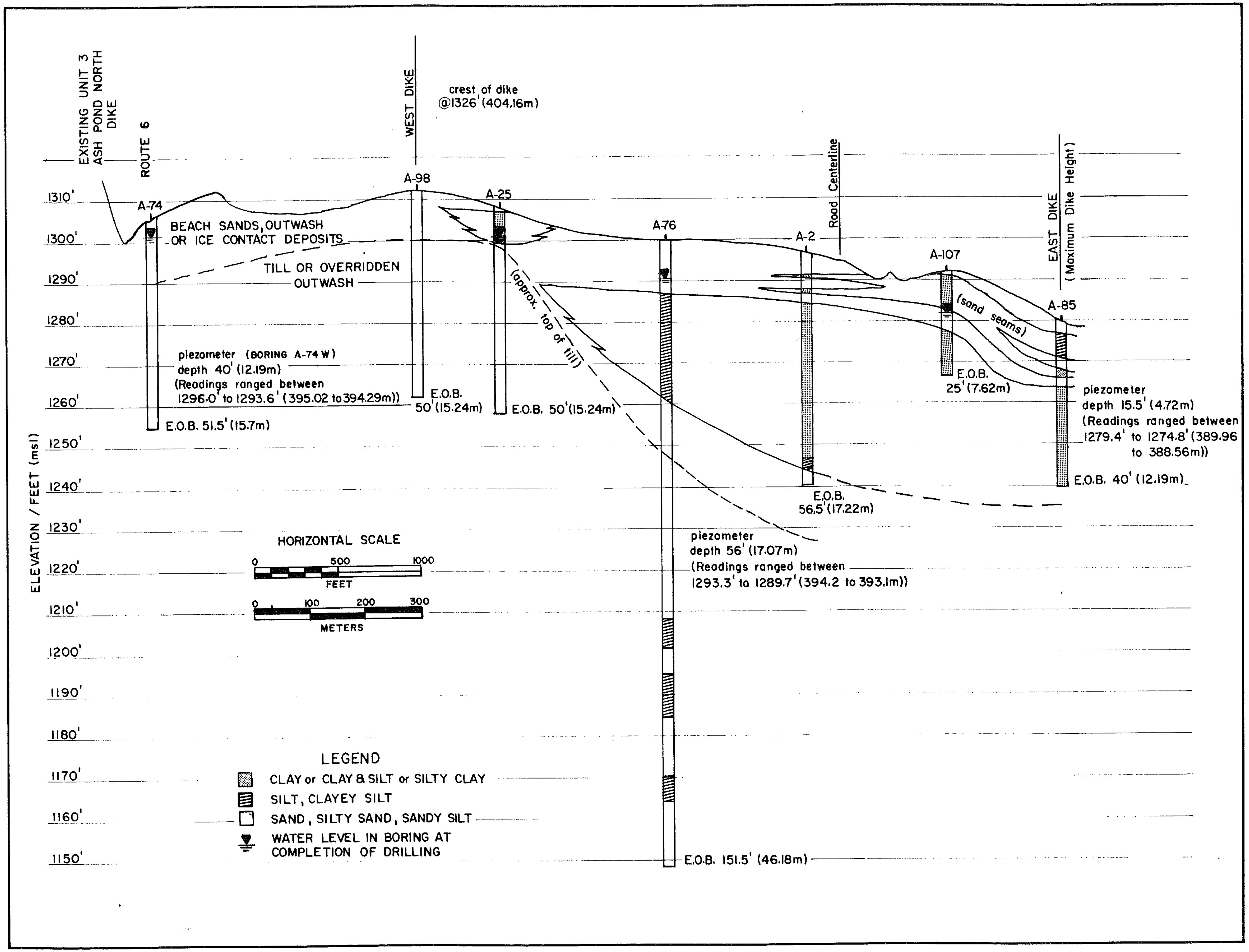
SOURCE: "MP&L CLAY BOSWELL STEAM ELECTRIC STATION, UNIT NO. 4, ASH DISPOSAL POND DIKE AND FOUNDATION STUDIES - ENGINEERING REPORT", APRIL 1977, FIGURE 6

FIGURE IV-17



SUBSURFACE CROSS-SECTION K -
PROPOSED UNIT 4 ASH DISPOSAL POND SITE
CLAY BOSWELL STEAM ELECTRIC STATION

FIGURE IV-18



SUBSURFACE CROSS-SECTION N - PROPOSED UNIT 4 ASH DISPOSAL POND SITE CLAY BOSWELL STEAM ELECTRIC STATION

FIGURE IV-19

TABLE IV- 3
EARTHQUAKE HISTORY - CLAY BOSWELL STEAM ELECTRIC STATION[a] (35)

Date	Location of Epicenter[b] area	Latitude °N	Longitude °W	Distance from Clay Boswell[c] mile	km	Intensity[d] MM	Magnitude[e] R	Affected Area[f] sq mile	sq km	Remarks
1860	central Minnesota	-	-	-	-	-	-	-	-	Fairly strong, but little is known about this earthquake
1900										
6/29/09	Illinois	42.5	89.0	450	724	VII		500,000	1,294,994	
9/03/17	Staples, Minnesota	46.3	94.5	110	177	VI		10,000	25,900	
2/28/25	St. Lawrence River Region*	47.7	70.5	1,280	2,060	VIII	7.0	2,000,000	5,179,976	Intensity not greater than VI in U.S.
11/01/35	Temiskaming, Canada*	46.8	79.1	780	1,255	VI	6.25	1,000,000	2,589,988	Intensity less than V at plant
11/09/68	South central Illinois*	38.0	88.5	740	1,191	VII	5.3	580,000	1,502,193	
7/09/75[g]	Morris, Minnesota*	45.6	96.1	200	322	Unknown as yet	4.8	60,000	155,399	

[a] Earthquakes of intensity V (Modified Mercalli Scale) or greater (except for the Morris, Minnesota earthquake).

[b] In some cases the epicentral locations are approximate and are where the earthquake was felt with greatest intensity. Starred (*) locations were determined by instrumental methods and are more accurate.

[c] Distances are approximate.

[d] Modified Mercalli (MM) Scale intensity at epicenter.

[e] Richter (R) Scale magnitude at epicenter.

[f] In most cases these areas are only approximate and include areas within isoseismal III.

[g] Information received from the U.S. Earthquake Information Center, Golden, Colorado.

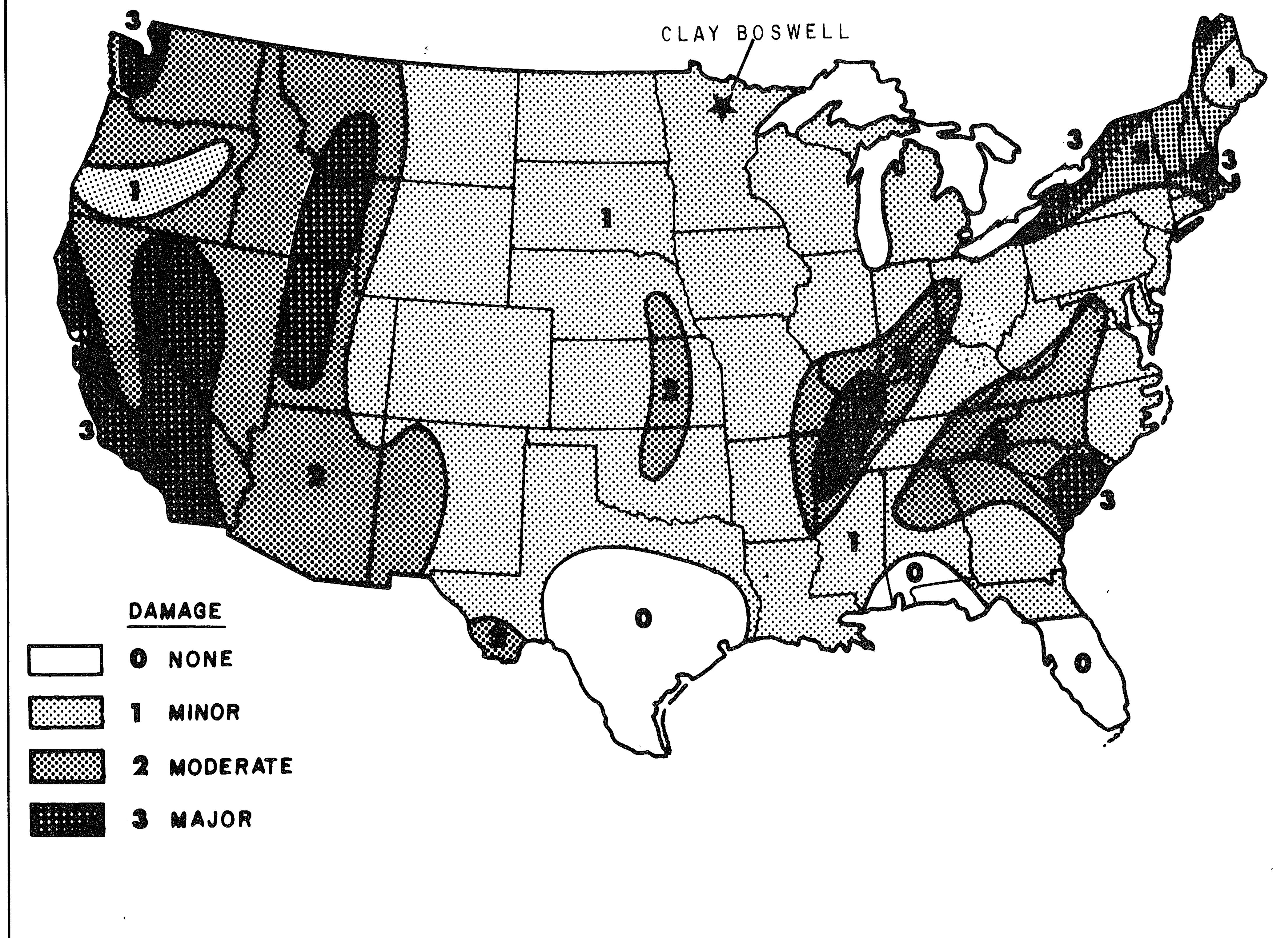
TABLE IV- 4

MODIFIED MERCALLI INTENSITY SCALE OF 1931 - ABRIDGED (36)

Scale	Intensity
I	Not felt except by a very few under especially favorable circumstances.
II	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
III	Felt quite noticeably indoors especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibrations like passing truck. Duration estimated.
IV	During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, and doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably.
V	Felt by nearly everyone; many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.
VI	Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of falling plaster or damaged chimneys. Damage slight.
VII	Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well built ordinary structures; considerable in poorly built or badly designed structures. Some chimneys broken. Noticed by persons driving motorcars.
VIII	Damage slight in specially designed structures; considerable in ordinary substantial buildings, with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motorcars disturbed.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial building with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water spashed (slopped) over banks.
XI	Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
XII	Damage total. Waves seen on ground surface, lines of sight and level distorted. Objects thrown upward into the air.

epicenters as indicated in Table IV-3. Distances from these epicenters to the Clay Boswell Station are great enough so that energy from the earthquake waves attenuated sufficiently to preclude damage at the Clay Boswell Station.

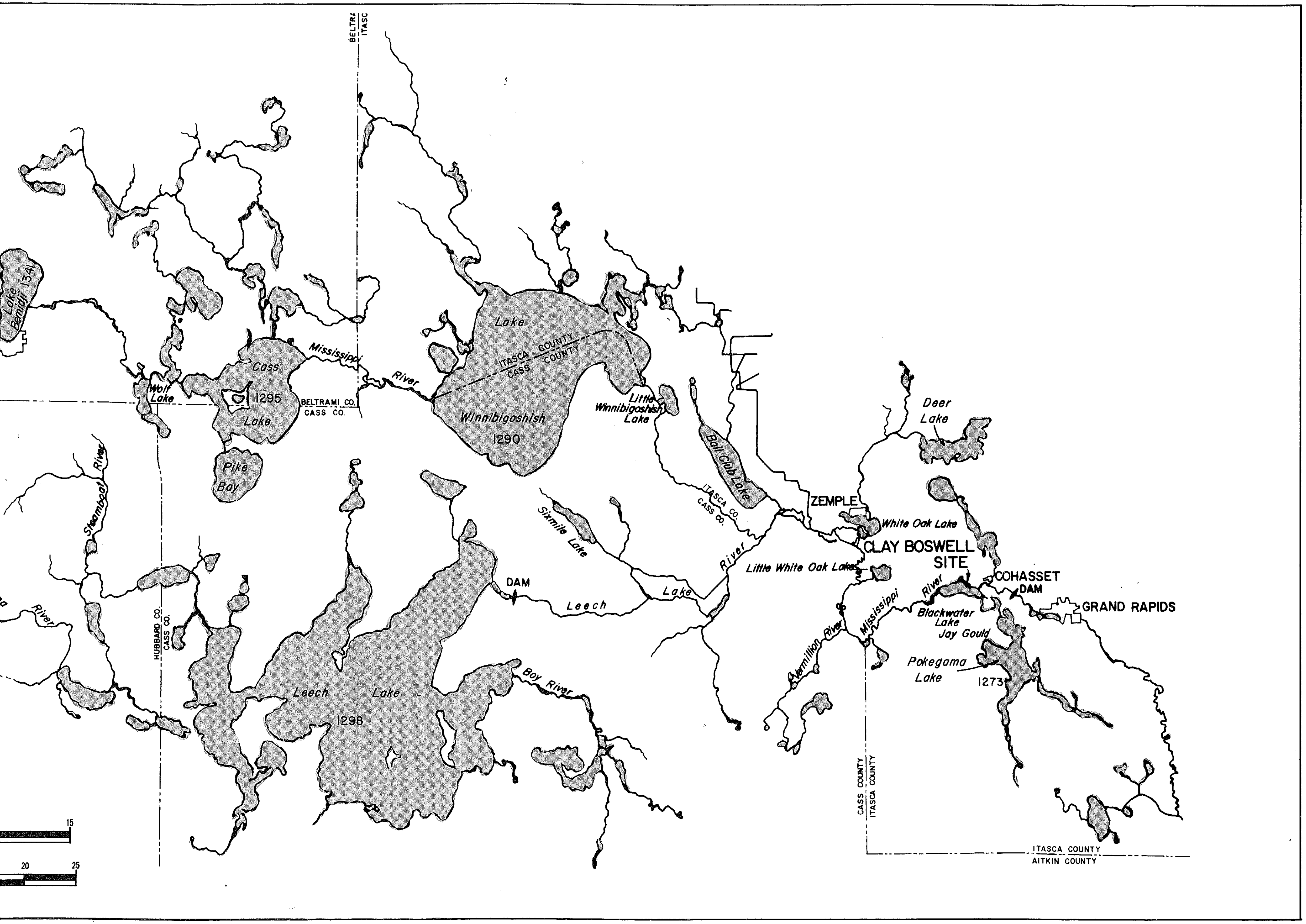
Figure IV-20 shows areas in the coterminous United States in which major, moderate, minor, or no damage is expected during an earthquake. The Clay Boswell Station is located in Zone 1, the region in which minor damage is expected during an earthquake. However, the risk of seismic activity at the Clay Boswell Station is considered to be very low.



SEISMIC RISK MAP -
UNITED STATES

SOURCE: MP&L, "ENVIRONMENTAL REPORT",
EXHIBIT III-A-6

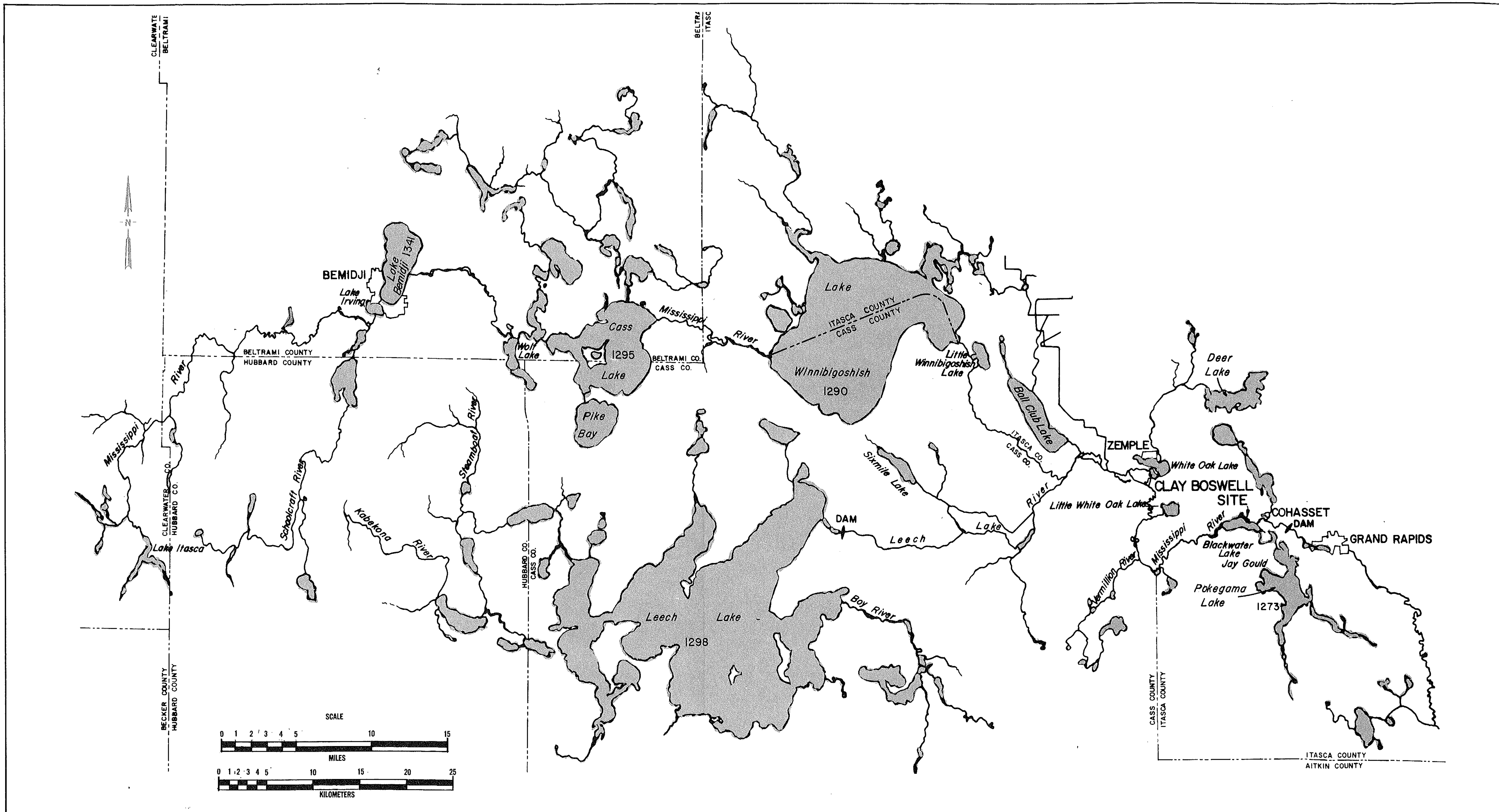
FIGURE IV-20



UPPER MISSISSIPPI RIVER DRAINAGE SYSTEM

SOURCE: ADAPTED FROM MP&L, "ENVIRONMENTAL REPORT", EXHIBIT III-D-1

FIGURE IV-21



CLEARWATER
BELTRAMI
BELTRAMI
ITASCA
N
BEMIDJI
Lake Bemidji 1341
Lake Irving
Mississippi
River
Cass
1295
Lake
Wolf Lake
Pike Bay
BELTRAMI COUNTY
HUBBARD COUNTY
BELTRAMI CO.
CASS CO.
Lake
ITASCA COUNTY
CASS COUNTY
Winnibigoshish
1290
Little Winnibigoshish Lake
Ball Club Lake
Deer Lake
ZEMPLE
White Oak Lake
CLAY BOSWELL SITE
Little White Oak Lake
COHASSET
DAM
GRAND RAPIDS
Blackwater Lake
Jay Gould
Pokegama Lake
1273
Vermilion River
Mississippi
River
ITASCA CO.
CASS CO.
Sixmile Lake
DAM
Leech
Lake
River
Boy River
Leech
Lake
1298
Steamboat River
Schoolcraft River
Kabekona River
Lake Itasca
Mississippi
River
CLEARWATER CO.
HUBBARD CO.
HUBBARD CO.
CASS CO.
BECKER COUNTY
HUBBARD COUNTY
CASS COUNTY
ITASCA COUNTY
ITASCA COUNTY
AITKIN COUNTY
SCALE
0 1 2 3 4 5 10 15
MILES
0 1 2 3 4 5 10 15 20 25
KILOMETERS

TABLE IV-5
LAKES OVER 500 ACRES (202 HECTARES) WITHIN 15 MILES (24 KM) RADIUS OF
CLAY BOSWELL STEAM ELECTRIC STATION (41)

Lake	Area		Shoreline		Inlets	Outlets	Depth			Ecology Class	Management Class	Percent Littoral[a]
	acre	hectare	mile	km			ft		m			
Bass	2,844	1,151	14.5	23.3	2	1	76	maximum	23.2	hardwater walleye	walleye	
Cowhorn	576	233	6.3	10.1	0	1	1	median	0.3	game	game waterfowl	100
Deer	3,926	1,589			1	1	121	maximum	36.9	fish	walleye	
Goose	844	347	41.0	66.0	7	1	5	maximum	1.5	game	waterfowl and/or furbearers	100
Moose	1,140	461			2	1	30	average	4.1	centrarchid (walleye)	walleye	30
Mud	1,440	583	8.0	12.9	2	1	3.5	maximum	1.1	game	waterfowl and/or furbearers	
Pokegama[b]	15,600	6,313			4	1	112	maximum	34.1	fish	walleye	31
Prairie	1,279	518	16.6	26.7	2	1	12	median	3.7	fish	centrarchid (walleye)	
Rice	959	388	2.9	4.7	2	1	21	median	6.4	fish	centrarchid (bass-panfish)	28
Shoal	661	267			1	1	9	maximum	2.7	marginal fish-game		100
Siseebakwet	1,350	546	7.8	12.5	1	1	105	maximum	32.0	fish	walleye	
Spider	1,266	512			0		12	average	3.7	fish		58
Sugar	711	288	5.8	9.3	0	1	17	median	5.2	centrarchid (walleye)		
Trout (Coleraine)	1,953	790			3	1	115		35.1	fish		
Trout	1,792	725	13.1	21.1	3	1	48	median	14.6	fish	centrarchid (walleye)	17
Wabana	2,146	868			1	1	115	maximum	35.1	fish	centrarchid (bass-panfish)	
White Oak	905	366	10.2	16.4	4	4	2.9	median	0.9	marginal fish-game		

[a] Refers to percent of lake which is less than 12 ft (3.6 m) in depth.

[b] Pokegama Lake is a Federal Reservoir. Also includes Blackwater, Jay Gould, Cutoff, and Little Jay Gould Lakes.

Lakes

It is estimated that there are nearly 1,000 lakes within the 7,068 square miles (18,306 sq km) of the Mississippi Headwaters Watershed. Lakes within a 15 mile (24 km) radius of the Clay Boswell Station and over 500 acres (202 hectares) in area are listed in Table IV-5.

Regional Ground Water Hydrology

In addition to the surface waters of the region, ground water provides a complementary water source. In the western portion of the Mesabi Iron Range, which includes the vicinity of the Clay Boswell Steam Electric Station, ground water is obtained from both bedrock and glacial drift aquifers (water bearing formations) (42) (43) (44).

The principal bedrock aquifer is the Precambrian age Biwabik Iron-Formation which flanks the south side of the Mesabi (Giants) Range and dips in a southeasterly direction. Fractured, oxidized, and leached portions of the Biwabik Iron-Formation yield as much as 1,000 gallons per minute (gpm) (3,785 lpm) to wells (42). Other bedrock formations in the area yield very little water (42). Most wells in the Biwabik Iron-Formation are artesian. This results from the southeasterly dip of the formation and the fact that it is overlain by relatively impervious Virginia Argillite (42). Recharge to the Biwabik Iron-Formation is from open pit mines, many of which are filled with water (44), and from infiltration of precipitation through glacial drift overlying the formation where it laps against the south flank of the Mesabi (Giants) Range (42) (43). The direction of ground water movement in the bedrock is largely unknown (44).

Glacial deposits in the area are complex with variable thicknesses, lateral extents, and permeabilities. Pervious stratified glaciofluvial sediments occur extensively between the 3 major till units of the area (44). In addition, relatively pervious, glaciofluvial, glaciolacustrine, and ice contact deposits occur at or near the ground surface at many locations in the area (42) (44). The best glacial drift aquifers are relatively coarse grained stratified sand and gravel deposits, though significant ground water yields can be obtained from some of the finer grained stratified sand deposits (42) (43) (44). Pumping rates of a few hundred gallons per minute to more than 1,000 gpm (3,785 lpm) have been reported for wells in stratified glacial drift (42) (43). Smaller yields sufficient for household use have been obtained from sandy till. Glacial drift wells may be either artesian or water table (42). Precipitation and surface water bodies recharge glacial drift aquifers; glacial drift aquifers discharge water to lowlands and low lying surface water bodies (42) (43) (44).

Ground Water Quality

The quality of ground water from the Biwabik Iron-Formation and from glacial drift is similar. Chemical data obtained in a 1960 survey of untreated water from wells in the Biwabik Iron-Formation and blacial drift are presented in Table IV-6 (42). Principal constituents of the well waters were calcium, magnesium, bicarbonate, and sulfate. The water generally contained a substantial amount of silica, hardness, iron, and manganese, a condition

TABLE IV-6
CHEMICAL COMPOSITION - UNTREATED GROUND WATER USED FOR MUNICIPAL SUPPLY
MESABI IRON RANGE AREA
1960

Constituent	Glacial Drift (24 wells)			Biwabik Iron Formation (15 wells)		
	maximum	minimum	average	maximum	minimum	average
Silica (SiO_2), ppm[a]	33	13	21	26	4.1	14
Iron (Fe), ppm	10	.04	1.9	4.9	.05	.82
Manganese (Mn), ppm	5.5	.00	.83	1.8	.00	.35
Calcium (Ca), ppm	90	20	52	76	18	45
Magnesium (Mg), ppm	48	8.9	19	36	6.6	18
Sodium (Na), ppm	9.1	2.5	5.8	12	4.1	7.1
Potassium (K), ppm	3.3	.6	1.8	5.8	.9	2.1
Bicarbonate (HCO_3), ppm	413	102	220	333	94	219
Sulfate (SO_4), ppm	88	3.8	34	88	2.0	23
Chloride (Cl), ppm	12	.0	3.5	12	.0	3.0
Fluoride (F), ppm	.3	.0	.2	.2	.0	.1
Nitrate (NO_3), ppm	1.6	.0	.5	7.1	.0	.9
Boron (B), ppm	.11	.00	.04	.09	.01	.06
Dissolved solids, ppm	477	127	253	396	104	213
Hardness (as $CaCO_3$), ppm	420	87	212	339	72	191
Noncarbonate hardness (as $CaCO_3$), ppm	-	-	32	-	-	11
Alkalinity (as $CaCO_3$), ppm	339	84	180	273	77	180
Sodium, %	-	-	6	-	-	8
Specific conductance, µmhos at 25° C	758	178	408	648	162	372
pH	7.8	6.5	7.4	7.8	6.8	7.4
Color	130	0	10	5	0	2
Temperature °F	49	42	45	50	43	45
Temperature °C	9.44	5.56	7.22	10.00	6.11	7.22

[a] Parts per million.

commonly found with ground waters. The color in most of the wells was 5 units or less. The average of 10 units of color for waters originating in the drift was biased because one result of 130 units significantly affected the average which otherwise would have been only 4 units (42).

The similarity in water quality from the 2 aquifers is partly attributed to the fact that much of the water in the Biwabik Iron-Formation probably was percolated through the overlying drift (42). In some parts of the Biwabik Iron-Formation, most of the soluble mineral matter was leached during formation of the ore bodies. This leaching generally is agreed to have been accomplished by ground water circulation. Consequently, little chemical alteration of ground water now occurs upon contact with the Biwabik Iron-Formation after percolation through the drift (42).

Ground Water Flow

Little is known regarding the direction of ground water movement in the bedrock (44). Ground water movement in glacial drift is largely toward lowland areas. On a more local scale, the direction of movement can be assumed to conform generally with the surface drainage characteristics of the area. The water table throughout the area is probably not more than 25 ft (7.6 m) below land surface and in most instances is within 10 ft (3.0 m) of the surface (44). Exceptions would of course be found in the vicinity of dewatered mine pits.

Most percolating waters do not infiltrate deeply into glacial drift but discharge from topographically high areas to adjacent streams, lakes, and swamps. Glacial drift ground water flow that does not discharge to local lowlands also is directed according to the topographic expressions of the area, but ultimately moves toward major streams (44). A relatively minor amount of water that percolates into the glacial deposits of the area infiltrates the underlying bedrock (42).

Local Surface Water Hydrology

Mississippi River Basin

The Clay Boswell Steam Electric Station is situated on the northern shore of the Blackwater Lake, a part of the Mississippi River-Pokegama Reservoir system. The site is about 5.5 miles (8.9 km) upstream from the Mississippi River Pokegama Dam. About 3,265 square miles (8.456 sq km) of surface area drain to the dam (45).

The water level in Blackwater Lake is controlled by the Pokegama Dam and upstream reservoirs in accordance with the reservoir operation manual (39) (40). The spillway elevation is 1,273 ft (388.0 m) above Mean Sea Level Datum of 1929 MSL-1929), and is also the normal pool elevation. The U.S. Geological Survey (USGS) and U.S. Army Corps of Engineers (COE) have maintained river flow gaging stations since 1883 at either Pokegama Dam or Paper Mill Dam, the latter being located in Grand Rapids, downstream from the Pokegama Dam.

Average Flow Conditions. The Mississippi River flow data accumulated by the USGS and the COE are given in Table IV-7. The average Mississippi River

TABLE IV-7
MISSISSIPPI RIVER FLOW - GRAND RAPIDS, MINNESOTA [a]
United States Geological Survey (46)

Water Year	Minimum Daily		Momentary Maximum		Monthly Minimum		Monthly Maximum		Yearly Mean	
	cfs	cu m per sec	cfs	cu m per sec	cfs	cu m per sec	cfs	cu m per sec	cfs	cu m per sec
1883										
84	328	9.29	-	-	462	13.08	1,517	42.96	821	23.25
85	0	0	-	-	257	7.28	3,052	86.43	993	28.12
86	332	9.40	-	-	387	10.96	2,684	76.01	1,313	37.18
87	178	5.04	-	-	269	7.62	1,881	53.27	931	26.37
88	225	6.37	-	-	338	9.57	2,688	76.12	1,212	34.32
89	269	7.62	-	-	292	8.27	2,966	84.00	1,281	36.28
1890	94	2.66	-	-	162	4.59	1,639	46.42	820	23.22
91	67	1.90	-	-	136	3.85	1,578	44.69	690	19.54
92	0	0	-	-	297	8.41	1,682	47.63	739	20.93
93	0	0	-	-	151	4.28	2,742	77.65	831	23.53
94	64	1.81	-	-	107	3.03	2,805	79.44	979	27.73
95	121	3.43	-	-	132	3.74	2,073	58.71	895	25.35
96	90	2.55	-	-	173	4.90	1,997	56.56	1,007	28.52
97	90	2.55	-	-	137	3.88	2,512	71.14	1,241	35.15
98	519	14.70	-	-	1,512	42.82	3,051	86.40	2,107	59.67
99	1,030	29.17	-	-	1,085	30.73	3,349	94.84	2,303	65.22
1900	424	12.01	-	-	900	25.49	3,585	101.53	1,912	54.15
01	376	10.65	-	-	420	11.89	3,674	104.05	2,122	60.10
02	938	26.56	-	-	1,176	33.30	3,547	100.45	1,931	54.69
03	457	12.94	-	-	863	24.44	3,260	92.32	1,639	46.42
04	0	0	-	-	454	12.86	1,705	48.29	978	27.70
05	250	7.08	-	-	396	11.21	4,538	128.52	1,454	41.18
06	764	21.64	-	-	1,522	43.10	3,309	93.71	2,427	68.73
07	675	19.12	-	-	858	24.30	2,838	80.37	1,676	47.46
08	520	14.73	-	-	606	17.16	2,127	60.24	1,253	35.48
09	406	11.50	-	-	445	12.60	2,077	58.82	1,036	29.34
1910	541	15.32	-	-	593	16.79	2,538	71.88	1,526	43.22
11	0	0	-	-	384	10.87	2,159	61.14	1,019	28.86
12	375	10.62	-	-	398	11.27	2,238	63.38	854	24.19
13	377	10.68	-	-	403	11.41	1,791	50.72	905	25.63
14	318	9.01	-	-	438	12.40	2,152	60.94	1,016	28.77
15	460	13.03	-	-	499	14.13	2,832	80.20	1,256	35.57
16	394	11.16	-	-	677	19.17	2,422	68.59	1,539	43.58
17	995	28.18	-	-	1,000	28.32	3,502	99.18	1,995	56.50
18	343	9.71	-	-	464	13.14	3,028	85.75	1,488	42.14
19	308	8.72	-	-	373	10.56	1,487	42.11	652	18.46
1920	507	14.36	-	-	565	16.00	1,626	46.05	1,097	31.07
21	200	5.66	-	-	396	11.21	2,080	58.91	881	24.95
22	308	8.72	-	-	386	10.93	1,530	43.33	891	25.23
23	343	9.71	-	-	385	10.90	1,494	42.31	784	22.20
24	322	9.12	-	-	393	11.13	1,491	42.23	527	14.92
25	309	8.75	-	-	384	10.87	1,540	43.61	577	16.34
26	100	2.83	-	-	393	11.13	639	18.10	420	11.89
27	339	9.60	-	-	380	10.76	1,980	56.07	725	20.53
28	300	8.50	-	-	1,389	39.34	1,700	48.14	920	26.05
29	0	0	-	-	407	11.53	2,145	60.75	963	27.27

TABLE IV-7 (continued)
MISSISSIPPI RIVER FLOW - GRAND RAPIDS, MINNESOTA[a]
United States Geological Survey (46)

Water Year	Mimimum Daily		Momentary Maximum		Monthly Minimum		Monthly Maximum		Yearly Mean	
	cfs	cu m per sec	cfs	cu m per sec	cfs	cu m per sec	cfs	cu m per sec	cfs	cu m per sec
1930	368	10.42	-	-	396	11.21	2,149	60.86	873	24.72
31	143	4.05	-	-	184	5.21	1,525	43.19	487	13.79
32	83	2.35	-	-	132	3.74	388	10.99	264	7.48
33	62	1.76	-	-	126	3.57	392	11.10	280	7.93
34	42	1.19	-	-	88.2	2.50	385	10.90	192	5.44
35	78	2.21	-	-	111	3.14	367	10.39	228	6.46
36	93	2.63	-	-	141	3.99	511	14.47	224	6.34
37	67	1.90	-	-	104	2.95	447	12.66	215	6.09
38	197	5.58	-	-	250	7.08	683	19.34	511	14.47
39	365	10.34	-	-	389	11.02	1,460	41.35	788	22.32
1940	174	4.93	-	-	194	5.49	1,025	29.03	414	11.72
41	289	8.18	-	-	390	11.04	1,595	45.17	698	19.77
42	235	6.66	-	-	404	11.44	1,603	45.40	951	26.93
43	282	7.99	-	-	766	21.69	1,759	49.81	1,325	37.52
44	271	7.67	-	-	393	11.13	1,616	45.77	1,207	34.18
45	750	21.24	4,070	115.26	1,520	43.05	3,442	97.48	2,166	61.34
46	448	12.69	2,260	64.00	941	26.65	1,977	55.99	1,316	37.27
47	358	10.14	2,220	62.87	1,043	29.54	1,652	46.78	1,411	39.96
48	22	.62	12,500	354.00	356	10.08	2,173	61.54	1,204	34.10
49	0	0	2,190	62.02	32.5	.92	1,769	50.10	1,002	28.38
1950	75	2.12	4,320	122.34	1,430	40.50	3,542	100.31	2,265	64.14
51	304	8.61	3,870	109.60	1,436	40.67	2,580	73.07	1,978	56.02
52	20	.57	3,320	94.02	1,268	35.91	2,503	70.88	1,859	52.65
53	160	4.53	3,390	96.00	682	19.31	2,527	71.56	1,612	45.65
54	251	7.11	3,170	89.77	1,098	31.10	2,496	70.69	1,923	54.46
55	268	7.59	2,280	64.57	698	19.77	1,450	41.06	1,113	31.52
56	160	4.53	1,840	52.11	505	14.30	1,094	30.98	664	18.80
57	360	10.20	3,250	92.04	565	16.00	2,552	72.27	1,242	35.17
58	58	1.64	2,490	70.52	182	5.15	2,051	58.08	1,067	30.22
59	144	4.08	1,840	52.11	247	7.00	1,174	33.25	439	12.43
1960	216	6.12	1,860	52.68	442	12.52	1,220	34.55	883	25.01
61	83	2.35	1,340	37.95	98.3	2.78	766	21.69	501	14.19
62	177	5.01	3,620	102.52	193	5.47	3,363	95.24	1,560	44.18
63	386	10.93	2,290	64.85	510	14.44	2,094	59.30	1,241	35.15
64	436	12.35	3,120	88.36	462	13.08	1,640	46.44	929	26.31
65	530	15.01	2,710	76.75	1,199	33.96	1,820	51.54	1,428	40.44
66	1,320	37.38	3,590	101.67	1,889	53.50	2,667	75.53	2,217	62.79
67	727	20.59	2,950 [b]	83.54	821	23.25	2,155	61.03	1,583	44.83
68	278	7.87	1,880	53.24	570	16.14	1,740	49.28	891	25.23
69	627	17.76	4,610 [b]	130.56	917	25.97	2,810	79.58	1,825	51.68
1970	238	6.74	3,120	88.36	277	7.84	2,641	74.79	1,597	45.23
71	190	5.38	3,710	105.07	250	7.08	2,346	66.44	1,063	30.10
72	309	8.75	2,800	79.30	309	8.75	2,180	61.74	1,641	46.47
73	168	4.76	2,010	56.92	336	9.52	1,940	54.94	1,019	28.86

[a] Average discharge (90 years of data) is 1,144 cfs (32.40 cu m per sec).
[b] Maximum daily discharge.

discharge at Grand Rapids is 1,144 cubic feet per second (cfs) (32.39 cu m per sec), calculated from a 90 year documented record period. The highest yearly mean flow was 2,427 cfs (68.72 cu m per sec) recorded in 1906. The lowest yearly mean flow was 192 cfs (5.44 cu m per sec) which occurred in 1934 during a period of drought, lasting from about 1931 to 1938, in which lower than normal flows were consistently recorded. The highest monthly flow of 4,538 cfs (128.50 cu m per sec) occurred in 1905 and the lowest monthly mean flow of 32.5 cfs (0.92 cu m per sec) occurred in 1949.

Average Flow Conditions

The regulation of the reservoir will have little effect upon the average values and the high values, however, the minimums encountered in 1934 would be greatly affected by regulation today. The most recent low flow occurred May 25, 1976 with a magnitude of 164 cfs (4.64 cu m per sec).

Low Flow Conditions

The Mississippi River headwater system has been controlled at low flows in accordance with the manual of operation since 1962. The regulation will have a profound effect upon any future low flow conditions. Currently during the water years 1976-1977, there has been an 8 month period in which lower than normal flows have occurred in the range of 200 cfs (5.66 cu m per sec).

Under Minnesota Regulations, a critical low flow must be defined and used for impact evaluations. Normally, this critical low flow is the stream flow that is "equal to or exceeded by 90% of the 7 consecutive daily average flows of record (the lowest weekly flow with a once in 10-year recurrence interval) for the critical month". In this case because the flow is dependent largely upon the regulation plan, a critical 10-year flow is not defined. By examination of the Commissioners' order and the manual of operation, there are established 2 minimum low flows for Pokegama Dam, a flow of 200 cfs (5.66 cu m per sec) and a flow of 100 cfs (2.83 cu m per sec).

To calculate the volume of water flowing to the Clay Boswell Station, it is necessary to add the outflows from Leech and Winnibigoshish Lakes shown in Table IV-8.

Table IV-8 shows the conditions that will dictate the volume of water which will flow to the Clay Boswell Station. For impact evaluaiton, the 100 cfs (2.83 cu m per sec) could be considered as the critical flow.

Flood Flow Conditions

The Mississippi River flood-of-record occurred on September 3, 1948 and was caused by the failure of the Paper Mill Dam in the center of Grand Rapids, Minnesota. A discharge of 12,500 cfs (353.95 cu m per sec) was estimated for the flood by extrapolating the rating curve about 4,500 cfs (127.42 cu m per sec) (47). The water level in the river was recorded at 15.2 ft (4.63 m) above the flood mark (47).

The USGS has established an elevation verses frequency curve for the

TABLE IV-8
MISSISSIPPI RIVER FLOW FROM UPSTREAM RESERVOIRS - CLAY BOSWELL STEAM ELECTRIC STATION

Reservoir	Stage Range At or Above ft	Stage Range At or Above m	Below ft	Below m	Reservoir Discharge cfs	Reservoir Discharge cu m per sec
Winnibigoshish	6.0	1.83	6.0	1.83	50	15.24
			8.0 or 10.25[a]	2.44 or 3.12[a]	100	30.48
Leech	0.0	0.00	0.0	0.0	50	15.24
			0.5 or 2.0[a]	.15 or .6[a]	100	30.48

[a] The higher or lower of these 2 stages will govern, depending on which is the desired stage at the time under consideration.

Pokegama Dam based upon 92 years of record at the site as presented in Table IV-9. The Federal government has established as a standard for flood plain regulations a flood with a 1% chance of occurrence, often termed a 100 year recurrence interval (48). This flood, as shown in Table IV-9, would reach a level of 1,278.1 ft (389.56 m) above MSL. A flood with a 0.2% chance of occurrence or a 500 year recurrence interval could reach an elevation of 1,278.5 ft (389.69 m).

TABLE IV-9
FLOOD FREQUENCY AND RESERVOIR ELEVATION - POKEGAMA DAM (49)

Annual Chance of Flood Occurrence	Elevation above MSL[a] ft	m
10% (10 years)	1,277.2	389.29
2% (50 years)	1,277.9	389.50
1% (100 years)	1,278.1	389.56
0.2% (500 years)	1,278.5	389.69

[a] MSL refers to mean sea level datum.

Lakes

There are many lakes within a 6 mile (9.7 km) radius of the Clay Boswell Station. The large lakes with an area of 500 acres (202 hectares) or more are included in Table IV-5. They are Pokegama, Prairie, Bass, Rice, and Shoal Lakes. The smaller lakes, with an area of 80 to 500 acres (32 to 202 hectares) are presented in Table IV-10.

Site-Specific Surface Water Hydrology

The surface environment at the Clay Boswell Station will contribute runoff affecting the quantity and quality of the surface water. The runoff sources during concentrated rainfall include: coal piles, the electric generating facilities site, and solid waste disposal sites. The runoff can be evaluated by using Figure IV-22 and a runoff coefficient determined for the area being evaluated. The rainfall-duration curve for the Clay Boswell Station site was determined from the weather Bureau publication Technical Paper No. 40.

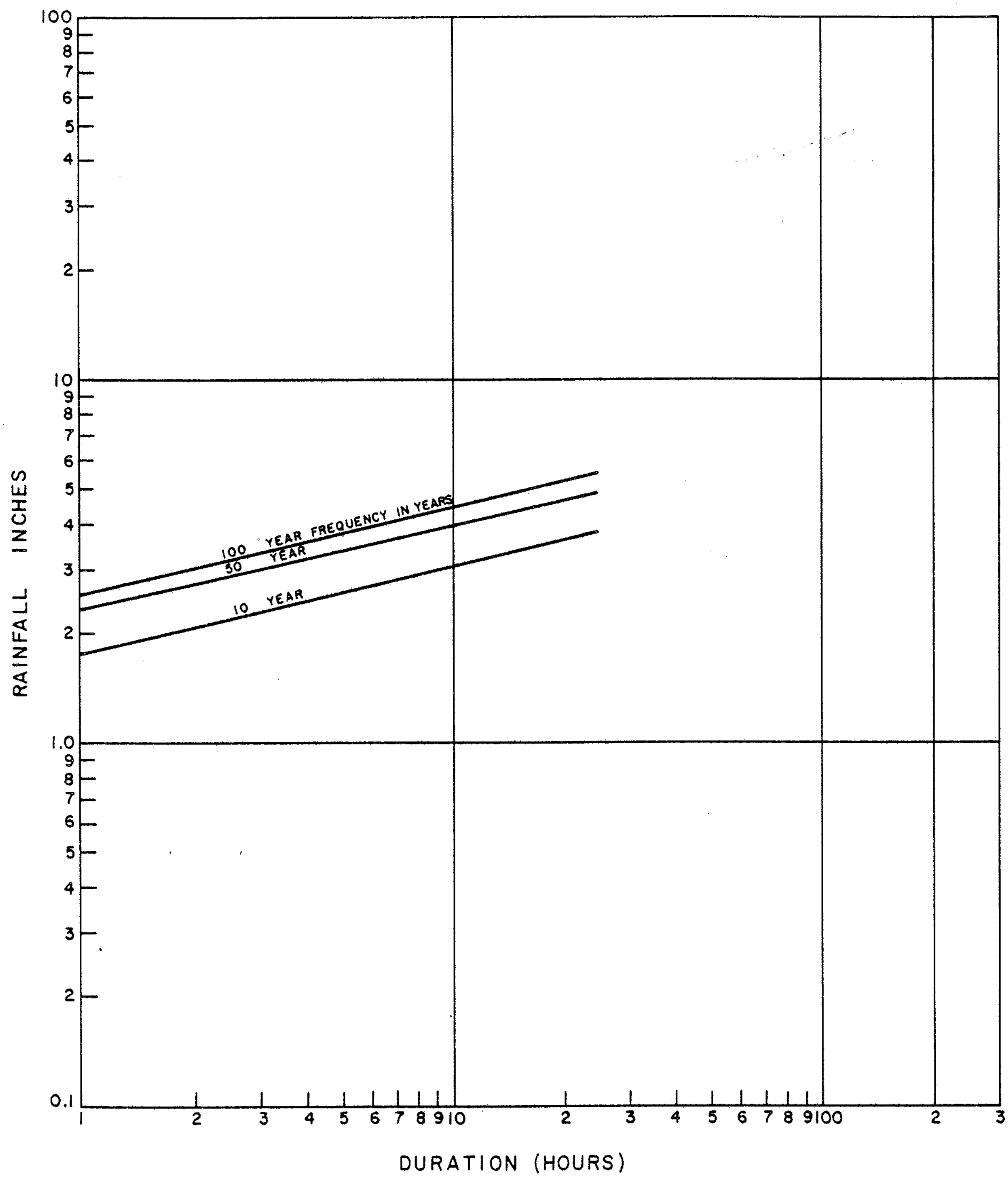
Low Flow Conditions

The low flows expained in the regional setting also are considered to be representative at both the discharge and intake points at the Clay Boswell Station. They, therefore, should be used for site impact analysis.

TABLE IV-10
LAKES OF 80 TO 500 ACRES (32 TO 202 HECTARES) WITHIN 6 MILES (9.7 KM) RADIUS OF CLAY BOSWELL STEAM ELECTRIC STATION (41)

Lake	Area		Shoreline		Inlets	Outlets	Depth			Ecology Class	Management Class	Percent Littoral[a]
	acre	hectare	mile	km			ft		m			
Blandin	455	184	9.9	15.9	2	1	44	maximum	13.4	fish	centrarchid	81
Cavanaugh	84	34	1.2	1.9		1	15	median	4.6	fish	centrarchid (largemouth bass)	60
Hale	127	51	3.2	5.1	1	1	30	median	9.1	fish	centrarchid (bass-panfish)	26
Horseshoe	150	61	3.5	5.6	0	2	4	median	1.2	bullhead shallow lakes - winter kill	regular winter kill	100
Little Drum	89	36			1	1	3	maximum	0.9	game		
Little Rice	137	55			1	1	32	maximum	9.8	fish		
Little White Oak	493	200	4.50	7.2			3.1	median	0.9	fish-game		
Long	117	47				1	75	maximum	22.9	fish		
Loon	220	89			1	1	69	maximum	21.0	fish		
McKinney	104	42	1.8	2.9	1	1	9	median	2.7	centrarchid		86
Stevens	223	90			1	1				marginal fish-game		100

[a] Littoral refers to percent of lake which is less than 12 ft (3.6 m) in depth.



RAINFALL DURATION CURVE

CLAY BOSWELL STEAM ELECTRIC STATION

FIGURE IV-22

Flood Flow Conditions

A flood of the Mississippi River with a 1% chance of occurrence would reach a level of 1,278.1 ft (389.56 m) above MSL (Table IV-9) and would have a 0.1% chance of occurrence during a 10 year period. It is evident as shown in Figures IV-23 and IV-24 that a flood of this magnitude would not affect the Clay Boswell Station. Neither would a flood with a 0.2% chance of annual occurrence which would reach an elevation of 1,278.5 ft (389.69 m) and the boundaries of which would approximate the same as those for the 100 year flood. The high levels for both floods hardly differ because steep embankments confine the additional flood water, preventing little additional flooding.

Site-Specific Ground Water Hydrology

Aquifers

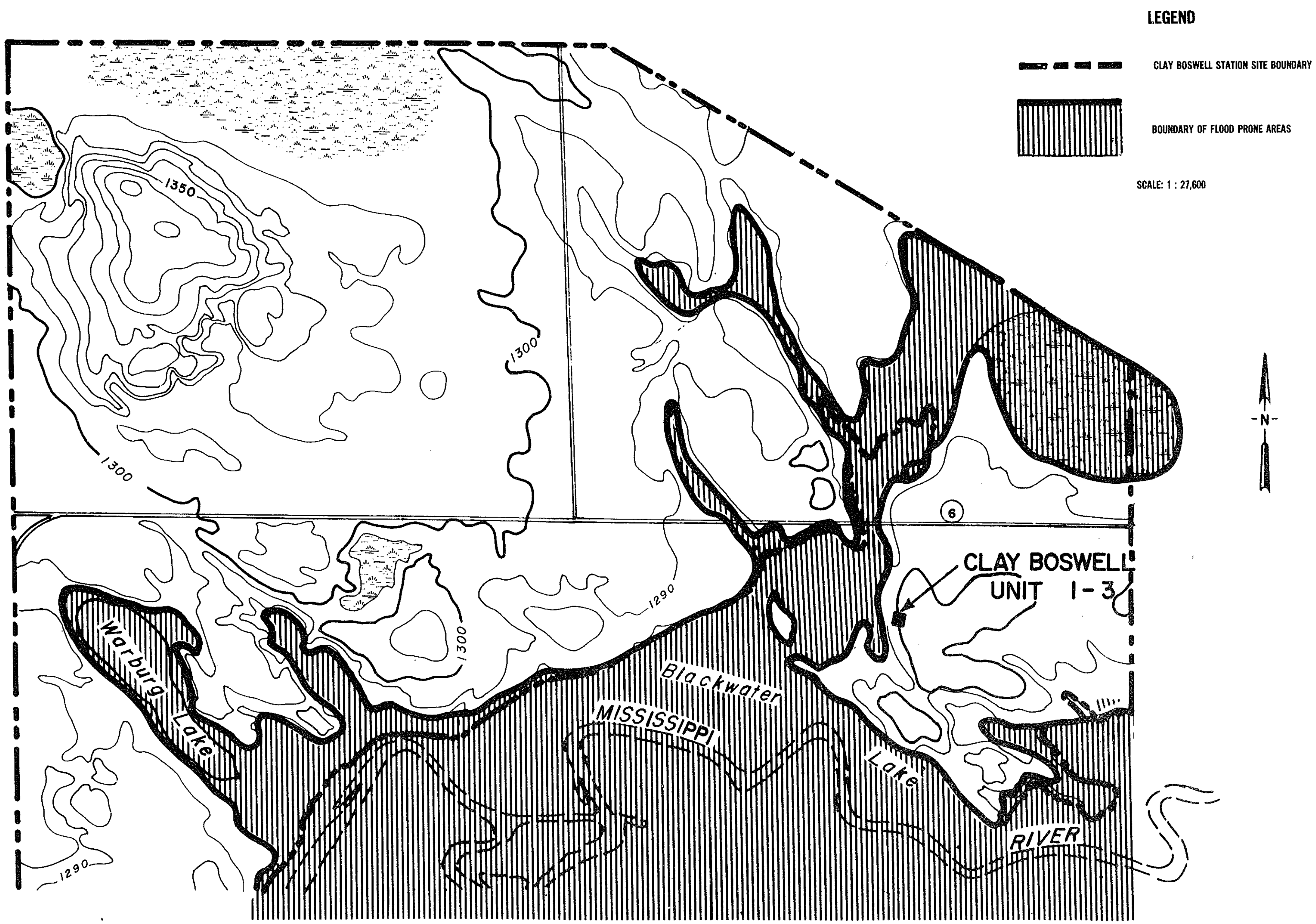
Discussion of the ground water in this section does not include the site of the proposed ash and SO_2 sludge pond for Unit 4.

Two glacial drift ground water systems exist at the Clay Boswell Station. A shallow perched water table occurs in a deposit of lacustrine silty sand and silt overlying relatively impervious lacustrine clay. A deeper main water table, confined beneath the clay, occurs in a deposit of silt and silty sand about 50 ft (15.2 m) thick and underlying fine to medium sand of more than 120 ft (36.6 m) thick (50)(52). The upper silt and silty sand in this deeper aquifer may be a basal lacustrine deposit or glacial outwash underlying the lacustrine clay. The lower sands in this deeper aquifer are probably glacial outwash.

Particle size analyses of samples from the upper aquifer reveal that 100% of the material is finer than 0.4 mm and 50% finer than 0.075 mm. Samples of the fine materials of the underlying 50 ft (15.2 m) deposit have grain size distributions where 100% of the sample is finer than 0.4 mm and 85% to 80% finer than 0.075 mm. Comparatively, the coarser materials in this deposit have a grain size distribution such that 100% of the sample is finer than 0.3 mm and only 25% finer than 0.075 mm. An analysis of the underlying fine to medium sand shows that 100% of the material is finer than 1.0 mm and 10% finer than 0.075 mm (50). It should be noted, however, that these particle size data are of limited use in assessing aquifer characteristics. Particle size analyses are made on thoroughly disturbed or remolded soil specimens while aquifer characteristics depend significantly on details of in-situ texture and stratification.

Data obtained from one shallow piezometer from June to August, 1975, indicate that the shallow perched water table lies from 1.8 to 7.2 ft (0.55 to 2.19 m) below the ground surface at about elevation 1,290 ft (393.2 m) above MSL. Data obtained from one deep piezometer during the same period indicate that the piezometric level in the deeper confined aquifer is about 20 ft (6.10 m) below the ground surface, essentially at Mississippi River level or elevation 1,274 ft (388.3 m) above MSL (50). It is probable that the position of the shallow perched water table fluctuates considerably during the course of a year and approaches the ground surface during wet periods. The piezometric level in the deeper outwash sand aquifer is not likely to fluctuate so much as it

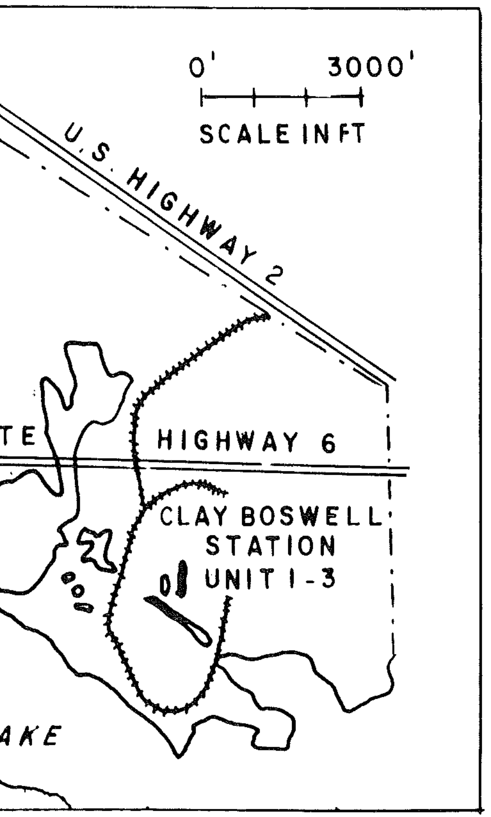
THIS MAP HAS BEEN REDRAWN FROM THE **MAP OF FLOOD PRONE AREAS** (COHASSET WEST, MINNESOTA QUADRANGLE) THAT WAS ORIGINALLY PREPARED BY THE U.S. DEPARTMENT OF THE INTERIOR. THE BOUNDARIES OF FLOOD PRONE AREAS ARE APPROXIMATE AND THERE IS ABOUT 1 CHANCE IN 100 IN ANY YEAR THAT THE OUTLINED AREAS WILL BE FLOODED. FLOOD PRONE AREAS ARE DELINEATED FROM INFORMATION ON PAST FLOODS



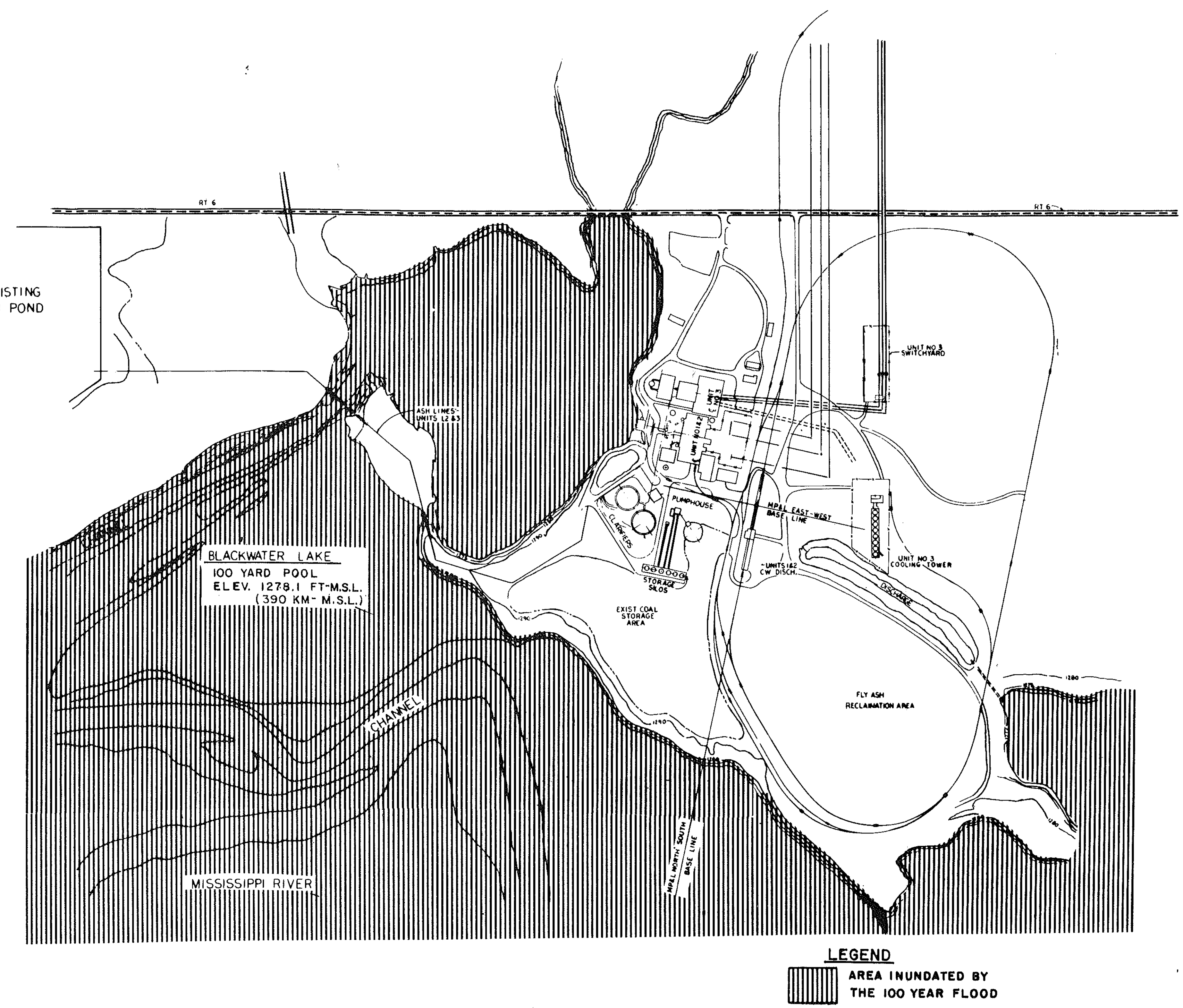
100 YEAR FLOOD PRONE AREA - VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION

SOURCE: ADAPTED FROM MP&L, "ENVIRONMENTAL REPORT", EXHIBIT III-B-1

FIGURE IV-23

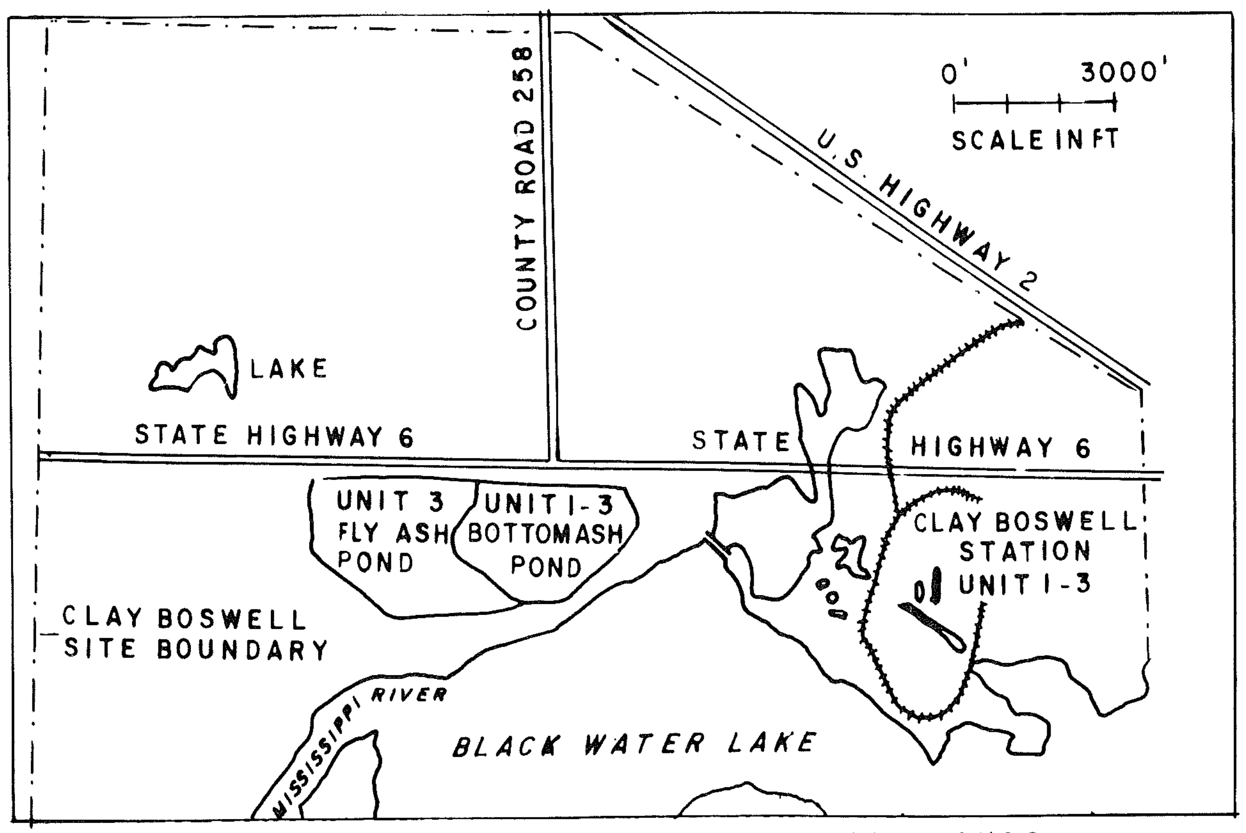


1-3 ASH PONDS

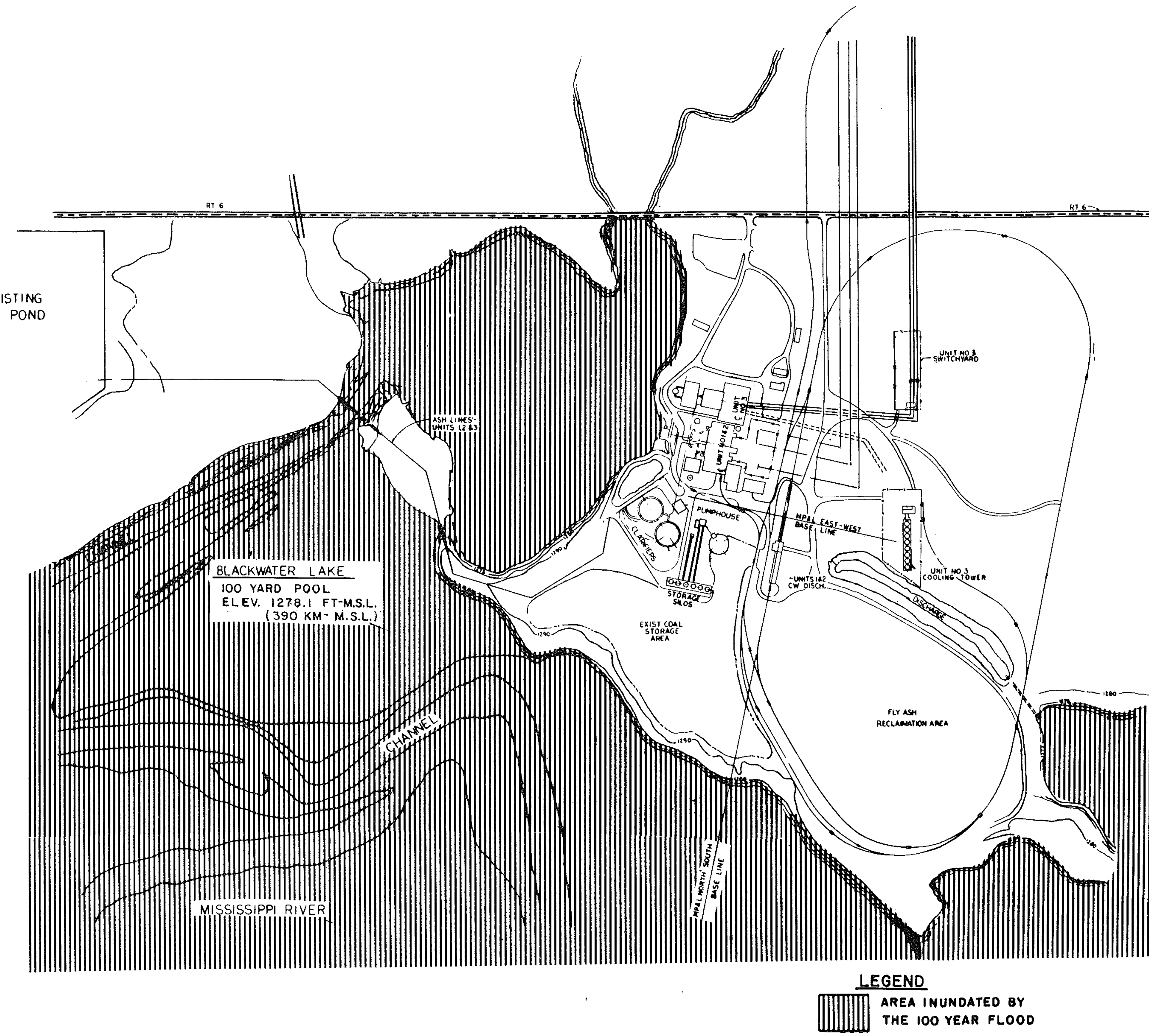


ENLARGEMENT - 100 YEAR FLOOD PRONE AREA - VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION

FIGURE IV-24



INSET : LOCATION OF UNITS 1-3 ASH PONDS



appears to be controlled by the Mississippi River (50), the level of which is maintained essentially constant by a downstream dam. The extent of the area of the deeper aquifer has not been established clearly, but it probably extends from just east of the community of Cohasset northwestward in the Mississippi River Valley (53).

Yield

Two wells, extending to the deeper outwash sand aquifer provide cooling and makeup water for the existing facilities at the Clay Boswell Station. Well A-1 (ground surface elevation 1,294 ft) (394.4 m) above Mean Sea Level (MSL) was completed in December, 1956, and Well A-2 (ground surface elevation unspecified but probably similar to that of Well A-1) was completed in February, 1957 (54). These wells were drilled to depths of 195 and 198 ft (59.4 and 60.4 m), respectively (54). Both wells are 10 in. (254 mm) in diameter with a double outer filter wall of gravel and filter sand. Well screens of 0.005 in. (0.127 mm) are positioned in Well A-1 at 145 to 155 ft (44.2 to 47.2 m) deep and from 184 to 194 ft (56.1 to 59.1 m) deep. Identical screens are present in Well A-2 at 154 to 164 ft (46.9 to 50.0 m) deep and from 184 to 194 ft (56.1 to 59.1 m) deep (54).

Well A-1 presently yields an average of 43.4 gpm per ft (539 lpm per m) of drawdown and Well A-2 presently yields an average of 16.3 gpm per ft (202 lpm per m) of drawdown (55). The specific capacities were computed from pumping tests during April, 1976, of 1.5 hours duration at rates from 150 to 375 gpm (568 to 1,419 lmp). Static water levels in both wells at the initiation of pumping were both 20.5 ft (6.25 m). The total drawdown during pumping at Well A-1 was 8.75 ft (2.67 m) while drawdown at Well A-2 was 25.25 ft (7.7 m) (55). The yield of Well A-2 has dropped some 60% from a value of 40.8 gpm per ft (506 lpm per m) at the time of installation (55), presumably due to iron encrustation of the well screen (56). Total design capacity of the 2 existing wells and their pumps is 400 gpm (1,514 lpm) or 576,000 gpd (2.18×10^6 lpd) (56). The potential for additional wells in this same deep aquifer is excellent (55).

Ground Water Quality

Data on the quality of water obtained from Wells A-1 and A-2 in May, 1976, (57) are summarized in Table IV-11. Comparison of these data with regional water quality data in Table IV-6 indicates that the sodium concentration in Wells A-1 and A-2 was noticeably greater than the regional maximum from wells in glacial drift or the Biwabik Iron-Formation. Potassium, calcium, and total alkalinity values from Wells A-1 and A-2 approach the regional maximum values for glacial drift wells. Above-average total hardness occurs, and above-average levels of total dissolved solids are present. Sulfate, chloride, manganese and nitrate values for Wells A-1 and A-2 are well below regional average values for glacial drift wells. However, the overall water quality appears to be generally within the range of glacial drift wells in the Mesabi Iron Range area.

Minnesota Ground Water Quality Regulations stipulate that pollutants cannot be discharged or deposited at any location where they could enter the ground water table or endanger the quality or uses of underground waters (51).

TABLE IV-11

WATER ANALYSIS[a] - PRODUCTION WELLS A-1 AND A-2
CLAY BOSWELL STEAM ELECTRIC STATION
May 18, 1976

Constituent	Well A-1 mg per liter	Well A-2 mg per liter
Calcium (Ca)	78	80
Magnesium (Mg)	24.5	24.6
Sodium (Na)	17.0	17.3
Potassium (K)	3.0	3.0
Iron (Fe)	1.20	1.33
Manganese (Mn)	0.25	0.22
Sulfate (SO_4)	12	9.6
Chloride (Cl)	< 1.0	< 1.0
Bicarbonate (as $CaCO_3$)	320	327
Carbonate (as $CaCO_3$)	< 1.0	< 1.0
Total alkalinity (as $CaCO_3$)	320	327
Calcium hardness (as $CaCO_3$)	194	200
Total hardness (as $CaCO_3$)	313	295
Total dissolved solids (TDS)	359	361
Nitrate nitrogen	0.01	< 0.01
Total Phosphorus (P)	0.121	0.106

[a] Methods: Analysis performed in accordance with "Standard Methods", 13th edition, 1971, American Public Health Association, or "Methods for Chemical Analysis of Water and Wastes", 1974, Environmental Protection Agency.

Ground Water Flow

No information is available on ground water flow directions in bedrock beneath the Clay Boswell Station.

At the station, there is only one piezometer (Dames and Moore P-9) in the deep outwash sand aquifer (50). Water levels observed in this piezometer from June to August 1975 were about 1 ft (0.3 m) above the water level in nearby Blackwater Lake (50). For all practical purposes, piezometric levels in the deep outwash sand aquifer at the Station site are governed by and essentially equal to the dam-regulated water level in Blackwater Lake and the Mississippi River. What slight tendency for flow that there is in this aquifer at the Station site is directed from the land to the lake and river.

No data are available on the direction(s) of ground water flow in the shallow perched aquifer at the Clay Boswell Station. It is probable that ground water in this aquifer flows toward local topographic depresions as well as toward Blackwater Creek, Blackwater Lake, and the Mississippi River.

TABLE IV-12
FIELD PERMEABILITY TEST (CONSTANT HEAD) - IN VICINITY OF UNIT 4 ASH POND SITE
CLAY BOSWELL STEAM ELECTRIC STATION

Boring Number	Depth of Test ft	Depth of Test m	Permeability cu m per sec
A1W	10	3.1	1.4×10^{-4}
	15	4.6	b
	20	6.1	a
	25	7.6	1.1×10^{-6}
	30	9.1	7.4×10^{-6}
	35	10.7	5.7×10^{-6}
	40	12.2	3.7×10^{-6}
A2W	5	1.5	a
	10	3.1	1.0×10^{-5}
	15	4.6	a
	20	6.1	a
	25	7.6	a
A8W	10	3.1	1.1×10^{-3}
	15	4.6	7.1×10^{-4}
	20	6.1	1.4×10^{-3}
	25	7.6	b
	31	9.5	2.1×10^{-3}
A9W	7	2.2	1.3×10^{-5}
	15	4.6	9.2×10^{-6}
	20	6.1	4.7×10^{-4}
	25	7.6	2.0×10^{-4}
	31	9.5	6.8×10^{-4}
	36	11.0	7.4×10^{-4}
	40	12.2	6.4×10^{-4}
A16W	10	3.1	1.6×10^{-5}
	15	4.6	1.0×10^{-4}
	20	6.1	2.0×10^{-3}
	25	7.6	3.3×10^{-3}
	30	9.1	2.3×10^{-3}
	35	10.7	4.1×10^{-4}
	40	12.2	1.6×10^{-4}
A18W	9	2.7	6.8×10^{-5}
	25	7.6	2.2×10^{-4}
	30	9.1	4.3×10^{-4}
	35	10.7	1.4×10^{-5}
	40	12.2	2.7×10^{-4}
A19W	15	4.6	4.0×10^{-6}
	20	6.1	a
	25	7.6	7.9×10^{-6}
	30	9.1	4.7×10^{-5}
	35	10.7	1.3×10^{-4}
A20W	10	3.1	2.1×10^{-4}
	15	4.6	8.7×10^{-4}
	20	6.1	9.4×10^{-4}
	25	7.6	5.9×10^{-4}
A23W	5	1.5	1.9×10^{-4}
	10	3.1	1.2×10^{-5}
	15	4.6	a
	20	6.1	1.9×10^{-4}
	25	7.6	3.9×10^{-5}
	30	9.1	1.7×10^{-5}
	35	10.7	4.3×10^{-5}
	40	12.2	5.1×10^{-5}
A25W	15	4.6	2.2×10^{-4}
	20	6.1	3.4×10^{-4}
	25	7.6	4.8×10^{-4}
	30	9.1	2.1×10^{-4}
	35	10.7	3.4×10^{-4}
	40	12.2	6.2×10^{-4}
A26W	10	3.1	a
	15	4.6	1.5×10^{-4}
	20	6.1	3.4×10^{-4}
	25	7.6	1.3×10^{-3}
	30	9.1	5.6×10^{-4}
	35	10.7	3.9×10^{-4}
	40	12.2	6.5×10^{-4}
A29W	10	3.1	2.9×10^{-6}
	15	4.6	1.6×10^{-4}
	20	6.1	3.4×10^{-5}
	25	7.6	1.1×10^{-5}
	30	9.1	2.3×10^{-5}
	35	10.7	2.0×10^{-5}
	40	12.2	8.1×10^{-6}
A67W	5	1.5	3.0×10^{-6}
	10	3.1	9.3×10^{-4}
	15	4.6	5.1×10^{-5}
	20	6.1	8.2×10^{-5}
	25	7.6	8.2×10^{-5}
	30	9.1	7.6×10^{-5}
	35	10.7	5.1×10^{-5}
	40	12.2	1.0×10^{-4}
A74W	11	3.4	1.3×10^{-5}
	15	4.6	1.3×10^{-3}
	20	6.1	3.4×10^{-3}
	25	7.6	2.4×10^{-3}
	30	9.1	1.8×10^{-3}
	35	10.7	1.4×10^{-3}
	40	12.2	1.9×10^{-4}
A85	5	1.5	1.4×10^{-5}
	10	3.1	1.4×10^{-4}
	15	4.6	2.1×10^{-4}
	20	6.1	a
	28	8.5	a
A90	5	1.5	6.9×10^{-6}
	10	3.1	a
	15	4.6	a
	20	6.1	a
	25	7.6	a
	30	9.1	1.2×10^{-4}
	35	10.7	1.2×10^{-5}
	40	12.2	4.6×10^{-5}
A109	5	1.5	a
	10	3.1	2.4×10^{-5}
	15	4.6	a
	20	6.1	a
	25	7.6	2.3×10^{-6}
A106	10 to 35	3.1 to 10.7	1×10^{-4}
A117	15	4.6	a
	20	6.1	a

[a] Seepage too small to measure.
[b] Leaky casing.

Unit 4 Ash and SO_2 Scrubber Sludge Pond Site

No information is available on ground water conditions in bedrock aquifers, beneath the Unit 4 pond site. Bedrock is overlain by very thick glacial soil deposits. Ground water conditions at the Unit 4 pond site are intimately related to glacial geology and soil conditions, both of which are extremely complex.

The ground water interpretations were developed from analysis of available information plus limited field reconnaissance work.

Aquifers. Several glacial drift aquifers exist at the Unit 4 ash and SO_2 scrubber sludge pond site. It should be noted that the hill at the west side of the pond site functions as a major local ground water recharge area due to its elevation and its peripheral ice contact features including kettle lakes and ponds. This recharge area corresponds to Zone 2 (and to a considerably lesser extent Zones 1 and 3) (Figure IV-15). Local ground water discharge areas include features at lower elevations than the above-mentioned hill, e.g., topographic depressions, streams, Blackwater Lake, and the Mississippi River. No information is available to indicate whether low areas of Zones 5 and 6 function as discharge or recharge areas. Both of these possibilities exist.

The first main aquifer of the Unit 4 pond site consists of sandy outwash, moraine, and ice contact materials extending outward from the recharge area of Zones 1 and 2 and dipping downward into Zones 3 and 4. This main aquifer probably includes pervious upper portions of the underlying till as well as the other deposits mentioned above. Field permeability test data provided in Tables IV-12 and IV-13 suggest that the first main aquifer has a coefficient of permeability on the order of 10-3 cm per sec; this level of permeability is consistent with its inferred geologic origin. Above approximately elevation 1,310 ft (399 m) MSL, the main aquifer extends to the ground surface. Below this approximate elevation, the main aquifer is confined beneath relatively impervious lacustrine clays and silts. This confinement plus the dip of the aquifer from the higher hill recharge area gives rise to artesian conditions in those portions of the aquifer in Zone 4 and much of Zone 3. Water level data for piezometers A9D, A74, A8, A35, A67D, A71, A18, and A76 given in Table IV-14 indicate a piezometric level of about elevation 1,290 ft (393 m) MSL in the first main aquifer.

The second main aquifer at the Unit 4 pond site consists of outwash, ice contact, and delta deposits in Zones 5 and 6. Materials in this second aquifer are predominantly sandy in nature and, based on limited available data (Piezometer No. A77D and A90), quite permeable. It is probable that there is hydraulic communication between this second main aquifer and the first main aquifer described above. These 2 main aquifers are considered separate (but probably are interconnected). The 2 main aquifers are considered separately here because of their different origins and their different positions relative to lacustrine clays and silts in the bed of former Lake Aitkin II.

As mentioned above, the 2 main aquifers are probably interconnected. The first main aquifer is clearly artesian. Water level data for piezometers A109D, A90D, A77, and A99 given in Table IV-14 suggest that the second main aquifer is artesian with a piezometric level of about elevation 1,278 ft (390 m) MSL at the

TABLE IV-13
FIELD PERMEABILITY TEST (TIME LAG)
IN VICINITY OF UNIT 4 ASH POND SITE
CLAY BOSWELL STEAM ELECTRIC STATION

Piezometer No.	Depth of Piezometer ft	m	Permeability cu m per sec
A1D	40	12.2	1.2×10^{-6}
A1S	12	3.65	2.5×10^{-4}
A8D	36	10.9	6.1×10^{-6}
A9D	39	11.9	6.7×10^{-5}
A9S	7	2.1	Dry
A18D	34	10.4	7.5×10^{-6}
A29D	40	12.2	Dry
A35D	30	9.1	-
A67D	40	12.2	7.4×10^{-6}
A71D	40	12.2	1.6×10^{-4}
A69D	40	12.2	1.8×10^{-4}
A74D	40	12.2	1.2×10^{-3}
A76D	56	17.1	2.4×10^{-4}
A77D	50	15.2	a
A90A	9.0	2.7	3.1×10^{-4}
A85	16.0	4.9	2.4×10^{-4}
A117	10.0	3.1	2.9×10^{-5}
A106	33	10.1	3.4×10^{-5}
A109	55	16.8	1.8×10^{-5}
A90	50	15.2	a

[a] Recharge too fast for test.

north end of the proposed Unit 4 ash and SO_2 scrubber sludge pond. No data are available on the portion of the second main aquifer located east of the proposed pond.

A shallow perched water table exists in lucustrine sand and silt overlying relatively impervious lacustrine clay, silty clay, and clayey silt in the bed of former Lake Aitkin II (58). Water level data for piezometers A1S, A95, and A90S given in Table IV-10 suggest that this shallow perched water table lies between elevations 1,290 and 1,300 ft (393 and 396 m) MSL. This shallow water table probably approaches the ground surface in wet seasons.

Local perched water tables are common in ice contact and moraine deposits like those at the Unit 4 pond site. Such local perched water tables probably exist in portions of the site other than the former lake bed.

Yield. No detailed information is available on yields of aquifers at the Unit 4 ash and SO_2 scrubber sludge pond site. Several large farms and a number of smaller farms and homes exist at and around the pond site; all of the farms

TABLE IV-14
READINGS FROM GROUND WATER MONITORING PROGRAM IN VICINITY OF
UNIT 4 ASH POND SITE -
CLAY BOSWELL STEAM ELECTRIC STATION (60)

Piezometer Number	Ground Surface Elevation		Ground Water Elevation											
			October 29, 1975		May 6-14, 1976		December 7, 1976		January 10, 1977		February 3, 1977		March 6, 1977	
	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m
A1S	1,296.5	395.2	1,290.9	393.5	1,293.4	394.2	1,289.6	393.1	1,289.6	393.1	1,289.6	393.1	1,289.4	393.0
A1D	1,296.4	395.1	1,285.2	391.7	1,285.4	391.8	1,284.0	391.4	1,283.8	391.3	1,283.8	391.3	1,283.5	391.2
A9S	1,302.4	397.0	1,295.4	394.8	Dry	Dry	1,295.3	394.8	1,295.3	394.8	1,295.4	394.8	1,295.5	394.9
A9D	1,302.3	397.2	1,292.6	394.0	1,292.4	393.9	1,290.7	393.4	1,289.8	393.1	1,290.4	393.1	1,290.0	393.2
A74	1,308[a]	399.0	1,296.0	395.0			1,293.7	394.3	1,293.6	394.3	Snow	Snow	Snow	Snow
A8	1,302.8	397.1	1,292.4	393.9			1,290.1	393.2	1,290.0	393.2	1,289.8	393.1	1,289.4	393.0
A35	1,311[a]	399.6	1,287.6	392.5			1,286.3	392.1	1,286.1	392.0	1,286.1	392.0	-	-
A106	1,293.1	394.2			1,279.9	390.1	1,278.4	389.7	1,278.3	389.6	1,278.3	389.6	1,278.5	389.7
A117	1,278.8	389.8			1,276.3	389.0	1,272.7	387.9	1,272.6	387.9	1,271.0	387.4	1,271.5	387.6
A85	1,281.4	390.6			1,279.4	390.0	1,276.0	388.9	1,275.7	388.8	1,275.5	388.8	1,274.8	388.6
A109D	1,288.1	392.6			1,277.7	389.4	1,276.4	389.1	1,276.2	389.0	1,276.2	389.0	1,276.2	389.0
A109S	1,289.1	392.9			1,280.3	390.2	1,283.3	391.2	1,283.2	391.1	1,283.0	391.1	1,282.8	391.0
A90D	1,300.7	396.3			1,277.6	389.4	1,276.2	389.0	1,276.4	389.1	1,276.6	389.1	1,276.6	389.1
A90S	1,301.0	396.5			1,297.9	396.0	1,293.3	394.2	1,293.4	394.2	1,293.3	394.2	1,293.4	394.2
A77	1,300.0	396.2	1,280.3	390.2	1,280.1	390.2	1,279.0	389.8	1,278.1	389.6	1,279.2	389.9	1,277.2	389.3
A94	1,300.6	396.4					1,278.4	389.7	1,278.5	389.7	1,278.5	389.7	1,278.5	389.7
A67D	1,308.3	398.8	1,295.6	394.9	1,294.7	394.6	1,292.9	394.1	1,292.6	394.0	1,292.6	394.0	1,292.3	393.9
A29D	1,334[a]	406.6	1,296.3	395.1			Dry	Dry	1,296.3	395.1	Dry	Dry	-	-
A69D	1,315.9	401.1	1,298.7	395.8	1,298.1	395.7	1,296.4	395.1	1,296.2	395.1	1,296.1	395.1	1,294.8	394.7
A71	1,310.1	399.3	1,297.4	395.5	1,294.5	394.6	1,294.1	394.4	1,293.8	394.4	1,293.6	394.3	1,293.3	394.2
A18	1,303.8	397.4	1,294.9	394.7	1,293.7	394.3	1,291.6	393.7	1,291.4	393.6	1,291.3	393.6	1,290.8	393.4
A76	1,299.8	396.2	1,293.3	394.2	1,292.4	393.9	1,290.3	393.3	1,290.1	393.2	1,290.0	393.2	1,289.7	393.1
D&M 1	1,297.5	395.5					1,289.1	392.9	1,288.4	392.7	1,288.1	392.6	1,288.1	392.6
Blackwater	-	-	1,272.7	387.9	1,273.2	388.0	1,272.2	387.7	1,272.2	387.7	1,272.4	387.8	1,272.6	387.9

[a] Elevation taken from contour map.

and most of the homes have wells. Most of the farms and homes at the site itself have been purchased by MP&L and are presently vacant. During field work on May 18, 1977, residents and landowners at the pond site adjacent to the west were surveyed for well information. The following discussion of yields is derived largely from the results of that survey.

Wells on the order of 40 to 50 ft (12 to 15 m) deep in the first main aquifer, i.e., outwash and moraine overlying till in Zone 3 and adjacent areas south and west of the hill on the west side of the pond site, are reported to each yield sufficient water for domestic consumption and for watering 50 to 100 head of cattle, even in dry summers. According to a landowner on the west side of County Road 251 (southwest of the hill at the west side of the Unit 4 pond site), the well driller who installed his 45 ft (13 m) deep well indicated that water in sufficient quantity for domestic and farm use was available at a depth of 40 to 50 ft (12 to 15 m) throughout the area (i.e., area southwest of pond site). While one may question such hearsay evidence, it is indeed consistent with geologic interpretation of the area (outwash plain overlying moraine and till) and with other information obtained on wells in the area. It therefore seems reasonable to conclude that wells in the first main aquifer, i.e., outwash sands extending from the west side of the pond site (Zones 2 and 3) beneath lacustrine soils of the central part of the pond site (Zone 4), will yield water sufficient for domestic and farm use, including watering substantial herds of cattle.

Information on wells in the second main aquifer, i.e., outwash, ice contact, and delta deposits in Zones 5 and 6, is more meager. The existing automobile junkyard on the west side of County Road 258, just north of the proposed Unit 4 pond, reportedly has 2 wells on the order of 80 to 90 ft (24 to 27 m) deep in the second main aquifer and obtains sufficient water for domestic purposes by using only one of the wells. The presently vacated dairy farm located approximately 1,000 ft (300 m) east and 3,000 ft (900 m) north of the southeast corner of the proposed Unit 4 pond reportedly has 2 wells 38 ft (12 m) deep. Water from one of these wells was reportedly sufficient to run the farm, which, when active, included a large dairy herd. It therefore seems that both deep and shallow wells in the second main aquifer (Zone 5 and perhaps also Zone 6) will yeild water sufficient for domestic and farm use, including watering substantial herds of cattle.

<u>Ground Water Quality</u>. Available information on Unit 4 pond site ground water quality is given in Tables IV-15 and IV-16. Pond site ground water has higher pH and specific conductance values and higher concentrations of sodium, potassium, chloride, nitrate, and total dissolved solids than typical ground water of the Mesabi Range. Concentrations of sodium and total dissolved solids in the ground water of the pond site are similar to concentrations in the ground water of the Station site. Sulfate concentrations at the pond site are similar to regional concentrations, but are higher than concentrations at the Station site. Concentrations of calcium, bicarbonate, total hardness, and silica in pond site ground water are generally similar to those in typical ground water of the region. Total iron concentrations in pond site ground water are significantly below regional levels.

<u>Ground Water Flow</u>. No information is available on ground water flow directions in bedrock beneath the pond site.

TABLE IV-15
GROUND WATER QUALITY IN VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION (63)

Constituent	A1D	A1S	A8D	A9D	A18	A35	A69	A74	A77	Lake[a]	Bay[b]	Well A[c]	Well B[c]
pH (lab)	6.1	7.9	8.5	7.8	8.2	8.2	8.3	8.3	12.1	6.5	7.94	7.63	7.63
Sodium (Na), mg per liter	8.92	8.56	79.0	4.0	5.18	7.86	21.4	4.36	64.0	1.50			
Potassium (K), mg per liter	7.86	6.71	7.29	5.0	5.93	6.66	6.50	5.43	13.9	4.21			
Calcium (Ca), mg per liter	70	144	17	78	68	73	61	75	122	3.3			
Magnesium (Mg), mg per liter	24.9	44.1	4.28	20.6	20.2	22.7	14.5	19.9	0.012	0.99			
Carbonate (as $CaCO_3$), mg per liter	0	0	0	0	0	0	0	0	144	0			
Bicarbonate (as $CaCO_3$), mg per liter	240	386	140	251	193	264	216	202	0	12.4	138	318	322
Hydroxide (as $CaCO_3$), mg per liter	0	0	0	0	0	0	0	0	219	0			
Chloride (Cl), mg per liter	3.7	112	4.7	8.7	15.5	4.6	2.1	38.2	< 1.0	1.2			
Sulfate (SO_4), mg per liter	20.1	13.9	77.9	22.8	24.9	18.7	33.1	10.5	88.2	< 1.0			
Nitrate (as N), mg per liter	0.06	< 0.05	0.14	1.60	4.80	1.48	< 0.05	1.90	0.13	< 0.05			
Specific conductance (μmhos per cm)	491	797	451	527	507	381	402	535	1,480	42.4	271	594	596
Total hardness (as $CaCO_3$), mg per liter	277	548	64	281	253	283	211	265	320	17.4	104	200	210
Iron (Fe), (total) mg per liter	0.02	0.02	0.07	< 0.02	< 0.02	0.02	0.04	< 0.02	< 0.02	0.13			
Aluminum (Al), mg per liter	< 0.01	< 0.1	< 0.1	< 0.01	0.3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1			
Silica (SiO_2), mg per liter	23.5	23.6	10.5	17.7	13.5	24.6	28.5	20.0	23.5	< 0.5	7.5	28.6	28.6
Titanium (Ti), mg per liter	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3			
Total dissolved solids, mg per liter	330	594	280	310	327	297	306	330	522	55			
Phosphorus (P), mg per liter	0.018	0.016	0.031	0.011	0.010	0.012	0.032	0.06	0.012	0.025			
Chlorine residual, mg per liter	-	-	-	-	-	-	-	-	-	-		0.35[d]	0.65[d]

[a] Sample taken from the unnamed lake near the NE corner of State Route 6 and County Road 251.

[b] This sample was collected near the intake structure for Units 1, 2, and 3 on Blackwater Lake. Data supplied by MP&L.

[c] These wells are the production wells which supply Clay Boswell Station with boiler makeup. Data supplied by MP&L.

[d] A chlorine residual appears in these 2 samples because they were chlorinated before collection.

TABLE IV-16

GROUND WATER QUALITY[a] IN VICINITY OF PROPOSED UNIT 4 ASH POND COMPARED WITH U.S. PUBLIC HEALTH SERVICE (1962) DRINKING WATER STANDARDS (64)

Constituent	Ground Water Quality Concentrations			USPHS[b] Drinking Water (1962)
	mean	minimum	maximum	
pH	8.4	7.62	12.1	no standard
Sodium (Na), mg per liter	22.6	4.00	79.0	no standard
Potassium (K), mg per liter	7.3	5.00	13.9	no standard
Calcium (Ca), mg per liter	79	17	122	no standard
Magnesium (Mg), mg per liter	19.0	0.012	44.1	no standard
Carbonate (as $CaCO_3$), mg per liter	16	0	144	no standard
Bicarbonate (as $CaCO_3$), mg per liter	230	0	385	no standard
Hydroxide, mg per liter	24	0	219	no standard
Chloride (Cl), mg per liter	< 21	< 1.0	112	250
Sulfate (SO_4), mg per liter	31	10.5	88.2	250
Nitrate (as N), mg per liter	1.13	< 0.05	4.80	10.17[c]
Specific conductance (μmhos per cm)	615	381	1,480	no standard
Total Hardness (as $CaCO_3$), mg per liter	264	64	548	no standard
Iron (Fe), (total) mg per liter	< 0.03	< 0.02	0.07	0.05
Aluminum (Al), mg per liter	< 0.1	0.01	0.3	no standard
Silica (SiO_2), mg per liter	22.1	10.5	28.6	no standard
Titanium (Ti), mg per liter	0.3	< 0.3	< 0.3	no standard
Total dissolved solids (TDS), mg per liter	366	280	594	500
Phosphorus (P), mg per liter	0.02	0.010	0.032	no standard

[a] Water quality data in Table IV-5 were used in preparing this Table.

[b] United States Public Health Service.

[c] The USPHS recommended maximum is 45 mg per liter nitrate but this number has been converted to 10.17 mg per liter nitrogen.

Ground water flow in the first main aquifer is radially outward from the recharge area around the hill in the western part of the pond site (Zones 1, 2, and 3). Flow in this first main aquifer probably continues some distance easterly beneath silts and clays in the bed of former Lake Aitkin II (Zone 4). No information is available on flow directions for either the first or the second main aquifer in the eastern part of the pond site (eastern part of Zone 4, Zones 5 and 6, area east of Zone 5). In the eastern part of the pond site, deep ground water probably flows southerly and southeasterly toward Blackwater Lake and the Mississippi River. Very limited data (59) suggest that ground water flow in the second main aquifer at the north edge of the pond site (Zone 5) is also southeasterly.

No data are available on the direction(s) of ground water flow in shallow perched aquifers at the pond site. It is probable that ground water in these aquifers simply flows to nearby topographic depressions.

WATER QUALITY

Regional

The upper Mississippi River Watershed has a predominantly sand river substrate. Loam soils predominate from the source of the river at Lake Itasca to Lake Bemidji, while light colored sand soils extend from this point to Grand Rapids. These soils are poor for farming which has contributed to current low population densities (65). Infertile soils also result in low levels of plant nutrients leaching into surface water bodies. The region generally is poorly drained (66).

The severe winters in the area, lasting from before September 15 to between May 23 and 30 (65), increase the chance of shallow water bodies freezing solid. In deeper systems, anoxia caused by aerobic decomposition occurs while oxygen replenishment is inhibited by ice and snow cover.

Approximately 10% of the land area in Itasca County is covered by water. Population densities are low resulting in generally low volumes of point source discharges into the Mississippi River system.

The early development of the Mississippi River as a transportation route resulted in stream channelization and headwater and river dams to augment river flow during low periods. Dam construction also provided water for power generation and potable water supplies. It limited flood control and created fish and wildlife habitats (67).

Transportation on the Mississippi has declined and the area now is being developed mainly for recreational purposes. The dams are being operated to optimize these purposes (67). Primary concerns have been maintaining wild rice production, protecting (by lowering levels) man-made shoreline structures, e.g. docks and boat-houses from ice damage, and preventing water impoundment freeze out.

The upper Mississippi River drainage system is comprised of a complex array of interconnected lakes, streams, and swamplands. Between Lake Winnibigoshish and the Pokegama Dam, over 100 lakes and potholes drain into the Mississippi River. Drainage is further complicated by the several dams on the river and its tributaries. Because the dams control flow rate and impoundment water levels, fish spawning, aquatic vegetation, and quality of the river bottom habitat are influenced directly by dam operations throughout much of the tributary system (67).

Local

The Clay Boswell Station is located within the upper Mississippi River drainage system at river mile 1188 on the northern shore of Blackwater Lake, about 5.5 miles (8.85 km) upstream from the Mississippi River Pokegama Dam (Figure IV-21).

The river section (RM-1208-1184) which includes the Clay Boswell Station is part of the Pokegama Dam impoundment. Summer depth ranges from 6 to 20 ft (1.8 to 6 m) while the width (open channels only) is between 80 and 120 ft (24.4 to 36.6 m). Maximum summer velocity is 0.6 feet per second (fps) (18 cm per sec).

Unlike upper stream sections, coloration due to dissolved organics is observed. However, clarity remains high except in areas and time of high algal densities. A silt covered sand bottom is found in this river section (66).

Detailed study of water quality of the Mississippi River in the vicinity of the Clay Boswell Station included analysis of data gathered from the following sources:

Source	Location	Period of Sampling
Minnesota Power and Light (MP&L)	River Mile 1188 (Clay Boswell Station)	1971 to 1974, 1975 to present
Minnesota Pollution Control Agency (MPCA)	River Mile 1186	1967 to present
United States Geological Survey (USGS)	River Mile 1182	1955 to present (Sporadic Sampling)
Minnesota Pollution Control Agency (MPCA)	River Mile 1172	1974 to present

In addition, data was gathered for the MP&L sponsored 316(a) study required under the National Pollutant Discharge Elimination System (NPDES) permit under the provisions of the Federal Water Pollution Control Act for point sources discharging thermal effluents which may affect aquatic ecosystems. This study was conducted during 1975 and 1976 to determine the impact of the Clay Boswell Steam Electric Station Units 1, 2, and 3 on the aquatic environment of the Mississippi River (68).

Water quality data gathered from the MPCA's station at river mile 1186, from the U.S. Geological Survey's station at river mile 1182, and at the Clay Boswell Station were considered similar. The most complete set of data was available from the MPCA Station. MPCA data were interpreted to show temporal variation of water quality in the area of the Clay Boswell Station (Table IV-17).

MPCA Data Gathered at River Mile 1186

Many water quality parameters were measured at the MPCA monitoring station at river mile 1186. Twelve of the most important are discussed here: temperature, pH, total hardness, total dissolved solids, turbidity, biochemical oxygen demand, chemical oxygen demand, dissolved oxygen, fecal coliform counts, heavy metals, sulfates, and nutrient levels.

Temperature. Water temperatures varied according to seasons ranging between an observed maximum summer temperature of 78°F (26°C), and an observed minimum winter temperature of 32°F (0°C), with an overall average of 49°F (9°C).

Primary Chemical Characteristics. The pH varied between an observed low of 6.8 and an observed high of 8.4. The median level was approximately 7.7. Average alkalinity of 143 mg per liter as $CaCO_3$ indicates that the river is well buffered. Total hardness as $CaCO_3$ ranges between a low of about 72 mg per liter

TABLE IV-17

AVERAGE WATER QUALITY MISSISSIPPI RIVER - COMMUNITY OF COHASSET, MINNESOTA (68)

	MPCA Station 1186				USGS Station 1182				MP&L[a] Station 1188			
	Number[b]	Mean	Maximum	Minimum	Number[b]	Mean	Maximum	Minimum	Number[b]	Mean	Maximum	Minimum
Temperature, °F	88	49	78	32								
Temperature, °C	88	9.4	25.6	0								
Turbidity JTU	96	3.1	15	0.2								
Color	42	27	130	0.0								
Conductivity, micromho	91	302	4,600	130.	38	279	362.	190.				
Dissolved oxygen, mg per liter	94	8.5	13.1	4.1								
BOD,[c] mg per liter	96	2.0	4.8	0.5					30	2.2	4.2	.3
COD,[d] mg per liter	15	37.5	59	21					39	30.6	58.8	10
pH	97	7.7	8.4	6.8	38	7.6	8.2	6.8				
Total alkalinity, mg per liter	95	143	180	72	35	139	106.	95.	40	134.	214.	68
Total residue, mg per liter	78	180	350	81	35	172	216.	122.	36	194.	304.	146
Suspended solids, mg per liter	96	6.1	32	0.5					36	5.	13.	0.5
Organic nitrogen, mg per liter N	78	0.72	1.5	0.14								
Ammonia, mg per liter N	96	0.12	0.52	0.03					40	0.01	0.16	0.0
Nitrite, mg per liter N	77	0.15	10.0	0.01								
Nitrate, mg per liter N	95	0.13	1.5	0.01					40	0.1	0.4	0.0
Kjeldahl, mg per liter N									40	0.51	1.07	0.0
Phosphorus, mg per liter P	96	0.063	.063	0.01					40	0.07	0.46	0.0
Total hardness, mg per liter $CaCO_3$	95	143	210	72								
Calcium, mg per liter $CaCO_3$	57	87	150	40	35	83	108	60				
Sodium, mg per liter	54	5.8	46	2.0	35	5.7	7.3	3.0				
Potassium, mg per liter	55	2.3	9.5	1.0	38	2.9	3.1	0.4				
Chloride, mg per liter	96	3.4	58	1.0	35	5.0	7.3	3.0				
Sulfate, mg per liter	40	6.5	12	4.0	35	7.9	12	4.2				
Fluoride, mg per liter	56	0.14	1.4	0.1	35	0.16	0.3	0.1				
Silica, mg per liter	5	9.9	11	9.2	35	7.4	11	1.4				
Arsenic, mg per liter	52	0.01	0.01	0.00								
Cadmium, mg per liter	84	0.01	0.07	0.01								
Copper, mg per liter	84	0.01	0.05	0.01								
Iron, mg per liter	82	0.19	0.65	0.01	37	0.13	0.9	0.0				
Lead, mg per liter	74	0.02	0.19	0.01								
Manganese, mg per liter	82	0.08	0.83	0.01	34	0.04	0.9	0.0				
Nickel, mg per liter	84	0.01	0.13	0.01								
Zinc, mg per liter	84	0.04	0.39	0.01								
Selenium, mg per liter	48	0.01	0.01	0.00								
Total coli, number per 100 ml	96	591	11,000	20								
Fecal coli, number	97											
Mercury, µg per liter	52	0.25	1.4	0.1								
Aluminum, mg per liter					31	0.31	0.8	0.0				

[a] Collected at circulating water intake.

[b] Total number of samples collected.

[c] Biochemical oxygen demand.

[d] Chemical oxygen demand.

and a high of about 210 mg per liter. The mean hardness value of 143 mg per liter indicates a general classification as "hard" water. Total dissolved solids ranged from an observed maximum of 350 mg per liter, and an observed minimum of 81 mg per liter. However, most measurements ranged between 130 mg per liter and 220 mg per liter with an average of 180 mg per liter.

Turbidity. Turbidity is very low, with a yearly mean of 3.1 Jackson Turbidity Units (JTU), and an average suspended solids concentration of 6.1 mg per liter. Water in the vicinity of the Clay Boswell Station is colored. Color results from drainage from the extensive peat bogs and swamps in the region. Primary coloring agents most probably are lignins and tannic acid which result from the decay of vegetable material in the bogs.

Organic Characteristics. Primary indicators of the organic characteristics of water are biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), and the number of coliform organisms. BOD levels are very low, with a yearly average of 2.0 mg per liter. COD levels are fairly high for a river system, with a yearly average of 37.5 mg per liter. DO levels have a yearly average of 8.5 mg per liter. The upper Mississippi River has an average DO saturation level of 73%. Fecal coliform counts are low averaging 68 colonies per 100 ml. (High numbers of fecal coliform organisms are an indication of recent sewage contamination).

Heavy Metals. Except for copper which occasionally exceeds MPCA Water Quality Standards, concentrations of heavy metals in the upper Mississippi River are extremely low. In many cases concentrations are below detection limits of the measuring instruments (Table IV-18).

TABLE IV-18
DETECTION LIMITS OF TESTS FOR METALS - MISSISSIPPI RIVER NEAR CLAY BOSWELL STEAM ELECTRIC STATION[a]

Metal	Detection Limit mg per liter	Percent of Samples less than Detection Limit
Iron	0.01	6
Manganese	0.01	17
Arsenic	0.01	100
Cadmium	0.01	93
Copper	0.01	89
Lead	0.01	81
Nickel	0.01	92
Zinc	0.01	31
Selenium	0.01 to 0.002	100
Mercury	0.0001 to 0.00005	33

[a] Detection limits refer to MPCA metal data on preceeding Table. Detection limits recently have been lowered.

Sulfates. Sulfate concentrations are of particular concern in the upper Mississippi River as wild rice may be sensitive to low-to-moderate sulfate concentrations, especially in the spring when the rice is emerging. Although wild rice has been found in water with sulfate concentrations ranging from 3 to 282 mg per liter, with a median concentration of 21.1 mg per liter (69), it has been observed that large stands of rice generally do not occur in waters having a sulfate content greater than 10 mg per liter and that rice is generally absent from water with sulfate concentrations greater than 50 mg per liter (69). A study sponsored by MP&L is currently being conducted by the University of Manitoba to examine the effects of the Clay Boswell Station on stands of wild rice in the Mississippi River. Preliminary results of the study indicate that the elevated sulfate concentrations resulting from electric generating facility discharges have no effect upon wild rice development in the Mississippi River. The average sulfate concentration at station 1186 is 6.5 mg per liter with a maximum of 12 mg per liter.

Data from 316(a) Study

Data for the 316(a) study conducted by Wapora Inc. for MP&L was gathered from 5 sampling stations at various points around the Clay Boswell Station (Figure IV-25). Water quality samples were obtained from 4 sampling zones (upstream control, immediate discharge, intermediate discharge, downstream recovery, and 2 samples at the intake structure) from September 17, 1975 to July 8, 1976. The frequency and duration of the sampling program were limited in comparison to the data gathered at the MPCA Station at river mile 1186. However, the data is of considerable value since it reflects the water quality in the immediate vicinity of the Clay Boswell Station both upstream and downstream from the facility. Samples could not be obtained during winter because of ice cover. Table IV-19 presents average values for water quality parameters determined for samples between the above dates. Averages were not determined for parameters which were below analytical detection on at least one sampling date.

The data gathered indicated that most water quality parameters did not differ greatly between zones. Sulfates, copper, and dissolved solids were the notable exceptions. Sulfate concentrations were considerably higher in the intermediate and immediate discharge zones (Table IV-19). The observed decreases in sulfate concentrations in the intermediate discharge and downstream recovery can be attributed to flow dilution. Fly ash scrubber blowdown is the major source of sulfates to the river, with lesser amounts present in demineralizer regenreant wastes and cooling tower blowdown. Dissolved oxygen (DO) concentrations were well within MPCA Water Quality Standards at all sampling locations (Table IV-20). Average total dissolved solids concentrations were highest in the discharge zone (226 mg per liter) while the lowest concentrations were found in the upstream control area (146 mg per liter).

Copper levels generally exceeded MPCA Water Quality Standards at both the immediate and intermediate zones throughout the study period. The elevated copper concentrations result from boiler blowdown and boiler tube cleaning effluents which contain small quantities of copper from the copper tubing used in the boilers.

Data gathered at the MPCA river mile 1186 and for the 316(a) studies together with data gathered by MP&L at the Clay Boswell Station indicate that the water quality in the vicinity of the electric generating facility is very good, with a few indications of significant municipal or industrial pollution.

According to the Classification of Interstate Waters of Minnesota, this stretch of the Mississippi River is classified 2B, 3B. It is also classified under classes 3C, 4A and B, 5 and 6 for all reaches where these classifications would apply. Class 2B waters shall be suitable for fish habitation and propagation; it also shall be safe for aquatic recreation (70). Class 3B waters shall be suitable for general industrial purposes. The water quality of the river as shown in Tables IV-17, IV-18, and IV-19 meets or surpasses the applicable water quality criteria for all parameters except copper and sulfate under the current MPCA Water Quality Standards (Table IV-21). The water quality data persented indicate that the water quality in the vicinity of the Clay Boswell Station has remained constant over a long period of time and is adequate to support a balanced population of aquatic organisms.

TABLE IV-19
WATER QUALITY SAMPLING PARAMETERS - 316(a) DEMONSTRATION STUDY
5 SAMPLING STATIONS NEAR CLAY BOSWELL STEAM ELECTRIC STATION
September 17, 1975 to July 8, 1976[a]

Chemical and Water Quality Parameters	Upstream Control[b]	Intake[b]	Immediate Discharge	Intermediate Discharge	Downstream Recovery
Total alkalinity (as $CaCO_3$), mg per liter	120	130	140.6	138	137.8
Biochemical oxygen demand (BOD_5)					
mg per liter	3.05	3.5	2.5	2.38	2.38
Chemical oxygen demand (COD)					
mg per liter	26.5	30.2	29.4	27	33.5
Total Kjeldahl nitrogen, mg per liter	0.80	0.80	0.75	0.70	0.62
Total phosphorus, mg per liter	0.035	0.035	0.040	0.033	0.034
Total suspended solids (TSS)					
mg per liter	3.0	1.75	4.33	3.0	3.0
Total dissolved solids (TDS)					
mg per liter	146	165	226	174.2	167.2
pH	7.8	8.1	8.05	8.1	8.1
Sulfate, mg per liter	3.0	6.3	39.25	11.7	8.9
Turbidity (JTU)[c]	2.15	1.4	2.58	2.0	2.0
Total hardness (as $CaCO_3$)					
mg per liter	120	135	177	145.6	143
Iron, mg per liter	0.25	0.18	0.26	0.23	0.22
Zinc, mg per liter	0.031	0.036	0.034	0.024	0.038
Copper, mg per liter	<0.01	<0.01	0.023	0.013	<0.01

[a] Combined average for samples taken between September 17, 1975 and July 8, 1976. Average concentrations were not determined for chemical parameters which at some time during the study period fell below levels detectable by the analytical procedures. Sulfate and total suspended solids were exceptions. Values <1 were computed as 0.5.

[b] Samples taken on only 2 dates during the study period.

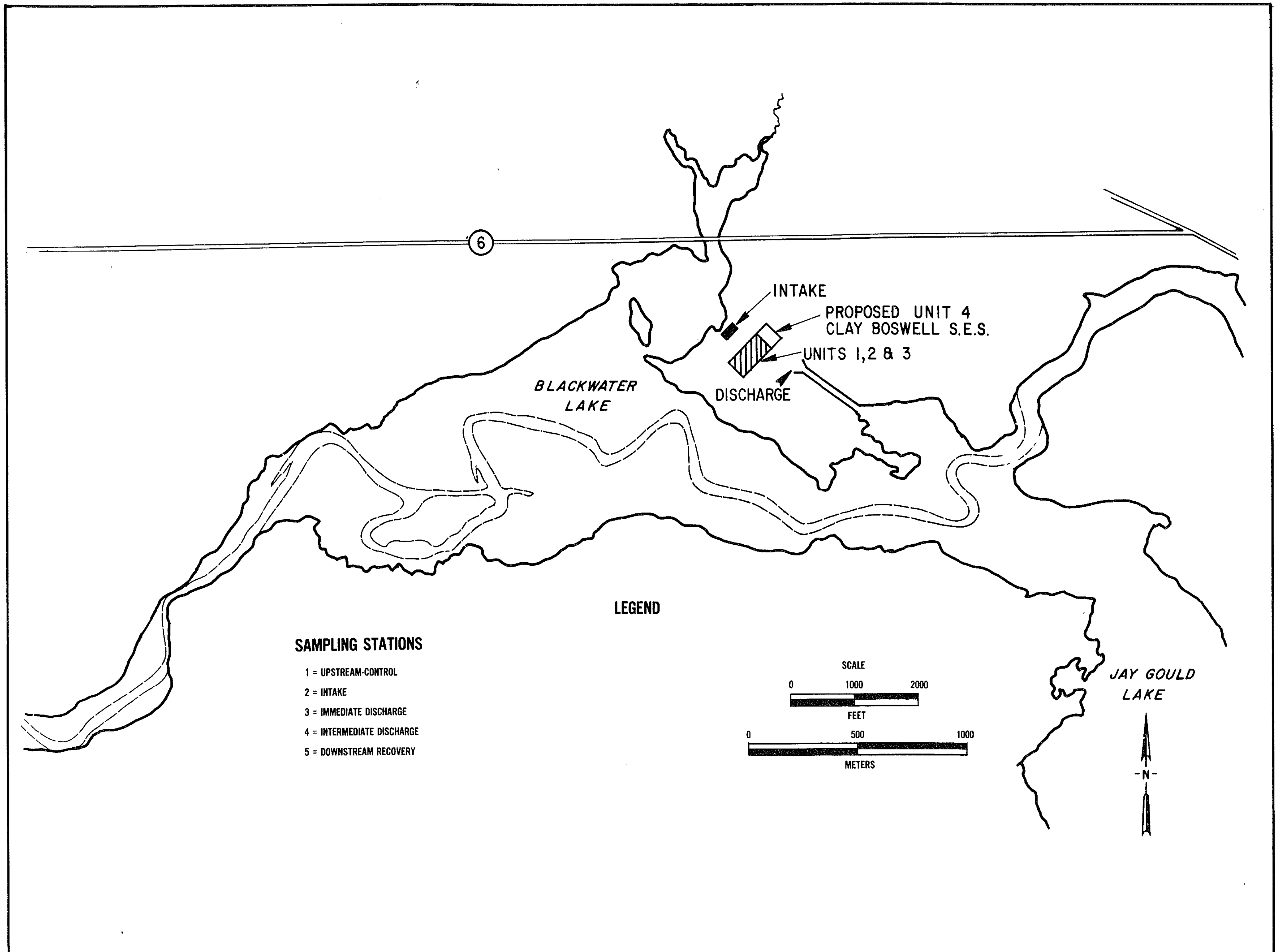
[c] JTU means Jackson Turbidity Unit.

TABLE IV-20
DISSOLVED OXYGEN CONCENTRATIONS - 5 SAMPLING STATIONS NEAR
CLAY BOSWELL STEAM ELECTRIC STATION

		Sampling Stations mg per liter							
		Upstream		Discharge		Intermediate Discharge		Downstream	
Date	Depth[a]	A	B	C	D	E	F	G	H
9/16/75	S	11.0	8.2	8.8	10.6	8.1	8.4	8.2	-
	B	7.8	5.8	7.6	9.6	7.8	8.0	7.8	-
9/20/75	S	8.6	8.6	8.8	9.6	9.0	9.2	9.6	9.2
	B	8.2	6.8	8.2	9.0	8.8	8.8	9.0	8.8
11/25/75	S	9.6	10.0	10.0	11.2	11.6	11.8	ice	ice
	B	9.8	10.2	10.0	11.0	11.2	11.2	ice	ice
12/9/75	S	9.0	10.0	9.6	10.0	10.2	10.0	ice	ice
	B	9.2	9.4	9.8	11.0	11.4	11.0	ice	ice
1/12/76	S	8.4	8.5	ice	ice	ice	ice	ice	ice
	B	8.3	8.4	ice	ice	ice	ice	ice	ice
1/27/76	S	8.6	9.2	ice	ice	ice	ice	ice	ice
	B	8.8	8.9	ice	ice	ice	ice	ice	ice
2/3/76	S	8.6	8.6	8.4	10.8	11.2	11.0	ice	ice
	B	7.8	8.4	7.8	9.4	9.4	9.6	ice	ice
2/24/76	S	7.6	7.9	7.4	8.9	9.3	9.3	ice	ice
	B	7.2	7.8	8.2	8.8	8.8	9.3	ice	ice
3/10/76[b]	S	5.2	5.4	4.6	4.6	4.4	4.4	ice	ice
	B	4.2	5.2	5.2	4.4	4.8	4.6	ice	ice
3/23/76	S	7.8	8.6	9.2	9.8	10.0	9.8	ice	ice
	B	7.8	8.0	8.7	9.5	9.8	9.7	ice	ice
4/5/76	S	7.4	8.5	8.6	9.1	9.0	9.0	ice	ice
	B	7.2	8.0	8.3	8.8	8.8	8.6	ice	ice
4/19/76	S	11.8	9.2	9.2	9.8	10.0	10.0	10.2	10.0
	B	9.4	8.2	9.0	9.8	9.8	9.6	10.0	9.6
5/3/76	S	10.3	10.2	9.8	10.6	11.3	10.9	11.4	10.8
	B	10.2	10.2	10.8	10.4	11.1	10.7	11.1	11.7
5/17/76	S	9.2	9.0	9.2	9.6	9.8	8.9	9.2	9.2
	B	9.0	8.0	8.4	8.9	9.0	8.2	9.0	8.4
6/7/76	S	7.2	6.6	6.4	6.6	6.2	6.2	6.6	7.2
	B	6.4	6.2	6.0	6.0	6.0	6.0	6.2	7.2
6/28/76	S	-	-	-	7.8	7.8	-	-	-
	B	-	-	-	6.2	7.6	-	-	-

[a] For depth, S means surface and B means bottom.

[b] Dissolved oxygen meter malfunction.



WATER QUALITY SAMPLING LOCATIONS

SOURCE: ADAPTED FROM, "316 (A) DEMONSTRATION STUDY FOR MINNESOTA POWER AND LIGHT COMPANY", JANUARY 1977, WAPORA, INC.

FIGURE IV-25

TABLE IV-21
WATER QUALITY STANDARDS
MISSISSIPPI RIVER NEAR CLAY BOSWELL STEAM ELECTRIC STATION[a]

Substance or Characteristic	Limit or Range
Dissolved oxygen	Not less than 6 mg per liter from April 1 through May 31 Not less than 5 mg per liter at other times
Temperature	5°F (2.78°C) above natural in streams and 3°F (1.67°C) above natural in lakes, based on monthly average of maximum daily temperature, except in no case shall it exceed daily average temperature of 86°F (30.0°C)
Ammonia (N)	1 mg per liter
Chromium (Cr+6)	0.05 mg per liter
Copper (Cu)	0.01 mg per liter or not greater than 1/10 the 96 hr TLM[b] value
Cyanides (CN)	0.02 mg per liter
Oil	0.5 mg per liter
pH	6.5 to 8.5
Phenols	0.01 mg per liter and none that could impart odor or taste to fish flesh or other fresh-water edible products such as crayfish, clams, prawns, and like creatures. Where it seems probable that a discharge may result in tainting of edible aquatic products, bioassays and taste panels will be required to determine whether tainting is likely or present.
Turbidity value	25 JTU[c]
Fecal coliform organisms	200 most probable number per 100 ml as a monthly geometric mean based on not less than 5 samples per month, nor equal or exceed 2000 most probable number per 100 ml in more than 10% of all samples during any month.
Radioactive materials	Not to exceed the lowest concentration permitted to be discharged to an uncontrolled environment as prescribed by the appropriate authority having control over their use.
Chlorides (Cl)	100 mg per liter
Hardness	250 mg per liter
Bicarbonates (HCO_3)	5 meq per liter
Boron (B)	0.5 mg per liter
Specified conductance	1,000 μmhos per cm
Total dissolved salts	700 mg per liter
Total salinity	1,000 mg per liter
Sodium (Na)	60% of total cations as meq per liter
Arsenic (As)	0.05 mg per liter
Barium (Ba)	1 mg per liter
Cadmium (Cd)	0.01 mg per liter
Fluoride (F)	1.5 mg per liter
Lead (Pb)	0.05 mg per liter
Selenium (Se)	0.01 mg per liter
Silver (Ag)	0.05 mg per liter
Unspecified toxic substances	None at levels harmful either directly or indirectly, or not greater than 1/10 the 96 hr TLM[b] value
Sulfates (SO_4)	10 mg per liter, applicable to water used for production of wild rice during periods when the rice may be susceptible to damage by high sulfate levels.
Hydrogen sulfide	0.02 mg per liter

[a] Sources: Minn. Reg. WPC 15 Use Class 2B, 3B, 4A, 4B, 5, and 6.

[b] TLM means Median Tolerance Limit.

[c] JTU means Jackson Turbidity Unit, which is a measure of light transmitted through a water sample.

AQUATIC BIOLOGY

The discussion of aquatic biota in the vicinity of the Clay Boswell Station presents data gathered from various sources. The Minnesota Department of Natural Resources (DNR), U.S. Environmental Protection Agency (EPA), and MP&L have sponsored a series of studies. Selected results of these studies are presented in the following section. In the late spring of 1969, the DNR conducted an intensive fisheries survey, using gill and trap netting. The location of sampling was in the discharge embayment of existing Units 1, 2, and 3 at the Clay Boswell Station and at 5 locations in the mainstream of the Mississippi River from just east of Blackwater and Cut-off Lakes to approximately one mile (1.6 km) downstream (east) of the community of Cohasset (Figure IV-26). The EPA through a grant to the University of Minnesota at Duluth is sponsoring a study of fish movements in the discharge bay (71).

MP&L has sponsored 2 studies required by MPCA. The 316(b) study was conducted to determine the extent of organism impingement and entrainment by the water intake structure at the Clay Boswell Station on Blackwater Lake.

The 316(a) study is to determine effects of thermal discharge from Units 1, 2, and 3 on the river ecology (68). During this study conducted between August 1975 and September 1976, representative groups from various trophic levels of the river ecosystem were surveyed. Information on phytoplankton periphyton, aquatic macrophytes, zooplankton, and benthic invertebrates, was collected and the following discussion focusses on data gathered for the 316(a) study. Fishery information has been compiled from data gathered by personnel from the DNR and the University of Minnesota at Duluth, as well as from the 316(a) study conducted by MP&L's consultant.

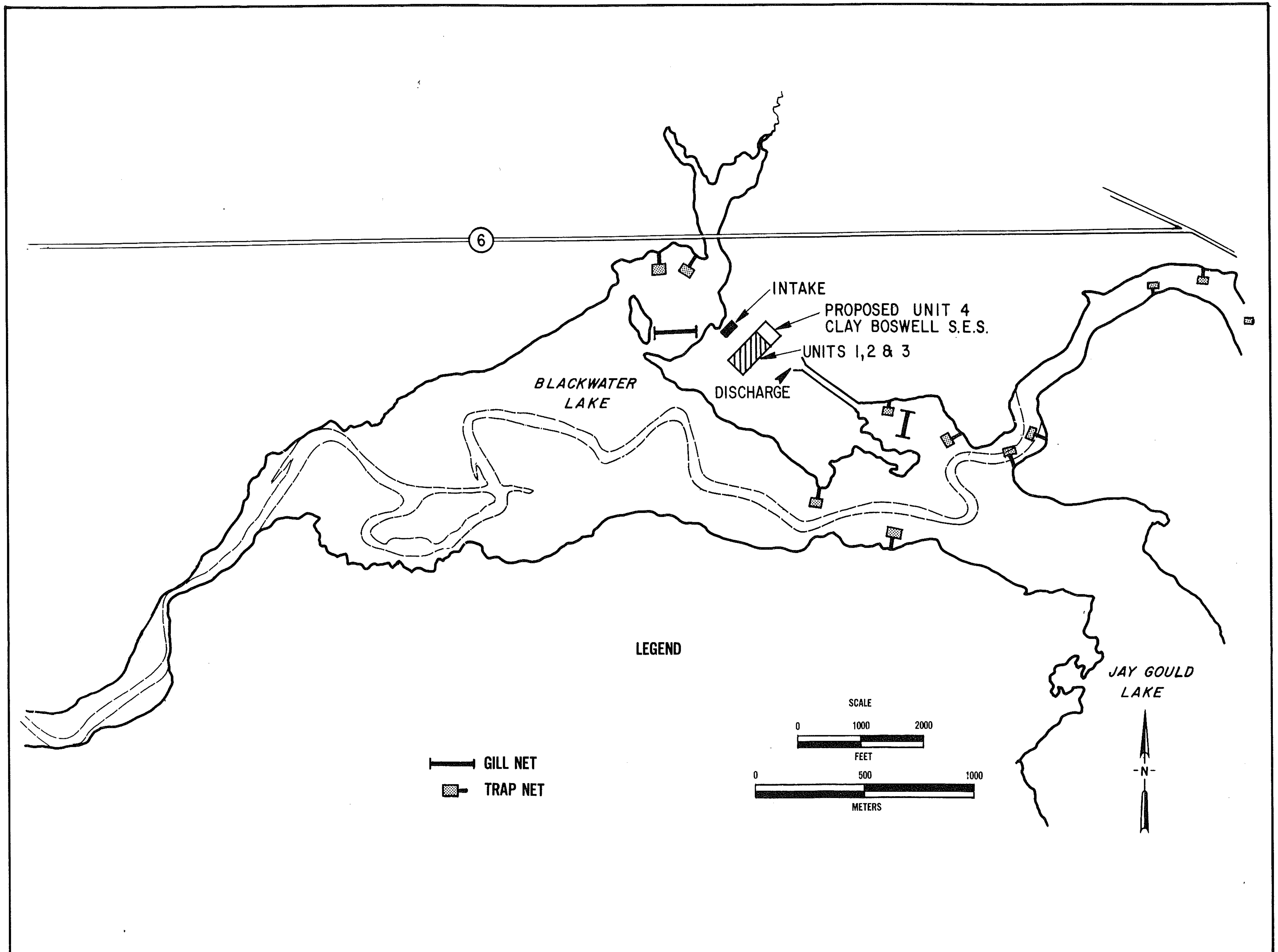
The 316(a) study gathered data from three monitoring zones corresponding to high, intermediate, and low levels of thermal elevation in the Mississippi River (Figure IV-25). A fourth zone upstream from the discharge was utilized as a control. Within each zone, various components of the aquatic community were examined. A fifth zone was established at the water intake on Blackwater Lake to examine periphyton, zooplankton, and phytoplankton.

Local and Site-Specific Biota

The following monitoring zones around the Clay Boswell Station will be examined: the upstream control zone; the immediate discharge zone; the intermediate discharge zone downstream from the Clay Boswell Station thermal discharge; and the downstream recovery zone (Figure IV-25).

Upstream Control

The upstream control zone (Figure IV-25) is not thermally enriched by the discharge from the Clay Boswell Station. Flow in the 8 to 10 ft (2.5 to 3 m) channel was observed to be sluggish with dense wild rice beds established on both sides of the channel. Depths vary from 1 to 3 ft (0.33 to 1 m) and the channel bottom is covered from fall to spring flood with a 1 to 2 ft (.30 to .60 m) layer of decaying vegetation contributed by the previous season's macrophyte growth. During spring floods, much of the detritus is washed downstream.



MINNESOTA D.N.R. FISH NETTING LOCATIONS - 1969

SOURCE: ADAPTED FROM, "316 (A) DEMONSTRATION STUDY FOR MINNESOTA POWER AND LIGHT COMPANY", JANUARY 1977, WAPORA, INC.

FIGURE IV-26

Immediate Discharge

The immediate discharge zone is enriched thermally from the effluents from Units 1, 2, and 3 of the Clay Boswell Station. Most of the water at this zone is drawn from Blackwater Lake and elevated from between 5.9 to 20.2°F (3.3 to 11.3°C) in winter, and 2 to 10.8°F (1.1 to 6.1°C) in summer depending on the generating load of the facility and circulating water flow rate. Thermal plume modeling has shown that the thermal decay within the discharge embayment is always at least 10°F (5.6°C) above ambient. Thermal decay or dilusion is always much more rapid at the confluence of the embayment with the river.

Under normal spring conditions, the 10°F (5.6°C) isotherm extends approximately 1,100 ft (335 m) downriver from the embayment-river confluence along one side of the river, and the 5°F (2.8°C) isotherm extends approximately 2,200 ft (671 m) downriver. Under average summer conditions, the extent of the 10°F (5.6°C) and 5°F (2.8°C) isotherms are approximately 100 ft (30 m) and 1,500 ft (457 m) downstream, respectively.

Under normal fall conditions, the 10°F (5.6°C) isotherm extends approximately 200 ft (61 m) downstream; the 5°F (2.8°C) isotherm approximately 1,500 ft (457 m). Under average winter conditions, the 20°F (11.2°C) isotherm extends to the confluence of the embayment with the river. The 10°F (5.6°C) isotherm extends downstream approximately 900 ft; (274 m); the 5°F (2.8°C) isotherm approximately 1,700 ft (518 m).

Under yearly average conditions, the 10°F (5.6°C) and 5°F (2.8°C) isotherms are restricted to the west side of the river. Under normal spring conditions the 5°F (2.8°C) isotherm extends more than half the width of the river.

During the winter, the plume centerline velocity within the discharge embayment ranged between 0.01 and 0.17 fps (.3 to 50 cm per sec) under average conditions and 0.01 to 0.04 fps (.3 to 1.2 cm per sec) under maximum conditions. Plume centerline velocities during the winter in the main channel of the river, downstream of the discharge, average approximately 0.54 fps (16 cu m per sec) under average flow conditions and 0.20 fps (6 cu m per sec) under maximum flow conditions.

Discharge plume centerline velocities during normal spring, summer, and fall flow conditions ranged from 0.02 to 0.15 fps (.6 to 5 cu m per sec) within the embayment. Corresponding current velocities within the main channel of the river were approximately 0.50 fps (15 cu m per sec).

Under spring, summer, and fall maximal flow conditions the plume centerline velocities within the embayment ranked between 0.02 and 0.11 fps (.6 to 3.4 cu m per sec). Corresponding current velocities within the main channel of the river ranged from 0.07 to 0.17 fps (2 to 4 cu m per sec).

For the most part, the discharge embayment is relatively shallow; the deepest point is a small area approximately 25 ft (7.6 m) in depth. The maximum depth of the main channel downstream from the station is approximately 10 ft (3 m). Dense growths of macrophytes, some of which is wild rice, extend from 50 to 100 ft (15 to 30 m) from shore depending on the season. Macrophyte beds reach a maximum depth of approximately 4 ft (1.2 m).

Intermediate Discharge

The intermediate discharge zone is very similar to the upstream control zone except that the main channel is slightly wider, and this area is thermally enriched. Macrophyte beds (primarily wild rice) extend 10 to 30 ft (3 to 10 m) out from the shore on both sides.

Downstream Recovery

The mainstream channel of the river at this point is approximately 10 ft (3 m). Some thermal enrichment occurs in this zone depending on river flow, season, and the Clay Boswell Station operating procedures. Macrophyte beds (primarily wild rice) occur on both sides of the channel and extend varying distances from the shore.

Results and Discussion of Monitoring

In the following section, discussion of aquatic biota found at and around the Clay Boswell Station will be presented using the following categories: phytoplankton, periphyton, aquatic macrophytes, zooplankton, macroinvertebrates, and fisheries.

Phytoplankton. From August 1975 to September 1976, phytoplankton were collected, analyzed, and studied using the following parameters: total abundance, dominant species, percent composition by major groups, diversity, and results of an anaylsis of variance between different zones and abundance by major groups or species, for each sampling date (Table IV-22). A graphic summary of abundance and percent composition is presented in Figure IV-27. Phytoplankton collected in the vicinity of the Clay Boswell Station included a diverse assemblage of diatoms, green and blue-green algae, and cryptophytes. Phytoplankton lists are included in the complete species list (Table IV-23).

Species observed in samples from throughout the study include those associated with both oligotraphic (e.g., *Merismopedia* sp., *Cyclotella* sp., *Rhizosolenia* sp.), and eutrophic (e.g. *Melosira* sp., *Stephanodiscus* sp., *Microcystis* ; ecosystems. Many euplanktonic (truly planktonic) phytoplankton species are present (e.g. *Attheya zachariasi* , *Diatoma* sp., *Fragilaria* sp., *Melosira* sp., *Synedra* sp., Several tychoplanktonic (benthic algae which are washed into the plankton) species are also found (e.g., *Nitzchia aucularis* , *Cymbella* sp.; (72). The *cryptophytes Chroomonas acuta* and *Cryptomonas erosa*, the blue-green *Oscillatoria* sp., the golden brown *Ochromonas* sp., and the diatoms *Ankistrodesmus falcatus* and *Cyclotella-Stephanodiscus* were the most common forms observed.

Seasonal variations or shifts in phytoplankton diversity and density occur among the zones. These variations or shifts could be attributed to the heated discharge, chemical plume, and natural variations.

However, on an annual basis, no significant difference between zones could be detected. Although real differences in total abundance occurred (Table IV-22) on sampling dates, no zone was significantly different throughout the sampling program.

TABLE IV-22
PHYTOPLANKTON POPULATION SUMMARY - 5 SAMPLING STATIONS NEAR CLAY BOSWELL STEAM ELECTRIC STATION[a]

Determination	Upstream	Intake Surface	Intake Middle	Intake Bottom	Discharge	Intermediate Discharge	Downstream
September 9, 1975							
Total number[b]	256	←	1,597[c]	→	611	735	577
Association[d]			*Chroomonas acuta* and *Cryptomonas erosa*				
% Diatoms[e]	14	←	14	→	18	9	12
% Green algae[e]	19	←	11	→	13	13	15
% Blue-green algae[e]	2	←	<1	→	<1	<1	1
% Cryptophytes[e]	63	←	69	→	63	75	71
% Others[e]	2	←	5	→	5	2	1
Diversity[f]	1.97	←	1.77	→	1.91	1.59	1.77
Number of species	26	←	40	→	29	30	28

ANOVA:[g] Total count - $\mu_3 > \mu_5 = \mu_6 = \mu_7 > \mu_1$
Cryptophytes - $\mu_3 > \mu_6 = \mu_7 = \mu_5 > \mu_1$
Chroomonas acuta - $\mu_3 > \mu_6 = \mu_7 = \mu_5 > \mu_1$
Cryptomonas erosa - $\mu_1 < \mu_5 = \mu_6 = \mu_7 < \mu_3$

Determination	Upstream	Intake Surface	Intake Middle	Intake Bottom	Discharge	Intermediate Discharge	Downstream
October 2, 1975							
Total number[b]	275	1,446	1,065	966	1,318	404	476
Association[d]			*Chroomonas acuta* and *Chryptomonas erosa*				
% Diatoms[e]	17	7	9	16	11	18	23
% Green algae[e]	18	8	8	10	12	16	13
% Blue-green algae[e]	3	<1	1	2	<1	2	2
% Cryptophytes[e]	60	82	78	67	73	63	59
% Others[e]	2	2	4	5	3	1	3
Diversity[f]	2.06	1.23	1.50	1.77	1.61	2.03	2.08
Number of species	29	36	32	35	37	34	33

ANOVA:[g] not computed

TABLE IV-22 (continued)

PHYTOPLANKTON POPULATION SUMMARY - 5 SAMPLING STATIONS NEAR CLAY BOSWELL STEAM ELECTRIC STATION[a]

Determination	Sampling Stations						
	Upstream	Intake Surface	Intake Middle	Intake Bottom	Discharge	Intermediate Discharge	Downstream
December 4, 1975							
Total number[b]		2,381	2,776	3,047	2,528	3,340	2,644
Association[d]	*Oscillatoria* sp. and *Ochromonas* sp.						
% Diatoms[e]		4.0	4.0	4.0	5.0	3.0	5.0
% Green algae[e]		4.0	4.0	4.0	4.0	4.0	3.0
% Blue-green algae[e]		71.0	75.0	76.0	77.0	74.0	66.0
% Cryptophytes[e]		8.0	7.0	6.0	6.0	6.0	7.0
% Others[e]		13.0	10.0	10.0	8.0	13.0	19.0
Diversity[f]		1.18	1.09	1.05	1.04	1.07	1.25
Number of species		32	34	31	23	23	25

ANOVA:[g] Total Count - $\mu_6 = \mu_4 = \mu_3 = \mu_7 > \mu_5 = \mu_2$

Blue-green algae - $\mu_2 = \mu_3 = \mu_4 = \mu_5 = \mu_7$

Oscillatoria sp. - $\mu_2 = \mu_3 = \mu_4 = \mu_5 = \mu_6 = \mu_7$

Ochromonas sp. - $\mu_7 = \mu_6 > \mu_2 = \mu_4 = \mu_3 = \mu_5$

Determination	Sampling Stations						
	Upstream	Intake Surface	Intake Middle	Intake Bottom	Discharge	Intermediate Discharge	Downstream
February 9, 1976							
Total number[b]	399	427	427	383	474	428	364
Association[d]	*Ankistrodesmus falcatus* and *Oscillatoria* sp.						
% Diatoms[e]	9.0	6.0	6.0	9.0	12.0	6.0	8.0
% Green algae[e]	53.0	61.0	64.0	54.0	53.0	52.0	61.0
% Blue-green algae[e]	24.0	19.0	16.0	19.0	22.0	29.0	13.0
% Cryptophytes[e]	13.0	11.0	11.0	13.0	11.0	10.0	14.0
% Others[e]	1.0	3.0	3.0	5.0	2.0	3.0	4.0
Diversity[f]	1.77	1.64	1.58	1.75	1.89	1.69	1.75
Number of species	22	19	15	17	26	18	19

ANOVA:[g] Total Count - $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 = \mu_6 = \mu_7$

Green algae - $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 = \mu_6 = \mu_7$

Ankistrodesmus falcatus - $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 = \mu_6 = \mu_7$

Oscillatoria sp. - $\mu_5 = \mu_6 = \mu_1 > \mu_2 = \mu_4 = \mu_3 = \mu_7$

TABLE IV-22 (continued)

PHYTOPLANKTON POPULATION SUMMARY - 5 SAMPLING STATIONS NEAR CLAY BOSWELL STEAM ELECTRIC STATION[a]

Determination	Sampling Stations						
	Upstream	Intake Surface	Intake Middle	Intake Bottom	Discharge	Intermediate Discharge	Downstream
April 15, 1976							
Total number[b]	960	2,262	2,078	1,855	1,875	3,337	2,232
Association[d]	*Chroomonas acuta* and Pennate diatoms						
% Diatoms[e]	21.0	24.0	34.0	48.0	35.0	24.0	28.0
% Green algae[e]	25.0	13.0	15.0	18.0	14.0	16.0	17.0
% Blue-green algae[e]	0.0	0.0	1.0	0.0	0.0	0.0	0.0
% Cryptophytes[e]	47.0	54.0	36.0	22.0	41.0	50.0	46.0
% Others[e]	7.0	9.0	14.0	12.0	10.0	10.0	9.0
Diversity[f]	2.12	1.92	2.23	2.08	2.11	1.97	2.03
Number of species	35	35	36	35	32	32	30

ANOVA:[g] Total Count - $\mu_5 > \mu_2 = \mu_7 = \mu_3 = \mu_6 = \mu_4 = \mu_1$

Diatoms - $\mu_4 = \mu_5 = \mu_3 = \mu_6 = \mu_7 = \mu_2 > \mu_1$

Chryptophyta - $\mu_5 = \mu_2 = \mu_7 > \mu_6 = \mu_3 = \mu_1 = \mu_4$

Pennate - $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 = \mu_6 = \mu_7$

Chroomonas acuta - $\mu_5 > \mu_2 = \mu_7 = \mu_6 = \mu_3 = \mu_1 = \mu_4$

Determination	Sampling Stations						
	Upstream	Intake Surface	Intake Middle	Intake Bottom	Discharge	Intermediate Discharge	Downstream
May 10, 1976							
Total number[b]	2,523	4,968	4,056	4,665	3,546	3,562	2,780
Association[d]	*Cyclotella - Stephanodiscus* and *Chroomonas acuta*						
% Diatoms[e]	42.0	33.0	50.0	40.0	41.0	40.0	37.0
% Green algae[e]	22.0	20.0	17.0	18.0	23.0	22.0	24.0
% Blue-green algae[e]	1.0	1.0	1.0	1.0	1.0	2.0	1.0
% Cryptophytes[e]	32.0	35.0	28.0	32.0	24.0	24.0	25.0
% Others[e]	3.0	11.0	4.0	9.0	11.0	12.0	13.0
Diversity[f]	2.13	2.22	2.00	2.11	2.34	2.25	2.27
Number of species	36	44	34	32	43	34	31

ANOVA:[g] Total Count - $\mu_2 = \mu_4 > \mu_3 = \mu_5 = \mu_6 > \mu_7 = \mu_1$

Diatoms - $\mu_3 = \mu_4 > \mu_2 = \mu_6 = \mu_5 > \mu_1 = \mu_7$

Chryptophyta - $\mu_2 = \mu_4 > \mu_3 > \mu_5 = \mu_6 = \mu_1 = \mu_7$

Cyclotella - Stephanodiscus - $\mu_3 = \mu_4 > \mu_2 = \mu_5 = \mu_6 > \mu_7 = \mu_1$

Chroomonas acuta - $\mu_2 = \mu_4 > \mu_3 = \mu_5 = \mu_6 = \mu_1 > \mu_7$

TABLE IV-22 (continued)

PHYTOPLANKTON POPULATION SUMMARY - 5 SAMPLING STATIONS NEAR CLAY BOSWELL STEAM ELECTRIC STATION[a]

Determination	Sampling Stations						
	Upstream	Intake Surface	Intake Middle	Intake Bottom	Discharge	Intermediate Discharge	Downstream
June 14, 1976							
Total number[b]	1,451	3,771	5,564	5,116	4,372	7,779	8,403
Association[d]	*Cyclotella - Stephanodiscus* and *Chroomonas acuta*						
% Diatoms[e]	2.0	52.0	55.0	56.0	65.0	71.0	76.0
% Green algae[e]	23.0	16.0	13.0	13.0	10.0	11.0	9.0
% Blue-green algae[e]	0.0	9.0	7.0	9.0	10.0	10.0	7.0
% Cryptophytes[e]	74.0	23.0	24.0	21.0	14.0	8.0	7.0
% Others[e]	1.0	0.0	1.0	1.0	1.0	0.0	1.0
Diversity[f]	1.58	2.06	1.86	1.90	1.84	1.57	1.45
Number of species	25	41	34	30	45	36	36

ANOVA:[g] Total Count - $\mu_7 = \mu_5 > \mu_3 = \mu_4 = \mu_6 = \mu_2 > \mu_1$

Diatoms - $\mu_7 > \mu_5 > \mu_3 = \mu_6 = \mu_4 > \mu_2 > \mu_1$

Cyclotella - Stephanodiscus - $\mu_7 > \mu_5 > \mu_3 = \mu_6 = \mu_4 > \mu_2 > \mu_1$

Chroomonas acuta - $\mu_3 = \mu_4 > \mu_2 = \mu_1 = \mu_5 = \mu_7 = \mu_6$

Determination	Sampling Stations						
	Upstream	Intake Surface	Intake Middle	Intake Bottom	Discharge	Intermediate Discharge	Downstream
July 29, 1976							
Total number[b]	1,648	924	634	1,015	502	398	377
Association[d]	*Chroomonas acuta* and *Cryptomonas erosa* → Coccoid greens and Coccoid green colonies						
% Diatoms[e]	28.0	24.0	20.0	21.0	27.0	23.0	20.0
% Green algae[e]	30.0	26.0	25.0	25.0	44.0	55.0	63.0
% Blue-green algae[e]	1.0	2.0	3.0	3.0	5.0	2.0	4.0
% Cryptophytes[e]	36.0	41.0	43.0	42.0	11.0	10.0	2.0
% Others[e]	5.0	7.0	9.0	9.0	13.0	10.0	11.0
Diversity[f]	2.51	2.61	2.63	2.64	2.95	2.87	2.78
Number of species	47	45	44	49	47	47	45

ANOVA:[g] Total Count - $\mu_1 > \mu_4 = \mu_2 > \mu_3 = \mu_6 = \mu_5 = \mu_7$

Green algae - $\mu_1 > \mu_4 = \mu_2 = \mu_7 = \mu_6 = \mu_5 = \mu_3$

Cryptophyta - $\mu_1 > \mu_4 = \mu_2 > \mu_3 > \mu_6 = \mu_5 = \mu_7$

Coccoid greens - $\mu_1 > \mu_2 = \mu_5 = \mu_7 = \mu_6 = \mu_4 = \mu_3$

Chroomonas acuta - $\mu_1 = \mu_4 = \mu_2 > \mu_3 > \mu_6 = \mu_5 = \mu_7$

Cryptomonas erosa - $\mu_1 > \mu_4 = \mu_2 = \mu_3 > \mu_6 = \mu_5 = \mu_7$

TABLE IV-22 (continued)
PHYTOPLANKTON POPULATION SUMMARY - 5 SAMPLING STATIONS NEAR CLAY BOSWELL STEAM ELECTRIC STATION[a]

Determination	Sampling Stations						
	Upstream	Intake Surface	Intake Middle	Intake Bottom	Discharge	Intermediate Discharge	Downstream
<u>August 17, 1976</u>							
Total number[b]	1,207	520	622	618	403	427	273
Association[d]	Coccoid greens and *Stephanodiscus tenuis* → Coccoid greens and Coccoid green colonies						
% Diatoms[e]	38	28.0	30.0	27.0	33.0	29.0	15.0
% Green algae[e]	35	37.0	38.0	34.0	51.0	45.0	72.0
% Blue-green algae[e]	4.0	4.0	4.0	4.0	7.0	21.0	5.0
% Cryptophytes[e]	15.0	18.0	19.0	26.0	1.0	0.0	0.0
% Others[e]	8.0	13.0	9.0	9.0	8.0	5.0	8.0
Diversity[f]	2.53	2.84	2.79	2.72	2.61	2.40	2.41
Number of species	50	49	55	48	47	43	46

ANOVA:[g] Total Count - $\mu_1 > \mu_3 = \mu_4 = \mu_2 = \mu_5 = \mu_6 = \mu_7$

Diatoms - $\mu_1 > \mu_3 = \mu_4 = \mu_2 = \mu_6 = \mu_5 = \mu_7$

Green algae - $\mu_1 > \mu_3 = \mu_4 = \mu_6 = \mu_5 = \mu_7 = \mu_2$

Stephanodiscus tenuis - $\mu_1 > \mu_3 = \mu_2 = \mu_4 = \mu_6 > \mu_5 = \mu_7$

Coccoid greens - $\mu_1 > \mu_4 = \mu_3 = \mu_2 = \mu_7 = \mu_6 = \mu_5$

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a Summary for 9 dates between September 9, 1975 and August 17, 1976.

b Total number is the average of the total abundance of organisms in 3 samples, expressed as thousands of organisms per liter.

c Mean of 3 samples; 1 each from surface, middle, and bottom on this date only.

d Association refers to the dominant species or group of phytoplankton on the sampling date.

e % refers to percent composition of total number.

f Diversity refers to the Shannon-Weaver Index, a method of calculating the ecological diversity of an aquatic community where smaller numbers indicate less diversity.

g ANOVA refers to a statistical analysis of variance summary where μ represents the true mean of the population at the sampling station; = indicates no significant difference; < or > indicates significantly less-than or greater-than differences between the means; and subscripts refer to sampling locations in order of occurrence upstream to downstream, e.g. μ_1 is the true mean of the population at the discharging station.

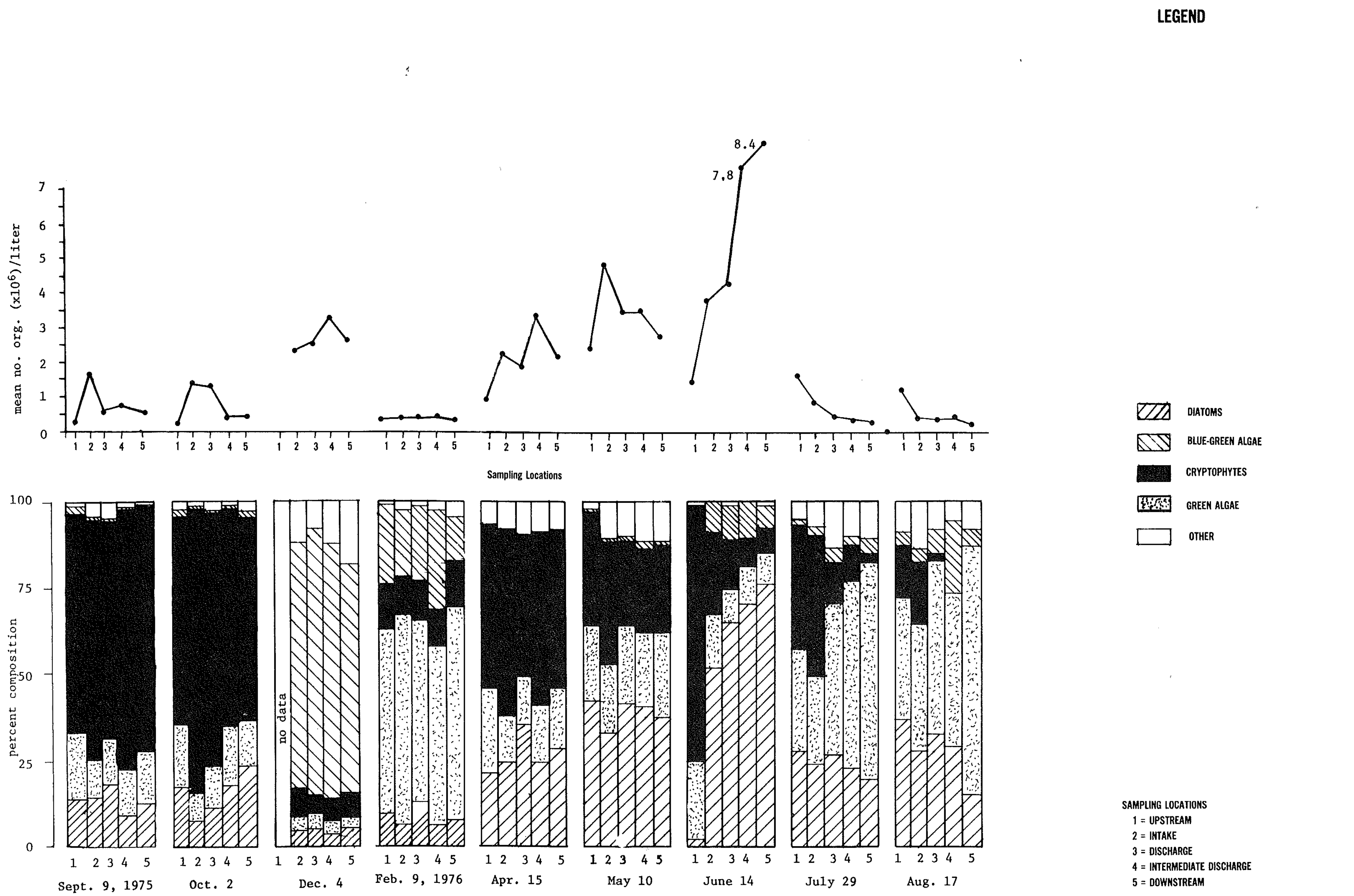
In most river systems, tychoplanktonic and some euplanktonic diatoms are usually dominant (73). In the Mississippi River at Clay Boswell, the large numbers of euplanktonic species reflect the lacustrine (lake-like) nature of the river there. The large backwater areas in the river and the close proximity of several lakes emptying into the river also contribute to this euplanktonic community.

Of special note are the low numbers of Cyanophyta which generally occur in lake type habits. Members of this phylum are considered undesirable in large numbers because they may impart taste and color to public water supplies; they inhibit zooplankton feeding (74) (75); and their blooms often result in anoxic conditions, which in turn can cause fish kills.

In general, the phytoplankton community reflects the excellent quality of the Mississippi River at this location.

TABLE IV-23
SUMMARY OF COLLECTED PHYTOPLANKTON SPECIES - CLAY BOSWELL STEAM ELECTRIC STATION
September 9, 1975 to August 17, 1976

Species	Species	Species
Acnanthes sp.	*Epithemia* sp.	*Pediastrum kawraiskyi*
Actidesmium sp.	*Eudorina* sp.	*Pediastrum tetras*
Actinastrum hantzschii	*Euglena* sp.	Pennate
Amphipleura pellucida	Filamentous green	*Peridinium* sp.
Anadaena sp.	*Fragilaria* sp.	*Phacus* sp.
Ankistrodesmus falcatus	*Gomphonema* sp.	*Pinnularia* sp.
Asterionella formosa	*Gymnodinium* sp.	*Platydorine* sp.
Attheya zachariasi	*Kirchneriella* sp.	*Polyedriopsis* sp.
Blue-green trichomes	*Lagerheimia quadriseta*	*Quadrigula* sp.
Chlorogonium sp.	*Mallomonas akrokomos*	*Radiosphaera* sp.
Chloromonad sp.	*Mallomonas globosa*	*Rhizosolenia* sp.
Chroomonas acuta	*Mallomonas tonsurata*	*Scenedesmus arcuatus*
Closterium sp.	*Mallomonas* sp.	*Scenedesmus bijuga*
Coccoid blue-green colonies	*Melosira ambigua*	*Scenedesmus dimorphus*
Coccoid greens	*Melosira binderana*	*Scenedesmus falcatus*
Coccoid green colonies	*Melosira granulata*	*Scenedesmus quadricauda*
Cocconeis sp.	*Melosira islandica*	*Scenedesmus* sp.
Coelastrum sphaericum	*Melosira varians*	*Sorastrum* sp.
Coscinodiscus sp.	*Merismopedia* sp.	*Spermatozoopsis exultans*
Cosmarium sp.	*Micractinium pusillum*	*Staurastrum* sp.
Crucigenia tetrapedia	*Microcystis* sp.	*Stephanodiscus astrea*
Crucigenia sp.	*Nephrocytium* sp.	*Stephanodiscus tenuis*
Cryptomonas erosa	*Nitzschia acicularis*	*Synedra* sp.
Cyclotella-stephanodiscus	*Nitzschia palea*	*Synura* sp.
Cyclotella sp.	*Nitzschia* sp.	*Tabellaria* sp.
Cymatopleura sp.	*Ochromonas* sp.	*Tetraedron minimum*
Cymbella sp.	*Oocystis* sp.	*Tetraedron* sp.
Diatoma elongatum	*Ophiocytium capitatum* var. *longspinum*	*Tetrastrum glabrum*
Diatoma sp.	*Oscillatoria* sp.	*Tetrastrum heteracanthum*
Dictyosphaerium sp.	*Pandorina morum*	*Tetrastrum staurogeniaeforme*
Dinobryon (solitary)	*Pediastrum boryanum*	*Trachelomonas* sp.
Dinobryon sp.	*Pediastrum duplex*	*Treubaria* sp.



PERCENT COMPOSITION BY MAJOR GROUPS AND TOTAL ABUNDANCE (ALL GROUPS) - PHYTOPLANKTON POPULATIONS SAMPLED AT SURFACE DURING 1975-1976 NEAR CLAY BOSWELL STEAM ELECTRIC STATION

(SOURCE: WAPORA, INC., WASHINGTON, D.C., STATISTICAL DATA TRANSMITTED TO MICHAEL BAKER, JR., INC. ON MARCH 17, 1977)

FIGURE IV-27

Periphyton. Diatoms and green algae were the most abundant groups of periphyton (attached algae) found in the Mississippi River near the Clay Boswell Station. A summary of population parameters, including total abundance, dominant species, percent composition by major groups, a diversity index, and results of analysis of variance for short-term exposure periods, for each sampling date is presented in Table IV-24. A graphic summary is presented in Figure IV-28. A complete species list is presented in Table IV-25.

Species observed throughout the study include those normally associated with running water habitats (e.g. - the stalked diatom *Achnanthes* , the epiphytic *Cocconeis* , the epipelic blue-green *Oscillatoria*) but were also observed in the plankton (e.g. - *Cyclotella, Melosira* , *Chroomonas*). The pennate diatoms, the diatoms *Cocconeis placentula v. lineata* , *Tabellaria* , *Achnanthes* , and the blue-green *Oscillatoria* were the most common forms observed throughout the study.

Pennate diatoms were clearly the overall most common periphyton form observed. Green algae were the second most abundant group throughout the study, in both short and long term samples, and were dominant, or nearly so, on several dates.

Based on the limited data, an analysis of variance, identical to that performed for the phytoplankton, showed no significant difference between zones when total abundance for all short term exposure periods was tested. By date, numerous zones were shown to have significantly higher or lower total abundance or abundances of major groups.

In most cases, the immediate discharge showed a lower diversity and greater dominance by diatoms. Apparently the discharge area is a more suitable habitat for diatoms, perhaps because of increased temperatures, flow velocities, chemical constituents of the water, or a combination of these and other factors.

As was noted for the phytoplankton, the low numbers of blue-green algal species in the periphyton may indicate the excellent water quality in this section of the upper Mississippi River.

Aquatic Macrophytes. The aquatic macrophytes (large aquatic plants) collected during the 316(a) study are presented in the Species List and list of zones of occurrence in Table IV-26. A more general list of aquatic macrophytes found in the upper Mississippi River reservoir system is presented in Table IV-27, and a site-specific list prepared during the summer of 1969 by the DNR is presented in Table IV-28 for comparative purposes.

For the 316(a) study, 13 species (the most at any zone) were collected in the immediate discharge. Ten were collected in the intermediate discharge, eight in the upstream control, and six in the downstream zone. Dominant species with zones of occurrence are included in Table IV-29.

TABLE IV-24
SUMMARY OF PERIPHYTON POPULATION - SHORT-TERM AND LONG-TERM EXPOSURE PERIODS
5 SAMPLING STATIONS NEAR CLAY BOSWELL STEAM ELECTRIC STATION

Determination	Sampling Stations				
	Upstream	Intake	Discharge	Intermediate Discharge	Downstream
October 16, 1975 - short term					
Total number[a]	10	187		195	34
Association[b]	*Cocconeis placentula* var. *lineata* and Pennate diatoms				
% Diatoms[c]	73.0	92.0		91.0	87.0
% Green algae[c]	11.0	5.0		6.0	7.0
% Blue-green algae[c]	13.0	3.0		3.0	4.0
% Cryptophytes[c]	3.0	< 1.0		< 1.0	1.0
% Others[c]	0.0	0.0		0.0	1.0
Diversity[d]	1.54	0.99		0.97	1.49
Number of species	24	21		24	30

ANOVA:[e] Total Count - $\mu_1 = \mu_5 < \mu_2 = \mu_4$

Diatoms - $\mu_1 = \mu_5 < \mu_2 = \mu_4$

Cocconeis placentula var. *lineata* - $\mu_1 = \mu_5 < \mu_2 = \mu_4$

Pennate diatoms - $\mu_1 = \mu_2 = \mu_4 = \mu_5$

Determination	Sampling Stations				
	Upstream	Intake	Discharge	Intermediate Discharge	Downstream
November 26, 1975 - short term					
Total number[a]			26	52	19
Association[b]	Pennate diatoms and Blue-green trichomes				
% Diatoms[c]			77.0	89.0	70.0
% Green algae[c]			2.0	3.0	4.0
% Blue-green algae[c]			21.0	8.0	24.0
% Cryptophytes[c]			< 1.0	< 1.0	1.0
% Others[c]			0.0	0.0	1.0
Diversity[d]			1.42	1.99	1.85
Number of species			28	26	30

ANOVA:[e] Total Count - $\mu_3 = \mu_5 < \mu_4$

Diatoms - $\mu_3 = \mu_5 < \mu_4$

Pennate diatoms - $\mu_5 = \mu_3$, $\mu_3 = \mu_4$, $\mu_4 > \mu_5$

Blue-green trichomes - $\mu_3 = \mu_4 = \mu_5$

TABLE IV-24 (continued)
SUMMARY OF PERIPHYTON POPULATION - SHORT-TERM AND LONG-TERM EXPOSURE PERIODS
5 SAMPLING STATIONS NEAR CLAY BOSWELL STEAM ELECTRIC STATION

	Sampling Stations				
Determination	Upstream	Intake	Discharge	Intermediate Discharge	Downstream
November 26, 1975 - long term					
Total number[a]				107.1	89.0
Association[b]	*Cocconeis placentula* var. *lineata* and Pennate diatoms				
% Diatoms[c]				93.0	97.0
% Green algae[c]				1.0	1.0
% Blue-green algae[c]				6.0	2.0
% Cryptophytes[c]				< 1.0	< 1.0
% Others[c]				1.0	0.0
Diversity[d]				1.49	1.37
Number of species				17	17
ANOVA:[e]					

	Sampling Stations				
Determination	Upstream	Intake	Discharge	Intermediate Discharge	Downstream
January 8, 1976 - short term					
Total number[a]			1.0	33	
Association[b]	Pennate diatoms and *Oscillatoria* sp.				
% Diatoms[c]			54.0	94.0	
% Green algae[c]			8.0	3.0	
% Blue-green algae[c]			37.0	3.0	
% Cryptophytes[c]			1.0	< 1.0	
% Others[c]			0.0	0.0	
Diversity[d]			1.46	1.99	
Number of species			18	25	
ANOVA:[e] Total Count - $\mu_3 < \mu_4$					
Diatoms - $\mu_3 < \mu_4$					
Pennate diatoms - $\mu_3 < \mu_4$					
Oscillatoria sp. - $\mu_3 < \mu_4$					

TABLE IV-24 (continued)
SUMMARY OF PERIPHYTON POPULATION - SHORT-TERM AND LONG-TERM EXPOSURE PERIODS
5 SAMPLING STATIONS NEAR CLAY BOSWELL STEAM ELCTRIC STATION

Determination	Sampling Stations				
	Upstream	Intake	Discharge	Intermediate Discharge	Downstream
January 8, 1976 - long term					
Total number[a]			9.0	42.0	3.0
Association[b]			Pennate diatoms and *Oscillatoria* sp.		
% Diatoms[c]			45.0	97.0	43.0
% Green algae[c]			8.0	< 1.0	0.0
% Blue-green algae[c]			47.0	3.0	54.0
% Cryptophytes[c]			0.0	0.0	3.0
% Others[c]			0.0	0.0	0.0
Diversity[d]			1.50	1.66	1.51
Number of species			10	13	17
ANOVA:[e]					

Determination	Sampling Stations				
	Upstream	Intake	Discharge	Intermediate Discharge	Downstream
February 9, 1976 - short term					
Total number[a]			26.0	28.0	13.0
Association[b]			Pennate diatoms and *Tabellaria* sp.		
% Diatoms[c]			79.0	96.0	96.0
% Green algae[c]			20.0	3.0	1.0
% Blue-green algae[c]			< 1.0	1.0	2.0
% Cryptophytes[c]			< 1.0	< 1.0	< 1.0
% Others[c]			1.0	1.0	1.0
Diversity[d]			1.92	1.43	1.68
Number of species			21	27	23

ANOVA:[e] Total Count - $\mu_3 = \mu_4 = \mu_5$
Diatoms - $\mu_3 = \mu_4 = \mu_5$
Pennate diatoms - $\mu_4 > \mu_3 > \mu_5$
Tabellaria sp. - $\mu_3 = \mu_4 = \mu_5$

TABLE IV-24 (continued)
SUMMARY OF PERIPHYTON POPULATION - SHORT-TERM AND LONG-TERM EXPOSURE PERIODS
5 SAMPLING STATIONS NEAR CLAY BOSWELL STEAM ELECTRIC STATION

Determination	Sampling Stations: Upstream	Intake	Discharge	Intermediate Discharge	Downstream
February 9, 1976 - long term					
Total number[a]			153.0	40.0	5.0
Association[b]			Pennate diatoms and *Characium* sp.		
% Diatoms[c]			53.0	96.0	93.0
% Green algae[c]			44.0	1.0	5.0
% Blue-green algae[c]			3.0	1.0	1.0
% Cryptophytes[c]			0.0	2.0	1.0
% Others[c]			0.0	0.0	0.0
Diversity[d]			1.46	1.44	1.70
Number of species			11	17	12
ANOVA:[e]					

Determination	Sampling Stations: Upstream	Intake	Discharge	Intermediate Discharge	Downstream
February 9, 1976 - long term (3 to 4 months)					
Total number[a]	23.0				
Association[b]	*Cocconeis placentula* var. *lineata* and *Synedra ulna*				
% Diatoms[c]	99.0				
% Green algae[c]	1.0				
% Blue-green algae[c]	0.0				
% Cryptophytes[c]	0.0				
% Others[c]	0.0				
Diversity[d]	1.55				
Number of species	15				
ANOVA:[e]					

TABLE IV-24 (continued)
SUMMARY OF PERIPHYTON POPULATION - SHORT-TERM AND LONG-TERM EXPOSURE PERIODS
5 SAMPLING STATIONS NEAR CLAY BOSWELL STEAM ELECTRIC STATION

Determination	Sampling Stations				
	Upstream	Intake	Discharge	Intermediate Discharge	Downstream
March 15, 1976 - short term					
Total number[a]		121.0	180.0	94.0	64.0
Association[b]		*Tabellaria fenestrata* and Pennate diatoms			
% Diatoms[c]		100.0	97.0	98.0	99.0
% Green algae[c]		< 1.0	1.0	1.0	< 1.0
% Blue-green algae[c]		< 1.0	3.0	< 1.0	0.0
% Cryptophytes[c]		< 1.0	0.0	1.0	0.0
% Others[c]		0.0	0.0	0.0	1.0
Diversity[d]		0.66	1.06	1.25	1.53
Number of species		12	9	19	15

ANOVA:[e] Total Count - $\mu_2 = \mu_3 = \mu_4 = \mu_5$
Diatoms - $\mu_2 = \mu_3 = \mu_4 = \mu_5$
Pennate diatoms - $\mu_2 = \mu_3 = \mu_5 < \mu_4$
Tabellaria fenestrata - $\mu_2 > \mu_3 = \mu_4 = \mu_5$

Determination	Sampling Stations				
	Upstream	Intake	Discharge	Intermediate Discharge	Downstream
March 15, 1976 - long term					
Total number[a]				108.0	3.0
Association[b]			Pennate diatoms and *Tabellaria fenestrata*		
% Diatoms[c]				100.0	96.0
% Green algae[c]				< 1.0	1.0
% Blue-green algae[c]				0.0	1.0
% Cryptophytes[c]				0.0	2.0
% Others[c]				0.0	0.0
Diversity[d]				1.66	1.84
Number of species				12	13

ANOVA:[e]

TABLE IV-24 (continued)
SUMMARY OF PERIPHYTON POPULATION - SHORT-TERM AND LONG-TERM EXPOSURE PERIODS
5 SAMPLING STATIONS NEAR CLAY BOSWELL STEAM ELECTRIC STATION

	Sampling Stations				
Determination	Upstream	Intake	Discharge	Intermediate Discharge	Downstream
<u>April 15, 1976 - short term</u>					
Total number[a]		36.0	71.0	155.0	80
Association[b]		Coccoid greens and *Achnanthes* sp.			
% Diatoms[c]		61.0	41.0	80.0	40.0
% Green algae[c]		26.0	7.0	18.0	48.0
% Blue-green algae[c]		4.0	51.0	1.0	9.0
% Cryptophytes[c]		9.0	1.0	1.0	3.0
% Others[c]		0.0	0.0	0.0	0.0
Diversity[d]		2.48	1.59	2.06	2.12
Number of species		35	27	26	34

ANOVA:[e] Total Count - $\mu_2 = \mu_3 = \mu_5 < \mu_4$
Diatoms - $\mu_2 = \mu_3 = \mu_5 < \mu_4$
Coccoid greens - $\mu_2 = \mu_3 < \mu_4 < \mu_5$
Achnanthes sp. - $\mu_2 \quad \mu_3 \quad \mu_5 < \mu_4$

	Sampling Stations				
Determination.	Upstream	Intake	Discharge	Intermediate Discharge	Downstream
<u>April 15, 1976 - long term</u>					
Total number[a]		79.0		342.0	152.0
Association[b]		*Achnanthes* sp. and Coccoid greens			
% Diatoms[c]		80.0		97.0	37.0
% Green algae[c]		15.0		1.0	56.0
% Blue-green algae[c]		1.0		2.0	4.0
% Cryptophytes[c]		3.0		0.0	1.0
% Others[c]		1.0		0.0	2.0
Diversity[d]		1.42		1.68	2.08
Number of species		22		20	23

ANOVA:[e]

TABLE IV-24 (continued)
SUMMARY OF PERIPHYTON POPULATION - SHORT-TERM AND LONG-TERM EXPOSURE PERIODS
5 SAMPLING STATIONS NEAR CLAY BOSWELL STEAM ELECTRIC STATION

Determination	Sampling Stations Upstream	Intake	Discharge	Intermediate Discharge	Downstream
May 10, 1976 - short term					
Total number[a]	86.0	124.9		58.0	37.0
Association[b]		*Gomphonema* sp. and *Nitzschia* sp.			
% Diatoms[c]	83.0	89.0		89.0	73.0
% Green algae[c]	14.0	9.0		8.0	20.0
% Blue-green algae[c]	1.0	1.0		2.0	3.0
% Cryptophytes[c]	2.0	1.0		1.0	2.0
% Others[c]	0.0	0.0		0.0	2.0
Diversity[d]	1.88	2.12		2.14	2.45
Number of species	28	27		33	35

ANOVA:[e] Total Count - $\mu_1 = \mu_2 > \mu_5$, $\mu_1 > \mu_4 > \mu_5$
Diatoms - $\mu_1 = \mu_2 = \mu_4 > \mu_5$
Gomphonema sp. - $\mu_1 > \mu_2 = \mu_4 = \mu_5$
Nitzschia sp. - $\mu_2 > \mu_1 = \mu_4 > \mu_5$

Determination	Sampling Stations Upstream	Intake	Discharge	Intermediate Discharge	Downstream
May 10, 1976 - long term					
Total number[a]	60.0	110.0	196.0	143.0	101.0
Association[b]		*Achnanthes* sp. and *Nitzschia* sp.			
% Diatoms[c]	84.0	82.0	98.0	89.0	82.0
% Green algae[c]	8.0	16.0	1.0	8.0	15.0
% Blue-green algae[c]	3.0	2.0	1.0	2.0	3.0
% Cryptophytes[c]	4.0	0.0	< 1.0	1.0	< 1.0
% Others[c]	1.0	0.0	0.0	0.0	0.0
Diversity[d]	2.55	2.12	0.36	1.85	2.21
Number of species	30	24	13	27	27

ANOVA:[e]

TABLE IV-24 (continued)
SUMMARY OF PERIPHYTON POPULATION - SHORT-TERM AND LONG-TERM EXPOSURE PERIODS
5 SAMPLING STATIONS NEAR CLAY BOSWELL STEAM ELECTRIC STATION

Determination	Sampling Stations: Upstream	Intake	Discharge	Intermediate Discharge	Downstream
June 14, 1976 - short term					
Total number[a]	127.0	41.0	152.0	27.0	75.0
Association[b]	*Cocconeis placentula* var. *lineata* and *Cyclotella Stephanodiscus*				
% Diatoms[c]	86.0	77.0	97.0	85.0	92.0
% Green algae[c]	10.0	14.0	1.0	6.0	2.0
% Blue-green algae[c]	3.0	4.0	1.0	6.0	3.0
% Cryptophytes[c]	0.0	5.0	1.0	6.0	3.0
% Others[c]	1.0	0.0	0.0	1.0	0.0
Diversity[d]	1.56	2.01	0.37	1.41	1.18
Number of species	14	26	13	20	23

ANOVA:[e] Total Count - $\mu_1 = \mu_3 > \mu_2 = \mu_4 = \mu_5$

Diatoms - $\mu_1 = \mu_3 > \mu_2 = \mu_4 = \mu_5$

Cocconeis placentula var. *lineata* - $\mu_1 = \mu_2 = \mu_4 = \mu_5 < \mu_3$

Pennate diatoms - $\mu_1 = \mu_2 = \mu_5 < \mu_4 = \mu_3$

Determination	Sampling Stations: Upstream	Intake	Discharge	Intermediate Discharge	Downstream
June 14, 1976 - long term					
Total number[a]	117.0	56.0		49.0	110.0
Association[b]	*Cocconeis placentula* var. *lineata* and Pennate diatoms				
% Diatoms[c]	85.0	86.0		98.0	94.0
% Green algae[c]	13.0	8.0		0.0	2.0
% Blue-green algae[c]	2.0	4.0		2.0	2.0
% Cryptophytes[c]	0.0	2.0		0.0	2.0
% Others[c]	0.0	0.0		0.0	0.0
Diversity[d]	1.66	1.39		0.67	1.02
Number of species	10	14		8	14

ANOVA:[e]

TABLE IV-24 (continued)
SUMMARY OF PERIPHYTON POPULATION - SHORT-TERM AND LONG-TERM EXPOSURE PERIODS
5 SAMPLING STATIONS NEAR CLAY BOSWELL STEAM ELECTRIC STATION

Determination	Sampling Stations				
	Upstream	Intake	Discharge	Intermediate Discharge	Downstream
July 15, 1976 - short term					
Total number[a]	28.0	169.0	53.0	28.0	126.0
Association[b]	*Cocconeis placentula* var. *lineata* and *Epithemia* sp.				
% Diatoms[c]	83.0	84.0	96.0	89.0	93.0
% Green algae[c]	11.0	8.0	2.0	5.0	4.0
% Blue-green algae[c]	2.0	7.0	1.0	5.0	2.0
% Cryptophytes[c]	4.0	1.0	1.0	1.0	1.0
% Others[c]	0.0	0.0	0.0	0.0	0.0
Diversity[d]	1.75	1.23	0.34	0.84	1.28
Number of species	37	23	28	23	20

ANOVA:[e] Total Count - $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$
Diatoms - $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$
Pennate diatoms - $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$
Cocconeis sp. - $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$

Determination	Sampling Stations				
	Upstream	Intake	Discharge	Intermediate Discharge	Downstream
July 15, 1976 - long term					
Total number[a]	57.0	132.0	119.0	50.0	35.0
Association[b]	*Cocconeis placentula* var. *lineata* and *Epithemia* sp.				
% Diatoms[c]	89.0	91.0	98.0	90.0	82.0
% Green algae[c]	5.0	6.0	1.0	3.0	10.0
% Blue-green algae[c]	4.0	3.0	1.0	7.0	5.0
% Cryptophytes[c]	2.0	< 1.0	< 1.0	0.0	3.0
% Others[c]	0.0	0.0	0.0	0.0	0.0
Diversity[d]	1.52	0.76	0.22	0.81	1.34
Number of species	22	20	11	13	17

ANOVA:[e]

TABLE IV-24 (continued)
SUMMARY OF PERIPHYTON POPULATION - SHORT-TERM AND LONG-TERM EXPOSURE PERIODS
5 SAMPLING STATIONS NEAR CLAY BOSWELL STEAM ELECTRIC STATIONS

Determination	Sampling Stations				
	Upstream	Intake	Discharge	Intermediate Discharge	Downstream
August 17, 1976 - short term					
Total number[a]	126.0	164.0	18.0	30.0	76.0
Association[b]	*Cocconeis placentula* var. *lineata* and Coccoid greens				
% Diatoms[c]	68.0	89.0	37.0	61.0	87.0
% Green algae[c]	19.0	9.0	36.0	32.0	12.0
% Blue-green algae[c]	13.0	1.0	27.0	7.0	1.0
% Cryptophytes[c]	< 1.0	< 1.0	< 1.0	< 1.0	0.0
% Others[c]	0.0	0.0	0.0	0.0	0.0
Diversity[d]	2.22	1.11	1.97	1.94	1.17
Number of species	34	20	32	28	14

ANOVA:[e] Total Count - $\mu_1 = \mu_2 > \mu_3 = \mu_4 = \mu_5$

Diatoms - $\mu_2 > \mu_5 = \mu_1 > \mu_3 = \mu_4$

Cocconeis placentula - $\mu_3 = \mu_1 = \mu_5 < \mu_4 < \mu_2$

Coccoid greens - $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$

Determination	Sampling Stations				
	Upstream	Intake	Discharge	Intermediate Discharge	Downstream
August 17, 1976 - long term					
Total number[a]	60.0	154.0	35.0	34.0	188.0
Association[b]	*Cocconeis placentula* var. *lineata* and *Epithemia* sp.				
% Diatoms[c]	86.0	92.0	77.0	90.0	95.0
% Green algae[c]	7.0	4.0	15.0	8.0	3.0
% Blue-green algae[c]	7.0	4.0	7.0	2.0	1.0
% Cryptophytes[c]	0.0	0.0	0.0	< 1.0	0.0
% Others[c]	0.0	0.0	1.0	0.0	1.0
Diversity[d]	2.00	1.38	1.11	0.90	0.59
Number of species	24	12	14	15	10

ANOVA:[e]

TABLE IV-24 (continued)
SUMMARY OF PERIPHYTON POPULATION - SHORT-TERM AND LONG-TERM EXPOSURE PERIODS
5 SAMPLING STATIONS NEAR CLAY BOSWELL STEAM ELECTRIC STATION

Determination	Sampling Stations: Upstream	Intake	Discharge	Intermediate Discharge	Downstream
September 20, 1976 - short term					
Total number[a]	13.0	85.0	59.0	9.0	14.0
Association[b]	*Cocconeis placentula* var. *lineata* and *Achnanthes lanceolata* and Pennate diatoms				
% Diatoms[c]	69.0	92.0	85.0	53.0	78.0
% Green algae[c]	8.0	1.0	8.0	14.0	6.0
% Blue-green algae[c]	3.0	1.0	1.0	2.0	1.0
% Cryptophytes[c]	19.0	6.0	6.0	28.0	15.0
% Others[c]	1.0	0.0	0.0	3.0	0.0
Diversity[d]	2.24	0.56	1.50	2.49	2.01
Number of species	33	21	27	47	40

ANOVA:[e] Total count - $\mu_1 = \mu_4 = \mu_5 < \mu_3 < \mu_2$

Diatoms - $\mu_1 = \mu_4 = \mu_5 < \mu_3 < \mu_2$

Pennate diatoms - $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$

Achnanthes lanceolata - $\mu_1 = \mu_2 = \mu_4 = \mu_5 < \mu_3$

Cocconeis placentula var. *lineata* - $\mu_1 = \mu_3 = \mu_4 = \mu_5 < \mu_2$

Determination	Sampling Stations: Upstream	Intake	Discharge	Intermediate Discharge	Downstream
September 20, 1976 - long term					
Total number[a]	9.0	66.0	73.0		15.0
Association[b]	*Cocconeis placentula* var. *lineata* and *Achnanthes lanceolata*				
% Diatoms[c]	64.0	93.0	91.0		74.0
% Green algae[c]	8.0	1.0	4.0		6.0
% Blue-green algae[c]	3.0	< 1.0	1.0		1.0
% Cryptophytes[c]	25.0	5.0	4.0		19.0
% Others[c]	0.0	0.0	0.0		0.0
Diversity[d]	2.24	0.69	1.52		2.12
Number of species	25	18	17		17

ANOVA:[e]

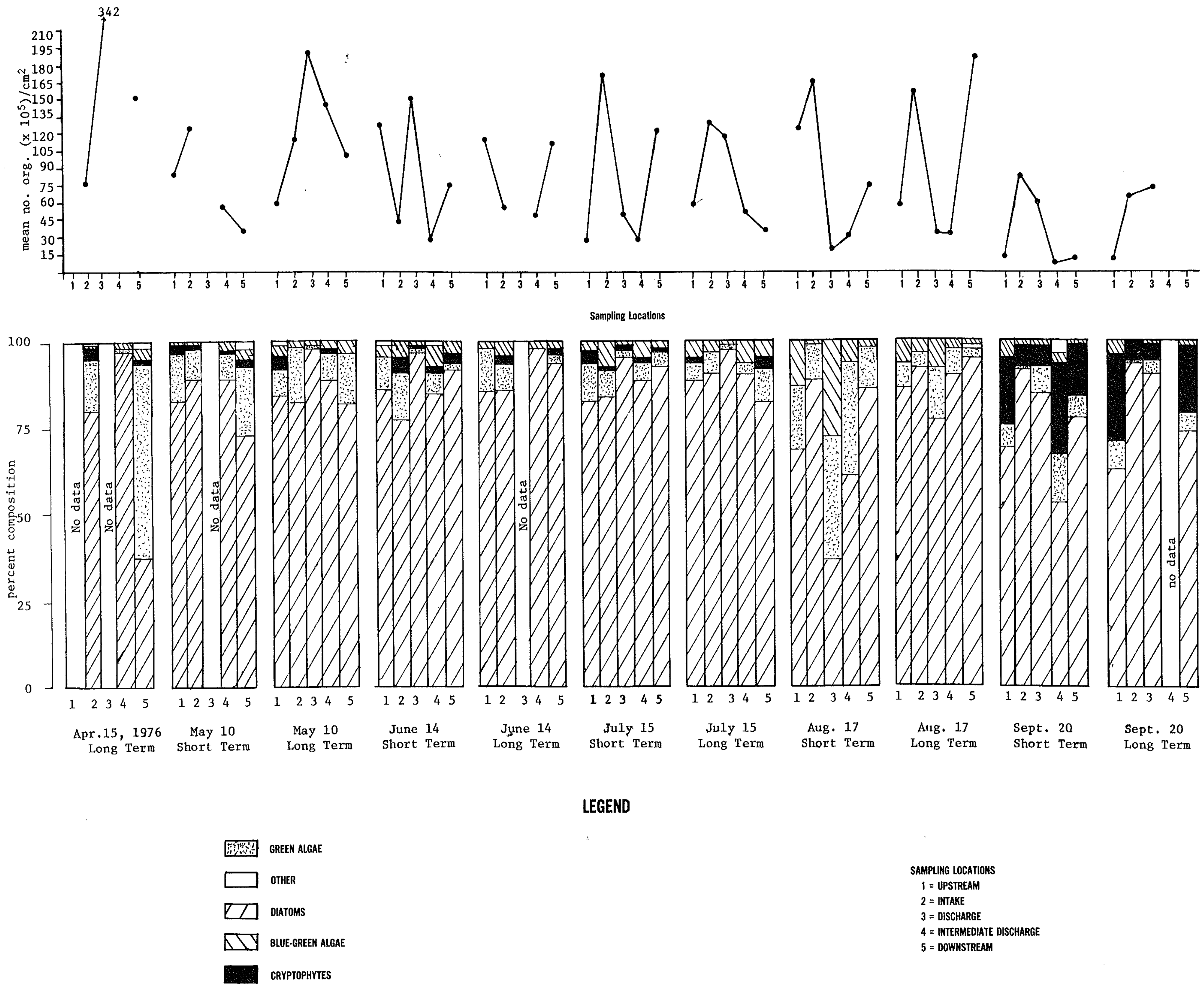
a Total number is the total abundance as organisms (x 10^5) per sq cm.

b Association refers to the dominant species or group of Periphyton on the sampling date.

c % refers to percent composition of total number.

d Diversity refers to the Shannon-Weaver Index, a method of calculating the ecological diversity of an aquatic community where smaller numbers indicate lesser diversity.

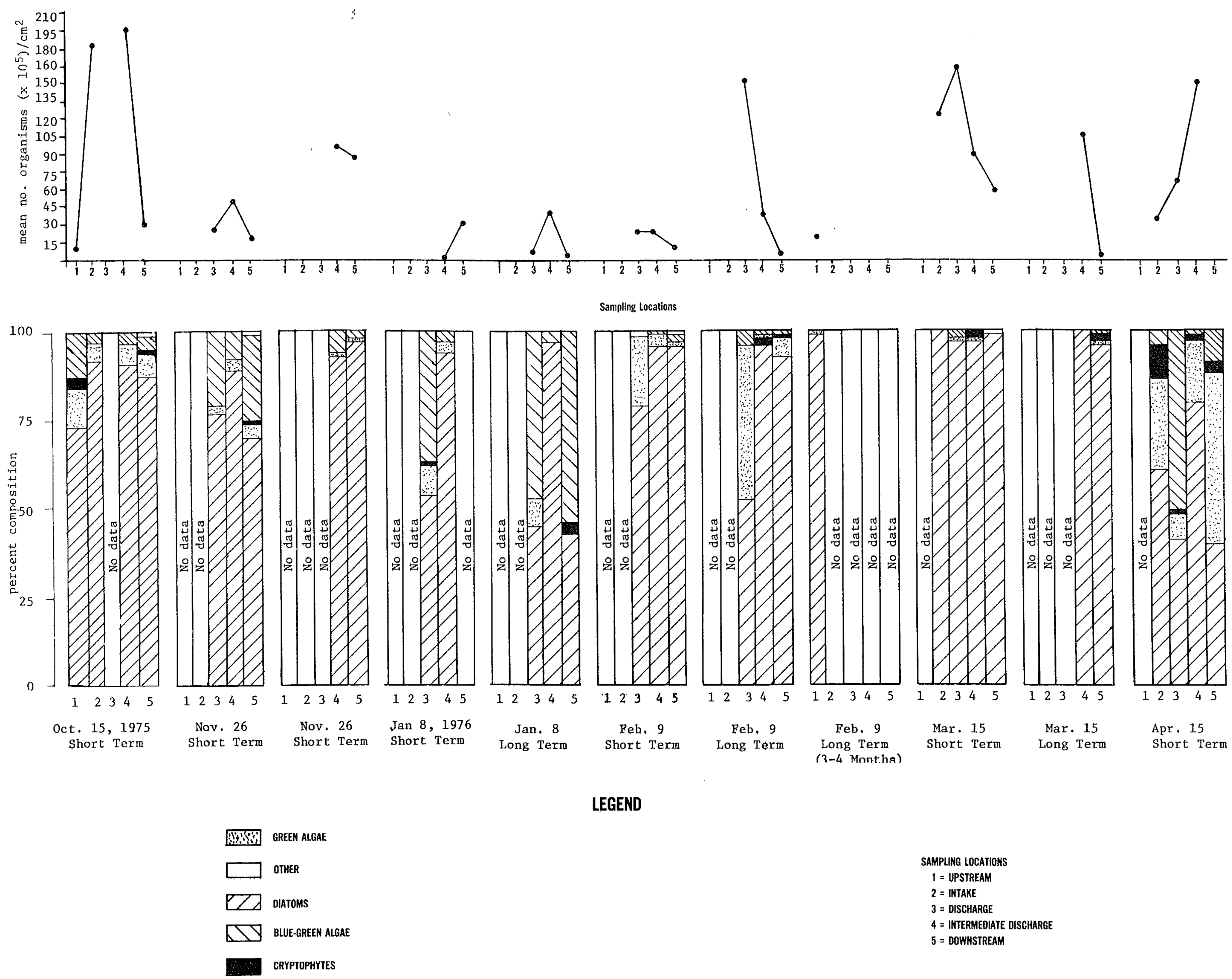
e ANOVA refers to a statistical analysis of variance summary where μ represents the true mean of the populations at the sampling station; = indicates no significant difference; < or > indicates significantly less-than or greater-than differences between the means; and subscripts refer to sampling locations in order of occurrence upstream to downstream, e.g. μ_1 is the true mean of the population at the upstream station.



PERCENT COMPOSITION BY MAJOR GROUPS AND TOTAL ABUNDANCE (ALL GROUPS) - PERIPHYTON POPULATIONS FROM ARTIFICIAL SUBSTRATES, BOTH SHORT AND LONG TERM EXPOSURE PERIODS, DURING 1975-1976 - NEAR CLAY BOSWELL STEAM ELECTRIC STATION

(SOURCE: WAPORA, INC., WASHINGTON, D.C., STATISTICAL DATA TRANSMITTED TO MICHAEL BAKER, JR., INC. ON MARCH 17, 1977)

FIGURE IV-28



PERCENT COMPOSITION BY MAJOR GROUPS AND TOTAL ABUNDANCE (ALL GROUPS) - PERIPHYTON POPULATIONS FROM ARTIFICIAL SUBSTRATES, BOTH SHORT AND LONG TERM EXPOSURE PERIODS, DURING 1975-1976 - NEAR CLAY BOSWELL STEAM ELECTRIC STATION

(CONTINUED)

(SOURCE: WAPORA, INC., WASHINGTON, D.C., STATISTICAL DATA TRANSMITTED TO MICHAEL BAKER, JR., INC. ON MARCH 17, 1977)

FIGURE IV-28

TABLE IV-25
SUMMARY OF COLLECTED PERIPHYTON SPECIES - CLAY BOSWELL STEAM ELECTRIC STATION
October 16, 1975 to September 20, 1976

Species	Species	Species
Achnanthes lanceolata	*Dinobryon* sp.	*Nitzschia* sp.
Achnanthes sp.	*Epithemia* sp.	*Ochromonas* sp.
Actidesmium sp.	*Eudorina* sp.	*Oscillatoria* sp.
Actinastrum hantzschii	*Euglena* sp.	*Pandorina morum*
Actinastrum hantzschii var. *fluviatile*	*Eunotia pectinalis*	*Pediastrum boryanum*
Amphora sp.	Filamentous green	*Pediastrum duplex*
Anabaena sp.	*Fragilaria* sp.	*Pediastrum kawraiskyi*
Ankistrodesmus falcatus	*Gomphonema angustatum*	*Pediastrum tetras*
Asterionella formosa	*Gomphonema olivaceum*	*Pediastrum* sp.
Attheya zachariasi	*Gomphonema parvulum*	Pennate
Blue-green trichomes	*Gomphonema* sp.	*Peridinium* sp.
Calothrix sp.	*Gonium* sp.	*Phacus brevicauda*
Chaetophora type	*Gymnodinium* sp.	*Phacus* sp.
Chaetophorales	*Gyrosigma macrum*	*Pinnularia* sp.
Characium sp.	*Gyrosigma* sp.	*Quadrigula* sp.
Chlamydomonas sp.	*Kirchneriella* sp.	*Rhizosolenia* sp.
Chlorogonium sp.	*Lagerheimia longiseta*	*Rhoicosphenia curvata*
Chroococcus minor	*Lagerheimia quadriseta*	*Scenedesmus abundans*
Chroomonas acuta	*Leptochaete* sp.	*Scenedesmus arcuatus*
Chroomonas sp.	*Lyngbya* sp.	*Scenedesmus bijuga*
Cladophorales type	*Mallomonas tonsurata*	*Scenedesmus denticulatus*
Closterium sp.	*Mallomonas* sp.	*Scenedesmus dimorphus*
Coccoid blue-greens	*Melosira ambigua*	*Scenedesmus quadricauda*
Coccoid blue-green colonies	*Melosira binderana*	*Schroederia* sp.
Coccoid greens	*Melosira granulata*	*Sorastrum* sp.
Coccoid green colonies	*Melosira islandica*	*Spermatozoopsis exultans*
Cocconeis pediculus	*Melosira italica*	*Spirogyra* sp.
Cocconeis placentula var. *lineata*	*Melosira varians*	*Stephanodiscus astrea*
Cocconeis sp.	*Melosira* sp.	*Surirella* sp.
Coelastrum microporum	*Meridion* sp.	*Synedra ulna*
Coelosphaerium sp.	*Merismopedia* sp.	*Synedra* sp.
Coscinodiscus rothii	*Micractinium pusillum*	*Synura* sp.
Cosmarium sp.	*Microcystis* sp.	*Tabellaria fenestrata*
Crucigenia tetrapedia	*Mougeotia* sp.	*Tabellaria* sp.
Crucigenia sp.	*Navicula exigua*	*Tetraedron caudatum*
Cryptomonas erosa	*Navicula mutica* var. *tropica*	*Tetraedron* sp.
Cryptomonas sp.	*Navicula rhynchocephala*	*Tetrastrum heteracanthum*
Cyclotella stephanodiscus	*Navicula tripunctata*	*Tetrastrum staurogeniaeforme*
Cyclotella sp.	*Navicula viridula*	*Trachelomonas* sp.
Cymatopleura sp.	*Naviculoid diatoms*	*Treubaria* sp.
Cymbella sp.	*Nitzschia acicularis*	*Ulothrix* sp.
Diatoma elongatum	*Nitzschia holsatica*	*Zygnema* sp.
Diatoma sp.	*Nitzschia palea*	
Dictyosphaerium pulchellum	*Nitzschia vermicularis*	
Dictyosphaerium sp.		

TABLE IV-26
LIST OF AQUATIC MACROPHYTES COLLECTED - MISSISSIPPI RIVER NEAR CLAY BOSWELL STEAM ELECTRIC STATION
August 1975 to August 1976

Species	Zones: Upstream Control	Immediate Discharge	Intermediate Discharge	Downstream Recovery
American elodea *(Elodea canadesis)*	x	x	x	
Arrowhead *(Sagittaria latifolia)*	x	x	x	x
Bladderwort *(Utricularia* sp.*)*	x	x	x	x
Buttercup *(Ranunculus* sp.*)*			x	
Coontail *(Ceratophyllum* sp.*)*	x	x	x	x
Giant duckweed *(Spriodela polyrhiza)*	x	x	x	
Leafy pondweed *(Potamogeton foliosus)*		x		
Pond lily *(Nuphar advena)*		x		
Pondweed *(Potamogeton* sp.*)*		x		
Star duckweed *(Lemna trisulca)*	x	x	x	x
Water milfoil *(Myriophyllum* sp.*)*	x	x		
Water stargrass *(Heteranthera dubia)*		x	x	
White water lily *(Nymphaea tuberosa)*		x	x	x
Wild rice *(Zizania aquatica)*	x	x	x	x
Total number species	8	13	10	6

The immediate discharge, which produced the most species and highest production, has a large littoral area and is thermally enriched year-round. The bottom slopes at the other zones are much steeper and drop off rapidly at the edge of the channel, thus limiting the available habitat. Thermal effluents apparently cause early emergence, enhance growth, and extend the growing season, thus creating unfavorable nuisance conditions at the discharge and intermediate discharge areas, as is evidenced by the higher biomass and increased productivity in the spring and early summer at these 2 zones. The standing crop in the intermediate discharge in the spring was greater than that in the 2 adjacent areas combined.

The aquatic macrophyte community within the study area is a variable but productive community which has the expected species diversity for the region. Localized productivity is apparently increased by the addition of thermal effluent, but large differences in species composition and growth from year to year is most likely due to natural variation and sampling differences.

Zooplankton. A summary of zooplankton population parameters, including total abundance, dominant species, percent composition by major groups, a diversity index, and results of an analysis of variance between zones for total abundance and abundance by major groups or species, for each sampling date, is presented in Table IV-30. A graphic summary of abundance and percent composition (by major groups) is presented in Figure IV-29. A complete species list, appears in Table IV-31.

TABLE IV-27
LIST OF AQUATIC MACROPHYTE GENERA COLLECTED - UPPER MISSISSIPPI RIVER (76)

Species	
Begger tick (*Bidens* sp.)	Cane (*Phragmites* sp.)
Bluepoint (*Calamogrostis* sp.)	Smartweed (*Polygonum* sp.)
Sedge (*Carex* sp.)	Pondweed (*Potamogeton* sp.)
Coontail (*Ceratophyllum* sp.)	Arrowhead, wapato (*Sagittaria* sp.)
Spike rush (*Eleocharis* sp.)	Bulrush (*Scirpus* sp.)
Elodea (*Elodea* sp.)	Bur reed (*Sparganium* sp.)
Manna grass (*Glyceria* sp.)	Giant duckweed (*Spirodela* sp.)
Marestail (*Hippuris* sp.)	Cattail (*Typha* sp.)
Duckweed (*Lemna* sp.)	Wild celery (*Vallisneria* sp.)
Water milfoil (*Myriophyllum* sp.)	Wild rice (*Zizania* sp.)
Yellow water lily (*Nuphar* sp.)	

TABLE IV-28
LIST OF AQUATIC MACROPHYTE GENERA COLLECTED NEAR
CLAY BOSWELL STEAM ELECTRIC STATION
MINNESOTA DEPARTMENT OF NATURAL RESOURCES (1969)

Taxa	Upstream of Discharge	Downstream of Discharge
Coontail (*Ceratophyllum* sp.)		x
Elodea (*Elodea* sp.)	x	x
Mare's tail (*Hippuris* sp.)		x
Duckweed (*Lemna* sp.)	x	x
Water marigold (*Megalodonta* sp.)		x
Water milfoil (*Myriophyllum* sp.)	x	x
Yellow water lily (*Nuphar* sp.)	x	x
White water lily (*Nymphaea* sp.)	x	x
Reed grass (*Phragmites* sp.)	x	
Pondweed (*Potamogeton* sp.)	x	x
Arrowhead (*Sagittaria* sp.)	x	x
Bulrush (*Scirpus* sp.)	x	x
Bur reed (*Sparganium* sp.)	x	x
Giant duckweed (*Spirodela* sp.)		x
Cattail (*Typha* sp.)	x	x
Bladderwort (*Utricularia* sp.)		x
Wild rice (*Zizania* sp.)	x	x

TABLE IV-29
DOMINANT AQUATIC MACROPHYTE SPECIES COLLECTED - MISSISSIPPI RIVER NEAR CLAY BOSWELL STEAM ELECTRIC STATION
316(a) DEMONSTRATION STUDY

Zone	Date	Species common name
Upstream Control	August 27, 1975	wild rice arrowhead
	June 2, 1976	coontail wild rice
	August 13, 1976	wild rice arrowhead
Immediate Discharge	August 27, 1975	arrowhead white water lily
	June 2, 1976	arrowhead white water lily coontail
	August 13, 1976	arrowhead white water lily
Intermediate Discharge	August 27, 1975	coontail wild rice star duckweed
	June 2, 1976	wild rice star duckweed
	August 13, 1976	arrowhead wild rice
Downstream Recovery	August 27, 1975	arrowhead bladderwort wild rice
	June 2, 1976	wild rice bladderwort
	August 13, 1976	arrowhead (no wild rice)

Lotic zooplankton populations are almost always dominated by rotifers, primarily because of their ability to withstand abrasion and turbulence normally associated with flowing water habitats. Crustaceans (primarily copepods and cladocerans) are usually found in small numbers and are commonly members of the genus *Cyclops* (Copepoda) and *Vosmina* (Cladocera) although *Alona*, *Chydorus*, and *Diaptomus* are also frequently encountered (77). During this study, *Daphnia* , *Ceriodaphnia*, *Moina*, and *Pleuroxis* were found in addition to these genera more typical of river systems and this may be indicative of the contribution of zooplankton from several tributary lakes and the overall lacustrine nature of the region.

TABLE IV-30
SUMMARY OF ZOOPLANKTON POPULATION
5 SAMPLING STATIONS NEAR CLAY BOSWELL STEAM ELECTRIC STATION

Determination	Sampling Stations				
	Upstream	Intake	Discharge	Intermediate Discharge	Downstream
September 3, 1975					
Total number[a]	4.6	16.7	10.4	7.3	5.6
Association[b]	Nauplii larvae and *Synchaeta* sp.				
% Rotifera[c]	29.0	76.0	43.0	46.0	42.0
% Copepoda[c]	15.0	5.0	15.0	14.0	11.0
% Nauplii[c]	33.0	14.0	24.0	27.0	28.0
% Cladocera[c]	21.0	4.0	17.0	11.0	15.0
% Others[c]	2.0	1.0	1.0	2.0	4.0
Diversity[d]	2.48	1.96	2.50	2.65	2.68
Number of species	35	33	32	35	38

ANOVA:[e] Total Count - $\mu_2 > \mu_3 = \mu_4 = \mu_5 = \mu_1$
Rotifera - $\mu_2 > \mu_3 = \mu_4 = \mu_5 = \mu_1$
Synchaeta sp. - $\mu_2 > \mu_3 = \mu_4 = \mu_5 = \mu_1$
Nauplii larvae - $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$

Determination	Sampling Stations				
	Upstream	Intake	Discharge	Intermediate Discharge	Downstream
October 1, 1975					
Total number[a]	2.4	7.4	53.0	3.2	11.1
Association[b]	*Keratella cochlearis*, Nauplii larvae, and unidentified rotifer				
% Rotifera[c]	57.0	78.0	89.0	52.0	63.0
% Copepoda[c]	11.0	6.0	3.0	13.0	14.0
% Nauplii[c]	24.0	11.0	2.0	24.0	16.0
% Cladocera[c]	8.0	5.0	6.0	10.0	7.0
% Others[c]	0.0	0.0	0.0	1.0	0.0
Diversity[d]	2.30	2.10	1.18	2.63	2.47
Number of species	45	39	36	45	41

ANOVA:[e] Total Count - $\mu_3 > \mu_5 = \mu_2 = \mu_4 = \mu_1$
Rotifera - $\mu_2 > \mu_5 = \mu_2 = \mu_4 = \mu_1$
Keratella cochlearis - $\mu_3 > \mu_2 = \mu_5 = \mu_4 = \mu_1$
Nauplii larvae - $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$

TABLE IV-30 (continued)
SUMMARY OF ZOOPLANKTON POPULATION
5 SAMPLING STATIONS NEAR CLAY BOSWELL STEAM ELECTRIC STATION

Determination	Sampling Stations				
	Upstream	Intake	Discharge	Intermediate Discharge	Downstream
December 4, 1975					
Total number[a]		19.0	108.8	76.1	60.9
Association[b]		*Keratella cochlearis* and *K. earlinae*			
% Rotifera[c]		66.0	94.0	89.0	90.0
% Copepoda[c]		13.0	1.0	3.0	4.0
% Nauplii[c]		11.0	3.0	3.0	3.0
% Cladocera[c]		10.0	2.0	5.0	3.0
% Others[c]		0.0	0.0	0.0	0.0
Diversity[d]		2.17	1.17	1.52	1.42
Number of species		24	20	21	23

ANOVA:[e] Total Count - $\mu_3 > \mu_4 = \mu_5 > \mu_2$

Rotifera - $\mu_3 > \mu_4 = \mu_5 > \mu_2$

Keratella cochlearis - $\mu_3 > \mu_4 > \mu_5 = \mu_2$

Nauplii larvae - $\mu_2 = \mu_3 = \mu_4 = \mu_5$

Determination	Sampling Stations				
	Upstream	Intake	Discharge	Intermediate Discharge	Downstream
February 9, 1976					
Total number[a]		132.7	4.9	21.4	
Association[b]		Nauplii larvae and *Keratella earlinae*			
% Rotifera[c]		53.0	66.0	67.0	
% Copepoda[c]		8.0	13.0	18.0	
% Nauplii[c]		36.0	19.0	12.0	
% Cladocera[c]		3.0	2.0	3.0	
% Others[c]		0.0	0.0	0.0	
Diversity[d]		2.22	2.11	2.18	
Number of species		29	24	27	

ANOVA:[e] Total Count - $\mu_2 = \mu_4 > \mu_3$

Rotifera - $\mu_2 = \mu_3 = \mu_4$

Nauplii larvae - $\mu_2 = \mu_3 = \mu_4$

Keratella earlinae - $\mu_2 = \mu_3 = \mu_4$

TABLE IV-30 (continued)
SUMMARY OF ZOOPLANKTON POPULATION
5 SAMPLING STATIONS NEAR CLAY BOSWELL STEAM ELECTRIC STATION

Determination	Sampling Stations: Upstream	Intake	Discharge	Intermediate Discharge	Downstream
April 12, 1976					
Total number[a]	11.2	19.0	17.9	20.3	13.2
Association[b]	Nauplii larvae and *Keratella earlinae*				
% Rotifera[c]	53.0	51.0	59.0	49.0	44.0
% Copepoda[c]	11.0	13.0	8.0	15.0	16.0
% Nauplii[c]	35.0	32.0	28.0	30.0	35.0
% Cladocera[c]	1.0	2.0	4.0	4.0	3.0
% Others[c]	0.0	2.0	1.0	2.0	2.0
Diversity[d]	2.25	2.38	2.40	2.53	2.38
Number of species	27	36	32	36	37

ANOVA:[e] Total Count - $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$

Rotifera - $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$

Nauplii larvae - $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$

Keratella earlinae - $\mu_3 = \mu_2 > \mu_4 = \mu_5 = \mu_1$

Determination	Sampling Stations: Upstream	Intake	Discharge	Intermediate Discharge	Downstream
May 10, 1976					
Total number[a]	30.3	83.0	63.9	101.7	131.7
Association[b]	Nauplii larvae and *Keratella earlinae*				
% Rotifera[c]	44.0	49.0	59.0	68.0	73.0
% Copepoda[c]	9.0	13.0	8.0	7.0	5.0
% Nauplii[c]	45.0	37.0	28.0	23.0	20.0
% Cladocera[c]	2.0	1.0	4.0	2.0	1.0
% Others[c]	0.0	0.0	1.0	0.0	1.0
Diversity[d]	2.01	2.01	2.27	2.29	2.17
Number of species	32	27	31	29	23

ANOVA:[e] Total Count - $\mu_5 > \mu_3 > \mu_2 > \mu_4 > \mu_1$

Rotifera - $\mu_5 > \mu_4 > \mu_2 = \mu_3 = \mu_1$

Nauplii larvae - $\mu_2 = \mu_5 = \mu_4 > \mu_3 = \mu_1$

Keratella earlinae - $\mu_5 > \mu_4 = \mu_2 = \mu_3 > \mu_1$

TABLE IV-30 (continued)
SUMMARY OF ZOOPLANKTON POPULATION
5 SAMPLING STATIONS NEAR CLAY BOSWELL STEAM ELECTRIC STATION

Determination	Sampling Stations				
	Upstream	Intake	Discharge	Intermediate Discharge	Downstream
June 20, 1976					
Total number[a]	15.3	47.9	55.3	58.6	53.4
Association[b]	Nauplii larvae, *Keratella earlinae*, and *K. cochlearis*				
% Rotifera[c]	22.0	59.0	52.0	75.0	80.0
% Copepoda[c]	9.0	4.0	6.0	2.0	1.0
% Nauplii[c]	35.0	25.0	23.0	17.0	15.0
% Cladocera[c]	34.0	12.0	19.0	6.0	3.0
% Others[c]	0.0	0.0	0.0	0.0	1.0
Diversity[d]	1.91	2.10	2.11	2.01	1.79
Number of species	28	24	27	27	25

ANOVA:[e] Total count - $\mu_4 = \mu_3 = \mu_5 = \mu_2 > \mu_1$

Rotifera - $\mu_4 = \mu_5 = \mu_3 = \mu_2 > \mu_1$

Keratella cochlearis - $\mu_5 = \mu_3 = \mu_4 = \mu_2 > \mu_1$

K. earlinae - $\mu_5 = \mu_4 > \mu_2 = \mu_3 > \mu_1$

Nauplii larvae - $\mu_3 = \mu_2 = \mu_4 = \mu_5 > \mu_1$

Determination	Sampling Stations				
	Upstream	Intake	Discharge	Intermediate Discharge	Downstream
July 15, 1976					
Total number[a]	76.0	51.2	57.9	83.7	79.5
Association[b]	Unidentified rotifer and *Keratella cochlearis*				
% Rotifera[c]	58.0	69.0	66.0	70.0	71.0
% Copepoda[c]	5.0	7.0	6.0	7.0	5.0
% Nauplii[c]	11.0	16.0	12.0	14.0	13.0
% Cladocera[c]	25.0	8.0	15.0	9.0	11.0
% Others[c]	1.0	0.0	1.0	0.0	0.0
Diversity[d]	2.13	2.22	2.13	2.19	2.14
Number of species	33	35	35	36	34

ANOVA:[e] Total Count - $\mu_4 = \mu_5 = \mu_1 > \mu_3 = \mu_2$

Rotifera - $\mu_4 = \mu_5 > \mu_1 > \mu_3 = \mu_2$

Keratella cochlearis - $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$

Unidentified rotifera - $\mu_5 = \mu_4 > \mu_3 = \mu_1 = \mu_2$

TABLE IV-30 (continued)
SUMMARY OF ZOOPLANKTON POPULATION
5 SAMPLING STATIONS NEAR CLAY BOSWELL STEAM ELECTRIC STATION

Determination	Sampling Stations				
	Upstream	Intake	Discharge	Intermediate Discharge	Downstream
August 17, 1976					
Total number[a]	73.1	46.0	27.7	44.9	25.1
Association[b]	Nauplii larvae, *Eubosmina coregoni*, and *Keratella cochlearis*				
% Rotifera[c]	48.0	39.0	29.0	22.0	15.0
% Copepoda[c]	6.0	14.0	17.0	17.0	24.0
% Nauplii[c]	12.0	32.0	38.0	39.0	54.0
% Cladocera[c]	34.0	15.0	16.0	18.0	6.0
% Others[c]	0.0	0.0	0.0	4.0	1.0
Diversity[d]	2.20	2.25	2.23	2.18	1.83
Number of species	27	28	31	34	32

ANOVA:[e] Total Count - $\mu_1 > \mu_2 = \mu_4 > \mu_3 = \mu_5$
Rotifera - $\mu_1 > \mu_2 = \mu_4 = \mu_3 = \mu_5$
Nauplii larvae - $\mu_4 > \mu_2 = \mu_5 = \mu_3 = \mu_1$
Eubosmina coregoni - $\mu_1 > \mu_4 = \mu_2 = \mu_3 > \mu_5$

[a] Total number is the average of the total abundance of organisms in 3 samples, expressed as organisms per liter.

[b] Association refers to the dominant species or group of Zooplankton on the sampling date.

[c] % refers to percent composition of total number.

[d] Diversity refers to the Shannon-Weaver Index, a method of calculating the ecological diversity of an aquatic community where smaller numbers indicate lesser diversity.

[e] ANOVA refers to a statistical analysis of variance summary where μ represents the true mean of the population at the sampling station; = indicates no significant difference; < or > indicates significantly less-than or greater-than differences between the means; and subscripts refer to sampling locations in order of occurence upstream to downstream, e.g. μ_1 is the true mean of the population at the upstream station.

In general, rotifers (primarily *Keratella*) were the dominant group throughout the study and Nauplii larvae (immature copepods) were the most common non-rotifer (Table IV-30 and Figure IV-29).

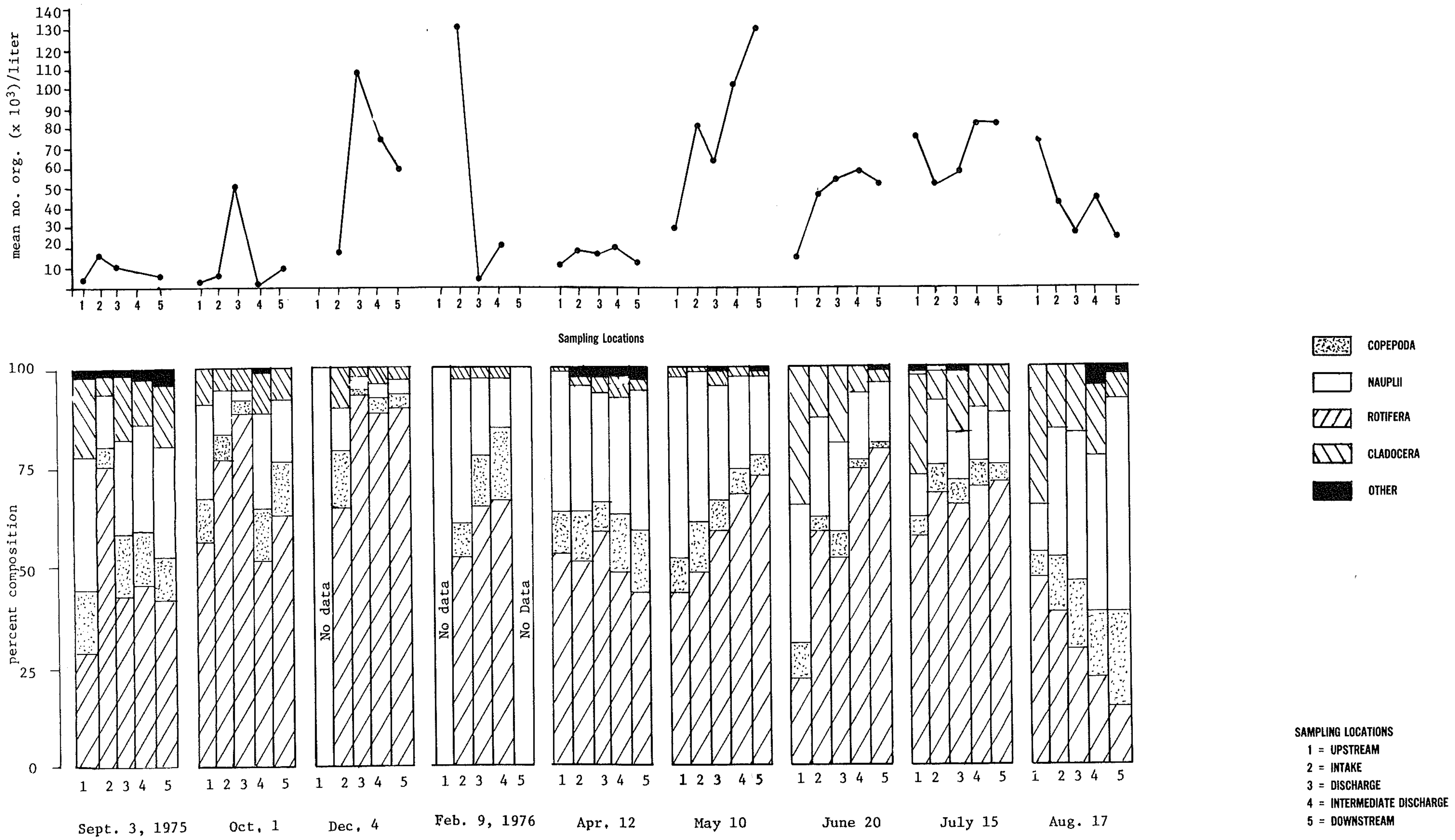
All species ranged from a low of less than 10 organisms per liter (several zones, several dates) to over 130 organisms per liter (several zones, several dates), which is within normal range for most large rivers, approximately average for most headwaters, but low for lower reaches and for zooplankton communities in general. Normal seasonal variation in abundance was evident with the cold-month samples containing fewer plankters than in warmer months.

On an annual basis, no significant difference (p=.05) was found between zones, all dates and zones considered.

The generally similar population densities observed throughout the study suggest that the chemical constituents in the river around the Clay Boswell Station are neither enhancing or inhibiting production, or that other factors are compensating for a change in production that may be occurring in these zones.

TABLE IV-31
SUMMARY OF COLLECTED ZOOPLANKTON SPECIES - CLAY BOSWELL STEAM ELECTRIC STATION
September 3, 1975 to August 17, 1976

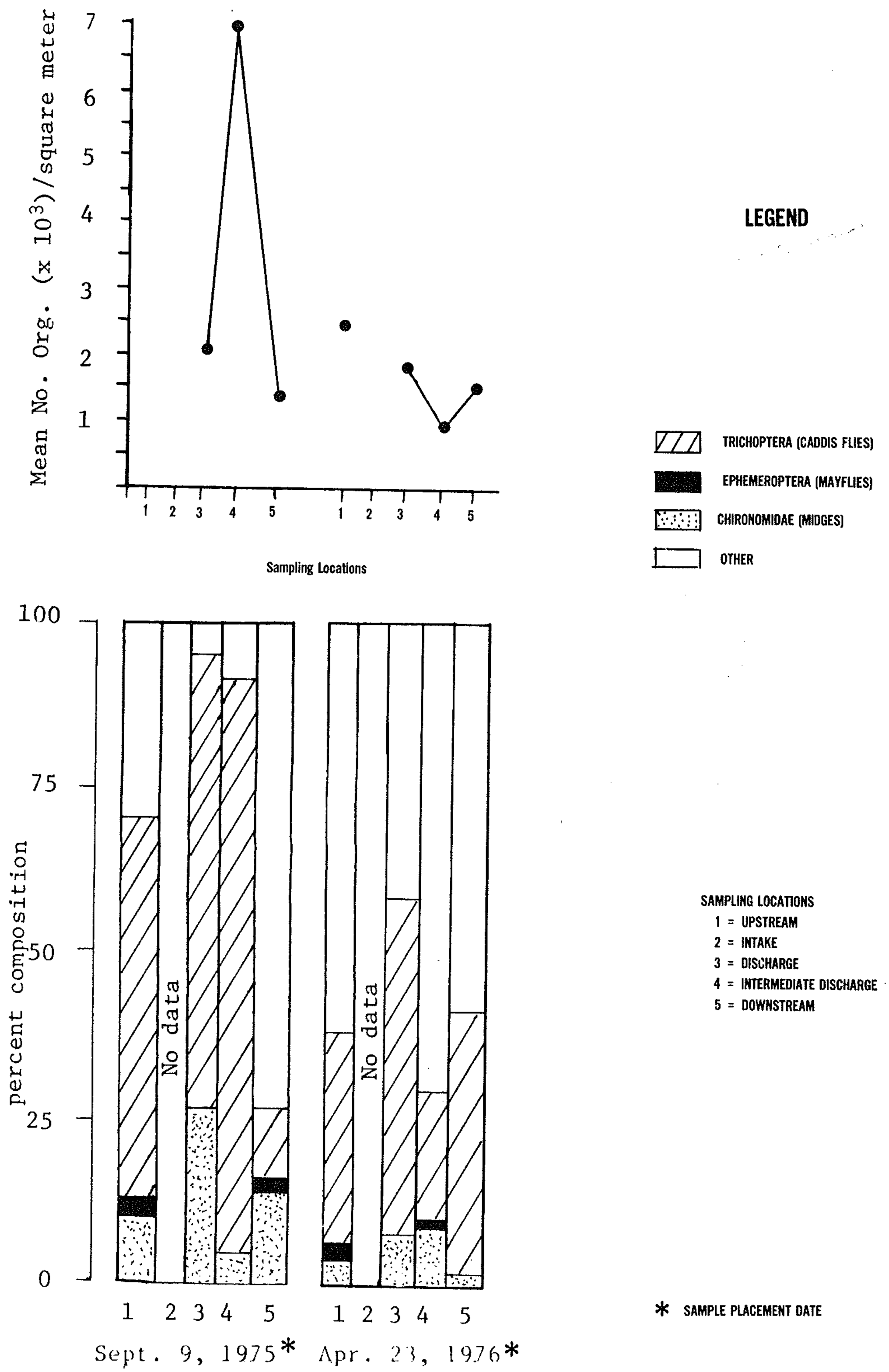
Species	Species	Species
Alona costata	*Dipleuchlanis propatula*	Nauplii larvae
Alona sp.	*Diplois* sp.	*Notholca acuminata*
Asplanchna sp.	Diptera larvae	*Notholca labis*
Bosmina longirostris	*Eubosmina coregoni*	*Notholca limnetica*
Brachionus angularis	*Euchlanis dilatata*	*Notholca squamula*
Brachionus calyciflorus	*Euchlanis* sp.	*Notholca* sp.
Brachionus capsuliflorus	*Eucyclops agilis*	Ostracoda
Brachionus quadridentatus	*Eucyclops* sp.	*Paracyclops* sp.
Brachionus sp.	*Eurycercus lamellatus*	*Platyias patulus*
Calanoid copepod	*Filinia longiseta*	*Platyias quadricornis*
Calanoid copepodid	*Graptoleberis testudinaria*	*Pleuroxis denticulatus*
Calanoid nauplii	Harpacticoid copepod	*Pleuroxis procurvus*
Camptocercus rectirostris	*Hexarthra* sp.	*Pleuroxis* sp.
Canthocamptus sp.	Hydracarina	*Ploesoma* sp.
Cephalodella sp.	*Illyocryptus* sp.	*Polyarthra* sp.
Ceriodaphnia sp.	*Kellicottia Bostoniensis*	*Polyphemus pediculus*
Chydorus sphaericus	*Kellicottia longispina*	*Polyphemus* sp.
Chydorus sp.	*Keratella cochlearis*	*Rotaria neptunia*
Cladoceran, immature	*Keratella crassa*	*Scapholeberis* sp.
Cladoceran, unidentified	*Keratella earlinae*	*Synchaeta* sp.
Collotheca pelagica	*Keratella quadrata*	*Testudinella* sp.
Collotheca sp.	*Keratella serrulata*	*Trichocerca capucina*
Conochiloides sp.	*Lecane leontina*	*Trichocerca cylindrica*
Conochilus hippocrepis	*Lecane* sp.	*Trichocerca elongota*
Conochilus unicornis	*Lepadella* sp.	*Trichocerca longiseta*
Conochilus sp.	*Leptodora kindii*	*Trichocerca multicrinis*
Cyclopoid copepod	*Manfredium* sp.	*Trichocerca porcellus*
Cyclopoid copepodid	*Moina* sp.	*Trichocerca* sp.
Cyclops bicuspidatus thomasi	*Monostyla bulla*	*Trichotria tetractis*
Cyclops vernalis	*Monostyla lunaris*	*Trichotria* sp.
Cyclops sp.	*Monostyla quadridentata*	*Tropocyclops prasinus*
Daphnia longispina	*Monostyla* sp.	Unid bdelloid rotifer
Daphnia sp.	*Mytilina* sp.	Unid rotifer
Diaptomus sp.		



PERCENT COMPOSITION BY MAJOR GROUPS AND TOTAL ABUNDANCE (ALL GROUPS) - ZOOPLANKTON POPULATIONS SAMPLED AT SURFACE DURING 1975-1976 - NEAR CLAY BOSWELL STEAM ELECTRIC STATION

(SOURCE: WAPORA, INC., WASHINGTON, D.C., STATISTICAL DATA TRANSMITTED TO MICHAEL BAKER, JR., INC. ON MARCH 21, 1977)

FIGURE IV-29



PERCENT COMPOSITION BY MAJOR GROUPS AND TOTAL ABUNDANCE (ALL GROUPS) - HESTER - DENDY MACROINVERTIBRATE POPULATIONS FROM TWO EXPOSURE PERIODS DURING 1975-1976 - NEAR CLAY BOSWELL STEAM ELECTRIC STATION

(SOURCE: WAPORA, INC., WASHINGTON, D.C., STATISTICAL DATA TRANSMITTED TO MICHAEL BAKER, JR., INC. ON MARCH 21, 1977)

FIGURE IV-30

Overall, the zooplankton populations in this stretch of the river exhibit characteristics common to normal plankton populations. Erratic and sudden changes in density, but predictable seasonal fluctuations as observed here, are considered normal to populations in flowing water habitats. Undoubtedly, the populations in the vicinity of the Clay Boswell Station are influenced by the various tributary lakes and rivers adjacent to the area, and much of the variation between dates and zones observed in this study could result, in a large part, from these influences.

Macroinvertebrates. A total of 107 taxa of macroinvertebrates were found in the vicinity of the Clay Boswell Station. Figure IV-30 is a graphic summary of abundance and percent composition (of major groups) for 2 exposure periods. A complete species list, number of organisms per square meter, and percent composition, for each exposure period appears in Table IV-32. A complete species list appears in Table IV-33.

Generally, ponar dredge samples taken from the bottom of the river showed species composition to be similar throughout the study area. Bottom samples from the immediate discharge area were slightly higher in percentages of tubifid worms than the other areas. This is primarily due to the larger percentages of silt in the substratum of this area.

No significant difference in total abundance of organisms of multiplate samplers was found between the immediate discharge and the unaffected areas. Lower numbers of several groups were found in the immediate discharge; however, with exception of *Hyallella azteca* , an amphipod, these organisms were not found to be particularly abundant in any area. Caddis flies were the most abundant organisms on the artificial substrate samplers and numbers of this group were similar between the immediate discharge and upstream control zones.

Diversity indices were also generally similar between the immediate discharge and upstream control areas, while seasonal fluctuations occurred in the other zones.

The data showed a wide variety of macroinvertebrate species present, some in very high densities. These densities reflect seasonal trends which also occur in natural populations. The data indicate that substrate habitat is probably the most important factor controlling numbers and taxa of benthic organisms. The thermal discharge, as well as river flow patterns, may be responsible for the distribution of organisms collected by artificial substrate samplers.

Fisheries. The species of fishes found in the vicinity of the Clay Boswell Station are essentially warm water fishes with the exception of the coregonids (lake whitefish, *Coregonus Clupeaformis*, and the cisco herring *Coregonus artedii*). A comprehensive species list of fishes known to inhabit the Mississippi River either in its upper reaches or in the vicinity of the Clay Boswell Station is presented in Table IV-34. The list has been compiled from

TABLE IV-32
MACROINVERTEBRATE SPECIES ABUNDANCE - MISSISSIPPI RIVER NEAR CLAY BOSWELL STEAM ELECTRIC STATION
September 9, 1975 and April 23, 1976

Taxa[a]	Sampling Stations: Upstream Control no. per sq m	%[b]	Immediate Discharge no. per sq m	%[b]	Intermediate Discharge no. per sq m	%[b]	Downstream Recovery no. per sq m	%[b]
September 9, 1975								
(P) Coelenterata (hydroids and jellyfish)								
Hydra sp.					7.2	.1		
(P) Platyhelminthes (flatworms)								
(C) Turbellaria (planarians)	32.3	1.1			7.2	.1	68.1	4.5
(P) Annelida (segmented worms)								
(C) Hirudinea (leeches)								
(F) Erpobdellidae	25.1	.8						
Glossiphonia complanata							3.6	.2
(P) Arthropoda								
(C) Crustacea								
(O) Amphipoda (scuds)								
Gammarus fasciatus					7.2	.1		
Hyalella azteca	810.6	26.5	75.3	3.6	606.1	8.6	921.8	60.5
(C) Insecta								
(O) Collembola (springtails)								
Isotomurus sp.			3.6	.2				
(O) Diptera (except chironomidae)								
(F) Ceratopogonidae								
			3.6	.2				
(F) Chaoboridae								
Chaoborus sp.			3.6	.2			3.6	.2
(F) Simuliidae	17.9	.6						
(O) Diptera (chironomidae)								
(T) Chironomini								
Dicrotendipes sp.	7.2	.2	17.9	.9			14.3	.9
Endochironomus sp.	68.1	2.2	308.5	14.6	104.0	1.5	7.2	.5
Glyptotendipes sp.					14.3	.2		
Microtendipes sp.	21.5	.7			25.1	.4	71.7	4.7
Polypedilum sp.					3.6	.1		
Pseudochironomus sp.			3.6	.2			10.8	.7
Tribelos sp.			3.6	.2	7.2	.1		

TABLE IV-32 (continued)

MACROINVERTEBRATE SPECIES ABUNDANCE - MISSISSIPPI RIVER NEAR CLAY BOSWELL STEAM ELECTRIC STATION

September 9, 1975 and April 23, 1976

Taxa[a]	Sampling Stations							
	Upstream Control		Immediate Discharge		Intermediate Discharge		Downstream Recovery	
	no. per sq m	% [b]	no. per sq m	% [b]	no. per sq m	% [b]	no. per sq m	% [b]
September 9, 1975 (continued)								
(T) Tanytarsini								
Cladotanytarsus sp.	10.8	.4	25.1	1.2	7.2	.1	7.2	.5
Micropsectra sp.					7.2	.1	14.3	.9
Paratanytarsus sp.	53.8	1.8	7.2	.3			17.9	1.2
Rheotanytarsus sp.	61.0	2.0			7.2	.1	14.3	.9
(SF) Orthocladiinae								
Cricotopus sp.	7.2	.2						
Corynoneura sp.							10.8	.7
Orthocladius sp.			39.5	1.9	17.9	.3		
Thienemanniella sp.	39.5	1.3					7.2	.5
(T) Coelotanypodini								
Clinotanypus sp.							17.9	1.2
(T) Pentaneurini								
Ablabesmyia sp.					35.9	.5		
Thienemannimyia sp.	28.7	.9	154.2	7.3	78.9	1.1	32.3	2.1
(O) Ephemeroptera (mayflies)								
(F) Baetidae								
Baetis sp.	46.6	1.5						
(F) Ephemerellidae								
Ephemerella sp.	3.6	.1					3.6	.2
(F) Heptageniidae								
Stenonema sp.	7.2	.2	3.6	.2			3.6	.2
Leptophlebia sp.	21.5	.7					17.9	1.2
(O) Lepidoptera (moths)								
Nymphula sp.			3.6	.2			7.2	.5
(O) Odonata (damselflies)								
(F) Coenagrionidae								
Enallagma sp.	3.6	.1	7.2	.3	7.2	.1	64.6	4.2
(O) Trichoptera (caddisflies)								
Trichoptera, pupae	10.8	.4						

TABLE IV-32 (continued)
MACROINVERTEBRATE SPECIES ABUNDANCE - MISSISSIPPI RIVER NEAR CLAY BOSWELL STEAM ELECTRIC STATION
September 9, 1975 and April 23, 1976

	Sampling Stations							
	Upstream Control		Immediate Discharge		Intermediate Discharge		Downstream Recovery	
Taxa[a]	no. per sq m	% [b]	no. per sq m	% [b]	no. per sq m	% [b]	no. per sq m	% [b]
September 9, 1975 (continued)								
(F) Hydropsychidae	139.9	4.6						
Cheumatopsyche sp.	1,553.0	50.8	154.2	7.3	297.7	4.2	71.7	4.7
Hydropsyche sp.	3.6	.1						
Hydropsyche frisoni	25.1	.8	28.7	1.4	7.2	.1		
Hydropsyche orris	3.6	.1	3.6	.2				
(F) Hydroptilidae	3.6	.1	3.6	.2	10.8	.2		
Agraylea sp.	17.9	.6	25.1	1.2	3.6	.1		
(F) Leptoceridae								
Oecetis sp.			10.8	.5	43.0	.6	14.3	.9
(F) Psychomyiidae			32.3	1.5	154.2	2.2	7.2	.5
Neureclipsis sp.	25.1	.8	1,169.3	55.4	5,570.1	78.9	50.2	3.3
Polycentropus sp.			21.5	1.0	28.7	.4	14.3	.9
(P) Mollusca								
(C) Gastropoda (snails)								
(F) Ancylidae								
Ferrissia sp.	7.2	.2					7.2	.5
(F) Lymnaeidae								
Lymnaea sp.							3.6	.2
(F) Physidae								
Physa sp.							10.8	.7
(F) Amnicolidae								
Amnicola sp.							3.6	.2
(C) Pelecypoda (clams)								
(O) Heterodonta (fingernail clams)								
(F) Sphaeriidae								
Sphaerium sp.							21.5	1.4

TABLE IV-32 (continued)
MACROINVERTEBRATE SPECIES ABUNDANCE - MISSISSIPPI RIVER NEAR CLAY BOSWELL STEAM ELECTRIC STATION
September 9, 1975 and April 23, 1976

	Sampling Stations							
	Upstream Control		Immediate Discharge		Intermediate Discharge		Downstream Recovery	
Taxa[a]	no. per sq m	%[b]	no. per sq m	%[b]	no. per sq m	%[b]	no. per sq m	%[b]
September 9, 1975 (continued)								
Total number of organisms	852		588		1,968		425	
Mean number organisms per sq m	3,055.8		2,109.0		7,058.6		1,524.3	
Total number of taxa	28		24		24		31	
Number of replicates	3		3		3		3	
Shannon-Weaver Diversity Index[c]	1.67		1.66		.94		1.84	
April 23, 1976								
(P) Porifera (sponges)								
(F) Spongillidae	28.7	1.2	7.2	.4	25.1	2.9	26.9	1.7
(P) Coelenterata (hydroids and jellyfish)								
Hydra sp.			7.2	.4				
(P) Platyhelminthes (flatworms)								
(C) Turbellaria (planarians)	1,144.1	46.6	695.8	35.1	218.8	25.2	328.2	21.0
(P) Bryozoa (moss animals)								
Cristatella sp.			32.3	1.6			5.4	.3
(P) Annelida (segmented worms)								
(C) Hirudinea (leeches)								
(F) Erpobdellidae	10.8	.4					16.1	1.0
(C) Oligochaeta (aquatic earthworms)								
(F) Lumbriculidae			3.6	.2				
(P) Arthropoda								
(C) Crustacea								
(O) Amphipoda (scuds)								
Hyalella azteca	283.3	11.5	57.4	2.9	254.7	29.3	462.7	29.6
(C) Insecta								
(O) Coleoptera (beetles)								
(F) Elmidae								
Elmidae, adult	10.8	.4						
Stenelmis sp.	10.8	.4			3.6	.4	5.4	.3

TABLE IV-32 (continued)
MACROINVERTEBRATE SPECIES ABUNDANCE - MISSISSIPPI RIVER NEAR CLAY BOSWELL STEAM ELECTRIC STATION
September 9, 1975 and April 23, 1976

Taxa	Sampling Stations							
	Upstream Control		Immediate Discharge		Intermediate Discharge		Downstream Recovery	
	no. per sq m	%[b]	no. per sq m	%[b]	no. per sq m	%[b]	no. per sq m	%[b]
April 23, 1976 (continued)								
(F) Gyrinidae								
Dineutus sp.					10.8	1.2		
(O) Diptera (except chrionomidae)								
(F) Ceratopogonidae								
Palpomyia sp.					14.3	1.7		
(F) Simuliidae			3.6	.2				
(O) Diptera (chironomidae)								
Chrionomidae, pupae			7.2	.4				
(SF) Chrionominae								
(T) Chrionomini								
Endochironomus sp.			118.4	6.0	14.3	1.7	5.4	.3
Glyptotendipes sp.			3.6	.2	7.2	.8		
Microtendipes sp.			3.6	.2	14.3	1.7		
Parachironomus sp.			3.6	.2	3.6	.4	10.8	.7
Polypedilum sp.	3.6	.1	10.8	.5			5.4	.3
(T) Tanytarsini								
Micropsectra sp.			7.2	.4				
Tanytarsus sp.			3.6	.2				
(SF) Orthocladiinae								
Corynoneura sp.	3.6	.1						
Thienemanniella sp.			3.6	.2				
(T) Pentaneurini								
Thienemannimyia sp.	104.0	4.2			39.5	4.5	16.1	1.0
(O) Ephemeroptera (mayflies)								
(F) Caenidae								
Caenis sp.					3.6	.4		
(F) Heptageniidae								
Stenonema sp.	35.9	1.5	3.6	.2	3.6	.4	5.4	.3
(O) Odonata (damselflies)								
(F) Coenagrionidae								
Enallagma sp.	39.5	1.6			50.2	5.8	53.8	3.4

TABLE IV-32 (continued)
MACROINVERTEBRATE SPECIES ABUNDANCE - MISSISSIPPI RIVER NEAR CLAY BOSWELL STEAM ELECTRIC STATION
September 9, 1975 and April 23, 1976

	Sampling Stations							
	Upstream Control		Immediate Discharge		Intermediate Discharge		Downstream Recovery	
Taxa[a]	no. per sq m	%[b]	no. per sq m	%[b]	no. per sq. m	%[b]	no. per sq. m	%[b]
April 23, 1976 (continued)								
(O) Trichoptera (caddisflies)								
(F) Hydropsychidae								
Cheumatopsyche sp.	412.5	16.8	731.7	37.0			290.5	18.6
Cheumatopsyche, pupae	96.8	3.9	25.1	1.3			134.5	8.6
Hydropsyche frisoni	7.2	.3						
Hydropsyche orris			3.6	.2				
(F) Leptoceridae								
Athripsodes sp.	3.6	.1						
Oecetis sp.	10.8	.4			14.3	1.7	26.9	1.7
Ocetis, pupae	10.8	.4	3.6	.2	35.9	4.1	48.4	3.1
(F) Limnephilidae								
Limnephilus sp.	3.6	.1						
(F) Psychomyiidae								
Neureclipsis sp.	182.9	7.4	186.5	9.4	21.5	2.5	86.1	5.5
Neureclipsis, pupae	21.5	.9	46.6	2.4			5.4	.3
Polycentropus sp.	21.5	.9			28.7	3.3	21.5	1.4
Polycentropus, pupae	7.2	.3			61.0	7.0		
(P) Mollusca								
(C) Gastropoda (snails)								
(F) Physidae								
Physa sp.			10.8	.5	3.6	.4		
(F) Amnicolidae								
Amnicola sp.	3.6	.1			39.5	4.5		
(C) Pelecypoda (clams)								
(O) Heterodonta (fingernail clams)								
(F) Sphaeriidae								
Sphaerium sp.							10.8	.7
Total number of organisms	685		552		242		291	
Mean number organisms per sq m	2,456.9		1,979.8		868.0		1,565.6	
Total number of taxa	23		24		21		20	
Number of replicates	3		3		3		2	
Shannon-Weaver Diversity Index[c]	1.82		1.69		2.26		2.07	

[a] P = Phylum, C = Class, O = Order, F = Family, SF = Subfamily, T = Tribe.

[b] Organism abundance measured by the Hester-Dendy method. % refers to percentage of all macroinvertebrates collected at that station on that sampling date. Dates are sampler placement dates.

[c] A method of calculating the diversity of an aquatic community where smaller numbers indicate lesser diversity.

TABLE IV-33
LIST OF ALL MACROINVERTEBRATE ORGANISMS COLLECTED - MISSISSIPPI RIVER NEAR
CLAY BOSWELL STEAM ELECTRIC STATION (68)
October 3, 1975 to June 7, 1976

Taxa[a]	Upstream Control	Immediate Discharge	Intermediate Discharge	Downstream Recovery
(P) Porifera (sponges)				
(F) Spongillidae	x	x	x	x
(P) Coelenterata (hydroids and jellyfish)				
Hydra sp.		x	x	
(P) Platyhelminthes (flatworms)				
(C) Turbellaria (planarians)	x	x	x	x
(P) Nematoda (roundworms)	x			x
(P) Bryozoa (moss animals)				
Cristatella sp.		x		x
(P) Annelida (segmented worms)				
(C) Hirudinea (leeches)				
Macrobdella decora	x			
(F) Erpobdellidae	x	x	x	x
Glossiphonia sp.	x		x	
Glossiphonia complanata	x		x	x
Helobdella sp.	x	x	x	x
Helobdella stagnalis	x			x
Placobdella sp.	x	x	x	
Illinobdella sp.			x	
(C) Oligochaeta (aquatic earthworms)				
(F) Naididae				x
(F) Tubificidae	x	x	x	x
(F) Lumbriculidae	x	x	x	x
(P) Arthropoda				
(C) Arachnoidea				
(O) Hydracarina (water mites)				
Arrhenurus	x			
(C) Crustacea				
(O) Amphipoda (scuds)				
Crangonyx sp.			x	
Gammarus fasciatus			x	x
Hyalella azteca	x	x	x	x
(C) Insecta				
(O) Coleoptera (beetles)				
Donacia sp.	x			
(F) Elmidae				
Elmidae, adult	x			
Dubiraphia sp.		x		
Stenelmis sp.	x		x	x
(F) Gyrinidae				
Dineutus sp.			x	
(F) Hydrophilidae				
Berosus sp.		x		x

TABLE IV-33 (continued)
LIST OF ALL MACROINVERTEBRATE ORGANISMS COLLECTED - MISSISSIPPI RIVER NEAR
CLAY BOSWELL STEAM ELECTRIC STATION
October 3, 1975 to June 7, 1976

Taxa[a]	Upstream Control	Immediate Discharge	Intermediate Discharge	Downstream Recovery
(P) Arthropoda (continued)				
(F) Noteridae	x			
(O) Collembola (springtails)				
Isotomurus sp.		x		
(O) Diptera (except chironomidae)				
(F) Ceratopogonidae				
Palpomyia sp.	x	x	x	
(F) Culicidae				
Chaoborus sp.		x		x
(F) Simuliidae	x	x		
(F) Tabanidae	x			
(O) Diptera (chironomidae)				
Chironomidae, pupae	x	x		
(SF) Chironominae				
(T) Chironomini				
Chironomus sp.	x	x	x	x
Cryptochironomus sp.	x	x		
Demicryptochironomus sp.		x		
Dicrotendipes sp.	x	x	x	x
Endochironomus sp.		x	x	x
Glyptotendipes sp.		x	x	
Microtendipes sp.	x	x	x	x
Parachironomus sp.		x	x	x
Polypedilum sp.	x	x	x	x
Pseudochironomus sp.	x	x	x	x
Tribelos sp.		x	x	
(T) Tanytarsini				
Cladotanytarsus sp.	x	x	x	x
Micropsectra sp.		x	x	x
Paratanytarsus sp.	x	x		x
Rheotanytarsus sp.	x	x	x	x
Tanytarsus sp.		x		
(SF) Orthocladiinae				
Cricotopus sp.	x			
Corynoneura sp.	x			x
Orthocladius sp.		x	x	
Thienemanniella sp.	x	x	x	
(T) Coelotanypodini				
Clinotanypus sp.	x	x	x	x
(T) Macropelopini				
Procladius sp.	x	x	x	x
(T) Pentaneurini				
Ablabesmyia sp.	x	x	x	x
Thienemannimyia sp.	x	x	x	x
(T) Tanypodini				
Tanypus sp.		x		
(O) Ephemeroptera (mayflies)				
(F) Baetidae				
Baetis sp.	x		x	x

TABLE IV-33 (continued)
LIST OF ALL MACROINVERTEBRATE ORGANISMS COLLECTED - MISSISSIPPI RIVER NEAR
CLAY BOSWELL STEAM ELECTRIC STATION
October 3, 1975 to June 7, 1976

Taxa[a]	Upstream Control	Immediate Discharge	Intermediate Discharge	Downstream Recovery
(P) Arthropoda (continued				
(F) Caenidae				
Caenis sp.	x	x	x	x
(F) Ephemerellidae				
Ephemerella sp.	x			x
(F) Ephemeridae				
Ephemera sp.	x			
Hexagenia sp.	x	x	x	
(F) Heptageniidae				
Stenonema sp.	x	x	x	x
Leptophlebia sp.	x			x
(O) Hemiptera (water bugs)				
(F) Corixidae				
Cenocorixa sp.	x			
Notonecta sp.			x	
(F) Pleidae				
Plea striola	x			
(O) Lepidoptera (moths)				
Nymphula sp.		x	x	x
(O) Megaloptera (alderflies)				
Sialis sp.		x		
(O) Odonata (dragonflies)				
(F) Gomphidae				
Gomphus sp.		x		
(F) Libellulidae				
Epicordulia sp.				x
Tetragoneura sp.		x	x	
Erythemis sp.	x	x		
Leucorrhinia sp.		x	x	x
Libellula sp.		x	x	x
(O) Odonata (damselflies)				
(F) Coenagrionidae				
Enallagma sp.	x	x	x	x
(O) Trichoptera (caddisflies)				
Trichoptera, pupae	x			
(F) Hydropsychidae				
Cheumatopsyche sp.	x	x	x	x
Cheumatopsyche, pupae	x	x		x
Hydropsyche sp.	x			
Hydropsyche frisoni	x	x	x	
Hydropsyche orris	x	x		
(F) Hydroptilidae				
Agraylea sp.	x	x	x	
Oxyethira sp.	x		x	
(F) Leptoceridae				
Athripsodes sp.	x			
Leptocerus americanus	x	x	x	x
Oecetis sp.	x	x	x	x
Oecetis, pupae	x	x	x	x

TABLE IV-33 (continued)
LIST OF ALL MACROINVERTEBRATE ORGANISMS COLLECTED - MISSISSIPPI RIVER NEAR
CLAY BOSWELL STEAM ELECTRIC STATION
October 3, 1975 to June 7, 1976

Taxa[a]	Upstream Control	Immediate Discharge	Intermediate Discharge	Downstream Recovery
(P) Arthropoda (continued)				
(F) Limnephilidae				
Limnephilus sp.	x			
(F) Molannidae				
Molanna, pupae			x	
(F) Phryganeidae				
Phryganea sp.			x	x
(F) Psychomyiidae				
Neureclipsis sp.	x	x	x	x
Neureclipsis, pupae	x	x		x
Phylocentropus sp.	x		x	x
Polycentropus sp.	x	x	x	x
Polycentropus, pupae	x		x	
(P) Mollusca				
(C) Gastropoda (snails)				
(F) Ancylidae				
Ferrissia sp.	x	x	x	x
(F) Lymnaeidae				
Lymnaea sp.				x
(F) Physidae				
Physa sp.	x	x	x	x
(F) Planorbidae				
Helisoma sp.	x		x	x
(F) Amnicolidae				
Amnicola sp.	x	x	x	x
(C) Pelecypoda (clams)				
(O) Schizodonta (clams)				
(F) Unionidae				
Anodonta imbecilis		x		
Ligumia regia	x			x
(O) Heterodonta (fingernail clams)				
(F) Sphaeriidae				
Pisidium sp.	x	x	x	x
Sphaerium sp.	x	x	x	x
Total number of taxa - 107	68	63	61	74

[a] P = Phylum, C = Class, O = Order, F = Family, SF = Subfamily, T = Tribe.

TABLE IV-34
LIST OF ALL FISH SPECIES CAPTURED - MISSISSIPPI RIVER NEAR CLAY BOSWELL STEAM ELECTRIC STATION
316(a) DEMONSTRATION STUDY
August 1975 to September 1976

Species	Upstream Control	Immediate Discharge	Intermediate Discharge	Downstream Recovery
Amia calva (bowfin)	x	x	x	x
Coregonus artedi (cisco herring)		x	x	
Coregonus clupeaformis (lake whitefish)		x	x	x
Umbra limi (central mudminnow)	x		x	
Esox lucius (northern pike)	x	x	x	x
Notemigonus crysoleucas (golden shiner)	x	x		
Notropis cornutus (common shiner)	x	x		
Notropis heterodon (blackchin shiner)	x	x	x	x
Notropis heterolepis (blacknose shiner)				x
Notropis hudsonius (spottail shiner)	x	x	x	x
Notropis atherinoides (emerald shiner)				x
Pimephales notatus (bluntnose minnow)				x
Catostomus catostomus (longnose sucker)		x		
Catostomus commersoni (white sucker)	x	x	x	x
Hypentelium nigricans (northern hog sucker)			x	
Moxostoma anisurum (silver redhorse)	x	x	x	x
Moxostoma macrolepidotum (shorthead redhorse)	x	x	x	x
Ictalurus melas (black bullhead)	x	x	x	x
Ictalurus natalis (yellow bullhead)	x	x	x	x
Ictalurus nebulosus (brown bullhead)	x	x	x	x
Noturus gyrinus (tadpole madtom)	x			
Lota lota (burbot)	x		x	
Fundulus diaphanus (banded killifish)		x		
Ambloplites rupestris (rock bass)	x	x	x	x
Lepomis gibbosus (pumpkinseed)	x	x	x	x
Lepomis macrochirus (bluegill)	x	x	x	x
Micropterus salmoides (largemouth bass)	x	x	x	x
Pomoxis nigromaculatus (black crappie)	x	x	x	x
Etheostoma exile (Iowa darter)	x	x		x
Etheostoma nigrum (johnny darter)			x	
Perca flavescens (yellow perch)	x	x	x	x
Percina caprodes (logperch)		x		
Stizostedion vitreum vitreum (walleye)	x	x	x	x

the studies on fisheries mentioned earlier in the section. Thirteen species are common to the 5 studies. They are:

1. northern pike *(Esox lucius)*
2. white sucker *(Catostomus commersomi)*
3. black bullhead *(Ictalurus melas)*
4. yellow bullhead *(Ictalurus natalis)*
5. brown bullhead *(Ictalurus nebulosus)*
6. rock bass *(Ambloplites rupestris)*
7. pumpkinseed *(Lepomis gibbosus)*
8. bluegill *(Lepomis macrochirus)*
9. largemouth bass *(Micropterus salmoides)*
10. black crappie *(Pomoxis nigromaculatus)*
11. yellow perch *(Perca flavescens)*
12. walleye *(Stizostedion vitreum vitreum)*
13. bowfish *(Amia calva)*

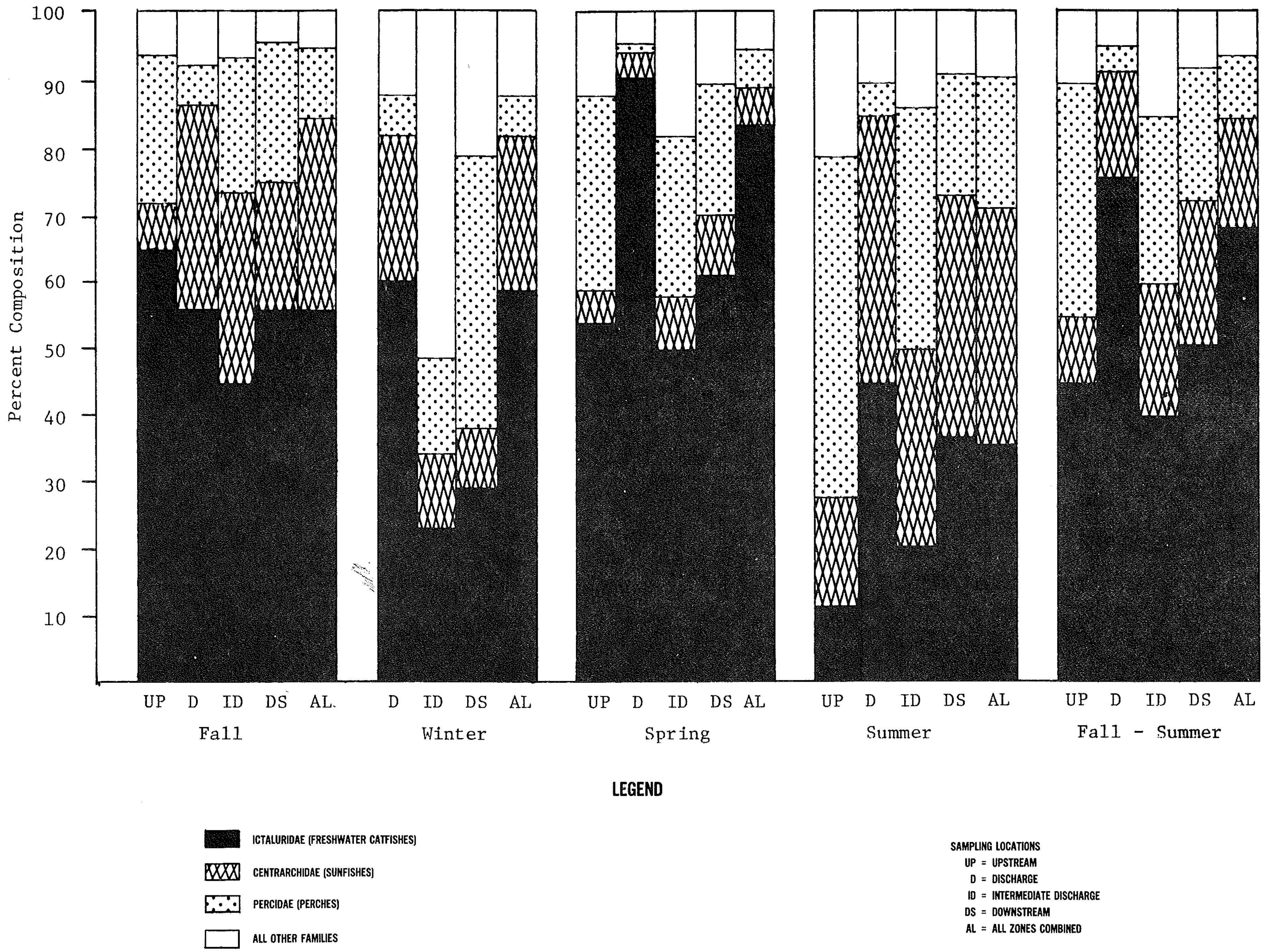
The following discussion is based on data gathered from 5 studies. The 316(b) study, the EPA sponsored University of Minnesota at Duluth Study, 2 studies sponsored by the DNR in 1962 and 1969, and the 316(a) study. However, the 316(a) study is the primary information source. Within the study area, 33 species of fish were collected using various collection devices. Each sampling zone produced 23 to 25 species, showing that fish are well mixed in this section of the river, and are not confined to specific zones. The greatest density of fish was found in the area of immediate discharge for all seasons. Figure IV-31 summarizes in percent composition of total catch by family in each sampling zone for each season from fall 1975 to summer 1976.

Fishes are attracted to the warm water of the discharge zone especially in the fall when temperatures start to drop. During the winter, fishes move away from the discharge zone and probably spend winter in deep areas under the ice. Spring shows a return to the discharge for most species, but it is uncertain if this attraction is based upon feeding, spawning activity, or natural movement. Fishes tend to move away from the discharge zone during the summer, although the catch remained somewhat higher here than in other zones. The dominant species group in the discharge zone as compared to the other zones during the summer was the centrarchids.

Tag and migration studies show that fishes tend to move through the thermal gradient with no apparent effect. Fishes in spawning condition were collected throughout the study area (Table IV-35).

Yellow perch were observed spawning in the discharge area prior to April 15, well before the normal spawning period for this species in Minnesota (71). The 1976 data (Table IV-36) also indicates yellow perch larvae in the discharge shortly after April 15, which agrees with 1975 observations. Earlier hatching of yellow perch larvae give this species a predatory advantage over the more desirable later spawning game fish species.

The sampling program collected fishes from all age classes; young-of-the-year of many species were evident, and scale analysis showed that older fish constituted a major part of the population (Figure IV-32). All zones combined, 77% of all fish were either >15 to 21 cm or >21 to 27 cm in length. The high



PERCENT COMPOSITION BY FAMILIES OF TOTAL FISH COLLECTIONS MADE AT EACH ZONE, AND ALL ZONES COMBINED FOR EACH SEASON - NEAR CLAY BOSWELL STEAM ELECTRIC STATION

(SOURCE: WAPORA, INC., WASHINGTON, D.C., STATISTICAL DATA TRANSMITTED TO MICHAEL BAKER, JR., INC. ON MARCH 25, 1977)

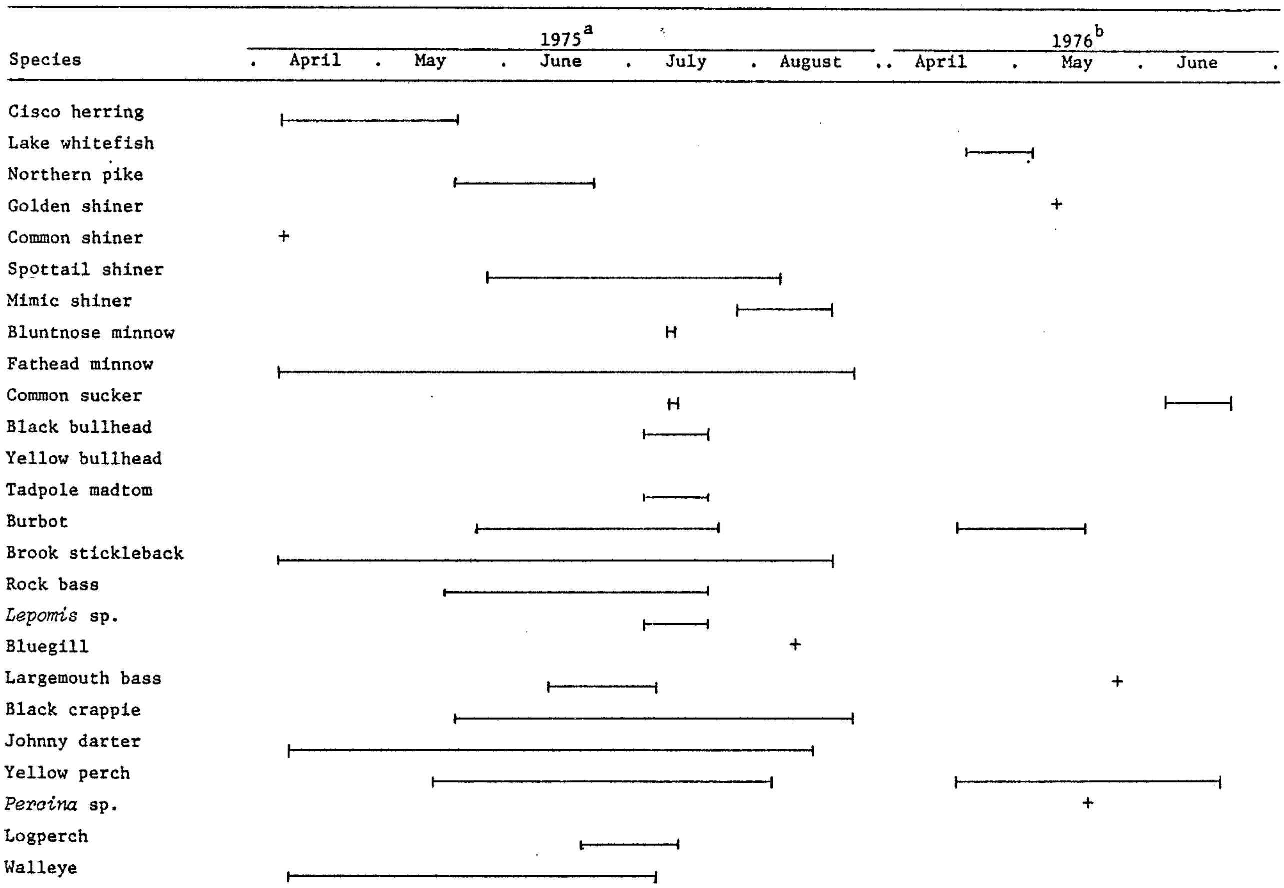
FIGURE IV-31

TABLE IV-35
SPAWNING HABITS AND HABITATS OF COLLECTED FISH - MISSISSIPPI RIVER NEAR CLAY BOSWELL STEAM ELECTRIC STATION
316(a) DEMONSTRATION STUDY

Species	Time	Preferred Water Temperature °C	Preferred Habitat
Ambloplites rupestris (rock bass)	May to June	15.5 to 21	shallow water with aquatic macrophytes
Amia calva (bowfin)	May to early June		aquatic macrophytes with sand or mud bottom
Catostomus commersoni (white sucker)	April to May	dependent upon spring thaw and rainfall	gravel beds in streams or lake margins
Coregonus artedii (cisco herring)	fall	5	shallow water
Coregonus clupeaformis (lake whitefish)	fall approximately November	1 to 2 (4 to 10 in New Hampshire)	gravel beds in 2 to 3 m of water in Red Lake; smooth sand and boulders in 2 to 23 m of water in Lake Superior
Esox lucius (northern pike)	April to May (after ice-off)	5 to 11	flooded, grassy lake and stream margins
Ictalurus nebulosus (brown bullhead)	early April in in southern Minnesota late June in northern Minnesota		sand or mud bottom in less than 1 m of water
Ictalurus melas (black bullhead)	late April to early June	18	sand or mud bottom in less than 1 m of water
Ictalurus natalis (yellow bullhead)	May to June	same as *I. nebulosus*	sand or mud bottom in less than 1 m of water
Lepomis gibbosus (pumpkinseed)	May to June		water 1 to 2 m deep with sandy bottom
Lepomis macrochirus (bluegill)	end of May to early July		bays with water 1 to 2 m deep and sandy bottom
Lepomis humilis (orangespotted sunfish)	usually May to June sometimes July		shallow waters with sandy bottom
Lota lota (burbot)	midwinter (December to January)		shallow water in lakes with sandy or rocky bottoms, streams
Micropterus salmoides (largemouth bass)	May to July	16	water 1 to 2 m deep with bottom consisting of sand or decaying vegetation; some mud bottoms tolerated
Moxostoma macrolepidotum (shorthead redhorse)	late May to early June		upper portions of riffles
Perca flavescens (yellow perch)	mid to late May	7 to 10	in open water; often over aquatic macrophytes or branches
Pomoxis nigromaculatus (black crappie)	May to June	14 to 18	softer, muddier bottoms than *Lepomis* sp.; often in vegetation
Stizostedion vitreum vitreum (walleye)	immediately after ice-out		rock and sand lake shoals, gravel gravel stream beds

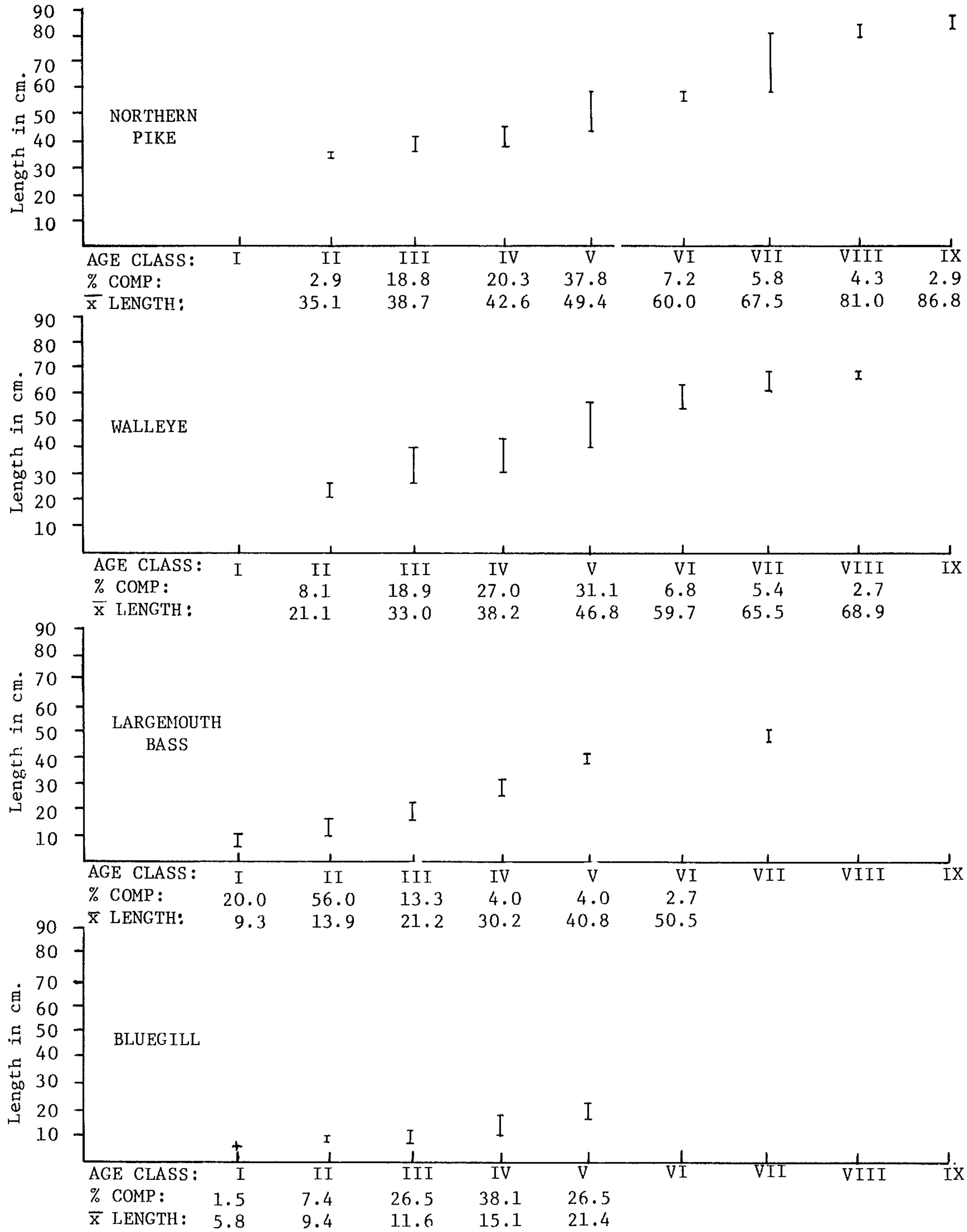
percentage of fish in these size ranges reflectes the abundance of bullheads (all species) and yellow perch. All zones except the discharge showed comparable size percent composition, while the discharge had a realtively higher percentage in the >21 to 27 cm range (68%) and a lower percentage (13.2%) in the > 15 to 21 cm range.

TABLE IV-36
OCCURENCE INTERVALS OF LARVAL FISH DURING 1975-1976 IN VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION



[a] 1975 data are from discharge canal samples and reflect Blackwater Lake larvae.
[b] 1976 data reflect discharge embayment larvae.

The fish community described in this section exploits a wide variety of energy sources, including detritus (decomposing particulate organic matter), algae, macrophytes, invertebrates, and fish. Food habits vary by species and size. Insect larvae comprise a large portion of the diet of the genera *Lepomis* (blue gill), *Ictalurus* (bullheads), and young *Pomoxis* (crappie), and *Stizostedion vitreum vitreum* (walleye). Fish larvae and fry feed on phytoplankton and zooplankton. Adult walleye, yellow perch and crappie feed mainly on forage fish; while Ictalurids ingest all sorts of organic matter (molluscs, insects, leeches, fish eggs, plants, etc.). Parasitism and gas bubble disease were not considered problems to fish within the study area.



(NOTE: DATA ARE DERIVED FROM SAMPLES OF APPROXIMATELY SEVENTY-FIVE SPECIMENS. % COMP = PERCENT OF SAMPLE; $\bar{X}$ LENGTH = MEAN TOTAL LENGTH (CENTIMETERS))

AGE FREQUENCY (DETERMINED BY SCALE EXAMINATION) OF MAJOR SPECIES OF FISH - NEAR CLAY BOSWELL STEAM ELECTRIC STATION

(SOURCE: WAPORA, INC., WASHINGTON, D.C., STATISTICAL DATA TRANSMITTED TO MICHAEL BAKER, JR., INC. ON MARCH 25, 1977)

FIGURE IV-32

Trophic Relationships

In most stream systems, the organic debris interactions are of much greater importance than direct utilization of primary producers as a food source. This is a result of the usual reliance of stream ecosystems on allochthonous production. However, in the Mississippi River in the vicinity of the Clay Boswell Station, the large quantities of aquatic macrophytes and phytoplankton found suggest that autochthonous production is also important.

The primary role of macrophytes in the food web is probably their contribution to the organic debris pool. Because allochthonous organic material is not directly utilized by the macrophytes, the amount of organic debris is expected to be greater as a result of macrophyte production.

The primary role of phytoplankton is probably its direct utilization by zooplankton grazers. Thus the secondary and tertiary consumers, many of whom are opportunistic predators, need not rely exclusively on the organic debris processing benthos as a food source. A more stable ecosystem is an expected result.

Since the zooplankton is comprised primarily of rotifers and the population density was relatively low, zooplankton probably is not a major source of food forage for small fish and macroinvertebrates. Benthic and drift organisms are, therefore, probably a major source of fish food.

The fish of this area are a diverse group occupying all habitats available and representing each major trophic level. From the field collections it appears that a reasonable balance exists between forage species, scavengers, detrital feeders, and predators. The community structure is somewhat modified in the discharge embayment towards warm water species but that does not constitute a simplification of community structure. It appears that the abundance and diversity of these fish are adequate to maintain a balanced community and no species or group was adversely dominant in the total area. The area as a whole was represented by species characteristic of a northern warmwater fishery.

Rare and Endangered Species

The DNR Division of Fish and Wildlife (78) has published a list of Minnesota animals and plants which permit special consideration and management. The categories included in this list are:

- endangered species,
- threatened species,
- species of changing or uncertain status,
- species of special interest,
- species extirpated or rare in Minnesota and have little future, and
- extinct species.

The species reported in the literature pertaining to the upper Mississippi River, and the species collected in the site-specific aquatic studies include none listed in this DNR publication. No aquatic species considered by the U.S. Fish and Wildlife Service to be endangered or threatened (79) are known to occur in north central Minnesota.

METEOROLOGY AND CLIMATOLOGY

Regional

Three air masses shape the regional climate in northern Minnesota. The Maritime Pacific air mass and Continental Polar air mass exert roughly equal influence. The Maritime Tropical air mass rarely found at the surface is present for approximately 80 hours (hr) per year. The Continental Polar air mass consists of air originating over northern Canada and/or the Arctic Ocean. This air brings the coldest weather to northern Minnesota and may result in temperatures of -50°F (-45.6°C) in the winter and near freezing temperatures even in July. Pacific air is mild and dry as a result of the long trek it must make over the mountains of western North America and is responsible for most of the warmer days of the year. Temperatures up to 50°F (10.0°C) in January and over 100°F (37.8°C) in summer are possible after the Pacific air mass has crossed the mountains and high plains of southwestern North America. Maritime Tropical air, from the Gulf of Mexico, is responsible for the occasional muggy, hot summer day or night. From November to March, Maritime Tropical air is never found in the surface region.

These 3 air masses frequently are major weather shapers when they move over or under each other. In winter, much of the snow in northern Minnesota is due to Pacific air aloft moving over the Continental Polar air at the surface. Some snow also is caused by one Pacific air mass moving over an older Pacific air mass already in the area, or by a fresh Continental Polar air mass moving under a Pacific air mass or an older Continental Polar air mass. In this case, snow often is in the form of showers, or, as more popularly known, "flurries". In summer, rains and thunderstorms often are generated in the region as fresh Polar air moves under any of the air masses that already may be in the area. Such storms may be especially severe when the Continental Polar air moves under Maritime Tropical air. Maritime Tropical air may move aloft over Continental Polar air at any time of the year, bringing longer-lasting (1 or 2 days) rains or snow.

Most of the summer rainfall is associated with thunderstorms that develop in the afternoon in April; in the early evening in May; in the late evening in June; about midnight in July; between midnight and sunrise in August; and around sunrise in September. These storms are associated with the summertime low pressure systems in the lee of the Rockies, centered at this latitude over North and South Dakota. The thunderstorm season stretches from April through September, but a thunderstorm can occur at any time of the year.

Distinct storm types occur only at certain times of the year. The blizzard, a storm characterized by heavy snow, a sharp temperature drop, and winds in excess of 40 mph (64 km per hr) nearly always is confined to the months of November, January, February, and March. Ice storms are most common in December, when both sleet and freezing rain and/or drizzle have their peak occurrences. However, such weather may occur from November to April. Tornadoes are most common from May through September.

From March 1 or thereabouts, to around April 10, large sized "equinoctial" storms may bring either snow, rain, or both in combination, and often in combination with sleet. These storms generally originate in Colorado or western

Kansas. There is a definite preponderance of storms moving through the area during the first week of May, August, and October. By contrast, there is a lack of storminess during the last 2 weeks of February and July, and during the second week of August. These phenomena forge the climate of the region and their effects can be seen in daily averages of wind, precipitation, temperature, and other statistics.

Local and Site Specific

Weather Data Sources

Weather conditions in northern Minnesota are observed and analyzed at 24 hr weather stations at Duluth, Hibbing, and International Falls and at several dozen stations which make temperature and precipitation readings once daily.

To examine climatic conditions at the Clay Boswell Station, it is necessary to use data from a weather station with similar conditions. An examination of 10 year wind roses prepared for International Falls, Hibbing, and Duluth reveals that the 3 stations had distinctly different wind regimes, with Duluth being, by far, the most unique. International Falls has more frequent westerly winds than Hibbing, which received more of its winds from the northwest and north. Neither Hibbing nor International Falls experience frequent winds from the northeast and east, while at Duluth such winds prevail.

Winds at the Clay Boswell Station were determined to most closely resemble those at International Falls when compared with winds from other round-the-clock observing stations in northern Minnesota and just across the Red River in North Dakota. This similarity was established by month-to-month comparisons of data from the Clay Boswell Station, International Falls, and Hibbing, as well as general comparisons with Grand Forks, Fargo, and Duluth. During 1975 and 1976, monthly wind roses for all 5 weather stations were compared with monthly wind roses at the Clay Boswell Station. This comparison of wind roses shows that winds recorded at the North Dakota stations were dissimilar to winds at the Clay Boswell Station.

Month-to-month comparisons then were made of 36 point, 10 year wind roses (1964 to 1973) for International Falls and Hibbing (80). The comparison shows that International Falls has more frequent winds from the west-northwest.

Thirty-six point wind roses were prepared for International Falls, Hibbing, and the Clay Boswell Station for those months in 1975 and 1976 for which data were available from the Clay Boswell Station. The results showed that winds at the Clay Boswell Station were more similar to International Falls to the north rather than to Hibbing to the east. This is physically reasonable, even though the Clay Boswell Station is closer geographically to Hibbing, since the east-to-west variation of the wind across northern Minnesota is much stronger than the north-to-south variation. The Lake Superior Shore, as known from other studies (81), has essentially prevailing easterlies, while Grand Forks and Fargo have a very strong southerly component. That north-to-south have lesser variations is illustrated by the fact that the 36 point wind roses from International Falls and Minneapolis-St. Paul have striking similarities, with the main variation being a somewhat higher preponderence of southwesterlies at Minneapolis-St. Paul and a greater preponderance of northwesterlies at International Falls.

Other meteorological data which had to be gathered to analyze climatic conditions at the Clay Boswell Station derived from 2 basic sources. Watson's meteorological-climatological model of Minnesota was used to determine the climatological means. Watson's model is based on long-term (up to 155 years) of information gathered in Minnesota, interrelating meteorological variables. The model is considered to give, in all instances, more stable climatic information than the general, fluctuating 30 year normals used by the National Weather Service (82). Data for analyzing climatological extremes was gathered from the Pokegama Cooperative Climatological Station, 5 miles (810 km) southeast of the community of Cohasset. Extremes at the Pokegama Falls site closely resemble extremes at nearby Cohasset. The Pokegama Falls station has gathered data continuously since May 1887.

Wind

The wind regime at the Clay Boswell Station is intermediate between the strong easterly regime along Lake Superior and the strong southerly regime over the Red River Valley. This east-west directional variation is much stronger than north-south variations, which exhibit mainly a shift in wind frequency from the south half of the compass circle to the north half as latitude becomes more northerly.

The round-the-clock meteorological observing station most similar to the Clay Boswell Station is International Falls. Table IV-37 presents mean monthly wind speeds, prevailing directions, and extreme observed winds at International Falls. The data were taken from aneomometer heights at 23 ft (7.0 m) above ground level from January 1, 1956 to September 30, 1963; at 34 ft (10.4 m) from September 30, 1965 to August 26, 1965; and at 20 ft (6.1 m) from August 26, 1965 to present.

TABLE IV-37
WIND STATISTICS
INTERNATIONAL FALLS, MINNESOTA (83)

Month	Prevailing Wind			Fastest Wind			Year of Occurrence
	Direction[a]	Mean Speed[b]		Direction[c]	Speed[c]		
		mph	km per hr	degrees	mph	km per hr	
Jan	W	9.2	14.8	230	32	51	1957
Feb	W	9.2	14.8	260	36	58	1965
Mar	W	9.5	15.3	290	42	68	1960
April	NW	10.6	17.0	230	52	84	1960
May	NW	10.1	16.3	200	52	84	1959
June	SE	8.7	14.0	180	46	74	1962
July	W	8.0	12.9	290	46	74	1959
Aug	SE	7.8	12.6	320	40	64	1965
Sept	SE	8.9	14.3	230	35	56	1959
Oct	SE	9.6	15.4	300	47	76	1972
Nov	W	9.9	15.9	270	35	56	1959
Dec	W	9.1	14.6	30	33	53	1968

[a] 11 years of record.
[b] 23 years of record.
[c] 20 years of record.

Wind data is best summarized by the use of wind roses. Figures IV-33 through IV-44 present the monthly International Falls wind roses. Figure IV-45 presents the annual (i.e. average of the 12 monthly wind roses) wind rose for International Falls. The International Falls wind roses are based on data collected during the period 1964 through 1973. Figures IV-46 through IV-49 present montly wind roses based on data collected at the Clay Boswell Station. The on-site wind roses are only for the months of January, March, July, and October for 1976, which provide representative examples of the seasonal variations in the wind regime in the vicinity of the Clay Boswell Station. The International Falls and the on-site wind roses were used for the air pollution diffusion modeling presented in the air quality sections of Chapters IV and V.

The wind roses give the percent of time (e.g. hr per 100 hr) at which winds of certain velocities blow from each compass direction. Moving out from the origin (which represents the monitor location), each solid or dashed line represents an incremental increase in velocity of 3 knots (5.6 km per hr). (The radius of the smooth, inner circle represents the percent of time of calm air during that month at the monitor locations.) Thus, the distance of any point on a line from the origin represents the percent of time at which winds of that velocity or less blow from the given compass direction. The distance between 2 lines along a given radial is the percent of time at which the winds blow from the given direction at velocities of the range represented by the 2 lines. Over the year, winds from the west-northwest and the southeast dominate. The 2 cold months of January and February are characterized very strongly by west-northwesterlies in association with the intense low pressure system over the Baffin Bay region. Southeasterlies begin to blow in March as the big storm season begins over the central United States, with easterlies prevailing in April, especially around the middle of April. Westerlies during March and April are still appreciable and velocities of these winds between 10 and 25 mph (16.1 and 40.2 km per hr) are especially prevalent.

Winds from all directions prevail in May, with no one direction dominating. Westerlies and southeasterlies occur in June through August, with strong southwesterlies occurring frequently from mid-July through August.

Southeasterlies and westerlies predominate during September and October. November and December have predominantly west to northwest winds, with southeasterlies and easterlies being appreciable - much more so than in January and February.

As is true over most of Minnesota, August is the least windy month and April is the most windy month. Next to August, December is the least windy month, and next to April, November is the most windy month. Generally, the wind speeds in northern Minnesota tend to be low. The persistence of cold high pressure in the winter contributes to the lower speeds in that season. Wind speeds are about 2 to 3 mph (3.2 to 4.8 km per hr) greater over the prairie to the west, along the lake, and over higher ground to the east. The highest wind ever observed at International Falls was from 200° at 52 mph (83.7 km per hr) in May 1959 and from 230° at 52 mph (83.7 km per hr) in April 1960. Table IV-38 estimates recurrence intervals of extreme wind speeds for the Clay Boswell Station. These charts assume flat topography and the values may be altered by local topographic conditions.

TABLE IV-38
RECURRENCE INTERVALS OF EXTREME MILE WIND SPEEDS AND GUSTS - CLAY BOSWELL STEAM ELECTRIC STATION[a] (84)

Recurrence Interval years	Extreme Mile Wind Speed[b]		Gusts[c]	
	mph	km per hr	mph	km per hr
(Years of Data Base)	(21)		(21)	
2	55	88	72	116
10	63	101	82	132
25	70	113	91	146
50	74	119	96	154
100	85	137	111	179

[a] It should be noted that the wind speeds given in this Table do not include tornadic winds.

[b] Extreme mile wind speeds are the one-mile (1.6 km) passage of wind with the greatest speed at a height of 30 ft (9.14m) above the ground.

[c] Gusts are peak wind speeds during a 2-sec interval.

Temperature

The average annual temperature at the Clay Boswell Station, according to Watson's model, is 37.3°F (2.9°C). Table IV-39 summarizes the effective 155 year monthly temperature means for the site and extremes for the 90 year record at the community of Cohasset.

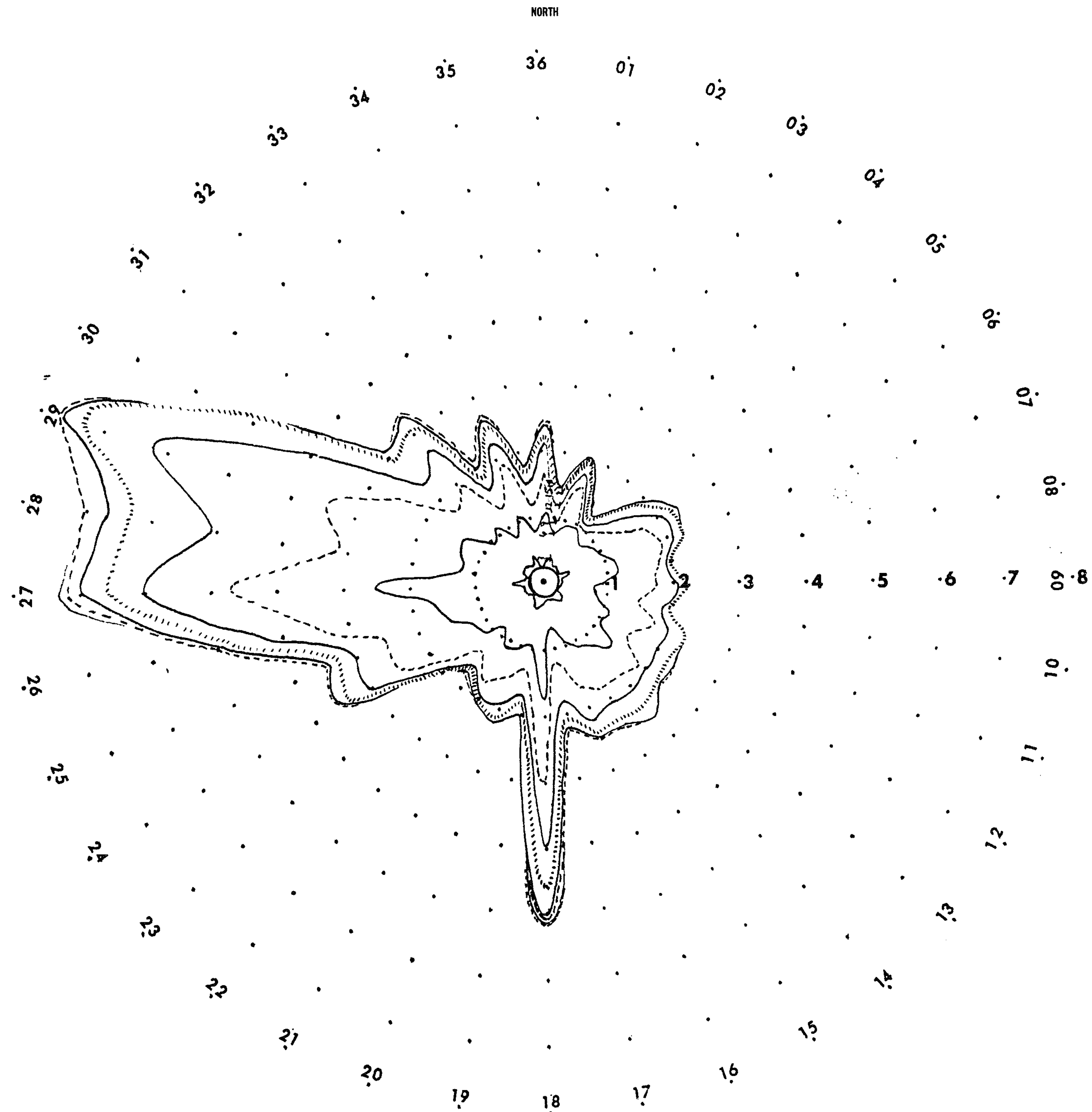
On the average, July is the warmest month with an average temperature of 65.4°F (18.5°C). On the average, the warmest day is July 26, with an average temperature of 67.4°F (19.7°C). The coldest month is January, with an average temperature of 5.6°F (-14.6°C). The coldest day is January 19, with an average temperature of 5.1°F (-14.9°C).

The hottest temperature observed at Pokegama Falls was 103°F (39.4°C) on July 13, 1936; coldest reported temperature was -59°F (-50.5°C), but examination of the original records indicates that this must have been an erroneous reading. However, readings of -57°F (-49.4°C) have been recorded on 2 other occasions, so temperatures of this degree can be expected at the Clay Boswell Station in the future.

The coldest monthly average temperature was -11.8°F (-24.3°C) in January 1912. In contrast, January 1944, the warmest January ever, averaged 20°F (-6.7°C). The hottest monthly average temperature occurred in July 1916 at 72.8°F (22.6°C). The coldest July was that of 1904, which averaged 60.7°F (15.9°C).

Over the period of record, there is about a 30°F (17.6°C) difference between the warmest and coldest monthly averages for the months of January, February, and March; 20°F (11.1°C) difference for April; 17°F (9.4°C) difference for May; 12°F (6.6°C) difference from June through September; and about 25°F (13.9°C) difference for October, November, and December.

LEGEND



MONITOR LOCATION - CENTER DOT (●)

RADIUS OF SMOOTH CENTER CIRCLE - % CALM

SURFACE WIND OF:

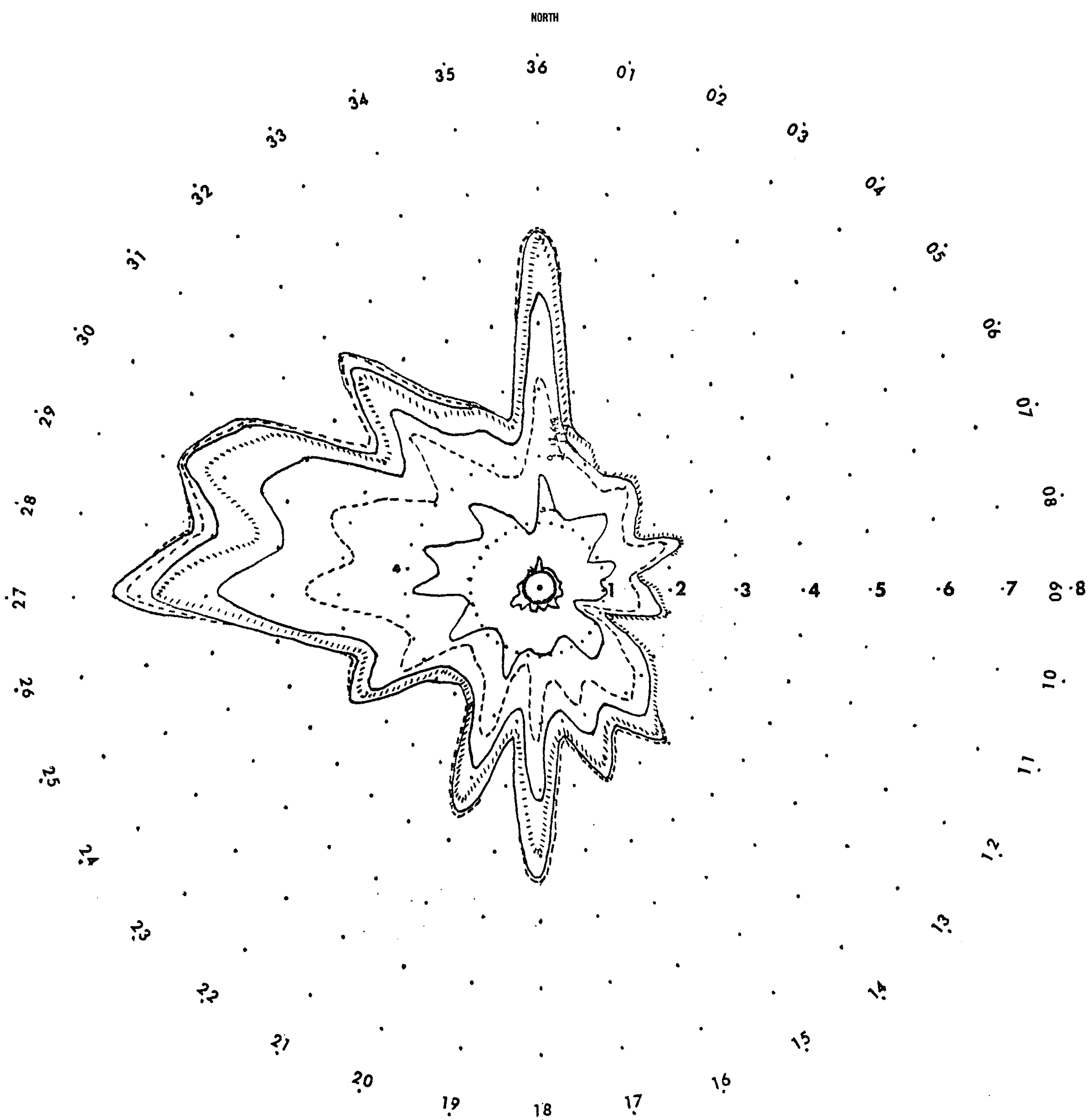
3 KNOTS (5.6 KM PER HR)	1ST SOLID LINE	(———)	FROM CENTER DOT
6 KNOTS (11.1 KM PER HR)	2ND SOLID LINE	(———)	FROM CENTER DOT
9 KNOTS (16.7 KM PER HR)	1ST DASHED LINE	(- - - -)	FROM CENTER DOT
12 KNOTS (22.2 KM PER HR)	3RD SOLID LINE	(———)	FROM CENTER DOT
15 KNOTS (27.8 KM PER HR)	2ND DASHED LINE	(\\\\\\)	FROM CENTER DOT
18 KNOTS (33.3 KM PER HR)	4TH SOLID LINE	(———)	FROM CENTER DOT
21 KNOTS (38.9 KM PER HR)	3RD DASHED LINE	(- - - -)	FROM CENTER DOT
24 KNOTS (44.5 KM PER HR)	5TH SOLID LINE	(———)	FROM CENTER DOT

NOTE: WHERE LINES RUN TOGETHER, SURFACE WIND SPEED IS THE SAME AS THE SURFACE WIND SPEED REPRESENTED BY THE PREDOMINANT LINE SHOWN

INTERNATIONAL FALLS SURFACE WIND ROSE - JANUARY

SOURCE: PREPARED BY BRUCE F. WATSON, METEOROLOGIST, ST. PAUL, MINNESOTA

FIGURE IV-33



LEGEND

MONITOR LOCATION - CENTER DOT (●)

RADIUS OF SMOOTH CENTER CIRCLE - % CALM

SURFACE WIND OF:

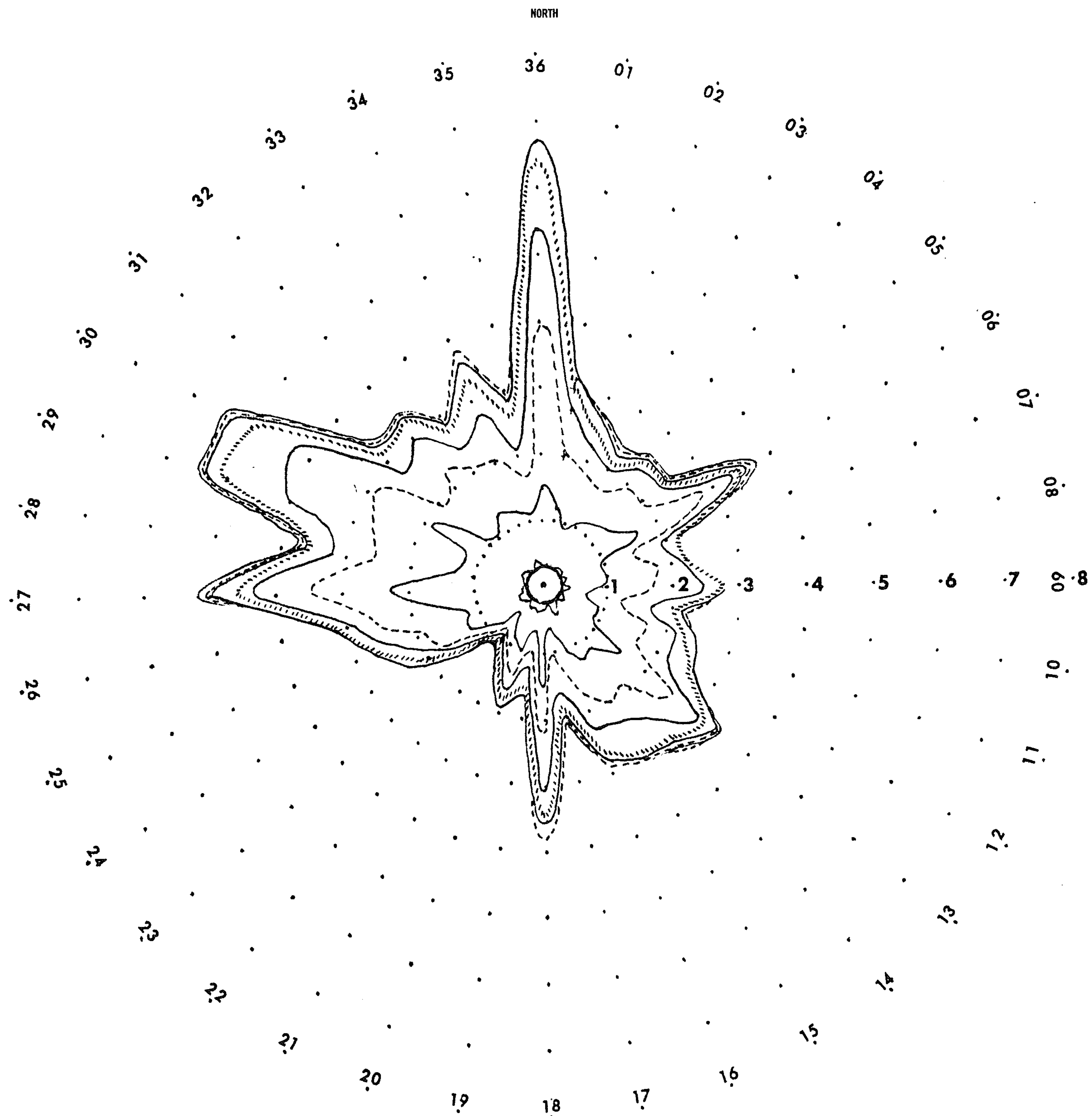
3 KNOTS (5.6 KM PER HR) - 1ST SOLID LINE (——) FROM CENTER DOT
6 KNOTS (11.1 KM PER HR) - 2ND SOLID LINE (——) FROM CENTER DOT
9 KNOTS (16.7 KM PER HR) - 1ST DASHED LINE (- - - -) FROM CENTER DOT
12 KNOTS (22.2 KM PER HR) - 3RD SOLID LINE (——) FROM CENTER DOT
15 KNOTS (27.8 KM PER HR) - 2ND DASHED LINE (\\\\\\) FROM CENTER DOT
18 KNOTS (33.3 KM PER HR) - 4TH SOLID LINE (——) FROM CENTER DOT
21 KNOTS (38.9 KM PER HR) - 3RD DASHED LINE (- - - -) FROM CENTER DOT
24 KNOTS (44.5 KM PER HR) - 5TH SOLID LINE (——) FROM CENTER DOT

NOTE: WHERE LINES RUN TOGETHER, SURFACE WIND SPEED IS THE SAME AS THE SURFACE WIND SPEED REPRESENTED BY THE PREDOMINANT LINE SHOWN

INTERNATIONAL FALLS
SURFACE WIND ROSE - FEBRUARY

SOURCE: PREPARED BY BRUCE F. WATSON, METEOROLOGIST, ST. PAUL, MINNESOTA

FIGURE IV-34



LEGEND

MONITOR LOCATION - CENTER DOT (●)

RADIUS OF SMOOTH CENTER CIRCLE - % CALM

SURFACE WIND OF:

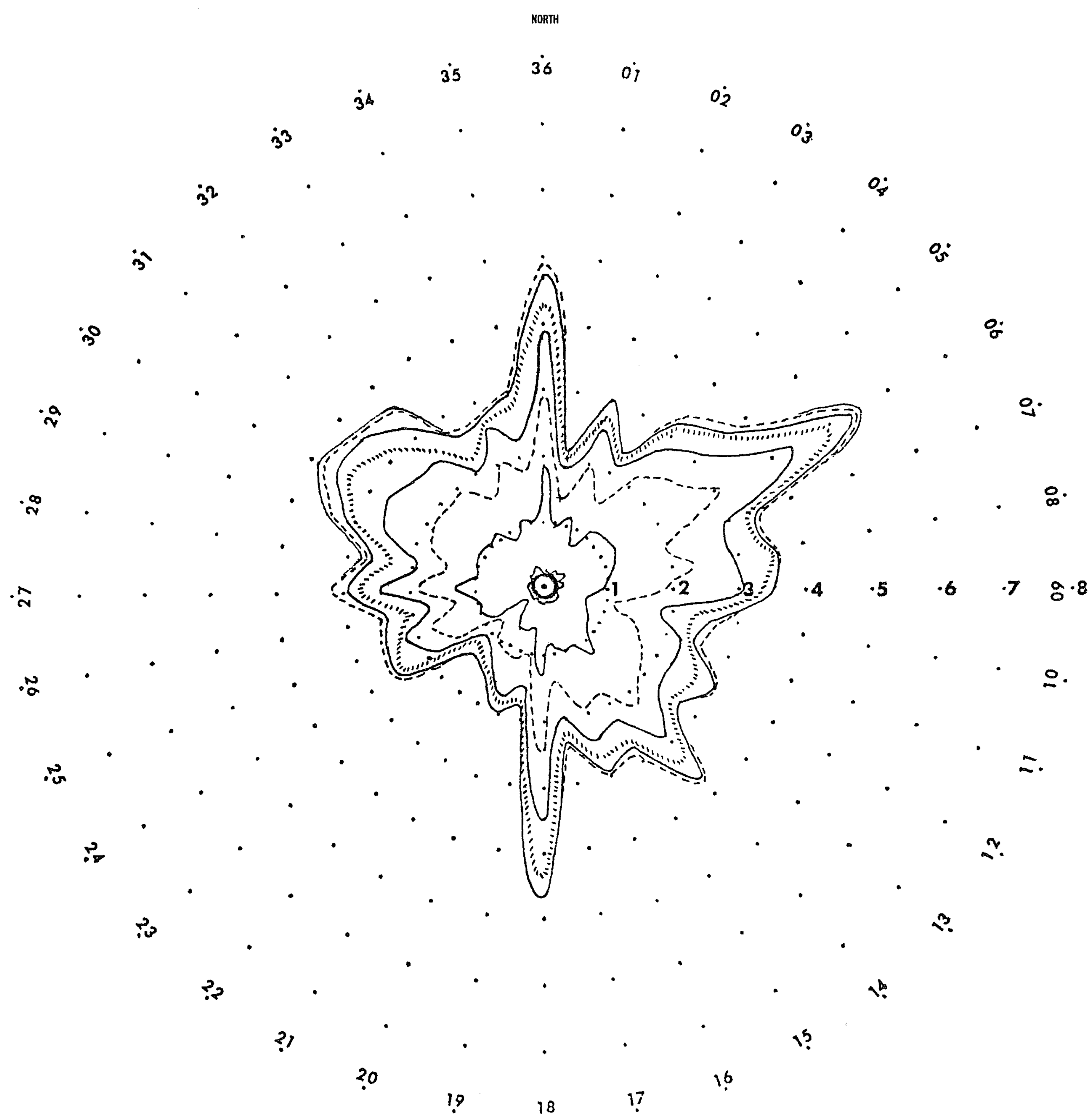
3 KNOTS (5.6 KM PER HR)	1ST SOLID LINE	(——)	FROM CENTER DOT
6 KNOTS (11.1 KM PER HR)	2ND SOLID LINE	(——)	FROM CENTER DOT
9 KNOTS (16.7 KM PER HR)	1ST DASHED LINE	(----)	FROM CENTER DOT
12 KNOTS (22.2 KM PER HR)	3RD SOLID LINE	(——)	FROM CENTER DOT
15 KNOTS (27.8 KM PER HR)	2ND DASHED LINE	(\\\\\\)	FROM CENTER DOT
18 KNOTS (33.3 KM PER HR)	4TH SOLID LINE	(——)	FROM CENTER DOT
21 KNOTS (38.9 KM PER HR)	3RD DASHED LINE	(----)	FROM CENTER DOT
24 KNOTS (44.5 KM PER HR)	5TH SOLID LINE	(——)	FROM CENTER DOT

NOTE: WHERE LINES RUN TOGETHER, SURFACE WIND SPEED IS THE SAME AS THE SURFACE WIND SPEED REPRESENTED BY THE PREDOMINANT LINE SHOWN

INTERNATIONAL FALLS
SURFACE WIND ROSE - MARCH

SOURCE: PREPARED BY BRUCE F. WATSON, METEOROLOGIST, ST. PAUL, MINNESOTA

FIGURE IV-35



LEGEND

MONITOR LOCATION - CENTER DOT (●)
RADIUS OF SMOOTH CENTER CIRCLE - % CALM

SURFACE WIND OF:

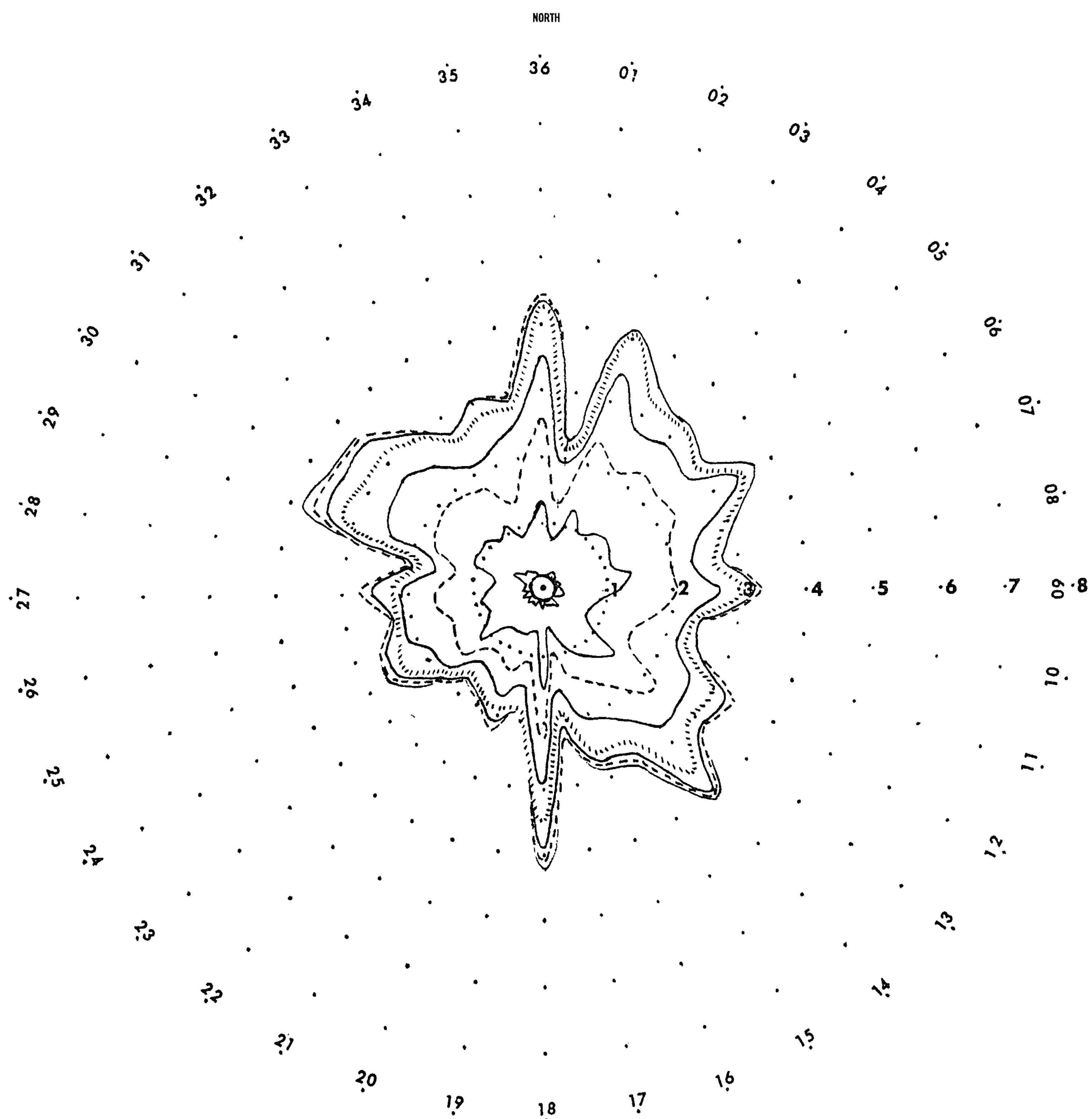
3 KNOTS (5.6 KM PER HR) - 1ST SOLID LINE (——) FROM CENTER DOT
6 KNOTS (11.1 KM PER HR) - 2ND SOLID LINE (——) FROM CENTER DOT
9 KNOTS (16.7 KM PER HR) - 1ST DASHED LINE (----) FROM CENTER DOT
12 KNOTS (22.2 KM PER HR) - 3RD SOLID LINE (——) FROM CENTER DOT
15 KNOTS (27.8 KM PER HR) - 2ND DASHED LINE (\\\\\\) FROM CENTER DOT
18 KNOTS (33.3 KM PER HR) - 4TH SOLID LINE (——) FROM CENTER DOT
21 KNOTS (38.9 KM PER HR) - 3RD DASHED LINE (----) FROM CENTER DOT
24 KNOTS (44.5 KM PER HR) - 5TH SOLID LINE (——) FROM CENTER DOT

NOTE: WHERE LINES RUN TOGETHER, SURFACE WIND SPEED IS THE SAME AS THE SURFACE WIND SPEED REPRESENTED BY THE PREDOMINANT LINE SHOWN

INTERNATIONAL FALLS
SURFACE WIND ROSE - APRIL

SOURCE: PREPARED BY BRUCE F. WATSON, METEOROLOGIST, ST. PAUL, MINNESOTA

FIGURE IV-36



LEGEND

MONITOR LOCATION - CENTER DOT (●)

RADIUS OF SMOOTH CENTER CIRCLE - % CALM

SURFACE WIND OF:

3 KNOTS (5.6 KM PER HR) - 1ST SOLID LINE (——) FROM CENTER DOT

6 KNOTS (11.1 KM PER HR) - 2ND SOLID LINE (——) FROM CENTER DOT

9 KNOTS (16.7 KM PER HR) - 1ST DASHED LINE (- - - -) FROM CENTER DOT

12 KNOTS (22.2 KM PER HR) - 3RD SOLID LINE (——) FROM CENTER DOT

15 KNOTS (27.8 KM PER HR) - 2ND DASHED LINE (\\\\\\) FROM CENTER DOT

18 KNOTS (33.3 KM PER HR) - 4TH SOLID LINE (——) FROM CENTER DOT

21 KNOTS (38.9 KM PER HR) - 3RD DASHED LINE (- - - -) FROM CENTER DOT

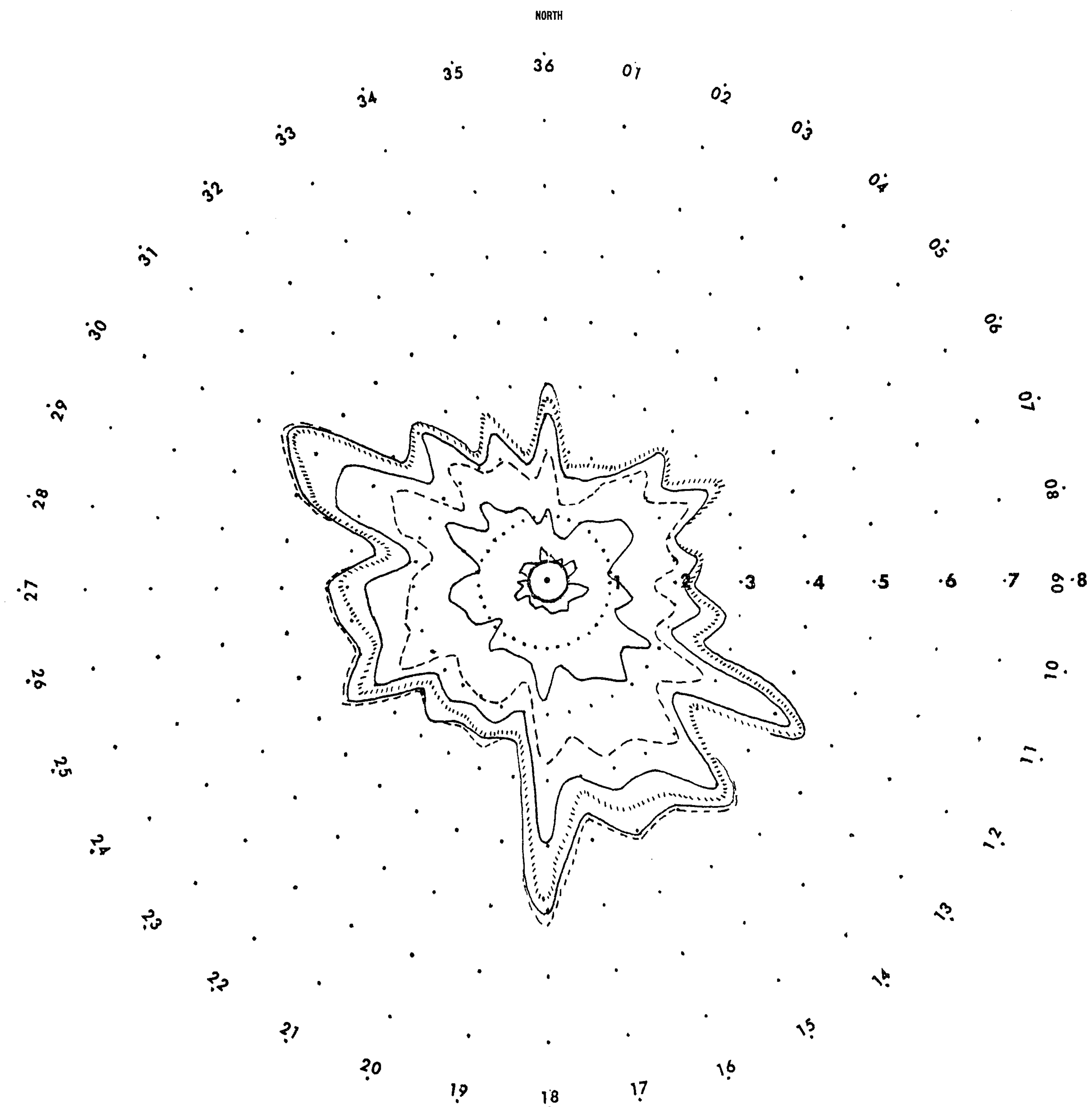
24 KNOTS (44.5 KM PER HR) - 5TH SOLID LINE (——) FROM CENTER DOT

NOTE: WHERE LINES RUN TOGETHER, SURFACE WIND SPEED IS THE SAME AS THE SURFACE WIND SPEED REPRESENTED BY THE PREDOMINANT LINE SHOWN

INTERNATIONAL FALLS SURFACE WIND ROSE - MAY

SOURCE: PREPARED BY BRUCE F. WATSON, METEOROLOGIST, ST. PAUL, MINNESOTA

FIGURE IV-37



LEGEND

MONITOR LOCATION - CENTER DOT (●)

RADIUS OF SMOOTH CENTER CIRCLE - % CALM

SURFACE WIND OF:

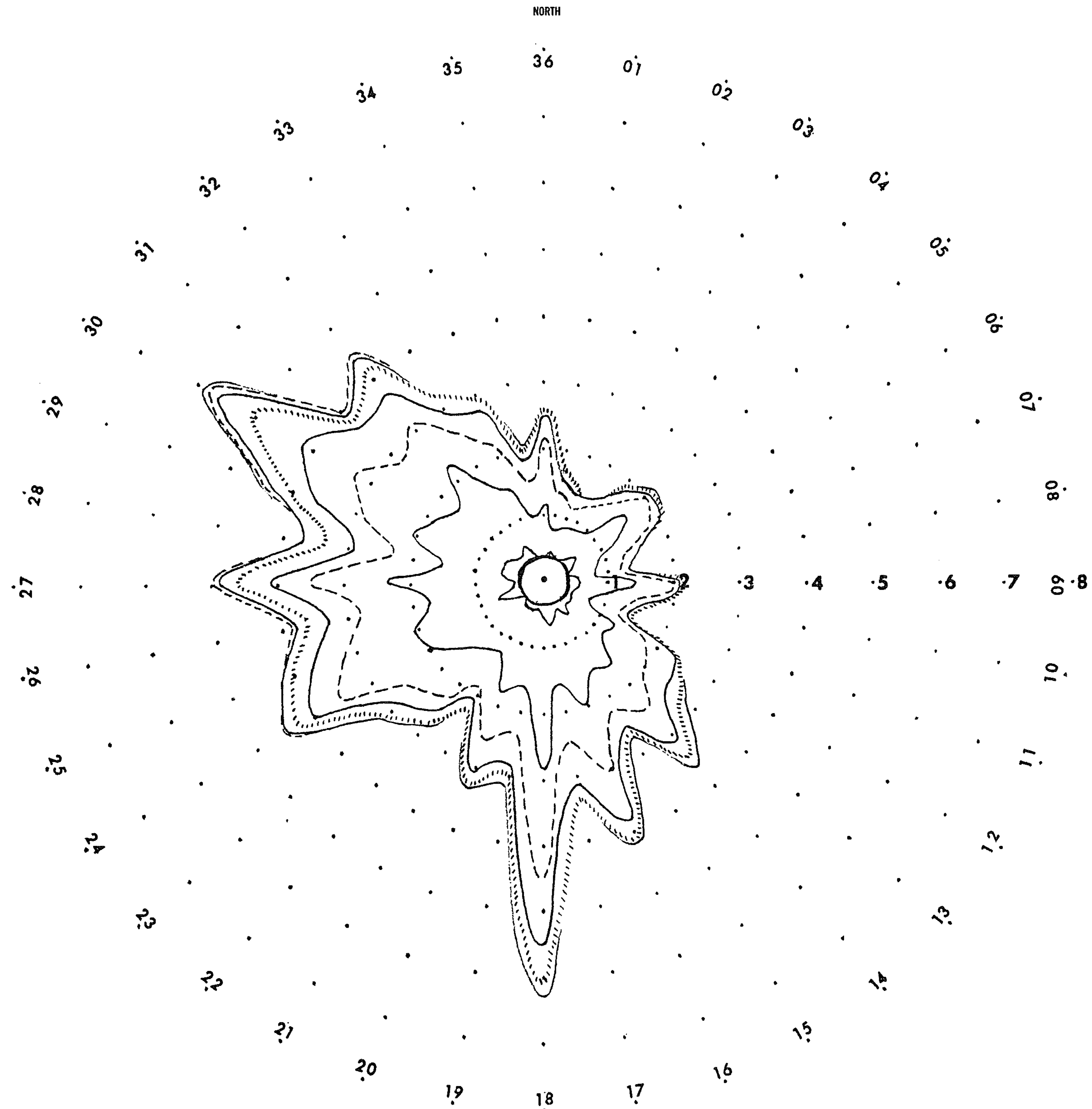
3 KNOTS (5.6 KM PER HR) - 1ST SOLID LINE (——) FROM CENTER DOT
6 KNOTS (11.1 KM PER HR) - 2ND SOLID LINE (——) FROM CENTER DOT
9 KNOTS (16.7 KM PER HR) - 1ST DASHED LINE (- - - -) FROM CENTER DOT
12 KNOTS (22.2 KM PER HR) - 3RD SOLID LINE (——) FROM CENTER DOT
15 KNOTS (27.8 KM PER HR) - 2ND DASHED LINE (\\\\\\) FROM CENTER DOT
18 KNOTS (33.3 KM PER HR) - 4TH SOLID LINE (——) FROM CENTER DOT
21 KNOTS (38.9 KM PER HR) - 3RD DASHED LINE (- - - -) FROM CENTER DOT
24 KNOTS (44.5 KM PER HR) - 5TH SOLID LINE (——) FROM CENTER DOT

NOTE: WHERE LINES RUN TOGETHER, SURFACE WIND SPEED IS THE SAME AS THE SURFACE WIND SPEED REPRESENTED BY THE PREDOMINANT LINE SHOWN

INTERNATIONAL FALLS
SURFACE WIND ROSE - JUNE

SOURCE: PREPARED BY BRUCE F. WATSON, METEOROLOGIST, ST. PAUL, MINNESOTA

FIGURE IV-38



LEGEND

MONITOR LOCATION - CENTER DOT (●)

RADIUS OF SMOOTH CENTER CIRCLE - % CALM

SURFACE WIND OF:

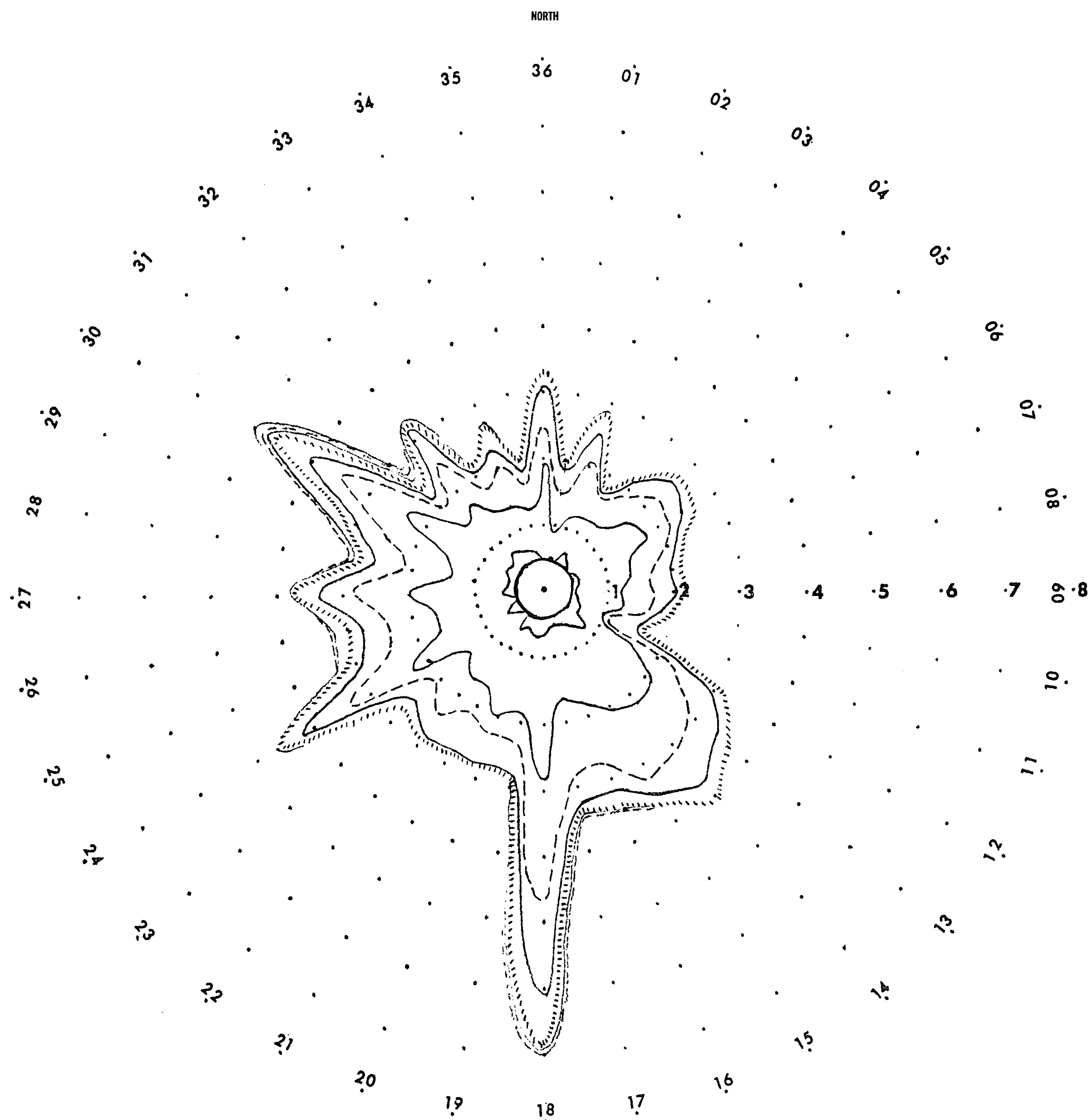
3 KNOTS (5.6 KM PER HR)	- 1ST SOLID LINE	(——)	FROM CENTER DOT
6 KNOTS (11.1 KM PER HR)	- 2ND SOLID LINE	(——)	FROM CENTER DOT
9 KNOTS (16.7 KM PER HR)	- 1ST DASHED LINE	(- - - -)	FROM CENTER DOT
12 KNOTS (22.2 KM PER HR)	- 3RD SOLID LINE	(——)	FROM CENTER DOT
15 KNOTS (27.8 KM PER HR)	- 2ND DASHED LINE	(\\\\\\)	FROM CENTER DOT
18 KNOTS (33.3 KM PER HR)	- 4TH SOLID LINE	(——)	FROM CENTER DOT
21 KNOTS (38.9 KM PER HR)	- 3RD DASHED LINE	(- - - -)	FROM CENTER DOT
24 KNOTS (44.5 KM PER HR)	- 5TH SOLID LINE	(——)	FROM CENTER DOT

NOTE: WHERE LINES RUN TOGETHER, SURFACE WIND SPEED IS THE SAME AS THE SURFACE WIND SPEED REPRESENTED BY THE PREDOMINANT LINE SHOWN

INTERNATIONAL FALLS
SURFACE WIND ROSE - JULY

SOURCE: PREPARED BY BRUCE F. WATSON, METEOROLOGIST, ST. PAUL, MINNESOTA

FIGURE IV-39



LEGEND

MONITOR LOCATION - CENTER DOT (●)

RADIUS OF SMOOTH CENTER CIRCLE - % CALM

SURFACE WIND OF:

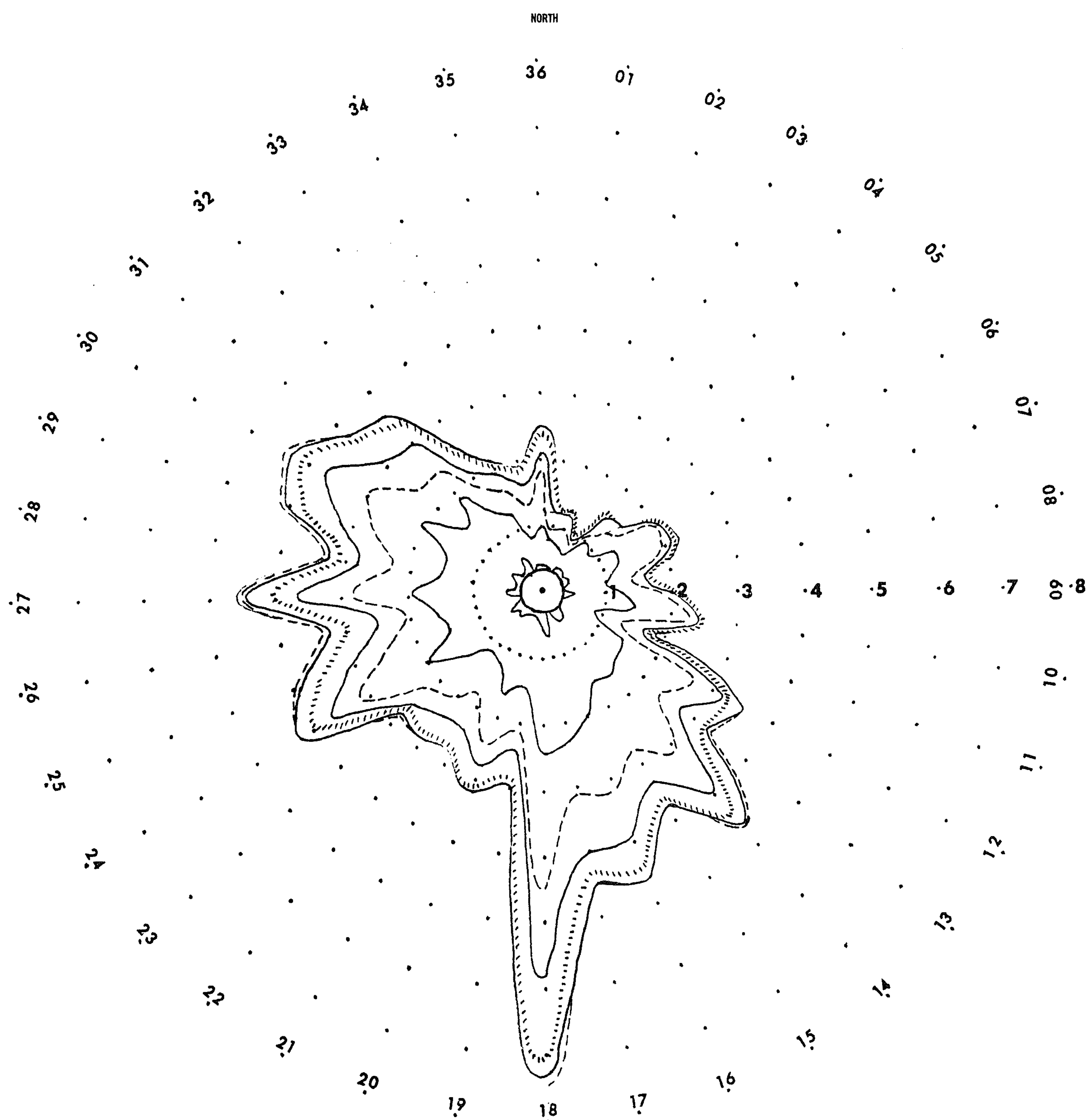
3 KNOTS (5.6 KM PER HR) - 1ST SOLID LINE	(——)	FROM CENTER DOT
6 KNOTS (11.1 KM PER HR) - 2ND SOLID LINE	(——)	FROM CENTER DOT
9 KNOTS (16.7 KM PER HR) - 1ST DASHED LINE	(- - - -)	FROM CENTER DOT
12 KNOTS (22.2 KM PER HR) - 3RD SOLID LINE	(——)	FROM CENTER DOT
15 KNOTS (27.8 KM PER HR) - 2ND DASHED LINE	(\\\\\\)	FROM CENTER DOT
18 KNOTS (33.3 KM PER HR) - 4TH SOLID LINE	(——)	FROM CENTER DOT
21 KNOTS (38.9 KM PER HR) - 3RD DASHED LINE	(- - - -)	FROM CENTER DOT
24 KNOTS (44.5 KM PER HR) - 5TH SOLID LINE	(——)	FROM CENTER DOT

NOTE: WHERE LINES RUN TOGETHER, SURFACE WIND SPEED IS THE SAME AS THE SURFACE WIND SPEED REPRESENTED BY THE PREDOMINANT LINE SHOWN

INTERNATIONAL FALLS
SURFACE WIND ROSE - AUGUST

SOURCE: PREPARED BY BRUCE F. WATSON, METEOROLOGIST, ST. PAUL, MINNESOTA

FIGURE IV-40



LEGEND

MONITOR LOCATION - CENTER DOT (●)

RADIUS OF SMOOTH CENTER CIRCLE - % CALM

SURFACE WIND OF:

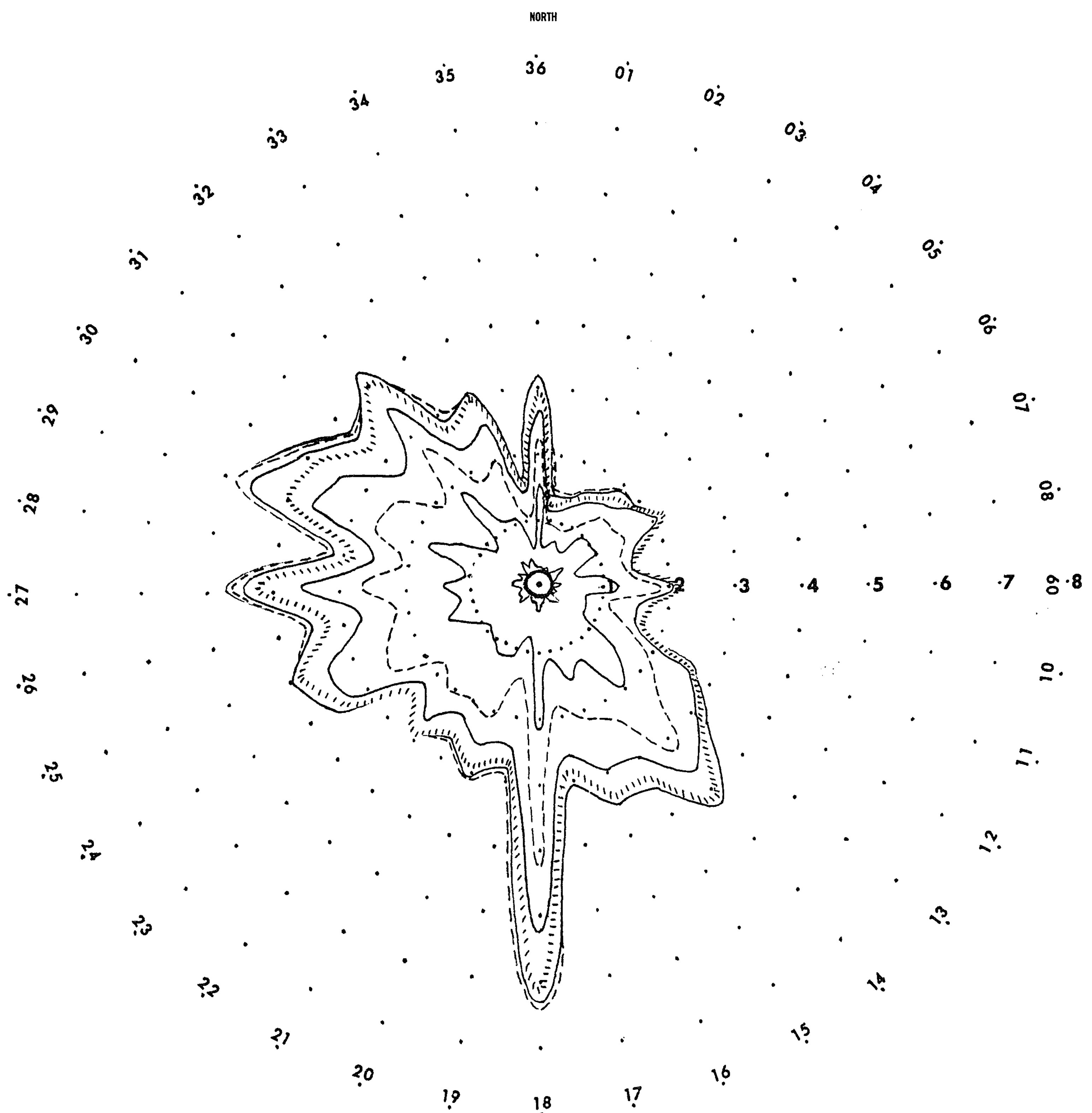
3 KNOTS (5.6 KM PER HR) - 1ST SOLID LINE (——) FROM CENTER DOT
6 KNOTS (11.1 KM PER HR) - 2ND SOLID LINE (——) FROM CENTER DOT
9 KNOTS (16.7 KM PER HR) - 1ST DASHED LINE (----) FROM CENTER DOT
12 KNOTS (22.2 KM PER HR) - 3RD SOLID LINE (——) FROM CENTER DOT
15 KNOTS (27.8 KM PER HR) - 2ND DASHED LINE (\\\\\\) FROM CENTER DOT
18 KNOTS (33.3 KM PER HR) - 4TH SOLID LINE (——) FROM CENTER DOT
21 KNOTS (38.9 KM PER HR) - 3RD DASHED LINE (----) FROM CENTER DOT
24 KNOTS (44.5 KM PER HR) - 5TH SOLID LINE (——) FROM CENTER DOT

NOTE: WHERE LINES RUN TOGETHER, SURFACE WIND SPEED IS THE SAME AS THE SURFACE WIND SPEED REPRESENTED BY THE PREDOMINANT LINE SHOWN

INTERNATIONAL FALLS
SURFACE WIND ROSE - SEPTEMBER

SOURCE: PREPARED BY BRUCE F. WATSON, METEOROLOGIST, ST. PAUL, MINNESOTA

FIGURE IV-41



LEGEND

MONITOR LOCATION - CENTER DOT (●)

RADIUS OF SMOOTH CENTER CIRCLE - % CALM

SURFACE WIND OF:

3 KNOTS (5.6 KM PER HR) - 1ST SOLID LINE (——) FROM CENTER DOT

6 KNOTS (11.1 KM PER HR) - 2ND SOLID LINE (——) FROM CENTER DOT

9 KNOTS (16.7 KM PER HR) - 1ST DASHED LINE (----) FROM CENTER DOT

12 KNOTS (22.2 KM PER HR) - 3RD SOLID LINE (——) FROM CENTER DOT

15 KNOTS (27.8 KM PER HR) - 2ND DASHED LINE (\\\\\\) FROM CENTER DOT

18 KNOTS (33.3 KM PER HR) - 4TH SOLID LINE (——) FROM CENTER DOT

21 KNOTS (38.9 KM PER HR) - 3RD DASHED LINE (----) FROM CENTER DOT

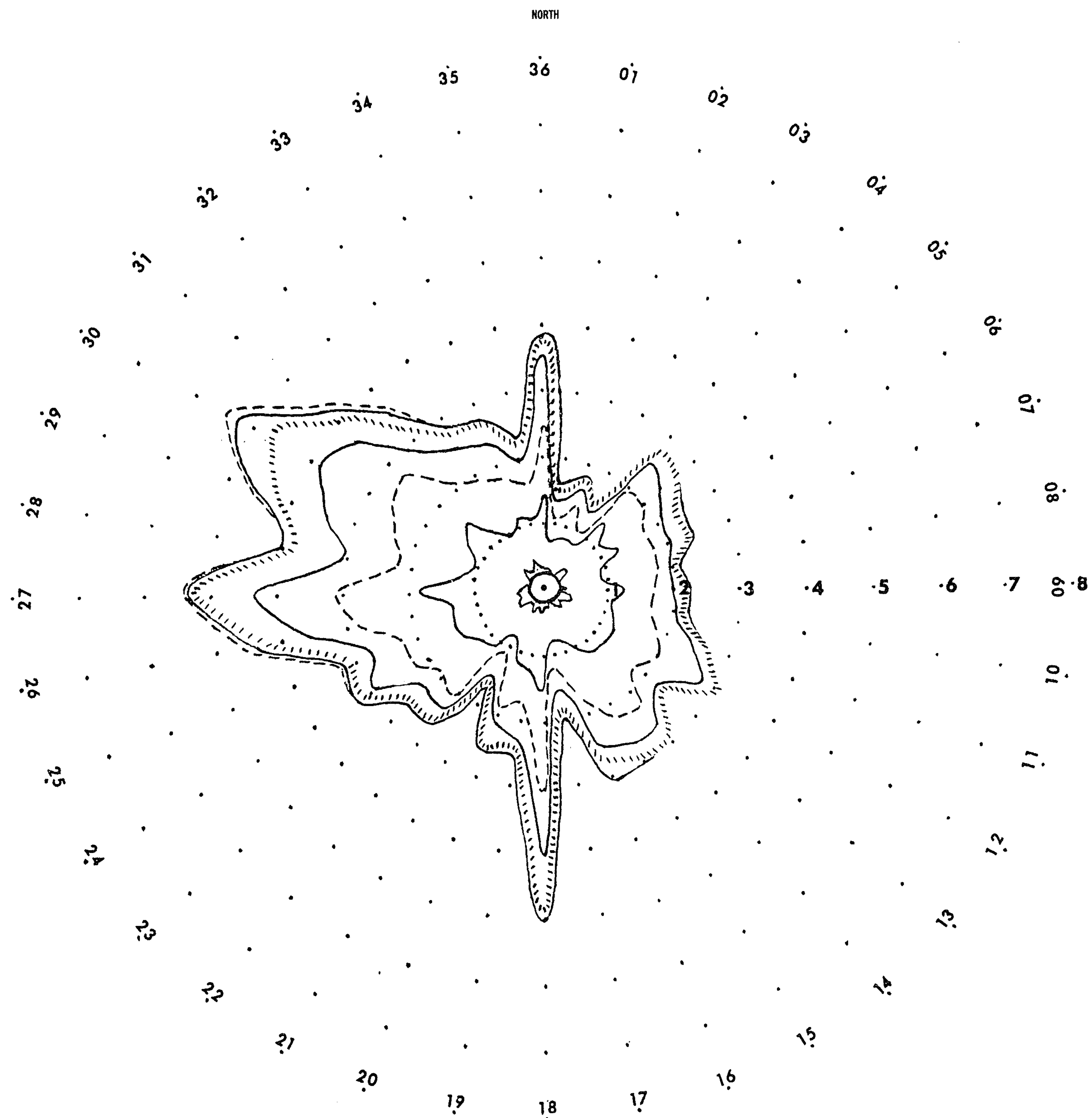
24 KNOTS (44.5 KM PER HR) - 5TH SOLID LINE (——) FROM CENTER DOT

NOTE: WHERE LINES RUN TOGETHER, SURFACE WIND SPEED IS THE SAME AS THE SURFACE WIND SPEED REPRESENTED BY THE PREDOMINANT LINE SHOWN

INTERNATIONAL FALLS
SURFACE WIND ROSE - OCTOBER

SOURCE: PREPARED BY BRUCE F. WATSON, METEOROLOGIST, ST. PAUL, MINNESOTA

FIGURE IV-42



LEGEND

MONITOR LOCATION - CENTER DOT (●)

RADIUS OF SMOOTH CENTER CIRCLE - % CALM

SURFACE WIND OF:

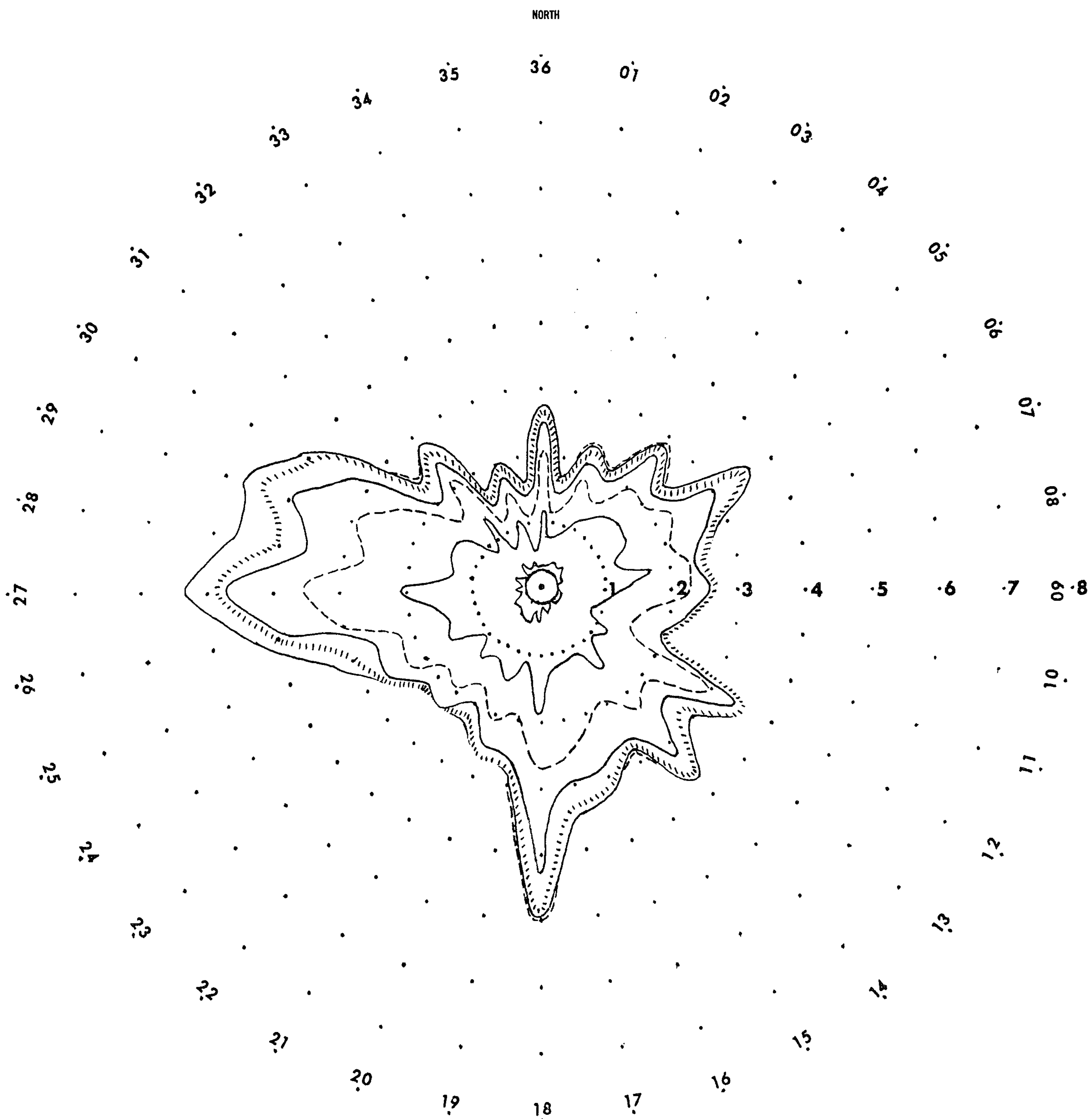
3 KNOTS (5.6 KM PER HR)	1ST SOLID LINE	(——)	FROM CENTER DOT
6 KNOTS (11.1 KM PER HR)	2ND SOLID LINE	(——)	FROM CENTER DOT
9 KNOTS (16.7 KM PER HR)	1ST DASHED LINE	(- - - -)	FROM CENTER DOT
12 KNOTS (22.2 KM PER HR)	3RD SOLID LINE	(——)	FROM CENTER DOT
15 KNOTS (27.8 KM PER HR)	2ND DASHED LINE	(\\\\\\\\\\\\)	FROM CENTER DOT
18 KNOTS (33.3 KM PER HR)	4TH SOLID LINE	(——)	FROM CENTER DOT
21 KNOTS (38.9 KM PER HR)	3RD DASHED LINE	(- - - -)	FROM CENTER DOT
24 KNOTS (44.5 KM PER HR)	5TH SOLID LINE	(——)	FROM CENTER DOT

NOTE: WHERE LINES RUN TOGETHER, SURFACE WIND SPEED IS THE SAME AS THE SURFACE WIND SPEED REPRESENTED BY THE PREDOMINANT LINE SHOWN

INTERNATIONAL FALLS
SURFACE WIND ROSE - NOVEMBER

SOURCE: PREPARED BY BRUCE F. WATSON, METEOROLOGIST, ST. PAUL, MINNESOTA

FIGURE IV-43



LEGEND

MONITOR LOCATION - CENTER DOT (●)

RADIUS OF SMOOTH CENTER CIRCLE - % CALM

SURFACE WIND OF:

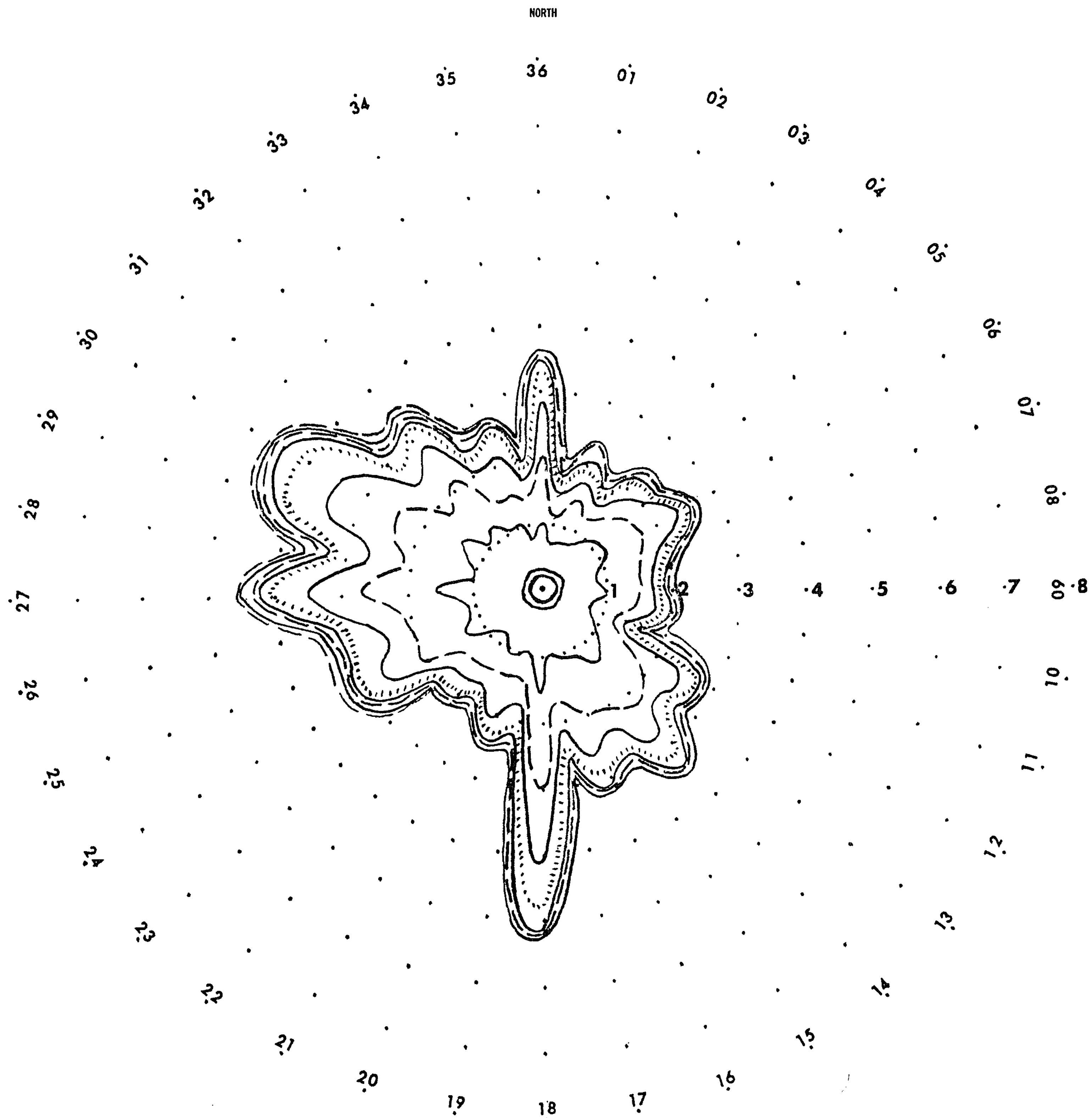
3 KNOTS (5.6 KM PER HR) - 1ST SOLID LINE (——) FROM CENTER DOT
6 KNOTS (11.1 KM PER HR) - 2ND SOLID LINE (——) FROM CENTER DOT
9 KNOTS (16.7 KM PER HR) - 1ST DASHED LINE (- - - -) FROM CENTER DOT
12 KNOTS (22.2 KM PER HR) - 3RD SOLID LINE (——) FROM CENTER DOT
15 KNOTS (27.8 KM PER HR) - 2ND DASHED LINE (\\\\\\) FROM CENTER DOT
18 KNOTS (33.3 KM PER HR) - 4TH SOLID LINE (——) FROM CENTER DOT
21 KNOTS (38.9 KM PER HR) - 3RD DASHED LINE (- - - -) FROM CENTER DOT
24 KNOTS (44.5 KM PER HR) - 5TH SOLID LINE (——) FROM CENTER DOT

NOTE: WHERE LINES RUN TOGETHER, SURFACE WIND SPEED IS THE SAME AS THE SURFACE WIND SPEED REPRESENTED BY THE PREDOMINANT LINE SHOWN

INTERNATIONAL FALLS
SURFACE WIND ROSE - DECEMBER

SOURCE: PREPARED BY BRUCE F. WATSON, METEOROLOGIST, ST. PAUL, MINNESOTA

FIGURE IV-44



LEGEND

MONITOR LOCATION - CENTER DOT (●)

RADIUS OF SMOOTH CENTER CIRCLE - % CALM

SURFACE WIND OF:

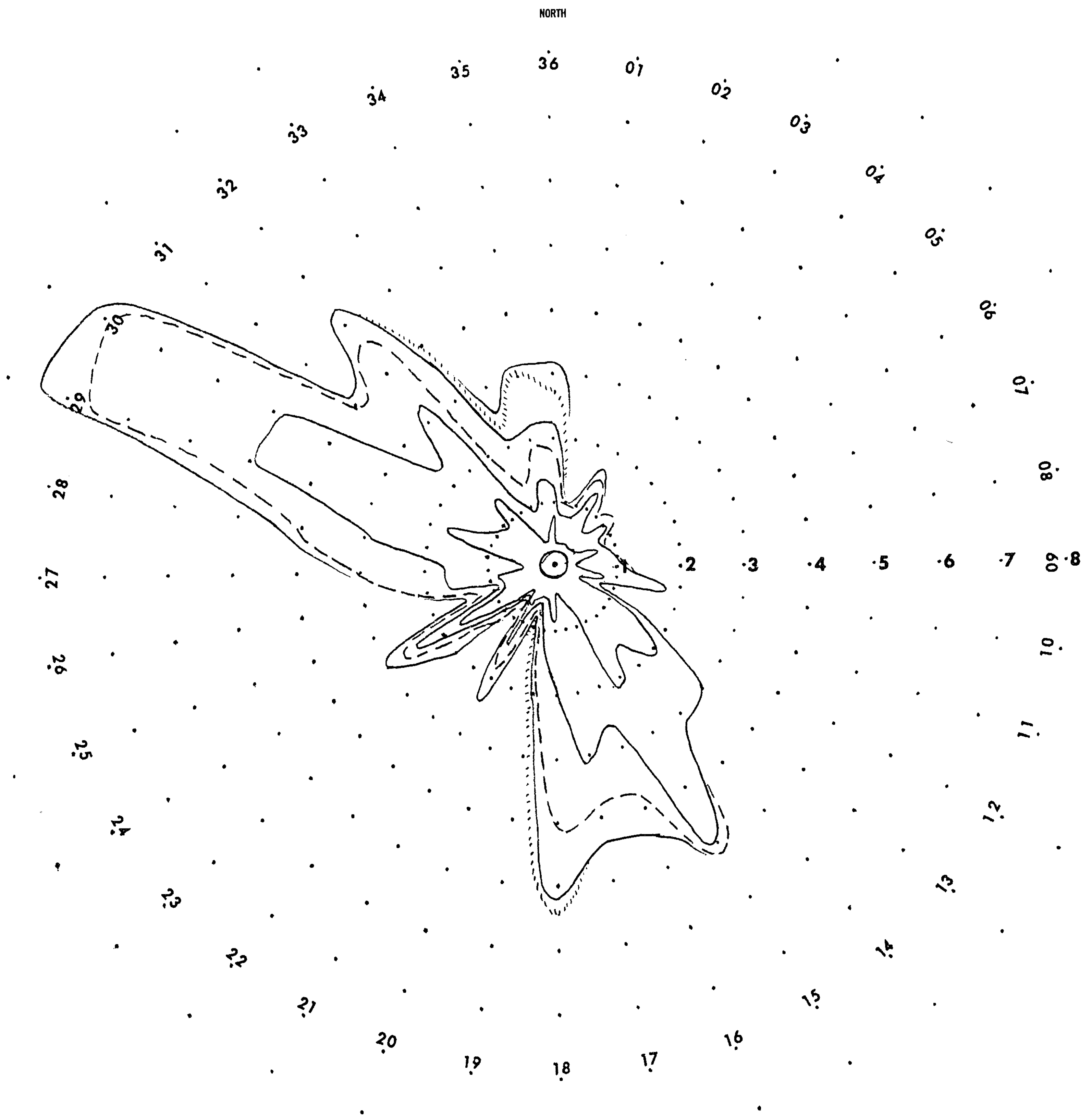
3 KNOTS (5.6 KM PER HR)	1ST SOLID LINE	(——)	FROM CENTER DOT
6 KNOTS (11.1 KM PER HR)	2ND SOLID LINE	(——)	FROM CENTER DOT
9 KNOTS (16.7 KM PER HR)	1ST DASHED LINE	(----)	FROM CENTER DOT
12 KNOTS (22.2 KM PER HR)	3RD SOLID LINE	(——)	FROM CENTER DOT
15 KNOTS (27.8 KM PER HR)	2ND DASHED LINE	(\\\\\\)	FROM CENTER DOT
18 KNOTS (33.3 KM PER HR)	4TH SOLID LINE	(——)	FROM CENTER DOT
21 KNOTS (38.9 KM PER HR)	3RD DASHED LINE	(----)	FROM CENTER DOT
24 KNOTS (44.5 KM PER HR)	5TH SOLID LINE	(——)	FROM CENTER DOT

NOTE: WHERE LINES RUN TOGETHER, SURFACE WIND SPEED IS THE SAME AS THE SURFACE WIND SPEED REPRESENTED BY THE PREDOMINANT LINE SHOWN

INTERNATIONAL FALLS
SURFACE WIND ROSE - ANNUAL (1964-1973)

SOURCE: PREPARED BY BRUCE F. WATSON, METEOROLOGIST, ST. PAUL, MINNESOTA

FIGURE IV-45



LEGEND

MONITOR LOCATION - CENTER DOT (●)

RADIUS OF SMOOTH CENTER CIRCLE - % CALM

SURFACE WIND OF:

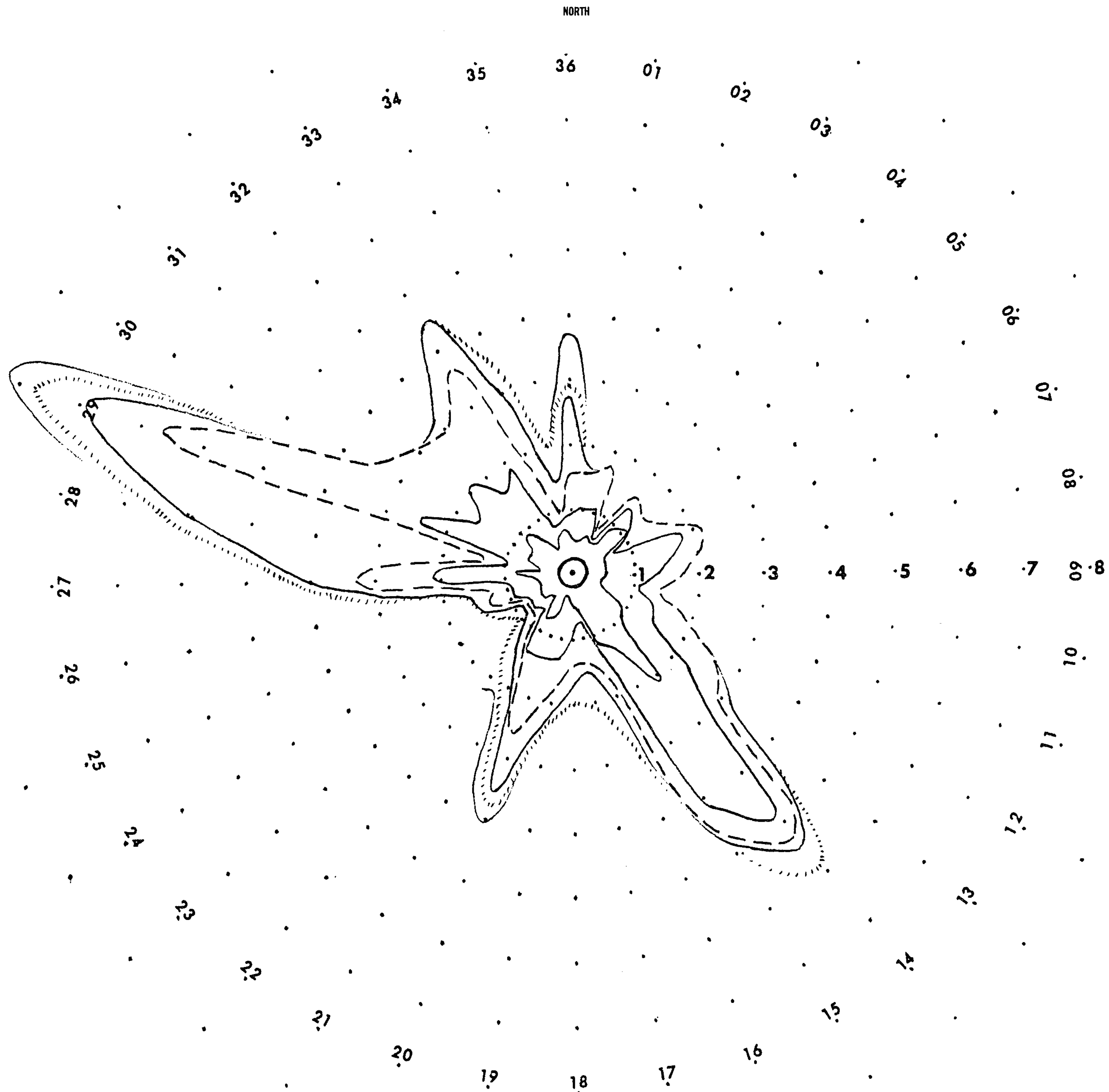
3 KNOTS (5.6 KM PER HR) - 1ST SOLID LINE (——) FROM CENTER DOT
6 KNOTS (11.1 KM PER HR) - 2ND SOLID LINE (——) FROM CENTER DOT
9 KNOTS (16.7 KM PER HR) - 1ST DASHED LINE (- - - -) FROM CENTER DOT
12 KNOTS (22.2 KM PER HR) - 3RD SOLID LINE (——) FROM CENTER DOT
15 KNOTS (27.8 KM PER HR) - 2ND DASHED LINE (\\\\\\) FROM CENTER DOT
18 KNOTS (33.3 KM PER HR) - 4TH SOLID LINE (——) FROM CENTER DOT
21 KNOTS (38.9 KM PER HR) - 3RD DASHED LINE (- - - -) FROM CENTER DOT
24 KNOTS (44.5 KM PER HR) - 5TH SOLID LINE (——) FROM CENTER DOT

NOTE: WHERE LINES RUN TOGETHER, SURFACE WIND SPEED IS THE SAME AS THE SURFACE WIND SPEED REPRESENTED BY THE PREDOMINANT LINE SHOWN

ON-SITE SURFACE WIND ROSE
CLAY BOSWELL STEAM ELECTRIC STATION
JANUARY, 1976

SOURCE: PREPARED BY BRUCE F. WATSON, METEOROLOGIST, ST. PAUL, MINNESOTA

FIGURE IV-46



LEGEND

MONITOR LOCATION - CENTER DOT (●)

RADIUS OF SMOOTH CENTER CIRCLE - % CALM

SURFACE WIND OF:

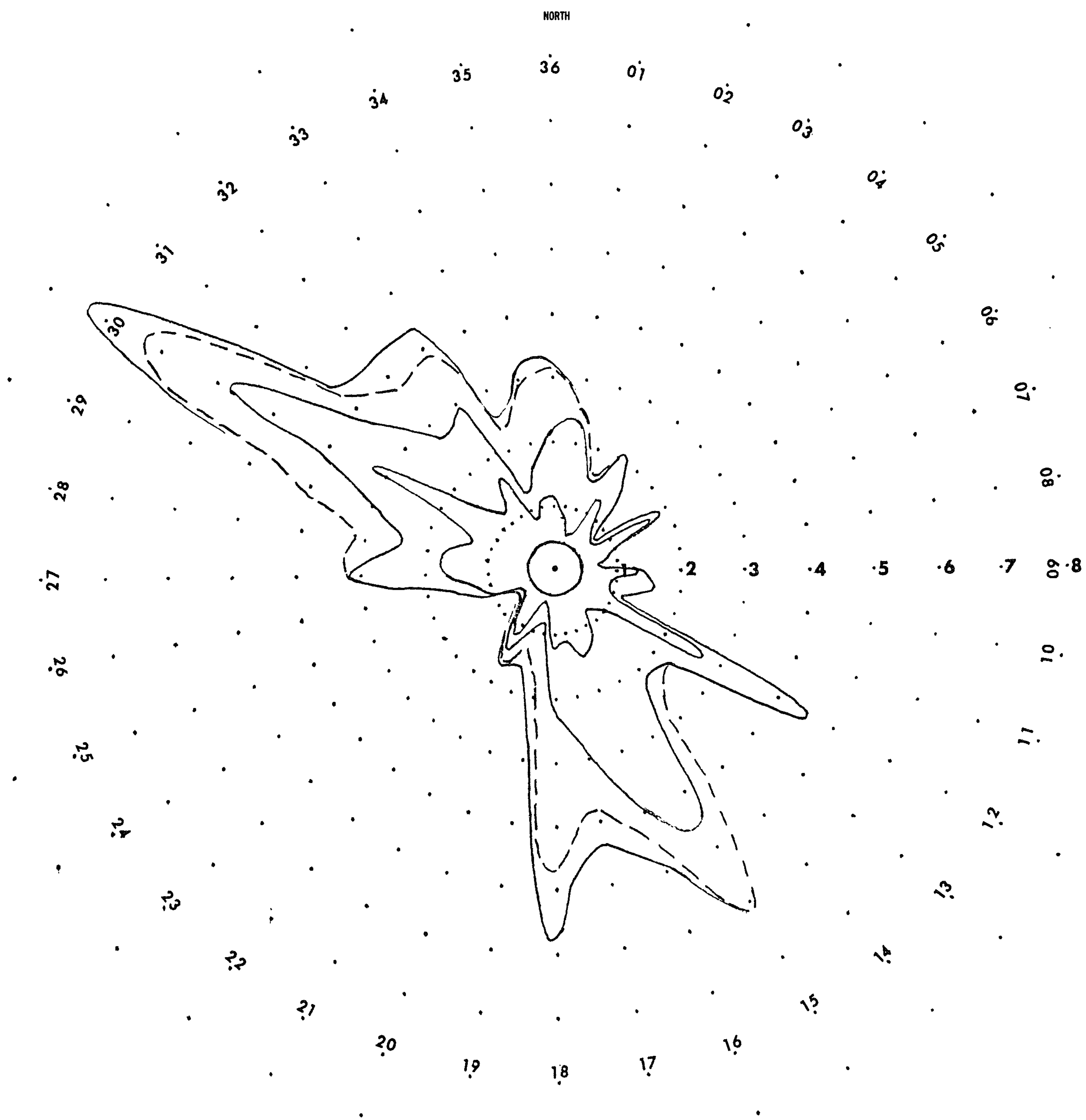
3 KNOTS (5.6 KM PER HR) - 1ST SOLID LINE (——) FROM CENTER DOT
6 KNOTS (11.1 KM PER HR) - 2ND SOLID LINE (——) FROM CENTER DOT
9 KNOTS (16.7 KM PER HR) - 1ST DASHED LINE (- - - -) FROM CENTER DOT
12 KNOTS (22.2 KM PER HR) - 3RD SOLID LINE (——) FROM CENTER DOT
15 KNOTS (27.8 KM PER HR) - 2ND DASHED LINE (\\\\\\) FROM CENTER DOT
18 KNOTS (33.3 KM PER HR) - 4TH SOLID LINE (——) FROM CENTER DOT
21 KNOTS (38.9 KM PER HR) - 3RD DASHED LINE (- - - -) FROM CENTER DOT
24 KNOTS (44.5 KM PER HR) - 5TH SOLID LINE (——) FROM CENTER DOT

NOTE: WHERE LINES RUN TOGETHER, SURFACE WIND SPEED IS THE SAME AS THE SURFACE WIND SPEED REPRESENTED BY THE PREDOMINANT LINE SHOWN

ON-SITE SURFACE WIND ROSE
CLAY BOSWELL STEAM ELECTRIC STATION
MARCH 1976

SOURCE: PREPARED BY BRUCE F. WATSON, METEOROLOGIST, ST. PAUL, MINNESOTA

FIGURE IV-47



LEGEND

MONITOR LOCATION - CENTER DOT (●)

RADIUS OF SMOOTH CENTER CIRCLE - % CALM

SURFACE WIND OF:

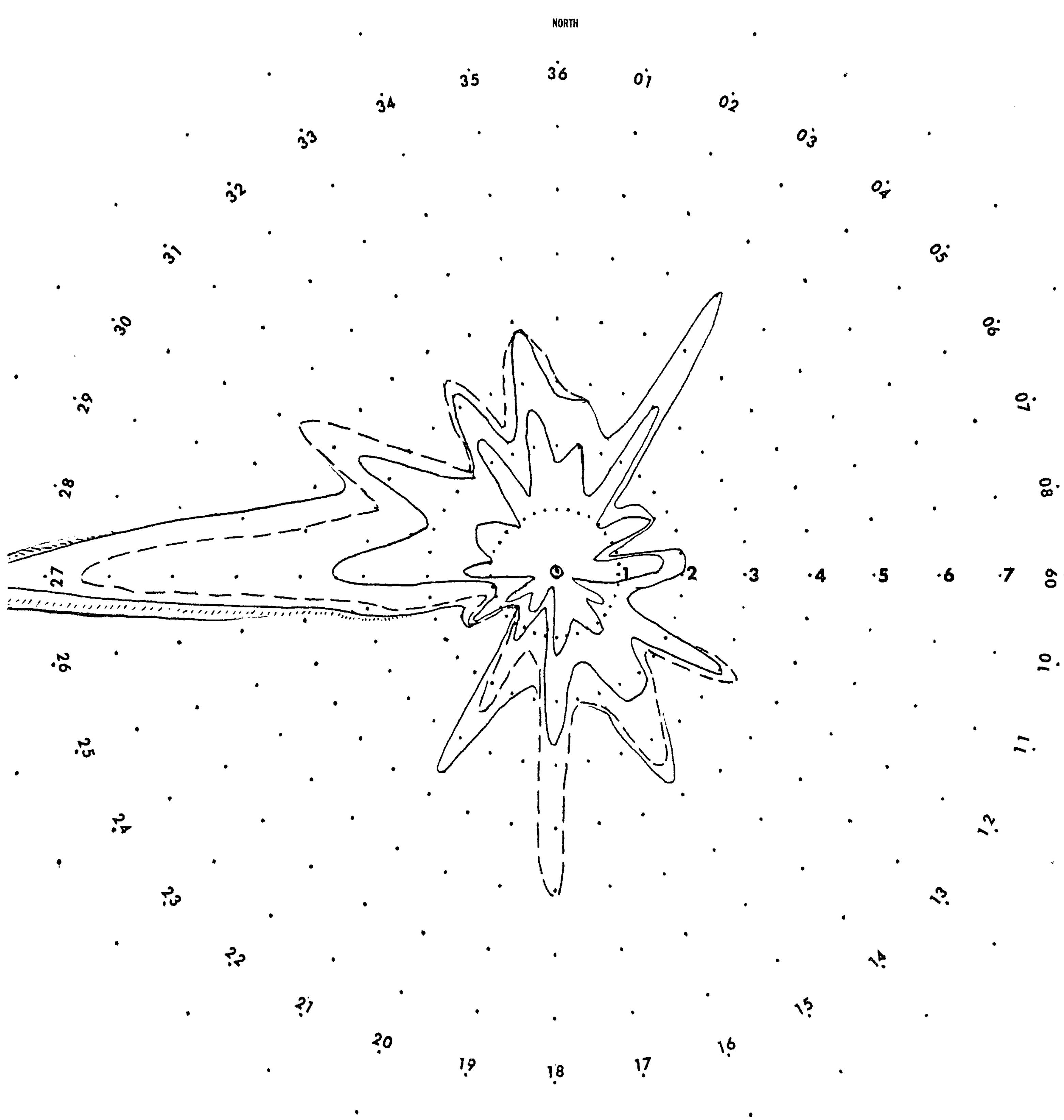
3 KNOTS (5.6 KM PER HR)	1ST SOLID LINE	(———)	FROM CENTER DOT
6 KNOTS (11.1 KM PER HR)	2ND SOLID LINE	(———)	FROM CENTER DOT
9 KNOTS (16.7 KM PER HR)	1ST DASHED LINE	(- - - -)	FROM CENTER DOT
12 KNOTS (22.2 KM PER HR)	3RD SOLID LINE	(———)	FROM CENTER DOT
15 KNOTS (27.8 KM PER HR)	2ND DASHED LINE	(\\\\\\)	FROM CENTER DOT
18 KNOTS (33.3 KM PER HR)	4TH SOLID LINE	(———)	FROM CENTER DOT
21 KNOTS (38.9 KM PER HR)	3RD DASHED LINE	(- - - -)	FROM CENTER DOT
24 KNOTS (44.5 KM PER HR)	5TH SOLID LINE	(———)	FROM CENTER DOT

NOTE: WHERE LINES RUN TOGETHER, SURFACE WIND SPEED IS THE SAME AS THE SURFACE WIND SPEED REPRESENTED BY THE PREDOMINANT LINE SHOWN

ON-SITE SURFACE WIND ROSE
CLAY BOSWELL STEAM ELECTRIC STATION
JULY 1976

SOURCE: PREPARED BY BRUCE F. WATSON, METEOROLOGIST, ST. PAUL, MINNESOTA

FIGURE IV-48



LEGEND

MONITOR LOCATION - CENTER DOT (●)
RADIUS OF SMOOTH CENTER CIRCLE - % CALM

SURFACE WIND OF:

3 KNOTS (5.6 KM PER HR) - 1ST SOLID LINE	(——)	FROM CENTER DOT
6 KNOTS (11.1 KM PER HR) - 2ND SOLID LINE	(——)	FROM CENTER DOT
9 KNOTS (16.7 KM PER HR) - 1ST DASHED LINE	(- - - -)	FROM CENTER DOT
12 KNOTS (22.2 KM PER HR) - 3RD SOLID LINE	(——)	FROM CENTER DOT
15 KNOTS (27.8 KM PER HR) - 2ND DASHED LINE	(\\\\\\)	FROM CENTER DOT
18 KNOTS (33.3 KM PER HR) - 4TH SOLID LINE	(——)	FROM CENTER DOT
21 KNOTS (38.9 KM PER HR) - 3RD DASHED LINE	(- - - -)	FROM CENTER DOT
24 KNOTS (44.5 KM PER HR) - 5TH SOLID LINE	(——)	FROM CENTER DOT

NOTE: WHERE LINES RUN TOGETHER, SURFACE WIND SPEED IS THE SAME AS THE SURFACE WIND SPEED REPRESENTED BY THE PREDOMINANT LINE SHOWN

ON-SITE SURFACE WIND ROSE
CLAY BOSWELL STEAM ELECTRIC STATION
OCTOBER 1976

SOURCE: PREPARED BY BRUCE F. WATSON, METEOROLOGIST, ST. PAUL, MINNESOTA

FIGURE IV-49

TABLE IV-39
TEMPERATURE MEANS - CLAY BOSWELL STEAM ELECTRIC STATION AND TEMPERATURE EXTREMES - POKEGAMA FALLS (85)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Mean maximum													
°F	15.1	19.2	32.7	48.9	63.0	71.2	77.0	74.1	65.0	51.9	34.0	20.9	47.8[a]
°C	-9.4	-7.1	0.4	9.4	17.2	21.8	25.0	23.4	18.3	11.1	1.1	-6.2	8.8[a]
Mean													
°F	5.6	9.4	23.4	38.3	51.5	60.1	65.4	62.6	53.7	40.9	25.2	11.7	37.3[a]
°C	-14.7	-12.6	-4.8	3.5	10.8	15.6	18.6	17.0	12.1	4.9	-3.8	11.3	2.9[a]
Mean minimum													
°F	-4.0	-0.4	14.0	27.8	39.9	49.0	53.9	51.1	42.4	29.9	16.3	2.5	26.9[a]
°C	-20.0	-18.0	-10.0	-2.3	4.4	9.4	12.2	10.6	5.8	1.2	-8.7	-16.4	-2.8[a]
Highest in month													
°F	54	57	81	90	101	98	103	98	99	85	71	60	103
°C	12	14	27	32	38	37	39	37	37	29	22	16	39
Highest monthly average													
Year	1944	1954	1910	1915	1922	1933	1916	1947	1897	1963	1899	1939	
°F	20.0	24.2	38.0	49.1	58.6	68.0	72.8	70.5	61.6	55.8	35.4	24.4	72.8
°C	-6.7	-4.3	3.3	9.5	14.8	20.0	22.7	21.4	16.4	13.2	1.9	-4.2	22.7
Lowest in month													
°F	-57	-59[b]	-49	-17	12	20	33	27	12	1	-45	-57	-57
°C	-49	-51[b]	-45	-27	-11	-7	-7	1	-11	-17	-43	-49	-49
Lowest monthly average													
Year	1912	1936	1899	1950	1907	1969	1904	1903	1965	1925	1896	1903	
°F	-11.8	-7.8	8.2	29.9	41.8	55.8	60.7	58.8	48.6	32.6	11.5	-0.6	-11.8
°C	-24.3	-22.1	-13.2	-1.2	5.4	13.2	15.9	14.9	9.2	0.3	-11.4	-18.1	-24.3

[a] Yearly average.
[b] Reading regarded to be erroneous, although official.

Humidity

Humidity is the water vapor content of the atmosphere. Table IV-40 presents humidity data for the Clay Boswell Station. Vapor pressure is the partial pressure of the air resulting from the presence of water vapor. It is an absolute measure of the actual amount of water vapor in the air. At the community of Cohasset, the vapor pressure varies from an average of 2.6 millibars (0.26 kilopascals) in January to 15.8 millibars (1.58 kilopascals) in July.

Relative humidity, which is the amount of water vapor in the air compared with the maximum water vapor the air could contain at a given temperature, varies from an average of 61% in May to 78% in November. The low value in May results from the mixing of dry air aloft with surface air in a generally turbulent regime. The high value in November results from the stability of the air in association with a shallow high pressure center over Manitoba and thrusts of chilly air from Canada. Generally, in the area around the Clay Boswell Station, relative humidity is quite high, except in the spring.

TABLE IV-40
HUMIDITY DATA - CLAY BOSWELL STEAM ELECTRIC STATION (82)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Mean vapor pressure													
mb	2.6	3.0	4.5	6.4	8.6	12.1	15.8	14.3	11.9	7.3	5.2	3.5	7.9[a]
kilopascals	.26	.30	.45	.64	.86	1.21	1.58	1.43	1.19	.73	.52	.35	.79 [a]
Mean relative humidity													
%	69	71	69	65	61	67	71	71	77	74	78	76	71[b]
Mean dew point													
°F	-7.5	1.7	14.7	27.6	38.6	49.1	55.6	53.0	46.6	33.3	19.0	5.5	-
°C	-21.9	-16.8	-9.6	-2.4	3.7	9.5	13.1	11.7	8.1	0.7	-7.2	-14.7	-

[a] Monthly mean vapor pressure.

[b] Monthly mean relative humidity.

Dew point is another expression of water vapor content, but dew point averages lack some significance since dew point values are non-linear with actual water vapor content. There is a slight difference between the actual average dew point as observed and a dew point as determined from average temperature and average vapor pressure or relative humidity. Neglecting this slight difference, the average dew point, using the latter methods of calculation, varies from -7.5°F (-21.9°C) in January to 55.6°F (13.1°C) in July.

The wet bulb temperature is the temperature an air parcel would have if cooled adiabatically at constant pressure by evaporation of the water in the air. At International Falls, the wet bulb is 72°F (22.2°C) or greater 1% of the time; 69°F (20.6°C) or greater 2-1/2% of the time; 68°F (20.0°C) or greater 5% of the time; and 65°F (18.3°C) or greater 10% of the time (81).

Precipitation

The avearge annual long-term precipitation for the community of Cohasset is 25.48 in. (64.72 cm). Table IV-41 presents precipitation data for the vicinity near the Clay Boswell Station. Precipitation for June and July is 3.83 in. (9.72 cm) and 3.86 in. (9.80 cm), respectively.

The driest month is February with only 0.63 in. (1.60 cm) of precipitation, although December and January also have sparse precipitation with 0.83 and 0.82 in. (2.10 and 2.08 cm), respectively. The wettest month ever observed at Pokegama Falls was August 1900 with 9.85 in. (25.02 cm) of precipitation. No measurable precipitation was recorded in November 1916 and in March 1895. The fact that the wettest month in 90 years yielded only 9.85 in. (25.02 cm) should not be taken as an indication that the value cannot or will not be exceeded in the next 90 years. That value is somewhat low for a 90 year period as compared with other stations in northern Minnesota. It is possible that during any month of the year there could be no measurable precipitation.

From June through August, precipitation occurs at any moment less than 10% of the time and less than 5% of the time during the last half of July. Precipitation is most likely to occur in November and December when

TABLE IV-41
PRECIPITATION MEANS - CLAY BOSWELL STEAM ELECTRIC STATION AND PRECIPITATION EXTREMES - POKEGAMA FALLS

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Mean monthly													
in.	.82	.63	1.10	1.86	2.92	3.83	3.86	3.54	2.77	1.92	1.40	.83	25.48[a]
cm	2.1	1.6	2.8	4.7	7.4	9.7	9.8	9.0	7.0	4.9	3.6	2.1	64.7[a]
Wettest month, Pokegama Falls													
Year[b]	1975	1951	1901	1896	1896	1888	1949	1900	1965	1973	1938	1887	
in.	3.18	1.85	4.11	5.66	7.26	9.39	9.08	9.85	8.10	7.39	4.42	2.65	9.85
cm	8.1	4.7	10.4	14.4	18.4	23.9	23.1	25.0	20.6	18.8	11.2	6.7	25.0
Driest month, Pokegama Falls													
Year[b]	1963	1935	1895	1926	1917	1961	1894	1930	1952	1944	1916	1913	
in.	.04	.03	0	.03	.20	.57	.36	.30	.49	.08	trace	.07	0
cm	.1	.1	0	.1	.5	1.4	.9	.8	1.2	.2	trace	.2	0
Mean days													
.10 in. (0.25 cm) or more[c]	3	2	3	5	8	7	7	6	6	4	4	2	57[d]
.50 in. (1.27 cm) or more[c]	0	x[e]	x[e]	1	1	3	4	2	2	1	1	x[e]	15[f]
Mean snowfall[g]													
in.	12.1	9.8	10.0	5.9	1.1	0	0	0	trace	2.1	9.3	9.7	60.0[h]
cm	30.7	24.9	25.4	15.0	2.8	0	0	0	trace	5.3	23.6	24.6	152.4[h]

[a] Annual mean precipitation.
[b] Watson, Bruce F., Minnesota Weather Almanac 1976, Bolger Press, Minneapolis, Minnesota, 1975.
[c] ___, "Climatography of the United States," No. 86-17, 1964, U.S. Department of Commerce.
[d] Annual mean number of days of .10 in. (0.25 cm) or more precipitation.
[e] Means less than half and greater than zero.
[f] Annual mean number of days of .50 in. (1.27 cm) or more precipitation.
[g] Watson, Bruce F., Climatological Model of Minnesota, 1973, unpublished.
[h] Annual mean snowfall.

precipitation occurs nearly 30% of the time. Most of this time, precipitation is in the form of very light snow. On many November and December days, such snow may occur all day with a total fall of only a trace.

Measurable precipitation occurs on approximately 125 days of the year at the Clay Boswell Station. From observations made at Pokegama Falls (Table IV-41), precipitation exceeded 0.10 in. (0.25 cm) on 57 days over a 7 year period and exceeded 0.50 in. (1.27 cm) on 15 days. Data on short-term, intense precipitation are presented in Table IV-42, which presents data for periods from 5 min to 24 hr at International Falls.

TABLE IV-42
SHORT PERIOD RAINFALL STATISTICS
INTERNATIONAL FALLS, MINNESOTA (86)

Time Period	Period of Record	Amount in.	Amount cm
5 minutes	1953 to 1961	.80	2.03
10 minutes	1953 to 1961	1.03	2.62
15 minutes	1953 to 1961	1.14	2.90
30 minutes	1953 to 1961	1.34	3.40
1 hour	1946 to 1961	1.45	3.69
2 hours	1946 to 1961	2.15	5.46
3 hours	1946 to 1961	2.68	6.80
6 hours	1946 to 1961	2.69	6.83
12 hours	1946 to 1961	2.94	7.47
24 hours	1946 to 1961	4.82	12.24

Snow and Frozen Precipitation

Snow may occur at the Clay Boswell Station from around September 12 to the end of May, although the season usually extends from early November to late April. Most of the precipitation from near November 1 to April 6 is snow. Snow does not occur normally in June, July, and August, although it is possible for snow to fall in early June and late August. Other types of frozen precipitation, such as ice pellets and hail, generally are included in snow statistics, with hail being the only form prevailing from June through August.

The average annual snowfall at the Clay Boswell Station is 60 in. (152 cm). January is the snowiest month, but the snowiest period on a per day basis is the first 20 days of March. The March snow also has a higher equivalent liquid water content due to snow forming at warmer temperatures and compacting during storms. January and February snows are usually "fluffy", since most of the snow forms at cold temperatures and falls frequently in small amounts, thus avoiding being compacted immediately.

Maximum snow depth occurs around February 1 when it averages about 12 in. (30.5 cm). There generally is an average snow cover (1-1/2 in. (1.3 cm) or more) from near November 10 to April 10. However, the period from before November 20 and after March 20 usually is characterized by intermittent snow cover.

Blowing snow occurs about 10% of the time when the snow cover is present. It occurs most often in conjunction with falling snow. Fewer than 50 hr a year have seriously restricted visibility due to blowing snow.

Severe Weather

Thunderstorms occur on an average of 35 days per year on a midnight-to-midnight basis. Table IV-43 presents thunderstorm information for the Clay Boswell Station. In July, the wettest month, thunderstorms occur on an average of 10 days; in June and August, thunderstorms occur on an average of 8 days; in May, thunderstorms occur on an average of 4 days; in April and September, on an average of 3 days; and in October, on an average of 1 day. Thunderstorms are rare from November to February, but they can occur on any date of the year. Since it occasionally happens that more than one thunderstorm occurs on a single date, and, since thunderstorms sometimes begin before midnight and last through midnight, the number of thunderstorms per year does not equal the number of thunderstorm days. When consideration of this is made, approximately 44 discrete thunderstorms can be expected each year. The average lifetime of a thunderstorm in the Clay Boswell area is a little less than 0.75 hr. Thus, there is electrical activity in the sky approximately 33 hr per year.

TABLE IV-43
MEAN NUMBER OF DAYS WITH THUNDERSTORMS - CLAY BOSWELL STEAM ELECTRIC STATION (82)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Mean number days midnight to midnight	x[a]	x[a]	1	3	4	8	10	8	3	1	x[a]	x[a]	38[b]

[a] Means less than half and greater than zero.
[b] Annual mean number of days with thunderstorms.

Freezing precipitation, also known as glaze, can occur at the Clay Boswell Station from near October 20 to April 20. It is most common in December, occurring on about 12% of the days, but can be expected on 5 to 10% of the days from January through March and after November 10. Freezing precipitation, as distinguished from frozen precipitation, is the freezing of liquid water (at or above 32°F) (0°C), raindrops, or drizzle drops on a surface where the temperature is below freezing. Frozen precipitation includes snow, ice pellets, and hail.

Ice pellets, also known as sleet, are composed of frozen raindrops or drizzle. To form, they require air below freezing to exist at and/or near the surface. The ice pellet season lasts longer than the freezing precipitation season, commencing around September 20 and lasting to around May 20. The ice pellet season has twin peaks: one in mid-to-late November and the other in late March and early April. There is a mid-winter minimum due to the rarity of temperatures above 32°F (0°C) at and near the surface from December through February. Ice pellets are not as frequent as freezing rain and occur on less than 5% of the days, even during the November and March-April peaks. In January, ice pellets occur on the average of less than 2% of the days.

The hail season runs from mid-March to mid-November. Hail is most common in late spring, but stones that fall in April and May are generally less than 4 millimeters (mm) in diameter. The storms of June, July, and August are most conducive to hailstones greater than 20 mm in diameter. It would be possible for a hailstone as large as 100 mm to fall at the Clay Boswell Station, but such an occurrence would be on the order of less than once every 1,000 years. Hail occurs on less than 2% of the days, even at the peak of the season in May, and averages less than 1% of the days over the season.

A conservative estimate of the probability (P) that a given point will be affected by a tornado in a given year is given by Thom's equation (87):

$$P = \frac{2.8209t}{A}$$

or

$$P - .000868t \text{ for } A = 3{,}250$$

and

$$R = \frac{1}{P}$$

where t is the mean frequency of tornadoes per year; A is the area of a 1 square at this latitude (3,250 sq miles) (8,417.5 sq meter); and R is the recurrence interval. Table IV-44 gives the tornado probabilities at the Clay Boswell Station (88). The tornado probability for the Station is 0.00026 to 0.00029 and a given point in the 1 square can be expected to be affected by a tornado once in approximately 3,450 to 3,850 years. Tornado probabilities may be higher than this in any single anomalous year.

Fog

Fog frequency is related to the local microclimate. Its frequency cannot be assumed to be the same for locations separated by even a few miles. Airport data often do not reflect fog frequencies elsewhere, since efforts are made to locate airports away from fog-prone regions. The Clay Boswell Station is in a microclimate that is fairly susceptible to heavy, shallow fogs so that such fogs can be expected to be frequent in the spring and fall - on the order of 2 or 3 days per month may have fog, limiting visibility to less than 500 m in April, May, September, and October. Generally, these fogs would not extend higher than 60 ft (18.3 m). These fogs generally last for no more than 3 hr. Such fogs would be expected about once or twice per month in June, July, and August, and, on occasion, in other months.

Fogs which restrict visibility to less than 500 m and, which also are due to air mass advection and mixing, can be expected about once per month from November to March, except about twice during December. These fogs often are deep and last, on the average, for about 4 or 5 hr.

Sunshine and Cloudiness

Clearness of the sky and percent of possible sunshine is greatest in summer and least in autumn. Table IV-45 presents sky data for the Clay Boswell Station. Clearness of the sky also is high in February, especially during the last 2 weeks of February. Statistics of percent of possible sunshine and of percent clearness of the sky are not perfectly related because of geometrical considerations (clouds are three-dimensional) and because many clouds are too

TABLE IV-44
TORNADO CHARACTERISTICS
TORNADO PROBABILITY - CLAY BOSWELL STEAM ELECTRIC STATION (88)

Item	Value
Tornado Characteristics[a]	
Maximum wind speed[b]	
mph	360
km per hr	579
Rotation speed	
mph	290
km per hr	467
Maximum translational speed	
mph	70
km per hr	113
Minimum translational speed	
mph	5
km per hr	8
Radius of maximum rotation speed	
ft	150
m	46
Pressure drop	
psi	3
kg per sq cm	1.3
Rate of pressure drop	
psi per sec	2
kg per sq cm per sec	.9
Tornado Probability	
Probability of occurrence	
10 yr data base,[c] %	0.026
13 yr data base,[d] %	0.029
Return period	
10 yr data base,[c] years	3,846
13 yr data base,[d] years	3,448

[a] As given in AEC Regulatory Guide 1.76.

[b] Maximum wind speed is sum of rotational and translation speeds.

[c] Based on 1953 to 1962 Data Base by H.C.S. Thom.

[d] Based on 1955 to 1967 Data Base by U.S. Department of Commerce.

thin to retard the bright sun from shining on the earth. In the United States, for statistical purposes, the sun is considered to be shining if a shadow is cast by solar light.

TABLE IV-45
SUNSHINE AND CLOUDINESS - CLAY BOSWELL STEAM ELECTRIC STATION (82)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Mean % possible sunshine	50	60	60	56	58	59	67	63	52	47	35	41	54
Mean clearness of sky, %	34	40	36	35	35	34	39	41	33	33	23	27	34
Mean cloudiness of sky, %	66	60	64	65	65	66	61	59	67	67	77	73	66

Percent of possible sunshine is greatest in July and least in November. Clearness of the sky also is least in November, but at a maximum in August. Clearness of the sky in February nearly equals the time the sky is clear in August. General high values for August, July, and February are due largely to the fine weather periods that prevail nearly every year from mid-July to August 20 and during the last 2 weeks of February.

The minimum of both sunshine and clearness of the sky in the autumn are due largely to the low stratus clouds that hover over northern Minnesota between early November and the time of the winter solstice.

Barometric Pressure

The barometer senses the weight of air over a point. At the Clay Boswell Station, January averages the highest in pressure at 102.02 kilopascals and June averages the lowest at 101.28 kilopascals. Table IV-46 gives the monthly mean pressure at the Clay Boswell Station.

TABLE IV-46
ATMOSPHERIC PRESSURE - CLAY BOSWELL STEAM ELECTRIC STATION (82)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Mean monthly													
kilopascals	102.02	101.86	101.79	101.47	101.43	101.28	101.40	101.46	101.50	101.57	101.58	101.77	101.59[a]
millibars	1020.2	1018.6	1017.9	1014.7	1014.3	1012.8	1014.0	1014.6	1015.0	1015.7	1015.8	1017.7	1015.9[a]

[a] Yearly average.

AIR QUALITY

Introduction

The principal air pollutants emitted by large coal-fired electric generating stations are particulates, nitrogen oxides (NO_x), and sulfur dioxide (SO_2). Associated with the 3 principal pollutants are trace elements, which are emitted either as constituents of the particulates or as vapors, and sulfates, which are primarily secondary reaction products of SO_2. Units 1, 2, and 3 at the Clay Boswell Station are significant elements of the present environmental setting. Thus, it is necessary to consider the way in which the emissions of the 5 pollutant types from existing Units 1, 2, and 3 are dispersed in the atmosphere around the Clay Boswell Station. It also is necessary to consider the background concentrations resulting from natural processes and the emissions of other industrial, commercial, residential, and transportation facilities in northern Minnesota. Fogging and salt deposition caused by the Unit 3 cooling tower at the Clay Boswell Station are discussed at the end of this section.

The term "air quality impact" is, in a sense, misleading. Of concern are the biological and physical impacts of pollutants which are transmitted by the atmosphere. The projection of environmental impacts is difficult when dealing with complex biological-physical systems. In many cases, the only practical, albeit simplistic procedure is to test the proposed action against the various environmental standards, regulations, and guidelines. The maximum legally permissable concentrations of air pollutants established by the Federal and state Ambient Air Quality Standards (AAQS) are thought to adequately protect human health and welfare. Consequently, the AAQS provide a legitimate index of environmental impact. That is, if the proposed action will cause these levels to be exceeded, the environmental impact will be significant and the proposed action may be socially unacceptable. If the proposed action will not lead to the violation of the AAQS, then most facets of the environment will be unharmed and the facility will be socially acceptable. A difficulty arises in this approach, however, when there are no standards. This is the case with trace elements and sulfates. Additionally, the AAQS and the New Source Performance Standards may be inadequate to the extent that they do not preclude long term impacts, which are required points of analysis in an environmental impact statement (89). Table IV-47 includes the EPA and MPCA AAQS which apply to the Clay Boswell Station Units 1, 2, and 3. As discussed in Chapter I, the more stringent applies when the EPA and MPCA standards differ. Note that the EPA Prevention of Significant Air Deterioration increments do not apply to existing Units 1, 2, and 3 because these regulations were promulgated subsequent to construction of Units 1, 2, and 3 (90). For discussions of the NSPS, the Air Quality Stipulation Agreement, and the engineering considerations utilized to establish the air pollutant emission rates of existing Units 1, 2, and 3, refer to Chapter II. For general discussions of the air emission impacts on terrestrial vegetation and wildlife, refer to Chapter V.

Regional

The region herein referred to is defined as northern Minnesota. Particulates, NO_x, and SO_2 are continuously monitored in this region by the MPCA. Figure IV-50 maps the location of the principal MPCA air quality monitors in northern Minnesota. A limited amount of monitoring has also been done by MP&L at 2 locations on the Clay Boswell Station site. Trace elements have been alanyzed for samples collected by the MPCA at the Moorhead, Brainerd, Grand Rapids, Hibbing, Virginia, Hoyt Lakes, and Duluth monitors during the period 1970 through 1975. Extensive monitoring of ambient sulfate concentrations also was conducted by the MPCA at 13 north central and northeastern Minnesota locations during the period 1970 through 1975.

Particulates

The ambient concentrations of particulates (the term "particulates" as used herein is synonymous with total suspended particulates" or TSP) are measured by the MPCA and MP&L by use of the EPA approved high-volume sampling method (91). At most monitor locations, measurements are taken once every 6 days. The MPCA field data for the period 1973 through 1976 were analyzed statistically to determine the 24-hr maximum and annual geometric mean concentrations of particulates at 12 monitoring locations in northern Minnesota. Note that annual particulate values are given as geometric means, while annual NO_x and SO_2 values are expressed as arithmetic means. Table IV-48 presents the annual geometric mean and 24-hr maximum concentrations measured at the 12 monitor locations.

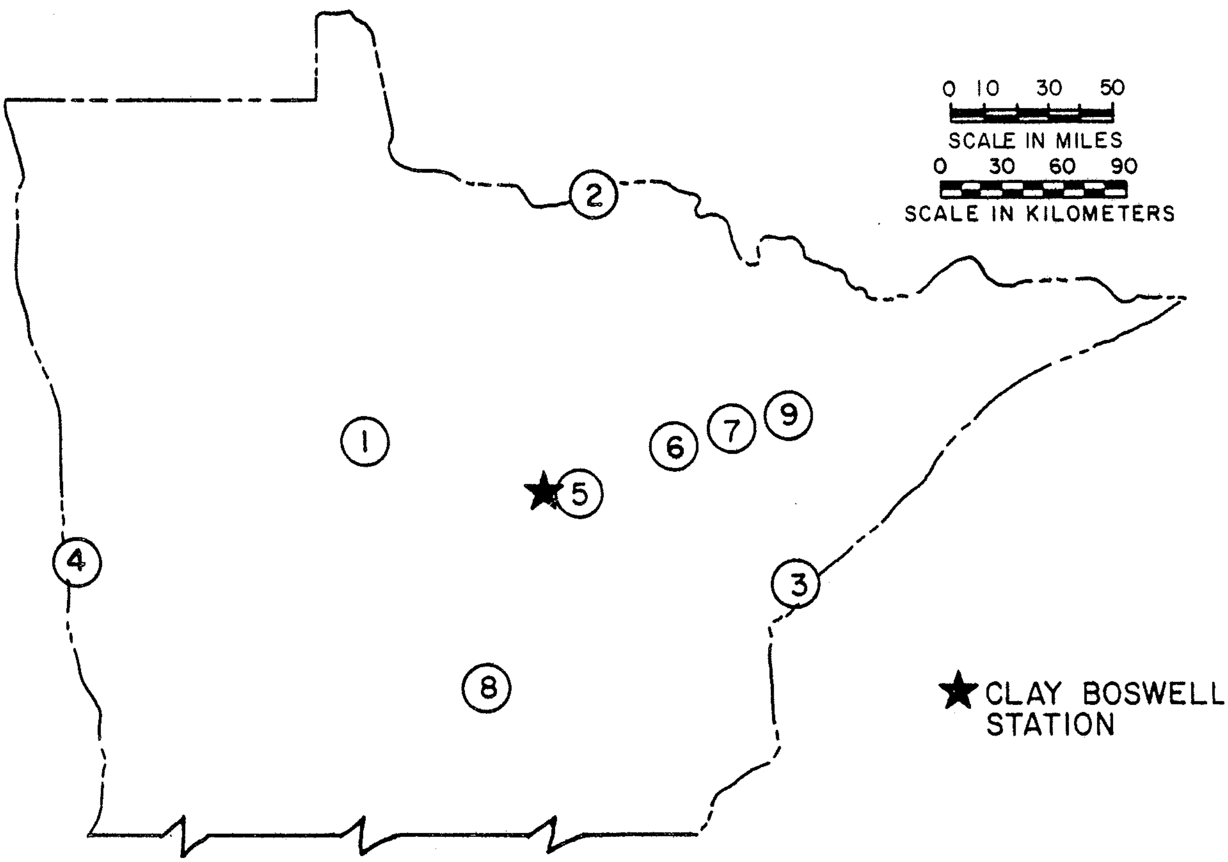
All areas of the country were to be in compliance with all primary AAQS by 1975 and with all secondary AAQS by 1977 (refer to Chapter I). By comparing Table IV-48 with Table IV-47, it can be seen that at several of the monitor locations the particulate concentrations violated the AAQS at various times during the 4 year period. Since the MPCA and EPA AAQS are identical for particulates, the controlling standards are an annual geometric mean concentration of 60 μg per cu m, and a 24-hr maximum concentration of 150 μg per cu m.

While many sources contribute to ambient concentrations of particulates, a frequent cause of excessive levels is fugitive dust blown from roads, fallow fields, sand and gravel operations, mining activities, and similar sources (92). The contribution made by this natural or man-assisted erosion is illustrated by Figure IV-51, which charts the monthly average particulate concentrations at Duluth, Hibbing, and Grand Rapids in 1974 and 1975. During the dry summer months, the particulate concentrations reach their highest levels, while during the wetter months or when there is snow cover, the particulate concentrations are generally at their lowest levels. Thus, fugitive dust emission rates are directly proportional not only to urbanization, but also to dryness (93). For example, it has been estimated that 90% of the ambient concentrations of particulates in Phoenix, Arizona is caused by fugutive dust (94). Fugitive dust is generally less harmful than the particulate emissions of fossil-fueled electric generating stations, mineral processing, and other industrial operations.

TABLE IV-47
AMBIENT AIR STANDARDS AND PREVENTION OF SIGNIFICANT DETERIORATION (PSD) INCREMENTS PROMULGATED BY THE U.S. ENVIRONMENTAL PROTECTION AGENCY AND MINNESOTA POLLUTION CONTROL AGENCY UNDER THE CLEAN AIR ACT

	Prevention of Significant Deterioration				Ambient Air Quality Standards and Class III PSD Designation[b]							
	Class I[a] Increment		Class II[a] Increment		Secondary AAQS				Primary AAQS			
					Federal (c)		Minnesota(d)		Federal (c)		Minnesota(d)	
Pollutant	µg per cu m[e]	ppm[e]	µg per cu m	ppm	µg per cu m	ppm	µg per cu m	ppm	µg per cu m	ppm	µg per cu m	ppm
Sulfur dioxide												
annual average	2	0.00076	15	0.0057	60[f]	0.02[f]	60	0.02	80	0.03	60	0.02
24 hr maximum	5	0.0019	100	0.038	260[f]	0.1[f]	260	0.1	365	0.14	260	0.1
3 hr maximum	25	0.0095	700	0.27	1,300	0.5	655	0.25	1,300	0.5	655	0.5
Particulates												
annual geometric mean	5		10		60		60		75		75	
24 hr maximum	10		30		150		150		260		260	
Carbon monoxide												
8 hr maximum	no standard		no standard		10	9	10	9	10	9	10	9
24 hr maximum	no standard		no standard		40	35	35	30	40	35	35	30
Photochemical oxidants												
1 hr maximum	no standard		no standard		160	0.08	130	0.07	160	0.08	130	0.07
Hydrocarbons (less methane)												
3 hr maximum (6 a.m. to 9 a.m.)	no standard		no standard		160	0.024	160	0.024	160	0.024	160	0.3
Nitrogen dioxide												
annual average	no standard		no standard		100	0.05	100	0.05	100	0.05	100	0.05
Hydrogen sulfide												
½ hr average	no standard		no standard		no standard		42	0.03	no standard		70	0.05

[a] Allowable incremental increase in pollution over the 1974 baseline concentration.
[b] Class III designation allows pollution up to the Federal Ambient Air Quality Standards.
[c] 40C.F.R. pt. 60 - not to be exceeded more than once a year.
[d] Minnesota Regulation APC 1 - not be be exceeded more than once a year.
[e] µg per cu m (micrograms per cubic meter) is a weight per volume ratio; ppm (parts per million) is a volume per volume ratio.
[f] These standards have been voided by Federal courts.



NO.	LOCATION	NO.	LOCATION
1	BEMIDJI	6	HIBBING
2	INTERNATIONAL FALLS	7	VIRGINIA
3	DULUTH	8	BRAINERD
4	MOOREHEAD	9	HOYT LAKES
5	GRAND RAPIDS		

LOCATIONS OF PRINCIPAL MPCA
AIR QUALITY MONITORS IN NORTHERN MINNESOTA

FIGURE IV-50

In 1972, approximately 99,000 tons (90,000 mt) of particulates were emitted by anthropogenic sources in the Duluth-Superior Air Quality Control Region (AQCR), which consists of Itasca, Koochiching, Aitkin, St. Louis, Carlton, Lake, and Cook counties (95). Of this total, approximately 53% was emitted by industrial processes (e.g. taconite and coke processing), 44% was emitted as a result of fossil fuel combustion by residential, utility, industrial, and commercial facilities, 1.5% was emitted by solid waste disposal activities, and 1.5% was emitted by transportation related sources (95). The 99,000 ton (90,000 mt) total has been substantially reduced since 1972, but the source category proportions are still approximately correct (95).

TABLE IV-48
MEASURED PARTICULATE CONCENTRATIONS - VARIOUS NORTHERN MINNESOTA CITIES

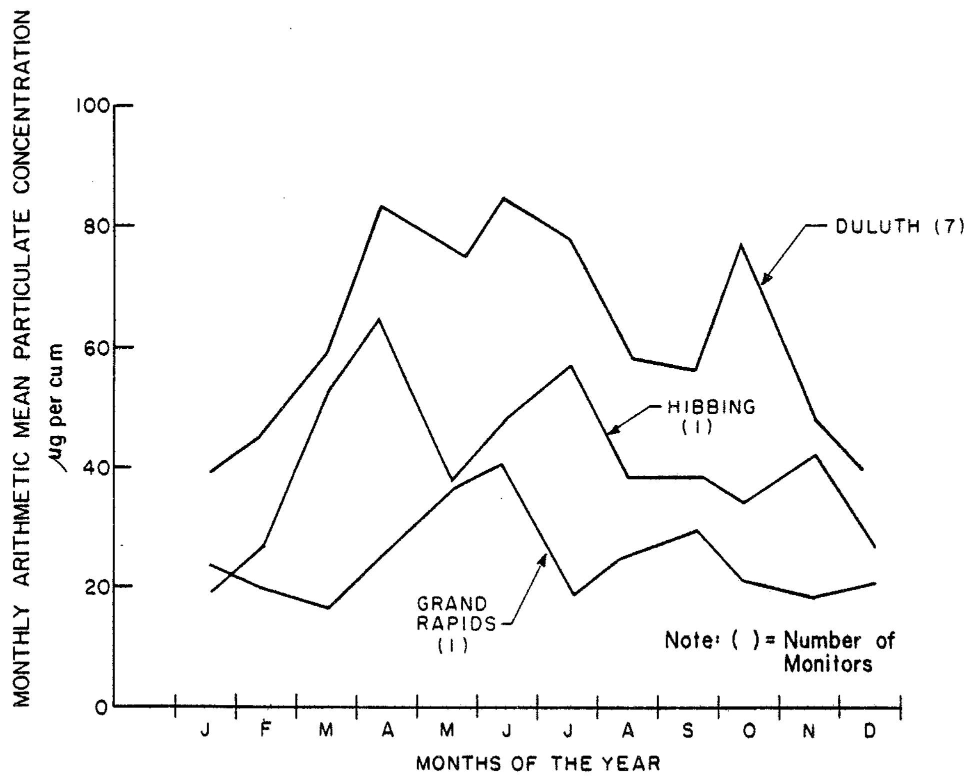
Monitor Location	Annual Geometric Mean µg per cu m 1973	1974	1975	1976	24-hr Maximum µg per cu m 1973	1974	1975	1976[a]
Grand Rapids	29	21	21	19[b]	189	66	87	49[b]
Hibbing	43	35	34	46	133	120	112	175
Bemidji	29	25	25	30	618	103	122	190
Hoyt Lakes	39	30	37	38	174	189	153	101
Brainerd	40	40	36	39	114	209	128	222
Virginia	42	47	45	62	228	160	205	367
Duluth								
1	61	46	43	50	187	186	195	217
2	78	63	62	67	220	254	161	242
3	81	71	72	74	280	243	218	221
4	45	36	39	40	206	187	152	257
5	62	45	47	47	213	207	212	174
6	62	52	47	56	157	164	170	259

[a] 1976 24-hr maximums unusually high due to wind-blown dust caused by drought conditions.

[b] Monitoring for January through June only.

Nitrogen Oxides

The oxides of nitrogen include nitric oxide (NO), nitrogen dioxide (NO_2), nitrous oxide (N_2O), nitrogen sesquioxide (N_2O_3), nitrogen tetroxide (N_2O_4), and nitrogen pentoxide (N_2O_5). As environmental contaminants, nitric oxide and nitrogen dioxide are the most significant (95). Nitrous oxide is a colorless



VARIATIONS IN AMBIENT PARTICULATE CONCENTRATIONS AT THREE LOCATIONS IN NORTHERN MINNESOTA - 1974 AND 1975

FIGURE IV-51

and odorless gas formed by the oxidation of a atmospheric nitrogen under high temperature conditions, such as those which exist in an automobile engine, steam boiler, or other processes involving the combustion of fossil fuels. Nitrogen dioxide, a brown gas with a pungent odor, also is formed during fuel combustion, but to a much lesser extent. Consequently, nearly all of the nitrogen emitted by coal-burning steam electric stations exists from the stack in the nitric oxide form. Nitric oxide itself is relatively harmless to living organisms, but through a complex series of photochemical reactions it is further oxidized into the more toxic and irritating nitrogen dioxide.

Nitrogen dioxide is a major ingredient of the brownish-colored photochemical smog seen in large urban areas. Nitrogen dioxide causes fading and discoloration of fabric, corrosion of certain metals, eye irritation, and transient reductions in pulmonary ability. When associated with particulates and/or sulfur oxides, the acute and insidious health effects of nitrogen dioxide are exacerbated. In the presence of sunlight and hydrocarbons, nitrogen dioxide also plays a major role in the formation of ozone, peroxyacetyl nitrate, and other photochemical oxidants (note that nitrogen dioxide is often termed a photochemical oxidant). Ozone and peroxyacetyl nitrate are biologically very reactive, and can cause severe human health effects and injury to vegetation at low dosages (e.g. 98 μg per cu m total oxidants for one hr) (96). The nitrogen oxides AAQS has been set at 100 μg per cu m annual arithmetic mean to preclude the deleterious effects of nitrogen dioxide, and to prevent the formation of significant concentrations of photochemical oxidants (97).

Ambient concentrations of nitric oxide and nitrogen dioxide are commonly monitored simultaneously and expressed as NO_x. The monitors take into account the different molecular weights of the 2 compounds and convert the data to μg of nitrogen dioxide per cu m. Duluth is the only monitor location in northern Minnesota for which NO_x data are available. Both NO_x monitors in Duluth use the wet chemical method for measuring ambient concentrations (98).

Table IV-49 presents the results of the MPCA NO_x monitoring in Duluth during the period 1973 through 1976. The annual arithmetic mean concentrations for this period were less than half of the applicable NO_x AAQS of 100 μg per cu m.

In 1972, approximately 51,000 tons (46,000 mt) of NO_x were emitted by human activities in the Duluth AQCR (95). By source category, the proportions were as follows (95):

Fuel combustion (except transportation)	71.5%
Transportation	26 %
Industrial processes	2 %
Solid waste disposal	1 %

TABLE IV-49
MEASURED NO_x CONCENTRATIONS AT DULUTH

	Annual Arithmetic Mean μg per cu m			
Monitor Number	1973	1974	1975	1976
1	36	56	62	42
2	14[a]	50	52	38[b]

[a] Monitoring for March through June only.
[b] Monitoring for January through September only.

Sulfur Dioxide

Sulfur dioxide is the most important air pollutant emitted by coal-fired steam electric generating stations becuase it is difficult to control, and because the SO_2 emissions of coal-fired steam electric generating stations comprise a greater portion of the total SO_2 emissions of most AQCR's than is the case with the particulates and NO_x emissions. Sulfur is an essential macronutrient of nearly all living organisms. Consequently, all fuels of organic origin contain sulfur in concentrations which are dependant upon the type of organisms from which the deposit was formed. When these fuels are burned in the presence of air, most of the sulfur is released and oxidized. Sulfur oxide emissions generally consist of a mixture of sulfur dioxide (SO_2), sulfur trioxide (SO_3), hydrogen sulfide (H_2S), and sulfate salts. Approximately 98% by weight of total sulfur oxide emissions is in the sulfur dioxide form (95).

Sulfur dioxide is a colorless, non-flammable gas with a pungent odor. Its half-life in the atmosphere is usually less than a week, though under proper meteorological conditions the SO_2 plume can last for longer periods and be transported over great distances. Sulfur dioxides emitted by coal-fired steam electric generating stations near St. Louis, Missouri have been found to reach as far as Minnesota, while remaining at significant concentrations (99). Sulfur dioxide is removed from the atmosphere principally by dry deposition on the earth's suface and on plants and other surfaces, or by washout by precipitation. Atmospheric SO_2 is readily transformed into sulfites (XSO_3), sulfates (XSO_4), and other gaseous or aerosol compounds by chemical and/or photochemical processes. Sulfur dioxide is directly toxic to vegetation at dosages of about 2,620 μg per cu m for one hr, or 1,572 μg per cu m for 2 hr (100). The EPA secondary 3-hr standard was established at 1,300 μg per cu m in part to preclude these phytotoxic effects (101). Known toxic effects of SO_2 on humans occur at slightly higher dosages, e.g. 3,930 μg per cu m for a few minutes causes a transient restriction of the bronchiolar airways (95). The EPA primary SO_2 standards were set at levels thought necessary to prevent the increased incidence of chronic respiratory diseases (95).

Ambient SO_2 is monitored by the MPCA at 7 locations in northern Minnesota. Both the wet-chemical (98) and the electronic (102) monitoring methods are used. Table IV-50 lists the ambient SO_2 concentrations measured at the 7 locations during the period 1973 through 1976. The AAQS against which Table IV-50 should be compared are 60 μg per cu m annual arithmetic mean and 260 μg per cu m 24-hr maximum. All but one of the measured concentrations were within these AAQS. Although the data are incomplete, they do indicate a downward trend in SO_2 concentrations. Most of 1976 measured concentrations are only small fractions of the applicable AAQS.

Natural processes, such as organic matter decomposition and volcanic activity, contribute approximately two-thirds of the global atmospheric load of sulfur (95). In 1972, United States anthropogenic sources emitted approximately 32 million tons (29 million mt) of SO_2 to the atmosphere (includes all anthropogenic sulfur emissions - expressed as SO_2) (95). More than 75% of the total resulted from fuel combustion in stationary sources (95). Approximately 120,000 tons (109,000 mt) of SO_2 were emitted by anthropogenic sources in the Duluth-Superior AQCR in 1972. By source category, the proportions were as follows (95):

Fuel combustion (except transportation)	90%
Industrial processes	9%
Transportation	<1%
Solid waste disposal	<1%

TABLE IV-50
MEASURED SO_2 CONCENTRATIONS - VARIOUS NORTHERN MINNESOTA CITIES

Monitor Location	Annual Arithmetic Mean µg per cu m 1973	1974	1975	1976	24-hr Maximum µg per cu m 1973	1974	1975	1976
Bemidji	11	10[a]	3	3[b]	24	24[a]	8	6[b]
Moorhead	11	3	3[c]	6	69	19	18[c]	60
International Falls	na[d]	3	5	3	na	3	15	15
Duluth								
1	21	13	na	na	84	81	na	na
2	31	na	na	na	89	na	na	na
3	26	18	na	na	89	71	na	na
4	50	21	na	na	267	131	na	na

[a] Monitoring for August through December only.

[b] Monitoring for January through October only.

[c] Not a complete monitoring year because of analysis problems.

[d] na means not available.

Trace Elements

The term "trace elements" as used herein refers to the various metals, metalloids, and non-metals which are contaminents of coal and are emitted by coal-fired steam electric generating stations. Some of these elements are emitted from anthropogenic sources as constituents or surface films of ash particulates, others, such as mercury and arsenic, are emitted as vapors or aerosols, and still others are emitted as unknown compounds containing 2 or more elements. The following data makes no reference to the chemical form in which the element appears in the atmosphere. Rather, the ambient concentrations are expressed in terms of the pure elements. The relative toxicity of trace elements is, or course, governed as much by the chemical formulation in which they occur as it is by the elements themselves. For general discussions of the environmental impacts of trace element emissions, refer to Chapter V and the report of the supplementary summer 1977 field study.

Ambient concentrations of trace elements have been monitored by the MPCA at several locations in northern Minnesota. The monitoring is conducted by collecting trace elements on the filters of high volume particulate samplers. Either the MPCA or the EPA analyzes portions of the filter for trace elements.

MPCA filter samples collected once every 12 days at Duluth and Moorhead are sent to the EPA at Research Triangle Park, North Carolina for optical emission spectrometer analysis for 11 trace elements. Thus far, only the analyses for the years 1970 through 1974 have been published (103). The results of the EPA analyses are presented in Table IV-51. Note that if the trace element concentration were below the threshold of detection of the analytical technique, the threshold value was used for Table IV-51.

The MPCA conducts atomic absorption analyses for cadmium, iron, lead, and nickel on 24-hr samples collected once each month at 5 northern Minnesota cities. The results of these analyses are available for the period 1973 through 1975 and are presented in Table IV-52.

Currently there are no EPA or MPCA ambient standards for trace elements emitted by coal-fired steam electric generating stations. Both the EPA (104) and the MPCA (105) have emission limitation regulations for mercury emitted by mercury ore processing facilities and sewage sludge incinerators. Mercury emissions from these sources are limited to 2.3 kg per day from ore processing

TABLE IV-51
MEASURED TRACE ELEMENT CONCENTRATIONS AT TWO NORTHERN MINNESOTA CITIES[a]

Trace Element	Annual Arithmetic Mean Concentration[b] μg per cu m	
	Duluth	Moorhead
Beryllium	0.00004[c]	0.00004[c]
Cadmium	0.00036[c]	0.00036[c]
Chromium	0.00429	0.00378
Cobalt	0.00076[c]	0.00076[c]
Copper	0.05860	0.03250
Iron	1.57400	0.90750
Lead	0.62500	0.53600
Manganese	0.03280	0.03830
Nickel	0.00190[c]	0.00190[c]
Titanium	0.05340	0.03700
Vanadium	0.00280[c]	0.00280[c]

[a] Laboratory analysis by the EPA.

[b] Average of the annual arithmetic mean concentrations for the years 1970 through 1974.

[c] Threshold of detection.

and 3.2 kg per day from incinerators. The MPCA has a similar regulation (106) for beryllium emitted by beryllium extraction plants, ceramic manufacturies, rocket propellant plants, and incinerators, which limit emissions to 10 gm of beryllium per day. The EPA beryllium standard (104) also limits emissions from beryllium-related facilities to 10 gm per day, but further allows the party controlling the source of emissions the option of complying with an ambient standard of 10 μg per cu m, 30-day average.

Sulfates

The term "sulfates" as used herein refers to compounds such as sulfuric acid (H_2SO_4), ammonium sulfate [$(NH_4)_2SO_2$], calcium sulfate ($CaSO_4$), magnesium sulfate ($MgSO_4$), and iron sulfate ($FeSO_4$). By convention these compounds are combined and a total sulfate value, expressed as SO_2, is computed and reported. Only a small portion of the sulfur emitted by anthropogenic sources is in the sulfate form. Most atmospheric sulfates result from chemical and/or photochemical reactions involving SO_2 and water vapor or other compounds. Atmospheric sulfates are generally in the physical form of aqueous aerosols, dry particles, or surface films adsorbed onto dry particles (107). The principal concern with sulfates is their adverse effects upon the human respiratory system.

Extensive ambient air sulfate measurements were made by the MPCA at 13 monitoring locations in northern Minnesota during the period 1973 through 1975. The monitoring program was terminated in 1975 because of a concern for quality assurance and problems related to analytical methods and catalytic activity of sulfur compounds on the filter paper during and after sampling. The MPCA will begin a new sulfate monitoring program soon using newly designed equipment and EPA monitoring guidelines (108). The MPCA sulfate monitoring results are presented in Table IV-53. The data indicate a marked reduction in ambient sulfate concentrations at all the monitoring locations from 1973 to 1975. Currently there are no ambient air sulfate standards being enforced in Minnesota, but it is probable that the EPA will promulgate a national standard by 1981 (109). Presently, California has a sulfate standard of 25 μg per cu m 24-hr maximum, and Montana has a sulfuric acid aerosol standard of 30 μg per cu m 1-hr maximum.

Local

The term "local" as used herein refers to the area within 12 miles (19.3 km) of the Clay Boswell Station. The description of the local air quality environmental setting is divided into 2 portions. The first deals with ambient pollutant concentrations resulting from emissions of existing, pre-modified Units 1, 2, and 3, and the second deals with ambient pollutant concentrations resulting from emissions of modified Units 1, 2, and 3. The modifications referred to are those being undertaken by MP&L pursuant to the 1976 Air Quality Stipulation Agreement between MP&L and the MPCA (110). The principal modifications are the following (refer to Chapter II).

- The installation and use of baghouse filters for removal of particulates from Unit 1 and 2 emissions in lieu of mechanical particulate collectors. This modification is required to correct past violations of particulate emission regulations.

TABLE IV-52
MEASURED TRACE ELEMENT CONCENTRATIONS - VARIOUS NORTHERN MINNESOTA CITIES[a]

	Annual Arithmetic Mean µg per cu m											
	1973				1974				1975			
Monitor Location	Cadmium	Iron	Lead	Nickel	Cadmium	Iron	Lead	Nickel	Cadmium	Iron	Lead	Nickel
Grand Rapids	0.002	0.480	0.084	0.003	0.001	0.445	0.071	0.102	0.001	0.350	0.068	0.009
Hibbing	0.003	1.662	0.299	0.005	0.002	1.571	0.239	0.012	0.002	1.185	0.230	0.021
Virginia	0.002	3.534	0.367	0.007	0.003	2.412	0.299	0.008	0.001	2.982	0.268	0.039
Hoyt Lakes	0.005	2.171	0.525	0.004	0.003	1.760	0.340	0.007	0.002	1.940	0.245	0.007
Brainerd	0.003	0.619	0.444	0.007	0.002	1.580	0.432	0.030	0.001	0.403	0.141	0.006

	24-hr Maximum Concentration µg per cu m											
	1973				1974				1975			
	Cadmium	Iron	Lead	Nickel	Cadmium	Iron	Lead	Nickel	Cadmium	Iron	Lead	Nickel
Grand Rapids	0.004	1.210	0.268	0.006	0.001	0.950	0.102	0.042	0.001	0.570	0.119	0.032
Hibbing	0.007	4.850	0.636	0.008	0.006	4.240	0.739	0.060	0.004	2.380	0.668	0.045
Virginia	0.004	7.180	0.766	0.028	0.012	6.300	0.632	0.047	0.002	5.420	0.364	0.212
Hoyt Lakes	0.015	10.620	1.218	0.009	0.012	4.250	1.036	0.025	0.005	4.640	0.717	0.024
Brainerd	0.011	0.990	1.112	0.017	0.003	4.130	0.683	0.105	0.002	0.740	0.279	0.007

[a] Laboratory analysis by the MPCA.

TABLE IV-53
MEASURED SULFATE CONCENTRATIONS - VARIOUS NORTHERN MINNESOTA CITIES

	Annual Arithmetic Mean µg per cu m			24-hr Maximum µg per cu m		
Monitor Location	1973	1974	1975	1973	1974	1975
Grand Rapids	13.9	7.8	4.3	32.4	18.6	6.5
Virginia	13.7	11.5	5.7	22.9	19.5	10.1
Brainerd	12.8	12.5	3.5	26.2	23.1	4.6
Hoyt Lakes	11.9	11.2	6.1	20.2	19.5	10.4
Hibbing	12.6	11.1	6.3	20.7	16.7	8.4
Duluth						
1	13.3	11.9	8.7	23.8	17.7	12.3
2	17.7	12.9	6.0	50.8	25.6	9.4
3	15.4	12.5	5.2	24.6	17.7	8.6
4	16.2	12.6	6.8	25.3	17.0	8.5
5	18.6	14.9	6.7	25.5	24.2	11.0
6	13.6	13.3	5.7	19.3	22.1	8.8
7	13.3	12.9	6.8	27.0	21.5	12.1
8	15.3	10.7	8.4	25.9	15.3	12.7

- The construction and use of a low velocity 700 ft (213 m) stack for Units 1, 2, and 3 in lieu of the 250 ft (76 m) Units 1 and 2 stack and the 400 ft (122 m) Unit 3 stack. This modification is required to control sulfuric acid mists emitted by Unit 3.

The Air Quality Stipulation Agreement requires that these modifications be completed by December 31, 1978, more than one year prior to the startup date of Unit 4.

The ambient pollutant concentration resulting from both the pre-modified and the modified Units 1, 2, and 3 are important for 2 reasons. First, the past emissions of pre-modified Units 1, 2, and 3 have had significant adverse impacts upon the surrounding ecosystem and, therefore, are facets of the present environmental setting. Second, the emissions of modified Units 1, 2, and 3 provide the proper starting point for projecting the ambient pollutant concentrations and environmental impacts of Units 1, 2, 3, and 4. For clarification, the following terminology has been chosen and used consistently throughout:

- "Measured pollutant concentrations" refers to monitoring data collected by the MPCA, the EPA, or MP&L;

- "Calculated pollutant concentrations" refer to ambient concentrations resulting from emissions of pre-modified Units 1, 2, and 3 and are based either on the known past emission rates of Units 1, 2, and 3 or on past on-site monitoring data collected by MP&L:

- "Projected pollutant concentrations" refer to ambient concentrations resulting from emissions of modified Units 1, 2, and 3 are based on the estimated emission factors presented in Tables II-23, II-24, and II-26 in Chapter II; and

- "Background pollutant concentrations" refer to ambient concentrations resulting from emissions of natural sources and anthropogenic sources other than the Clay Boswell Station and are based on concentrations monitored by the MPCA, the EPA, or MP&L.

To calculate or project the ambient concentrations resulting from emissions of the Clay Boswell Station, a statistical process known as diffusion modeling has been used. This process involves computer modeling where the inputs are the appropriate emission factors and meteorological conditions. The diffusion models utilized are listed in Table IV-54. The EPA models PTDIS, PTMTP, and PTMAX were used to predict the short term (24-hr and 3-hr) concentrations. Specifically, the PTDIS and PTMAX models were run for all combinations of wind speed and atmospheric stability, while the PTMTP model was run primarily to predict the magnitude and location of the maximum concentration. The CDM model was used to predict the annual geometric mean and annual average concentrations. The resultant tabulations predict the worst case ambient concentrations, while the isopleth maps illustrate the spatial distribution of the worst case concentration and lesser concentrations.

The meteorological conditions used as inputs for the diffusion modeling were based primarily on data collected at the National Oceanic and Atmospheric

TABLE IV-54
AIR QUALITY DIFFUSION MODELS UTILIZED TO CALCULATE OR PROJECT POLLUTANT CONCENTRATIONS RESULTING FROM EMISSIONS OF CLAY BOSWELL STEAM ELECTRIC STATION

Model Designation	Application	Concentrations Predicted
EPA-PTDIS	To emissions of a single point source with inputs of a single set of meteorological conditions to predict concentrations over a map-like grid.	Downwind 1-hr maximum particulates and SO_2.
EPA-PTMTP	To emissions of multiple point sources with inputs of sets of meteorologial conditions for each time period; to predict concentrations over a map-like grid.	Downwind and worst case 24-hr maximum particulates and 24-hr and 3-hr maximum SO_2.
EPA-PTMAX	To emissions of a single point source with inputs of a single set of meteorological conditions to predict magnitude and location of occurrence of maximum concentration.	Downwind 1-hr maximum particulates and SO_2.
EPA-CDM	To emissions of multiple point and area sources with inputs of frequency distributions of meteorological conditions to predict concentrations over a map-like grid.	Annual geometic mean particulates and annual arithmetic mean NO_x and SO_2.

Administration's (NOAA) weather station at International Falls, (111). International Falls weather conditions more closely resemble the conditions at the Clay Boswell Station than do conditions at Duluth, Hibbing, and other locations where complete meteorological data are recorded (refer to preceeding section on Meteorology and Climatology). Meteorological data collected by MP&L at the Clay Boswell Station site also were used as inputs where appropriate. The coal analyses used as inputs for the dispersion modeling are presented in Table IV-55. The stack exhaust characteristics used for the diffusion modeling are presented in Table IV-56. The particulates, NO_x, and SO_2 emission rates used for the diffusion modeling are presented in Table IV-57. The trace element and sulfate emission rate utilized for modeling ambient trace element and sulfate concentrations are presented in Table IV-58. The calculations used to predict ambient sulfate concentrations are presented below under sulfates.

The data and isopleth figures generated by the diffusion modeling give worst case concentrations. These concentrations are calculated or projected to occur only once each year. The AAQS specify, however, that the secondary 24-hr maximum particulate standard and the secondary 24-hr and 3-hr maximum SO_2 standards may be exceeded once each year without violating the law; e.g. "150 µg per cu m maximum 24-hr concentration not to be exceeded more than once per year" (112). Consequently, the concentrations presented below which are in excess of the appropriate AAQS do not necessarily indicate that the AAQS are being or will be violated by the Clay Boswell Station. Second worst case concentrations in excess of levels specified in the AAQS would signify a violation of the AAQS, but these second highest concentrations are not presented.

The emission factors presented in Tables IV-55 through IV-59 were used consistently throughout the modeling procedures. Therefore, the differences in magnitude and location of occurrence of the worst case and second worst case concentrations would depend only upon the meteorological data used as inputs to the models. That is, the worst case ambient concentrations depend on the worst case meteorological conditions, while the second worst case ambient concentrations depend on the second worst case meteorological conditions. The type of meteorological data used for diffusion modeling is most easily summarized in terms of "stability categories". There are 6 principal stability categories used in diffusion modeling, varying from A, extremely unstable, to F, moderately stable. The major factors which determine the stability category into which a given set of meteorological conditions will be placed are surface wind speed and amount of solar radiation. The stability categories and associated plume behavior are explained in Table IV-59. Figure IV-52 illustrates the relations between stability category and plume behavior. Based on International Falls meteorological data, the annual percentage of occurrence of stability categories A, B, C, D, E, and F at the Clay Boswell Station are as follows:

Stability Category	Annual Percentage of Occurence
A	0.3%
B	3.4%
C	9.1%

TABLE IV-55
COAL ANALYSES USED FOR AIR QUALITY DIFFUSION MODELING
UNITS 1, 2, AND 3 - CLAY BOSWELL STEAM ELECTRIC STATION

Parameter	Pre-Modified Units 1, 2, and 3			Modified Units 1, 2, and 3	
	Range	Annual Average	Worst Case	Annual Average	Worst Case
Heating value					
Btu per lb	7,847 to 8,617	8,557	7,847	8,610	7,509
kg-cal per kg	4,355 to 4,783	4,749	4,355	4,783	4,172
Ash, %	8.61 to 16.53	9.12	16.53	9.35	15.99[a]
Sulfur, %	0.87 to 2.00	0.91	2.00[b]	1.03	4.55[c]
Arsenic, ppm[d]	na[e]	1.75	na	1.75	na
Barium, ppm	na	425.00	na	425.00	na
Beryllium, ppm	na	0.63	na	0.63	na
Cadmium, ppm	na	0.10	na	0.10	na
Chromium, ppm	na	2.75	na	2.75	na
Cobalt, ppm	na	0.88	na	0.88	na
Copper, ppm	na	6.93	na	6.93	na
Fluorine, ppm	na	63.50	na	63.50	na
Gallium, ppm	na	2.75	na	2.75	na
Lead, ppm	na	7.00	na	7.00	na
Manganese, ppm	na	26.25	na	26.25	na
Mercury, ppm	na	0.07	na	0.07	na
Molybdenum, ppm	na	5.43	na	5.43	na
Nickel, ppm	na	2.75	na	2.75	na
Strontium, ppm	na	162.50	na	162.50	na
Titanium, ppm	na	252.50	na	252.50	na
Uranium, ppm	na	0.70	na	0.70	na
Vanadium, ppm	na	6.60	na	6.60	na
Zinc, ppm	na	4.70	na	4.70	na

[a] For units 1 and 2 to comply with MPCA regulations limiting particulate emissions to 0.1 lbs per million Btu (0.180 kg per million kg-cal) input, a particulate removal efficiency of 99.4% is necessary and coal must have an ash content of 14.72% or less and a highest heating value of 7,509 Btu per lb (4,172 kg-cal per kg) or more. For Unit 3 to comply with MPCA regulations limiting particulate emissions to 0.6 lbs per million Btu (1.08 kg per million kg-cal) input, a particulate removal efficiency of 96.6% is necessary and coal must have an ash content of 15.59% or less and a highest heating value of 7,509 Btu per lb (4,172 kg-cal per kg) or more. A fly ash to bottom ash ratio of 85% to 15% is assumed for all 3 units.

[b] Actual value for compliance with emissions regulations not to exceed 1.8% sulfur for coal used in Units 1 and 2.

[c] For Units 1 and 2 to comply with MPCA regulations limiting SO_2 emissions to 4.0 lbs per million Btu (7.20 kg per million kg-cal) input, coal must have a sulfur content of 1.58% or less and a highest heating value of 7,509 Btu per lb (4,172 kg-cal per kg) or more. For Unit 3 to comply with MPCA regulations limiting SO_2 emissions to 4.0 lbs per million Btu (7.20 kg per million kg-cal) input, a SO_2 removal efficiency of 15% is necessary and coal must have a sulfur content of 1.86% or less and a highest heating value of 7,509 Btu per lb (4,172 kg-cal per kg) or more. For Units 1, 2, and 3, the emission rate is based on 38(%S) or 95% of the sulfur leaving the boiler.

[d] ppm means parts per million.

[e] na means not available.

TABLE IV-56
STACK EXHAUST CHARACTERISTICS USED FOR AIR QUALITY DIFFUSION MODELING
UNITS 1, 2, AND 3 - CLAY BOSWELL STEAM ELECTRIC STATION

Parameter	Pre-Modified Units 1, 2, and 3		Modified Units 1, 2, and 3
	Units 1 and 2	Unit 3	
Stack height			
ft	250[a]	400	700[b]
m	76.5[a]	122.3	214.1[b]
Stack diameter			
ft	9.5[a]	17.5	29.0[b]
m	2.91[a]	5.35	8.87[b]
Exhaust temperature			
°F	360	136	193
°C	182.2	57.8	89.4
Average gas flow rate			
cfm	547,000	1,201,000	1,698,641
cu m per second	260	572	808.87

a One stack serves Units 1 and 2.

b One stack serves Units 1, 2, and 3.

TABLE IV-57
PARTICULATES, NO_x, AND SO_2 EMISSION RATES USED FOR AIR QUALITY DIFFUSION MODELING
UNITS 1, 2, AND 3 - CLAY BOSWELL STEAM ELECTRIC STATION

Pollutant	Pre-Modified Units 1, 2, and 3				Modified Units 1, 2, and 3	
	Units 1 and 2		Unit 3			
	Annual Average[a]	Worst Case[b]	Annual Average[a]	Worst Case[b]	Annual Average	Worst Case
Particulates						
lb per hr	5,091	10,065	2,142	2,142	2,220[c]	2,351[c]
kg per hr	2,311	4,570	972	972	1,008[c]	1,066[c]
NO_x[d]						
lb per hr	1,507	1,507	3,819	3,819	5,332	5,332
kg per hr	684	684	1,734	1,734	2,420	2,420
SO_2						
lb per hr	2,845	5,632	6,131	14,280	10,111	51,216
kg per hr	1,292	2,557	2,784	6,483	4,590	23,231

a Average emissions based on typical coal of 8,557 Btu per lb (4,755 kg-cal per kg) heating value, 9.1% ash, and 0.91% sulfur.

b Worst case emission rate based on maximum allowed by MPCA for SO_2 and NO_x from Units 1, 2, and 3, and for particulates from Unit 3. Units 1 and 2 particulate emissions are equal to 7.15 lb per million Btu (13.11 kg per million kg-cal) input.

c Assumed bottom ash to fly ash ratio of 15% to 85%.

d NO_x emissions based on 1.07 lb NO_x per million Btu (1.93 kg NO_x per million kg-cal) input.

TABLE IV-58
TRACE ELEMENT AND SULFATE EMISSION RATES
USED FOR AIR QUALITY DIFFUSION MODELING
MODIFIED UNITS 1, 2, AND 3[a]
CLAY BOSWELL STEAM ELECTRIC STATION

Pollutant	lb per hr	kg per hr
Arsenic	0.39	0.18
Barium	24.21	10.98
Beryllium	0.04	0.02
Cadmium	0.04	0.02
Chromium	0.55	0.25
Cobalt	0.04	0.02
Copper	0.79	0.36
Fluorine	34.08	15.46
Gallium	1.25	0.57
Lead	3.19	1.45
Mercury	0.05	0.02
Manganese	2.99	1.36
Molybdenum	1.23	0.56
Nickel	0.31	0.14
Strontium	9.28	4.21
Sulfates	257.00	116.57
Titanium	44.93	20.38
Uranium	0.04	0.02
Vanadium	1.50	0.68
Zinc	2.11	0.96
Total	383.39	173.92

[a] Worst case emission rates. Emission rates for pre-modified Units 1, 2, and 3 are not presented.

Note: Units 1, 2, and 3 will discharge stack gas via a single 700 ft (213 m) stack. The baghouse filters used to control particulate emissions from Units 1 and 2 have estimated removal efficiencies of 95% for metals, 90% for mists, and 10% for gaseous trace elements. The wet scrubbers used to control particulate emissions from Unit 3 have estimated removal efficiencies of 90% for metals and mists and 10% for gaseous trace elements. The maximum air emissions are based on coal with a heating value of 7,509 Btu per lb (4,172 kg-cal per kg).

D	31.9%
E	27.8%
F	27.5%

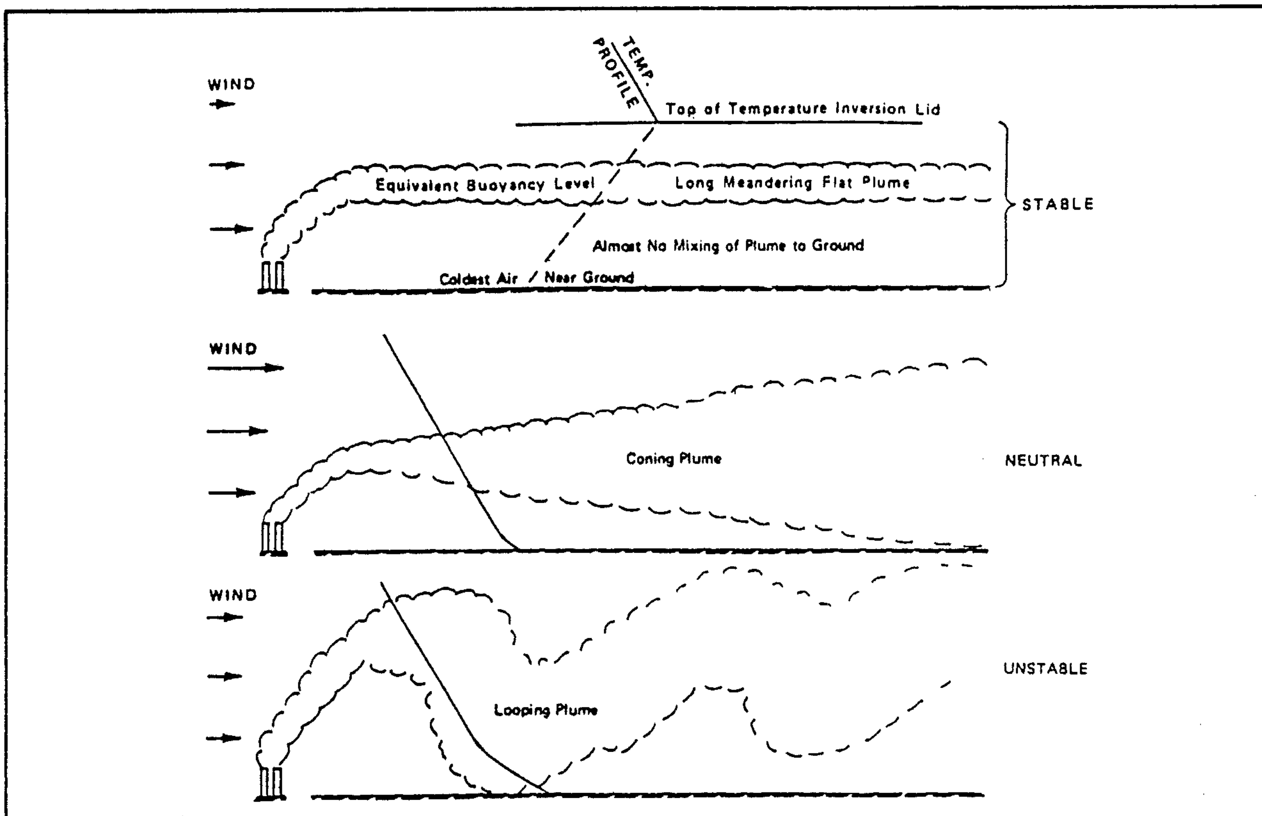
TABLE IV-59
ATMOSPHERIC STABILITY CATEGORIES UTILIZED FOR AIR QUALITY DIFFUSION MODELING (113)

Stability Category	Description	Plume Behavior
A - Extremely unstable	This classification is associated with conditions of low surface wind speeds and strong solar radiation.	There are rapid changes in wind direction with time. Surface heating has eliminated all temperature inversions near the ground. Wind speeds are generally less than 11 mph (17.7 km per hr). Rapidly rising parcels of warm air from near the earth's surface are replaced by equal amounts of air moving downward nearby. A plume is carried with this "looping" motion. It is typical that cumulus clouds will be seen above terrain. Highly transitory maxima in ground-level concentration relatively near the source occur with this category.
B - Moderately unstable	This stability class is most common when the wind speeds are slightly higher (4 to 6 mph)(6.4 to 9.7 km per hr) and the solar radiation is still strong.	
C - Slightly unstable	This category is typified by wind speeds from 7 to 10 mph (11.3 to 16.9 km per hr) with moderate to strong radiation or lower wind speeds coupled with slight radiation.	
D - Neutral	Conditions which produce this type of stability are fairly high wind speeds during a period of slight solar radiation or at night.	This category includes most cases with winds stronger than 12 mph (19.3 km per hr). Duration is 2 hours or more. The vertical temperature profile is near the adiabatic lapse rate. A plume is dispersed rapidly with a "coning" motion.
E - Slightly stable	This classification is associated with wind speeds from 4 to 6 mph (6.4 to 9.7 km per hr) at night.	Coolest air is located at the earth's horizon and stack plumes move horizontally at effective stack height. Almost no pollution can be measured at the ground.
F - Moderately stable	This level of stability is found at night when wind speed is even lower than in Class E.	
Transition	Conditions which change in a relatively short period of time from stable to neutral or unstable.	A portion of the plume will experience limited mixing prior to complete linkage of surface airflow to synoptic airflow, which is controlled by pressure pattern winds.

The annual geometric mean particulate and annual arithmetic mean NO_x, SO_2, trace element, and sulfate concentrations were modeled using the International Falls "Star Program" (111), which summarizes the wind speed, wind direction, and atmospheric stability data collected during the period 1964 through 1973. The magnitudes of the worst case annual concentrations were found to depend primarily on the D, E, and F type atmospheric stabilities.

The 24-hr and 3-hr maximum pollutant concentrations were calculated or projected by employment of the on-site meteorological data collected by MP&L during the period August 1975 through November 1976. Specifically, an initial analysis was performed to determine which meteorological conditions would produce the worst case 24-hr and 3-hr maximum concentrations. This analysis indicated that the worst case 24-hr maximum particulate, SO_2, trace element, and sulfate concentrations would occur during summertime, unstable atmospheric conditions dominated by the A, B, or C stability chategories, while the 3-hr maximum SO_2 concentrations would occur during periods of A or B stability. Next, the 16 months of on-site data were searched to find which ambient temperatures, wind speeds and directions, and atmospheric mixing heights would produce the worst case 24-hr and 3-hr maximum concentrations. Finally, these worst case meteorological conditions were used to calculate or project the magnitude of the 24-hr and 3-hr maximum concentrations. It should be noted that this hour-by-hour analysis technique produced results which were in excellent agreement with methods which first calculate the worst case 1-hr maximum concentrations and then statistically convert them to 24-hr and 3-hr values (114) (115).

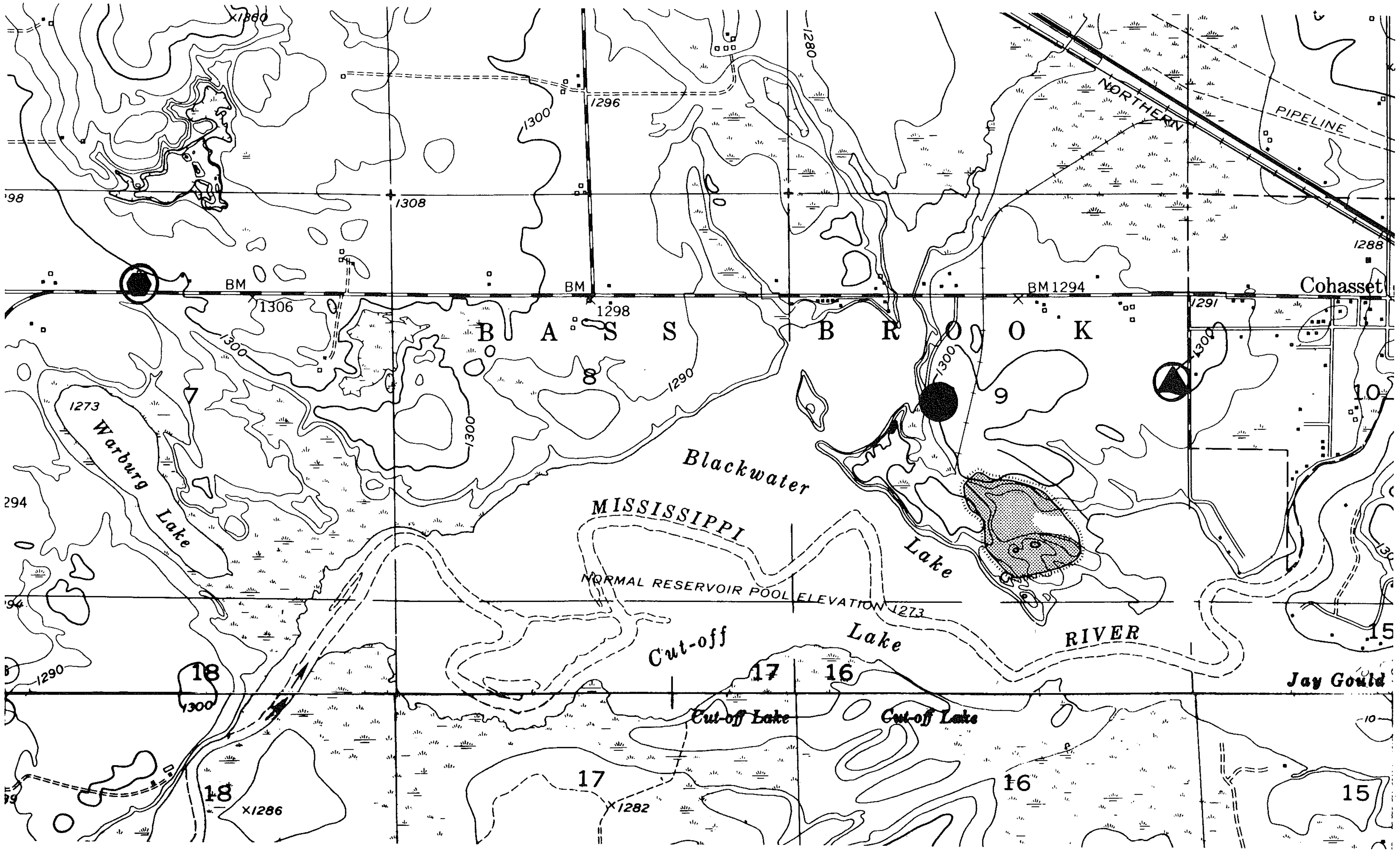
The locations where the worst case pollutant concentrations occur primarily depend on the wind speed and direction. These 2 parameters are best summarized by use of "wind roses", which illustrate the average wind speed and direction over a given time period. The wind roses for modeling the dispersion of emissions from the Clay Boswell Station were developed from International Falls data collected during the period 1964 through 1973, and from on-site data collected by MP&L during the period August 1975 through November 1976. The monthly and annual surface wind roses for International Falls data and for the on-site data are presented in the Meteorology and Climatology section of Chapter IV. The International Falls annual wind rose illustrates that north-northwesterly and southeasterly winds predominate in the Clay Boswell Station area.



SCHEMATIC DIAGRAMS OF TYPICAL STACK PLUME PATTERNS UNDER THREE IDENTIFIABLE STABILITY CATEGORIES

FIGURE IV-52

SOURCE: "CUMULATIVE AIR QUALITY IMPACTS OF FOUR POWER AND COAL GASIFICATION FACILITIES IN THE NORTHWESTERN CORNER OF NEW MEXICO", MAY 1977, R. W. BECK AND ASSOCIATES, EXHIBIT 3



MONITOR NO. 1 (INITIAL LOCATION)

MONITOR NO. 2

CLAY BOSWELL STATION SITE

LOCATION OF ON-SITE AMBIENT AIR QUALITY MONITORS VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION

SOURCE: "RESULTS OF AMBIENT AIR QUALITY MONITORING AT THE MP&L CLAY BOSWELL POWER PLANT", JULY 8, 1976, INTERPOLL, INC.

FIGURE IV-53

Pre-modified Units 1, 2, and 3

Ambient concentrations of particulates, NO_x, and SO_2 were monitored by MP&L at 2 locations on the Clay Boswell Station site (116). Monitor 1 was located approximately 0.6 miles (1.1 km) east of the Station from August 1975 to August 13, 1976. This location was downwind of the Station, and was strategically located to measure the 3-hr maximum SO_2 concentrations resulting from emissions of pre-modified Units 1, 2, and 3. From September 13, 1976 through November 1976, monitor 1 was located 1.5 miles (2.4 km) south-southwest of the Clay Boswell Station. This location was selected to measure the Unit 1, 2, and 3 contribution to the annual geometric mean particulate, annual average NO_x and SO_2, and 24-hr maximum particulate and SO_2 concentrations. Local weather parameters such as wind speed and direction, temperature, and humidity also were measured by monitor 1. The initial location of monitor 1 is illustrated on Figure IV-53.

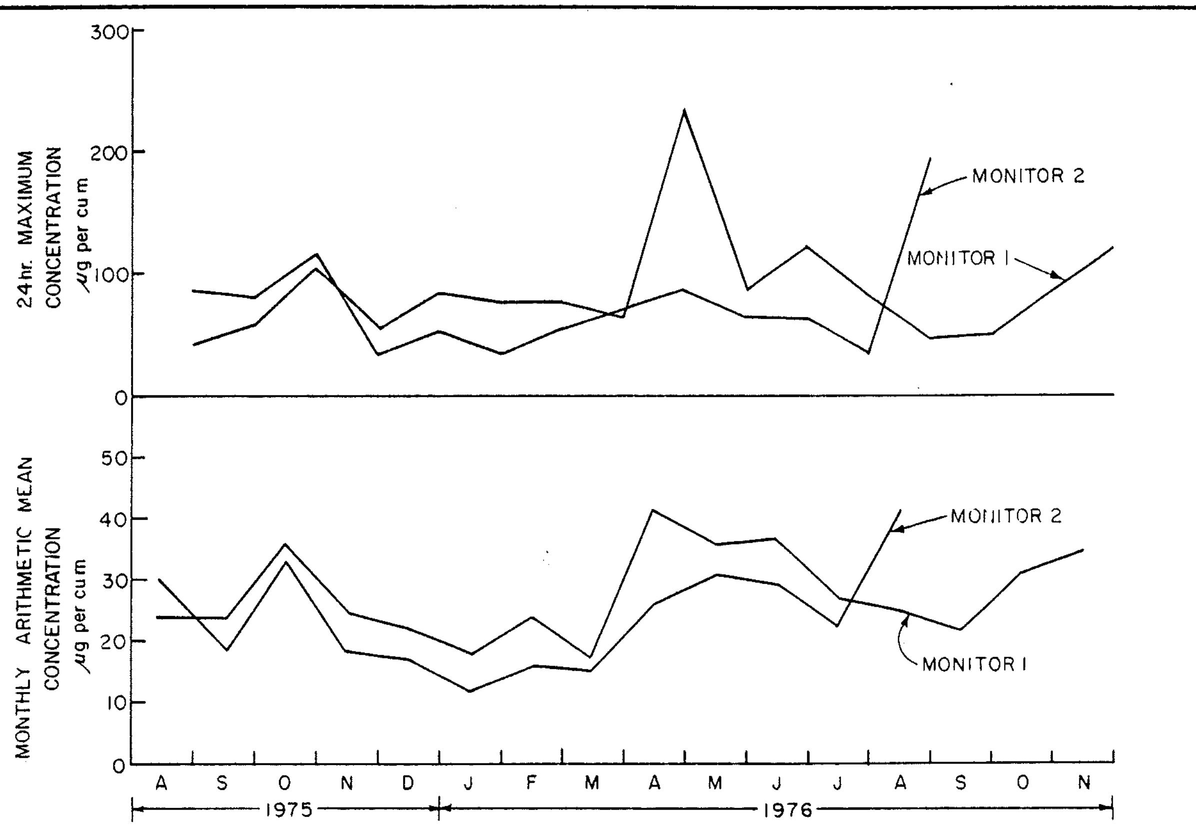
Monitor 2 was situated approximately 1.8 miles (2.9 km) west-northwest of the Clay Boswell Station from August 1975 through August 1976. This location is upwind of the Station and was chosen primarily to measure the background annual pollutant concentrations (i.e., concentrations resulting from sources other than the Clay Boswell Station). The location of monitor 2 is illustrated on Figure IV-53. Monitor 2 was removed from service at the end of August, 1976 and monitor 1 was removed from service in the spring 1977.

Particulates. Ambient particulate concentrations were measured on a daily basis by monitors 1 and 2 using the standard high-volume sampling technique. The data were distributed in a log-normal pattern (114). The 16 month mean particulate concentration measured during the sampling period was 28 g per cu m at monitor 1, and 24 μg per cu m at monitor 2. Figure IV-54 illustrates the variation in the monthly average and 24-hr maximum particulate concentrations measured during the monitoring period. The over-all 24-hr maximum concentrations were 235 and 192 μg per cu m at monitors 1 and 2, respectively. The annual geometric mean particulate concentration was 24 μg per cu m at monitor 1 and 18 μg per cu m at monitor 2.

Pollution roses were developed for monitors 1 and 2 to estimate the background particulate concentrations. The pollution roses are based on the wind roses and on daily average wind directions calculated from hourly wind data. Figure IV-55 illustrates the distribution of the 24-hr maximum and 24-hr mean particulate concentrations around monitor 1, and Figure IV-56 does the same for monitor 2. Note that these pollution roses are not "isopleths" (where points of equal concentration are connected). Rather, on pollution roses the maximum or mean concentration occurring at each of 16 compass directions are plotted. Thus, pollution roses give no indication of the distance from the Station where the values occurred. The pollution rose for monitor 1 has been adjusted for the movement of monitor 1 to the new location in September 1976.

Based on the pollution rose analysis, the background 24-hr maximum particulate concentration is estimated to be 107 μg per cu m in the vicinity of the Clay Boswell Station. The background annual geometric mean concentration is estimated to be 18 μg per cu m. These values are in agreement with typically reported non-urban particulate concentrations, such as those presented in Figure IV-57 and those presented in Table IV-49.

The results of diffusion modeling for particulate emissions from pre-modified Units 1, 2, and 3 are given in Table IV-60. This table indicates that the pre-modified Units were not in compliance with the 24-hr maximum particulate AAQS (MPCA secondary and primary AAQS). Figures IV-58 and IV-59 illustrate the spatial distribution of the particulate emissions around pre-modified Units 1, 2, and 3. Figure IV-58 presents the isopleths for annual geometric mean particulate concentrations while Figure IV-59 does the same for 24-hr maximum concentrations.

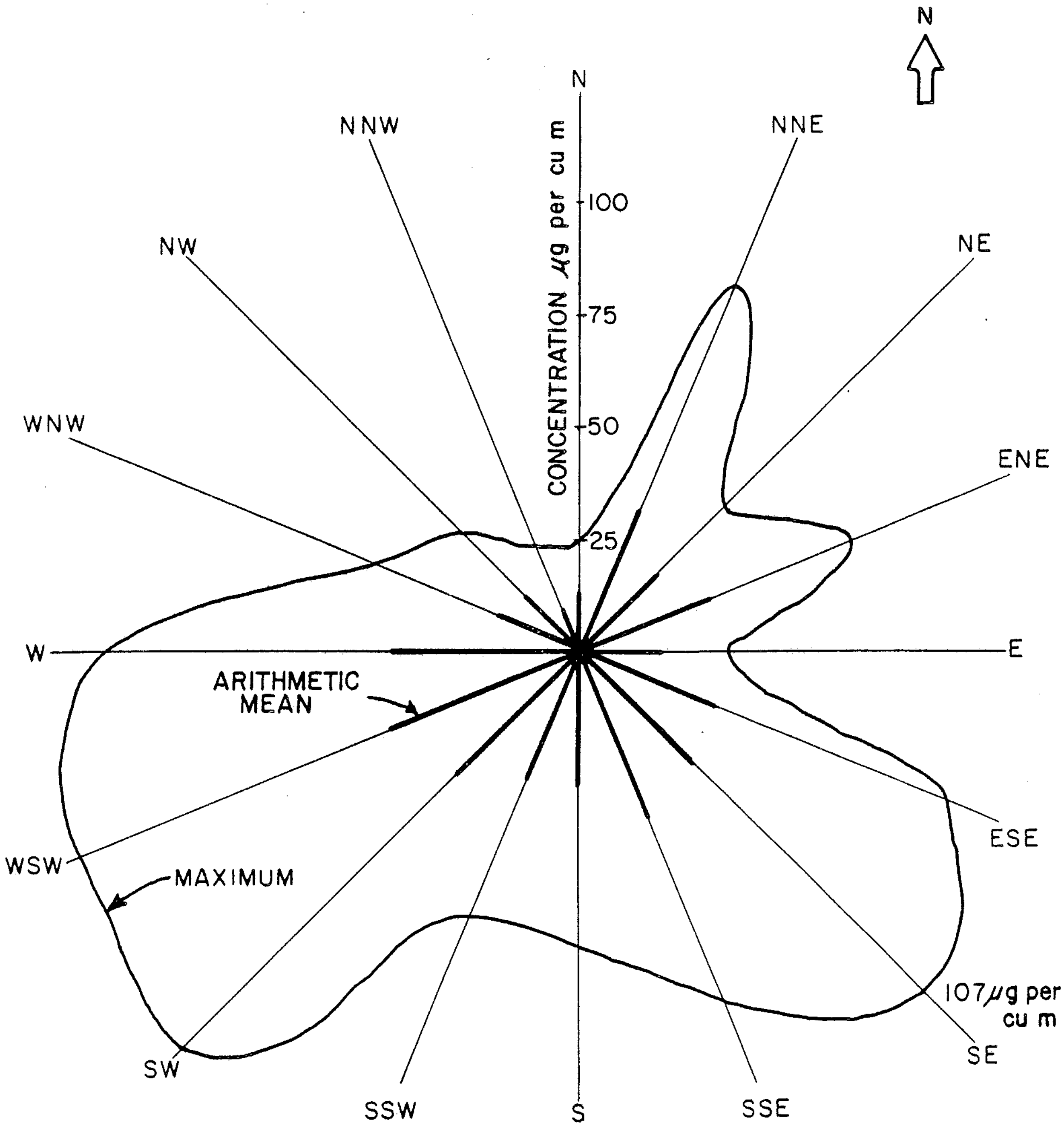


MEASURED PARTICULATE CONCENTRATIONS

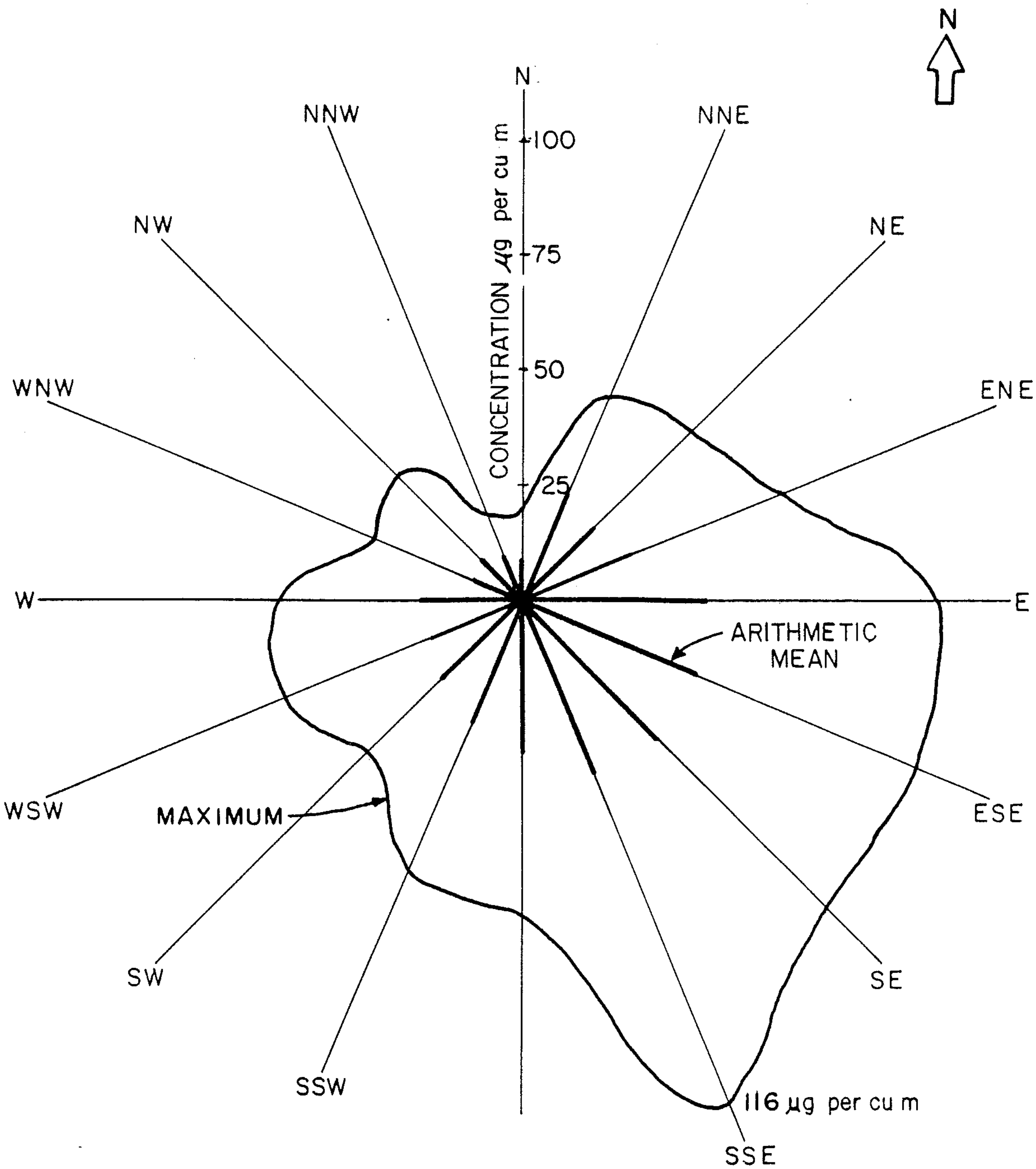
CLAY BOSWELL STATION SITE

FIGURE IV-54

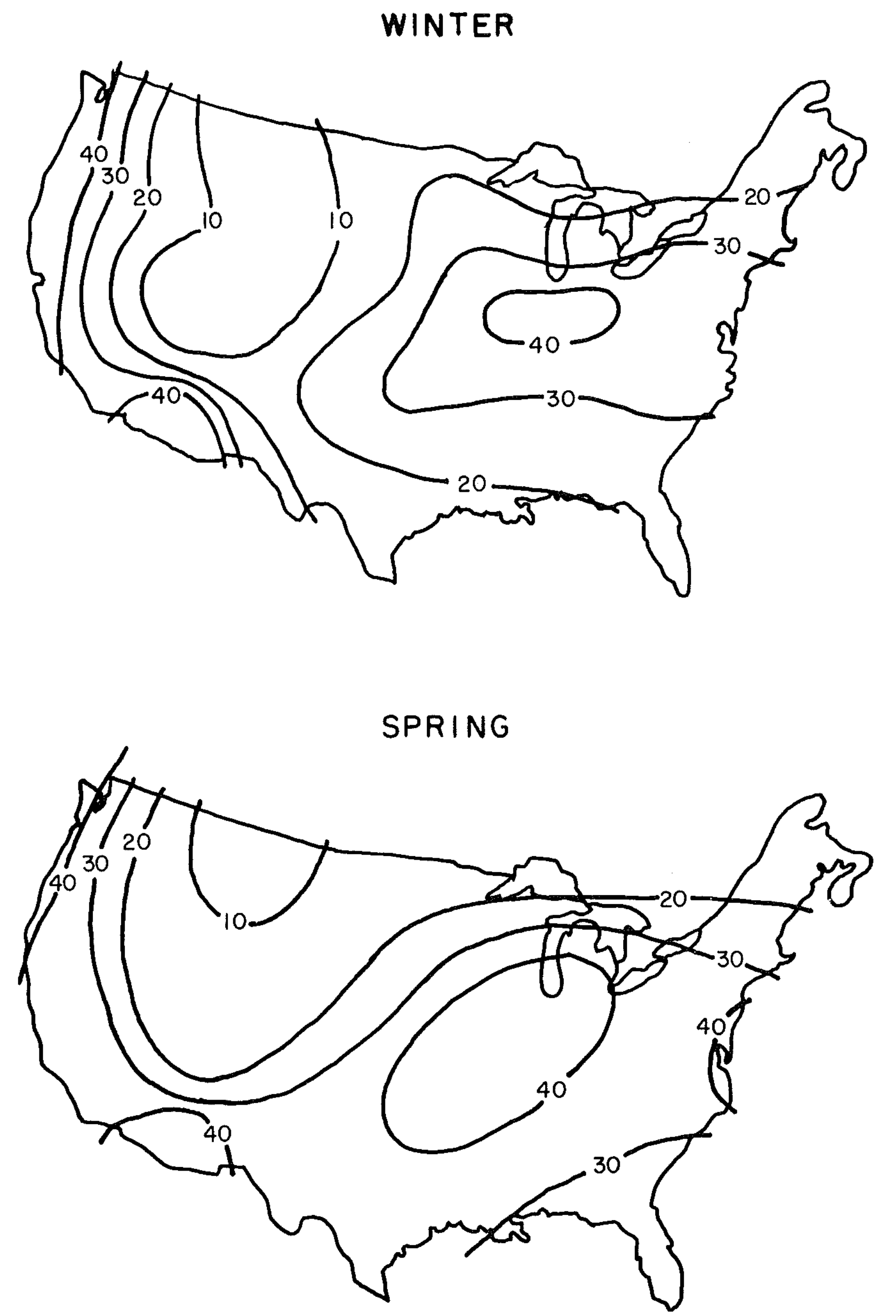
SOURCE: ADAPTED FROM, "RESULTS OF AMBIENT AIR QUALITY MONITORING AT THE MP&L CLAY BOSWELL POWER PLANT", WEEKLY REPORTS, INTERPOLL INC.



CALCULATED POLLUTION ROSE OF 24-HR MAXIMUM AND 24-HR ARITHMETIC MEAN PARTICULATE CONCENTRATIONS AT MONITOR 1- AUGUST 1975 THROUGH NOVEMBER 1976	FIGURE IV-55



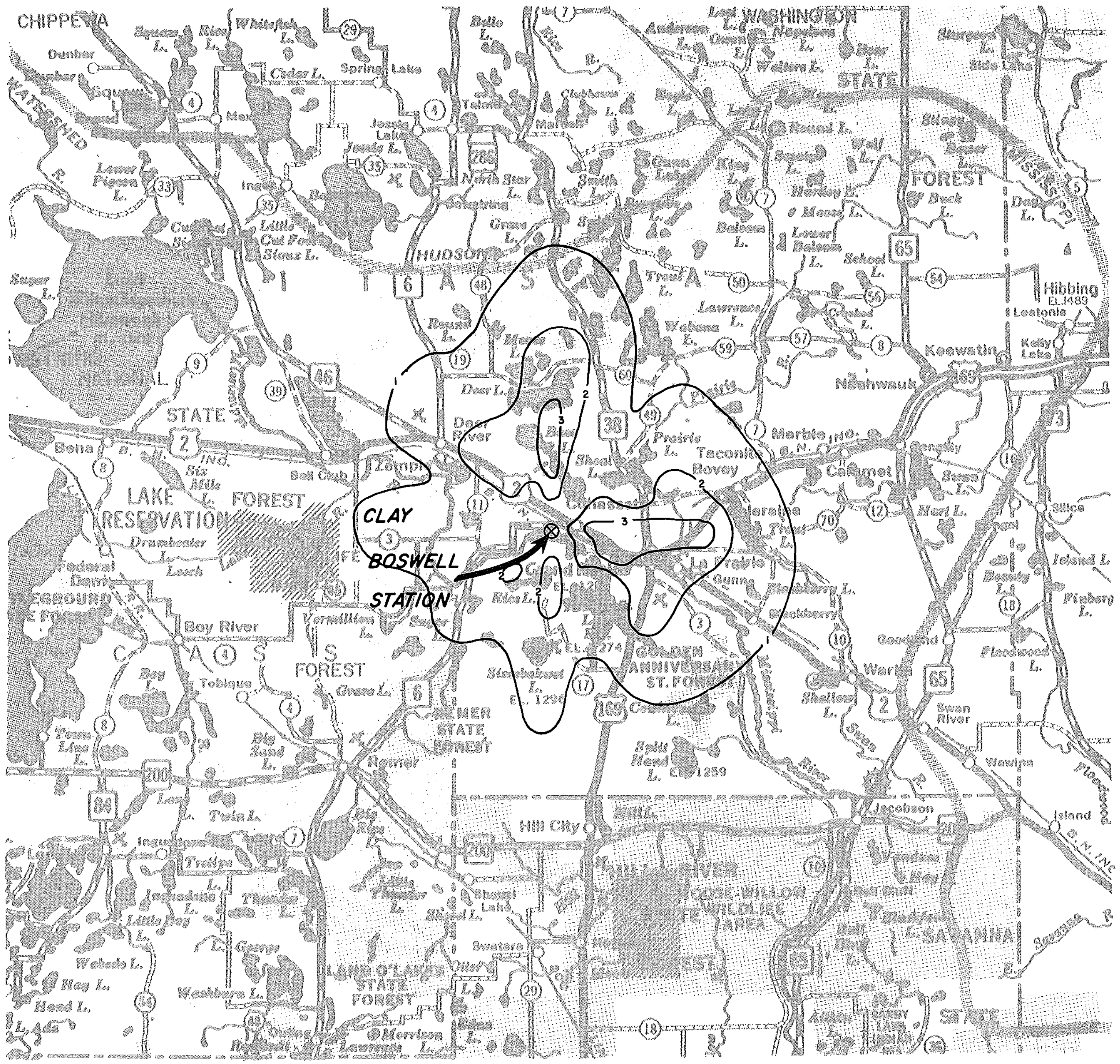
CALCULATED POLLUTION ROSE OF 24-HR MAXIMUM AND 24-HR ARITHMETIC MEAN PARTICULATE CONCENTRATIONS AT MONITOR 2- AUGUST 1975 THROUGH AUGUST 1976	FIGURE IV-56



ANNUAL GEOMETRIC MEAN PARTICULATE CONCENTRATIONS AT NONURBAN U.S. LOCATIONS, IN μg per cu m

SOURCE: STERN, A.C., ED. AIR POLLUTION, 3rd EDITION, 1976, ACADEMIC PRESS, NEW YORK

FIGURE IV-57



LEGEND

⊗ CLAY BOSWELL STATION

NOTE: ISOPLETHS IN MICROGRAMS PER CUBIC METER (μg per cu m)

FOR TOTAL WITH BACKGROUND, ADD 18 μg per cu m TO EACH ISOPLETH VALUE

BASE MAP LEGEND

- MULTILANE DIVIDED HIGHWAY
- MULTILANE UNDIVIDED HIGHWAY
- INTERMEDIATE TYPE
- SECONDARY ROAD-HARD SURFACED
- SECONDARY ROAD-GRAVEL
- NATIONAL FOREST
- STATE FOREST
- WILDLIFE MANAGEMENT AREA

N

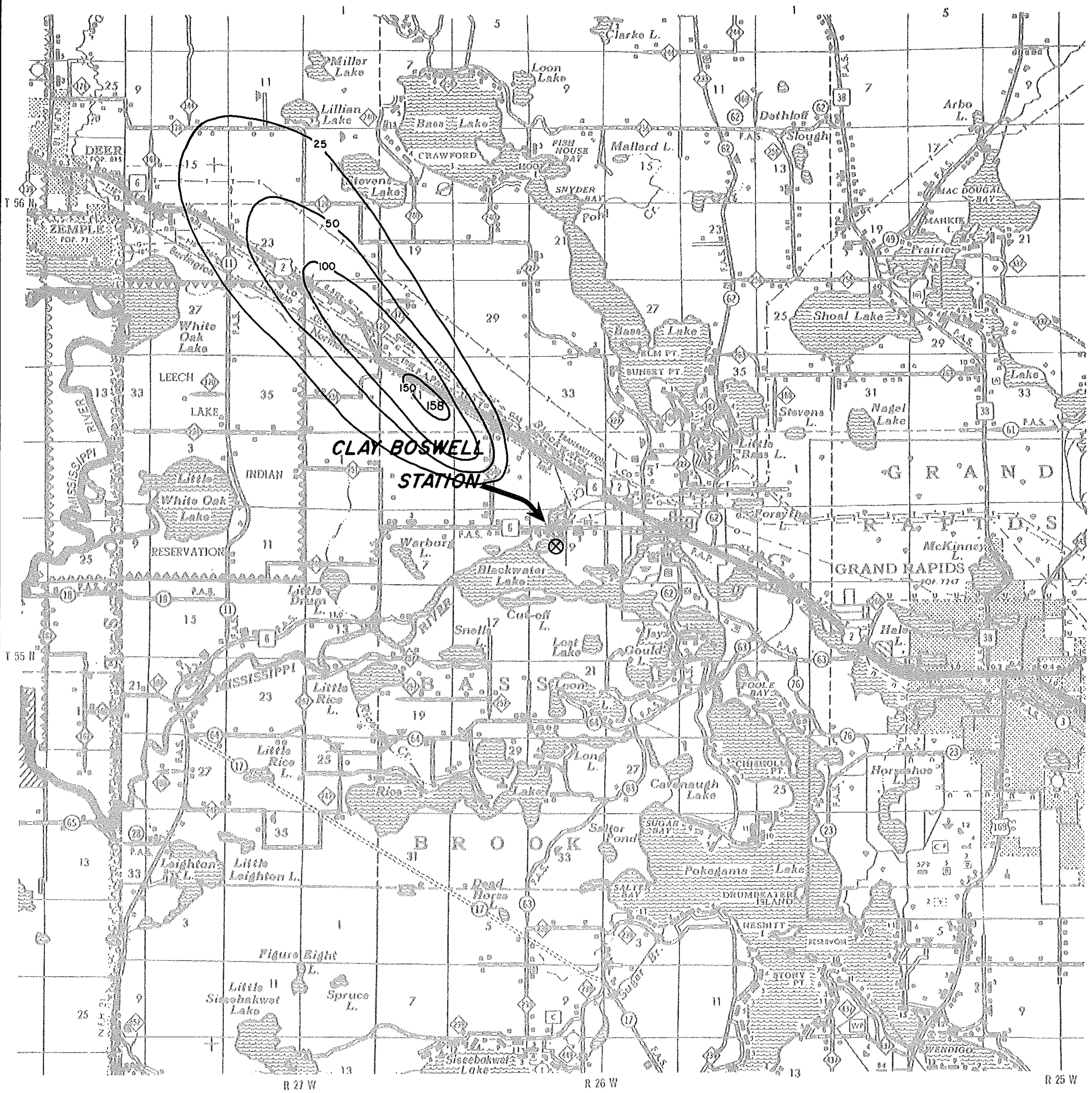
5 0 5 10
MILES

0 5 10
KILOMETERS

CALCULATED ISOPLETHS OF ANNUAL GEOMETRIC MEAN PARTICULATE CONCENTRATIONS

PRE-MODIFIED UNITS 1,2, AND 3

FIGURE IV-58



LEGEND

⊗ CLAY BOSWELL STATION

NOTE: ISOPLETHS IN MICROGRAMS PER CUBIC METER (μg per cu m)

FOR TOTAL WITH BACKGROUND, ADD 107 μg per cu m TO EACH ISOPLETH VALUE

BASE MAP LEGEND

ROAD AND ROADWAY FEATURES

- PROJECTED ROAD
- GRADED AND DRAINED ROAD
- GRAVEL OR STONE ROAD
- BITUMINOUS ROAD
- PAVED ROAD

BOUNDARIES

- COUNTY
- CIVIL TOWNSHIP
- CONGRESSIONAL TOWNSHIP (U.S. LAND)
- SECTION LINE
- NATIONAL OR STATE PARK
- NATIONAL OR STATE FOREST
- NATIONAL INDIAN RESERVATION

DRAINAGE

- INTERMITTENT STREAM
- NARROW STREAM
- MARSH OR SWAMP LAND
- POND OR LAKE

PUBLIC SERVICE FACILITIES

- PIPE LINE, GAS
- PIPE LINE, OIL
- TRANSMISSION LINE (33 KV OR OVER)
- POWER PLANT

EDUCATIONAL AND CORRECTIONAL INSTITUTIONS

- SCHOOL HOUSE
- CONSOLIDATED OR LARGE SCHOOL

N

0 1 2 3
MILES

0 1 2 3
KILOMETERS

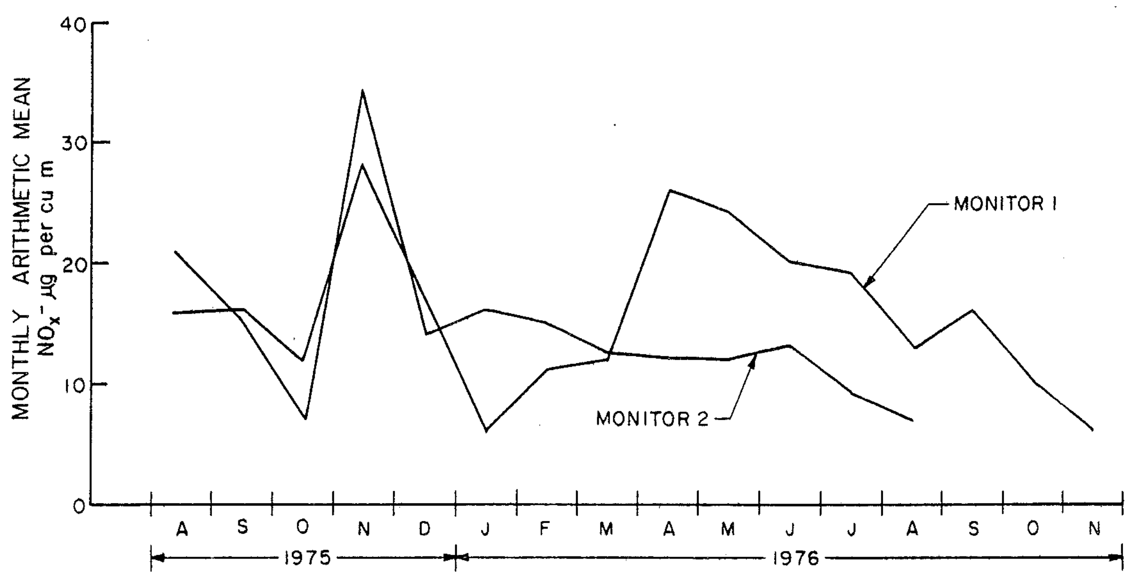
CALCULATED ISOPLETHS OF 24-HR MAXIMUM PARTICULATE CONCENTRATIONS

PRE-MODIFIED UNITS 1, 2, AND 3

FIGURE IV-59

Nitrogen oxides. Ambient NO_x concentrations were measured continuously at monitors 1 and 2 by use of the chemiluminescence technique (102). The measured 16 month mean NO_x concentration was 16 µg per cu m at monitor 1 and 14 µg per cu m at monitor 2. Figure IV-60 illustrates the variation in the monthly average NO_x concentrations at the 2 monitoring locations. Based on this data (no pollution roses were drawn) the background NO_x concentrations in the vicinity of the Clay Boswell Station is estimated to be 14 g per cu m, annual arithmetic mean.

Table IV-60 includes the calculated NO_x concentrations caused by pre-modified Units 1, 2, and 3. The 2.3 µg per cu m annual arithmetic mean is only 16.4% of the background concentration, and only 2.3% of the applicable AAQS. Figure IV-61 presents the calculated isopleths of annual arithmetic mean NO_x concentrations resulting from emissions of the pre-modified Units 1, 2, and 3.



CLAY BOSWELL STATION SITE
MEASURED NOx CONCENTRATIONS

SOURCE: "RESULTS OF AMBIENT AIR QUALITY MONITORING AT THE MP&L CLAY BOSWELL POWER PLANT", WEEKLY REPORTS, INTERPOLL, INC.

FIGURE IV-60

TABLE IV-60
CALCULATED PARTICULATES, NO_x, AND SO_2 CONCENTRATIONS RESULTING FROM EMISSIONS OF PRE-MODIFIED UNITS 1, 2, AND 3
CLAY BOSWELL STEAM ELECTRIC STATION

Pollutant	Units 1 and 2 µg per cu m	Unit 3 µg per cu m	Units 1, 2, and 3 µg per cu m	Measured Background µg per cu m	Total µg per cu m	Minnesota Secondary Standard µg per cu m
Particulates						
Annual geometric mean	2.1	0.9	3.0	18	21	60
24-hr maximum	133	25	158	107	265	150
NO_x						
Annual arithmetic mean	0.8	1.5	2.3	14	16.3	100
SO_2						
Annual arithmetic mean	1.6	2.4	4.0	0.4	4.4	60
24-hr maximum	69	183	252	5	257	260
3-hr maximum	144	896	1,040	15	1,055	655

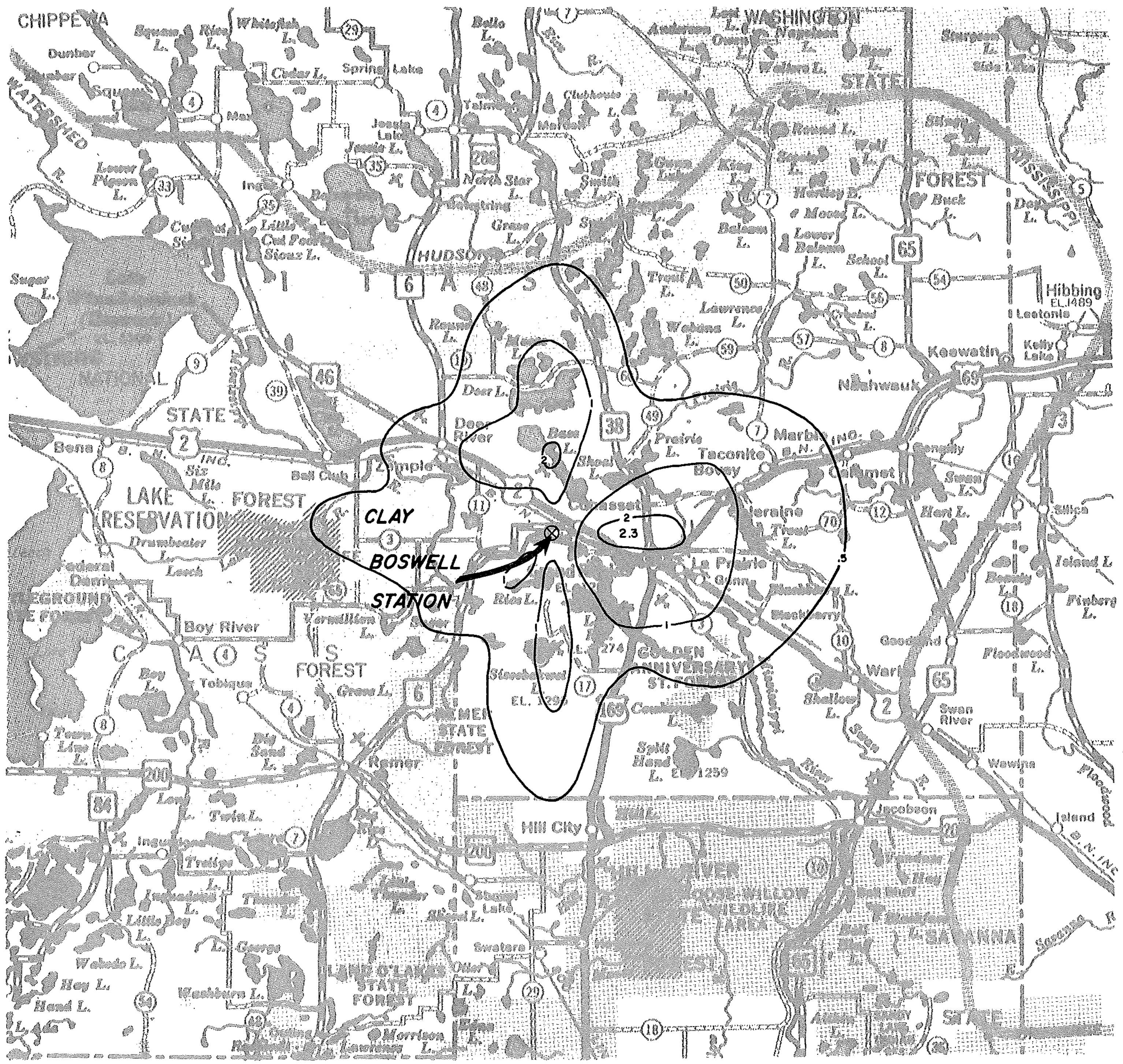
Sulfur dioxide. The on-site SO_2 monitoring data was collected continuously during the monitoring period by use of the flame photometric technique (102). Table IV-61 lists the annual arithmetic mean, 24-hr maximum, and 3-hr maximum SO_2 concentrations measured by monitors 1 and 2. The SO_2 data is not adaptable for drawing charts of the monthly variations in concentrations, but pollution roses have been estimated and are presented in Figures IV-62 and IV-63.

The ambient SO_2 concentrations were monitored continuously and the data were converted to 1-hr maximum and 1-hr mean values. The estimated background 1-hr maximum concentration was 18 µg per cu m. Using the statistical conversion factor 0.84, the background 3-hr maximum concentration is estimated to be 15 µg per cu m (117) (118). Similarly, a statistical conversion factor of 0.26 and the background 1-hr mean concentration of 21 µg per cu m were used to estimate the background 24-hr maximum SO_2 concentration at 5.0 µg per cum (115). The background annual arithmetic mean concentration is estimated to be 0.4 µg per cu m, the annual value measured at the upwind monitor 2.

The results of the SO_2 dispersion modeling for pre-modified Units 1, 2, and 3 are included in Table IV-60. Note that pre-modified Units 1, 2, and 3 are calculated to cause the ambient 3-hr maximum concentration to exceed the applicable MPCA AAQS by a factor of approximately 1.59. The isopleths in Figures IV-64 through IV-66 illustrate the distribution of the pre-modified Units 1, 2, and 3 emissions around the Station.

TABLE IV-61
MEASURED SO_2 CONCENTRATIONS - ON-SITE
CLAY BOSWELL STEAM ELECTRIC STATION (115)

Monitor Number	Annual Arithmetic Mean µg per cu m	Monthly Arithmetic Mean µg per cu m	24-hr Maximum µg per cu m	3-hr Maximum µg per cu m
1	1.2	3.5	81	383
2	0.4	2.0	20	93



LEGEND

⊗ CLAY BOSWELL STATION

NOTE: ISOPLETHS IN MICROGRAMS PER CUBIC METER (μg per cu m)

FOR TOTAL WITH BACKGROUND, ADD 14 μg per cu m TO EACH ISOPLETH VALUE

BASE MAP LEGEND

- MULTILANE DIVIDED HIGHWAY
- MULTILANE UNDIVIDED HIGHWAY
- INTERMEDIATE TYPE
- SECONDARY ROAD-HARD SURFACED
- SECONDARY ROAD-GRAVEL
- NATIONAL FOREST
- STATE FOREST
- WILDLIFE MANAGEMENT AREA

MILES: 5 0 5 10

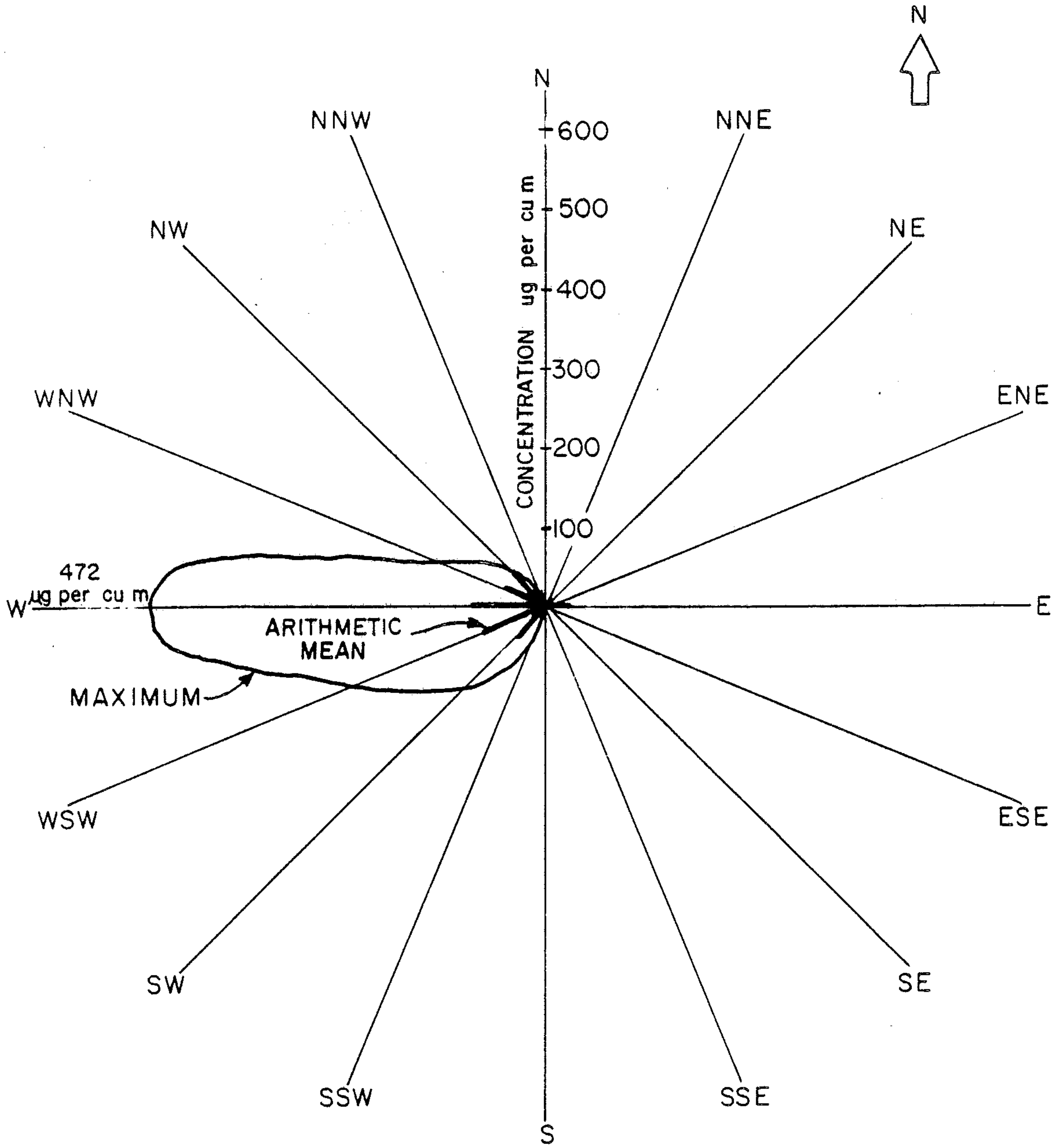
KILOMETERS: 0 5 10

N

CALCULATED ISOPLETHS OF ANNUAL ARITHMETIC MEAN NO_x CONCENTRATIONS

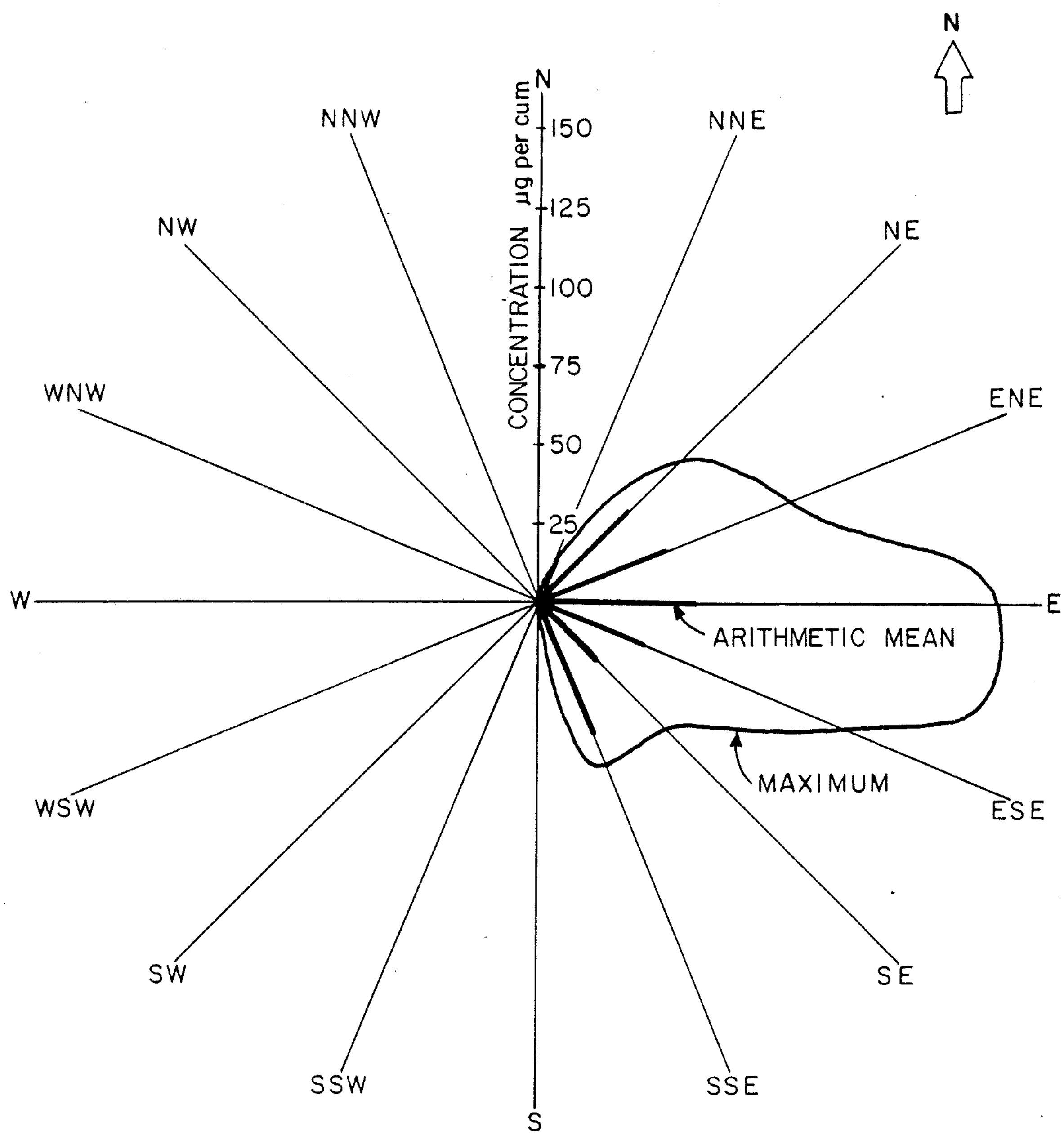
PRE-MODIFIED UNITS 1, 2, AND 3

FIGURE IV-61



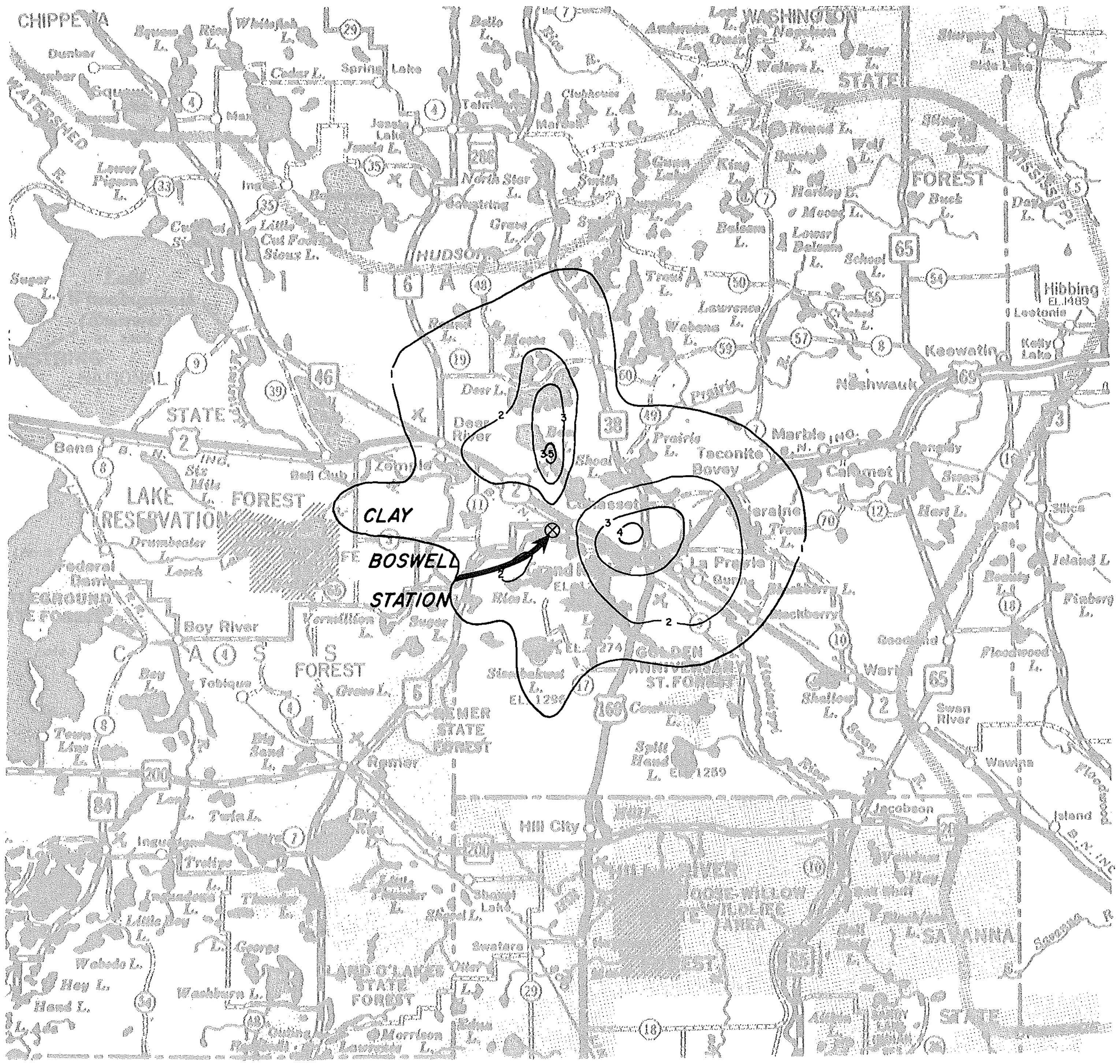
CALCULATED POLLUTION ROSE OF 1-HR MAXIMUM AND 1-HR ARITHMETIC MEAN SO_2 CONCENTRATIONS AT MONITOR 1- AUGUST 1975 THROUGH NOVEMBER 1976

FIGURE IV-62



CALCULATED POLLUTION ROSE OF 1-HR MAXIMUM AND 1-HR ARITHMETIC MEAN SO_2 CONCENTRATIONS AT MONITOR 2–AUGUST 1975 THROUGH AUGUST 1976

FIGURE IV-63



LEGEND

⊗ CLAY BOSWELL STATION

NOTE: ISOPLETHS IN MICROGRAMS PER CUBIC METER (μg per cu m)

FOR TOTAL WITH BACKGROUND, ADD 0.4 μg per cu m TO EACH ISOPLETH VALUE

BASE MAP LEGEND

- MULTILANE DIVIDED HIGHWAY
- MULTILANE UNDIVIDED HIGHWAY
- INTERMEDIATE TYPE
- SECONDARY ROAD-HARD SURFACED
- SECONDARY ROAD-GRAVEL
- NATIONAL FOREST
- STATE FOREST
- WILDLIFE MANAGEMENT AREA

5 0 5 10
MILES

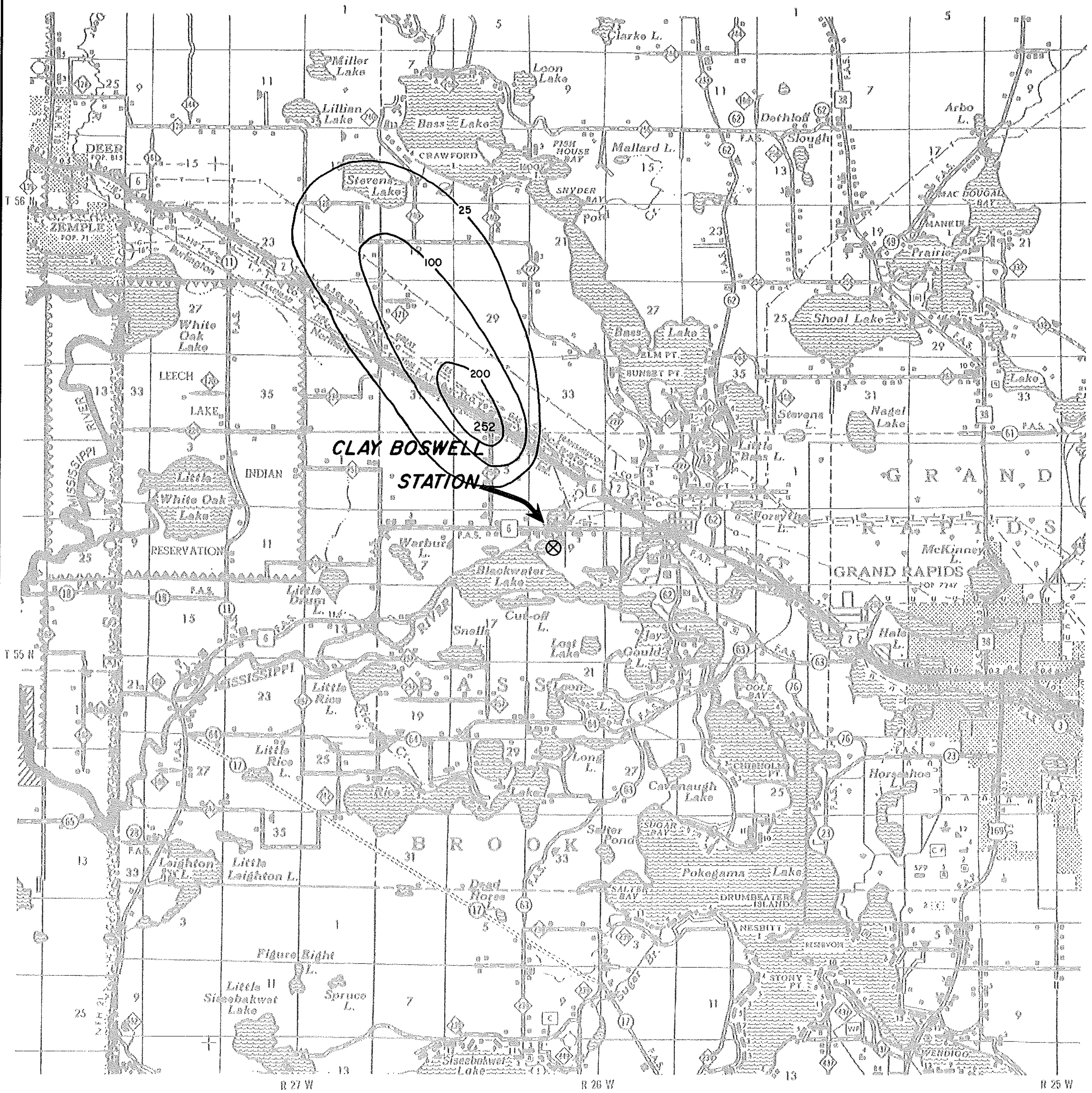
0 5 10
KILOMETERS

N

CALCULATED ISOPLETHS OF ANNUAL ARITHMETIC MEAN SO_2 CONCENTRATIONS

PRE-MODIFIED UNITS 1, 2, AND 3

FIGURE IV-64



LEGEND

⊗ CLAY BOSWELL STATION

NOTE: ISOPLETHS IN MICROGRAMS PER CUBIC METER (μg per cu m)

FOR TOTAL WITH BACKGROUND, ADD 5 μg per cu m TO EACH ISOPLETH VALUE

BASE MAP LEGEND

ROAD AND ROADWAY FEATURES

- PROJECTED ROAD
- GRADED AND DRAINED ROAD
- GRAVEL OR STONE ROAD
- BITUMINOUS ROAD
- PAVED ROAD

BOUNDARIES

- COUNTY
- CIVIL TOWNSHIP
- CONGRESSIONAL TOWNSHIP (U.S. LAND)
- SECTION LINE
- NATIONAL OR STATE PARK
- NATIONAL OR STATE FOREST
- NATIONAL INDIAN RESERVATION

DRAINAGE

- INTERMITTENT STREAM
- NARROW STREAM
- MARSH OR SWAMP LAND
- POND OR LAKE

PUBLIC SERVICE FACILITIES

- PIPE LINE, GAS
- PIPE LINE, OIL
- TRANSMISSION LINE (33 KV OR OVER)
- POWER PLANT

EDUCATIONAL AND CORRECTIONAL INSTITUTIONS

- SCHOOL HOUSE
- CONSOLIDATED OR LARGE SCHOOL

-N-

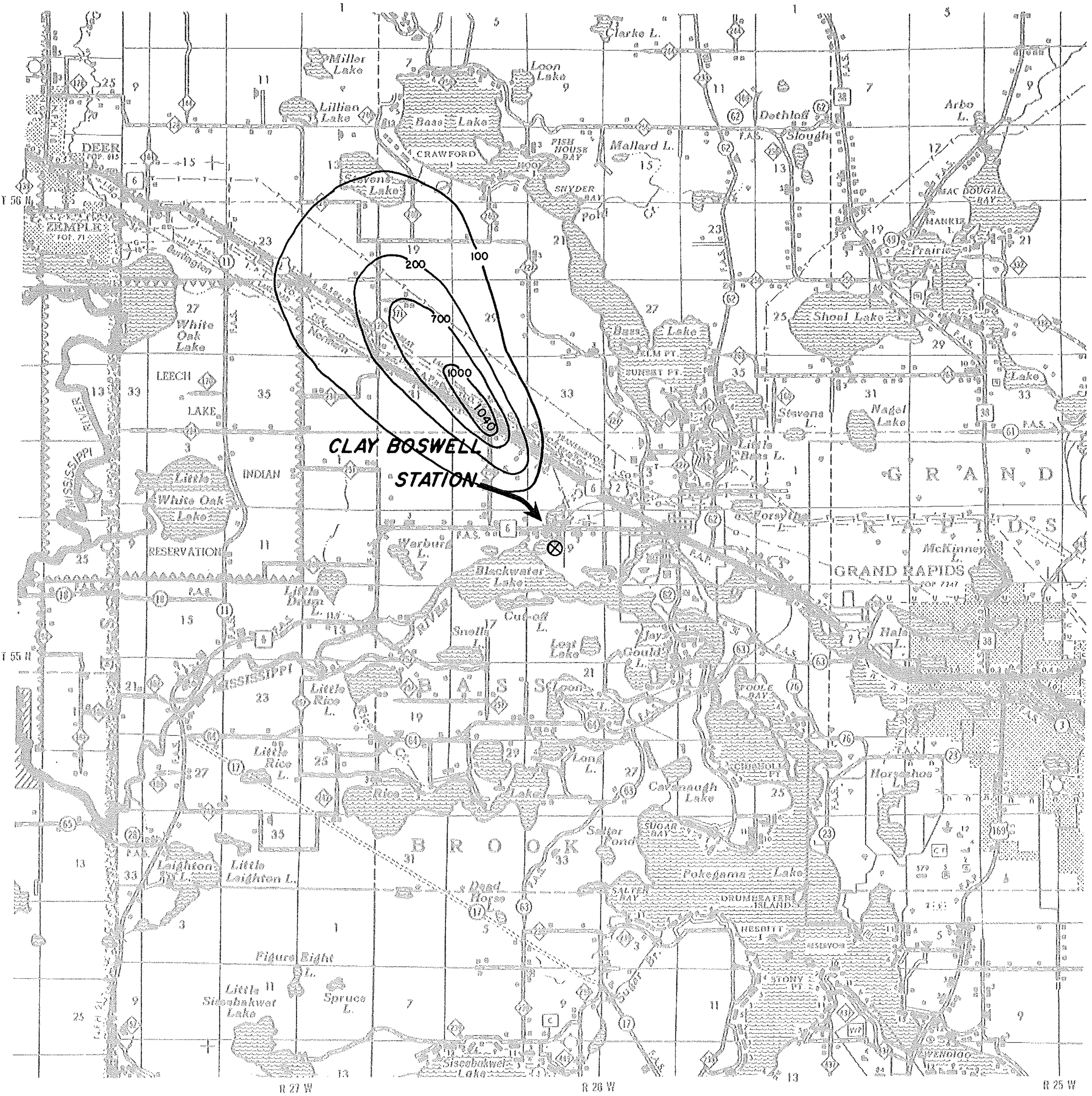
0 1 2 3
MILES

0 1 2 3
KILOMETERS

CALCULATED ISOPLETHS OF 24-HR MAXIMUM SO_2 CONCENTRATIONS

PRE-MODIFIED UNITS 1, 2, AND 3

FIGURE IV-65



LEGEND

⊗ CLAY BOSWELL STATION

NOTE: ISOPLETHS IN MICROGRAMS PER CUBIC METER (μg per cu m)

FOR TOTAL WITH BACKGROUND, ADD 15 μg per cu m TO EACH ISOPLETH VALUE

BASE MAP LEGEND

ROAD AND ROADWAY FEATURES

- PROJECTED ROAD
- GRADED AND DRAINED ROAD
- GRAVEL OR STONE ROAD
- BITUMINOUS ROAD
- PAVED ROAD

BOUNDARIES

- COUNTY
- CIVIL TOWNSHIP
- CONGRESSIONAL TOWNSHIP (U.S. LAND)
- SECTION LINE
- NATIONAL OR STATE PARK
- NATIONAL OR STATE FOREST
- NATIONAL INDIAN RESERVATION

DRAINAGE

- INTERMITTENT STREAM
- NARROW STREAM
- MARSH OR SWAMP LAND
- POND OR LAKE

PUBLIC SERVICE FACILITIES

- PIPE LINE, GAS
- PIPE LINE, OIL
- TRANSMISSION LINE (33 KV OR OVER)
- POWER PLANT

EDUCATIONAL AND CORRECTIONAL INSTITUTIONS

- SCHOOL HOUSE
- CONSOLIDATED OR LARGE SCHOOL

-N-

0 1 2 3
MILES

0 1 2 3
KILOMETERS

CALCULATED ISOPLETHS OF 3-HR MAXIMUM SO_2 CONCENTRATIONS

PRE-MODIFIED UNITS 1, 2, AND 3

FIGURE IV-66

Trace Elements. Trace elements concentrations were not measured at the on-site monitors 1 and 2. The worst case background concentrations have been estimated, however, using the monitoring data from Grand Rapids and other northern Minnesota cities (see Tables IV-52 and IV-53). The estimated background trace element concentrations are presented in Table IV-62.

TABLE IV-62
CALCULATED BACKGROUND CONCENTRATIONS OF TRACE ELEMENTS AND SULFATES - ON-SITE
CLAY BOSWELL STEAM ELECTRIC STATION

Pollutant	Annual Arithmetic Mean µg per cu m	24-hr Maximum µg per cu m
Beryllium	0.00004	0.001
Cadmium	0.001	0.004
Chromium	0.00378	0.06426
Cobalt	0.00076	0.0190
Copper	0.03250	0.1950
Iron	0.350	0.570
Lead	0.068	0.119
Manganese	0.03830	0.2298
Nickel	0.009	0.032
Titanium	0.03700	0.1480
Vanadium	0.00280	0.0700
Sulfates	5.0	10.0

Diffusion modeling for trace element concentrations is less precise than that for particulates, NO_x, and SO_2 for at least 2 reasons: 1) the coal trace element analyses used may vary from actual coal received by as much as a factor of 2 or 3 in either direction (refer to Chapter II), and 2) the chemical and physical form in which each trace element will be emitted cannot be predicted with certainty. The calculations which have been done are, however, the "state of the art".

Table IV-63 presents the results of diffusion modeling for the trace-elements emitted by pre-modified Units 1, 2, and 3. Isopleths have not been calculated for the trace element emissions of pre-modified Units 1, 2, and 3. The distribution of many of the trace elements would follow that for total particulates (Figures IV-58 and IV-59).

TABLE IV-63
CALCULATED TRACE ELEMENT AND SULFATE CONCENTRATIONS RESULTING FROM EMISSIONS OF PRE-MODIFIED UNITS 1, 2, AND 3
CLAY BOSWELL STEAM ELECTRIC STATION

	Annual Arithmetic Mean μg per cu m			24-hr Maximum μg per cu m		
Pollutant	Units 1, 2, and 3	Measured Background	Total	Units 1, 2, and 3	Measured Background	Total
Beryllium	0.0000019	0.00004	0.0000419	0.000050	0.00100	0.001050
Cadmium	0.0027700	0.00100	0.0037700	0.071560	0.00400	0.075560
Chromium	0.0023500	0.00378	0.0061300	0.060800	0.06426	0.125060
Cobalt	0.0004580	0.00076	0.0012180	0.011747	0.01900	0.030747
Copper	0.0099000	0.03250	0.0424000	0.250000	0.19500	0.445000
Iron	0.7664200	0.35000	1.1164200	19.779600	0.57000	20.349600
Lead	0.0074000	0.06800	0.0754000	0.229403	0.11900	0.348402
Manganese	0.0092900	0.03830	0.0475900	0.240000	0.22980	0.469800
Nickel	0.0007100	0.00900	0.0097100	0.017894	0.03200	0.049894
Titanium	0.0982500	0.03700	0.1352500	2.536900	0.14800	2.684900
Vanadium	0.0010600	0.00280	0.0038600	0.027000	0.07000	0.097000
Sulfates	5.0	5.0	10.0	35.0	10.0	45.0

Sulfates. The emissions of the Clay Boswell Station can increase the ambient sulfate concentration in 2 ways (119). First, sulfates can be emitted directly from the stack. Second, and more important, sulfuric acid and sulfate salts can be formed in the plume by conversion of the SO emissions. The variables which affect the rates of conversion are atmospheric moisture content, the presence of metal oxides, particulates, and other pollutants, and the amount of sunlight. Basically, 2 types of reactions can occur. First, during daylight hours the SO_2 can be converted by photochemical reactions. Secondly, at any time of the day or night the SO_2 can be converted by catalytic reactions. These 2 processes may occur simultaneously or separately, depending on the ambient conditions.

In the presence of atmospheric moisture, SO_2 in the plume can be converted directly to the sulfite ion ($SO_3^{=}$). Thus, some of the highest SO_2 conversion rates have been observed during the presence of fog or atmospheric moisture (e.g., as when the stack plume mingles with the plume of a cooling tower). The presence of additional atmospheric pollutants can also accelerate the rate of SO_2 conversion. Vanadium, iron oxides, and other catalytic particulate matter commonly present in plumes emitted by the combustion of fossil fuels have been identified as possible catalysts which increase the rate at which SO_2 is converted to sulfates. Accelerated SO_2 conversion rates also are caused by high (urban) concentrations of NO_x, hydrocarbons, and carbon monoxide.

The final factor in SO_2 to sulfate conversion is sunlight. In general, photochemical conversion occurs at a faster rate than does catalytic conversion.

For example, in Log Angeles ground level conversion rates of 1 to 13% per hour have been measured (120), while in St. Louis, which has less photochemical activity than Los Angeles, conversion rates of only 1 to 2% per hr were measured (109). Table IV-64 lists some of the major reactions which may occur to convert SO_2 to sulfates. Note that the SO_2 concentration also is an important variable.

TABLE IV-64
MECHANISMS WHICH CONVERT SO_2 TO SULFATES IN THE ATMOSPHERE (121)

Mechanism	Overall Reaction	Principal Factors Influencing Conversion Rates
Direct photo-oxidation	$SO_2 \xrightarrow[\text{water}]{\text{light, oxygen}} H_2SO_4$	SO_2 concentration, sunlight intensity
Indirect photo-oxidation	$SO_2 \xrightarrow[\text{organic oxidants, hydroxyl radical (OH)}]{\text{smog, water, } NO_x} H_2SO_4$	SO_2 concentration, organic oxidant concentration, OH, NO_x
Air oxidation in liquid droplets	$SO_2 \xrightarrow{\text{liquid water}} H_2SO_3$	Ammonia concentration
	$NH_3 + H_2SO_3 \xrightarrow{\text{oxygen}} NH_4^+ + SO_4^=$	Ammonia concentration
Catalyzed oxidation in liquid droplets	$SO_2 \xrightarrow[\text{heavy metal ions}]{\text{oxygen, liquid water}} SO_4^=$	Concentration of heavy metal (Fe, Mn) ions
Catalyzed oxidation on dry surfaces	$SO_2 \xrightarrow[\text{carbon, water}]{\text{oxygen, particulate}} H_2SO_4$	Carbon particle concentration (surface area)

In-plume SO_2 conversion rates from 1 to 50% per hr have been reported (109). In general, conversion rates for emissions from fuel oil combustion are higher than rates for coal combustion. The rates remain different even at distances of 30 miles (48.3 km) downwind from the stack. The rate differences are thought to be caused by the lack of particulate emission control in sources burning fuel oil. Table IV-65 lists some SO_2 to sulfates conversion rates which have been reported. Note that some of the large differences in reported conversion rates may be caused by differences in sampling procedures.

Presently, there is no diffusion model which is acceptable and applicable to calculate or project the ground level ambient sulfate concentration resulting from the emissions of the Clay Boswell Station. Furthermore, most monitoring and other data is given as total sulfates. This method does not distinguish between the harmful sulfates, such as sulfuric acid (H_2SO_4) and the many other relatively harmless sulfates.

Since the reported SO_2 conversion rates vary from nearly 0 to 50% per hr, one reasonable method to estimate the sulfate concentrations resulting from emissions of the Clay Boswell Station is to examine a range of conversion rates, process them through the appropriate diffusion model, and compare the results with the sulfate concentrations measured at various northern Minnesota cities (Table IV-53) and elsewhere (Figure IV-67). (Note, however, that the ambient monitoring done for Table IV-53 may not have been measuring maximum sulfate

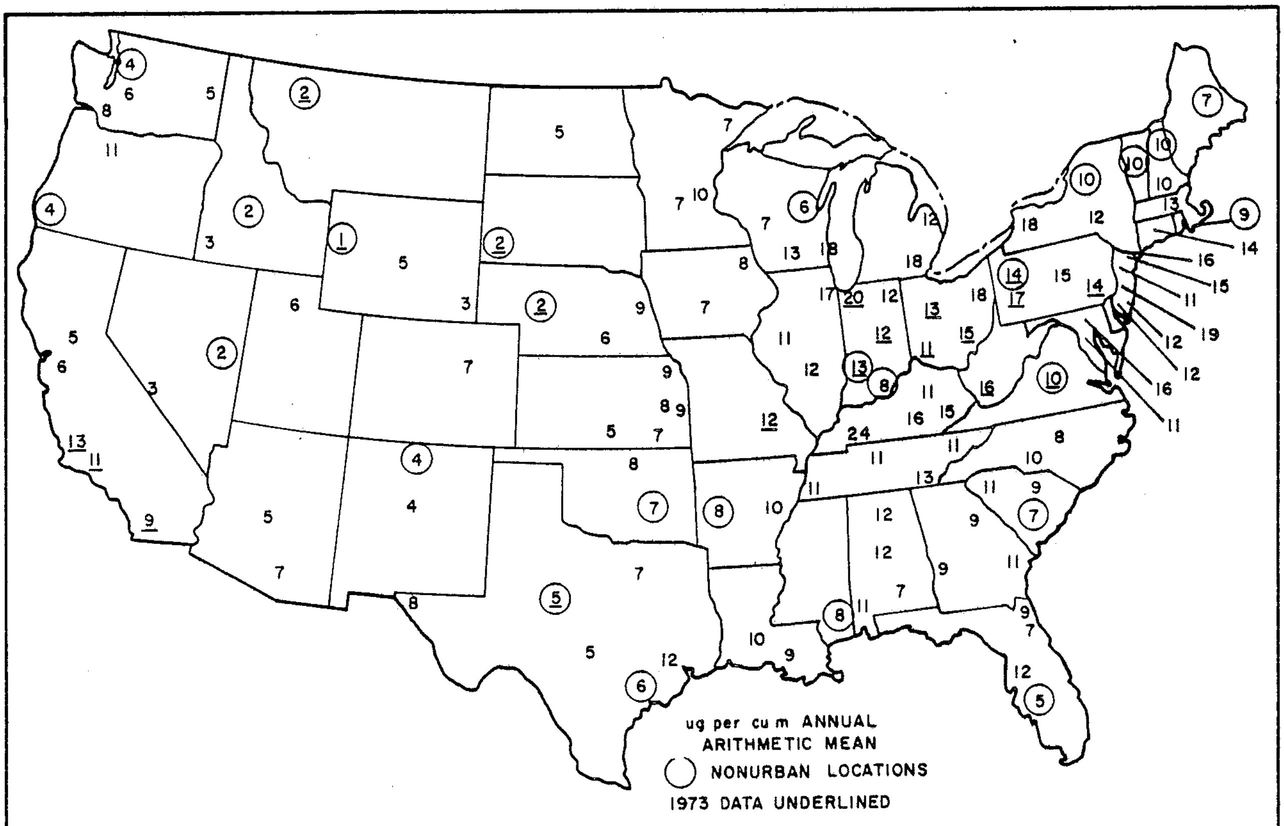
TABLE IV-65
REPORTED CONVERSION RATES OF SO_2 TO SULFATES IN THE ATMOSPHERE

Mechanism	Conversion Rate % SO_2 per hr	Reference Number[a]
Photochemical (in clean air)	0.65	122
Photochemical	0.1 to .2	123
Photochemical	24.0	124
Photochemical and catalytic (TVA Study)	6 (70% relative humidity) 30(100% relative humidity)	121 121
Photochemical and catalytic	0.1 to 30	125
Catalytic	2.00	125
Photochemical and catalytic	10 to 20 (oil firing)	126
Photochemical and catalytic	1 to 2 (coal firing)	127

[a] References are located at end of Chapter IV.

concentrations). The comparison was made for conversion rates of 2%, 5%, 10%, and 30% per hr. Conversion rates of 5% and 15% per hr for the annual arithmetic mean and 24-hr maximum concentrations, respectively, correlate best with the monitoring data (15% was selected by interpolation). The high conversion rates reported near the Tennessee Valley Authority (TVA) power plants (121) are not applicable to the Clay Boswell Station because the TVA facilities have higher particulate and SO_2 emission rates, and are located in areas which have higher ambient concentrations of particulates and SO_2, and which experience more solar radiation and atmospheric stagnation. Similarly, the Los Angeles and St. Louis studies are not clearly applicable to the situation near the Clay Boswell Station. Consequently, the 5% and 15% per hr conversion rates represent the current state of the art and cannot be improved upon until a more sophisticated model is developed, or until the Clay Boswell plume is monitored for sulfates. Finally, it should be noted that the 15% per hr conversion rate is an average for the 24-hr period. Maximum conversion rates corresponding to those reported in the literature (e.g. 20 to 30% per hr) may occur and are accounted for in the average. These maximum conversion rates could potentially occur during 6 to 8 hours per day (non-winter).

The calculated background sulfate concentrations in the vicinity of the Clay Boswell Station are given in Table IV-62. Using the SO_2 to sulfates conversion rates of 5% and 15% per hr for the annual arithmetic mean and 24-hr maximum concentrations, respectively, the diffusion analysis yields the results presented in Table IV-63. Note that the emissions of pre-modified Units 1, 2, and 3 approximately double the annual arithmetic mean sulfate concentration, and increase the 24-hr maximum concentration by a factor of 3.5 over the background.



ANNUAL AVERAGE SULFATE CONCENTRATIONS AT VARIOUS U.S. URBAN AND NONURBAN LOCATIONS- 1972 AND 1973

FIGURE IV-67

SOURCE: ADAPTED FROM, "POSITION PAPER ON REGULATION OF ATMOSPHERIC SULFATES", EPA-450/2-75-007, 1975, U.S. ENVIRONMENTAL PROTECTION AGENCY, RESEARCH TRIANGLE PARK, NORTH CAROLINA

Modified Units 1, 2, and 3

The same diffusion modeling analysis used for emissions of pre-modified Units 1, 2, and 3 was used for modified Units 1, 2, and 3. The emission factors and coal analyses used for the modeling of the emissions of modified Units 1, 2, and 3 are presented in Tables IV-55 through IV-58.

Particulates. The projected ambient particulate concentrations resulting from the emissions of modified Units 1, 2, and 3 are presented in Table IV-66. Note that after modification, Units 1, 2, and 3 are projected to be in compliance with the secondary particulate AAQS. Figures IV-68 and IV-69 present the projected distribution of the particulate emissions.

The size distribution of the particulates emitted by stationary sources is very significant from a public health viewpoint because size is the principal factor in determining the ability of the particle to be drawn into the lung. Particle size distribution data has been developed for modified Units 1, 2, and 3 based on reports of the EPA (128) and information submitted by MP&L to the EPA in the application for the Prevention of Significant Deterioration permit for proposed Unit 4 (129). The particle size distribution are presented in Table IV-67.

TABLE IV-66
PROJECTED PARTICULATES, NO_x, AND SO_2 CONCENTRATIONS RESULTING FROM EMISSIONS OF MODIFIED UNITS 1, 2, AND 3
CLAY BOSWELL STEAM ELECTRIC STATION

Pollutant	Units 1, 2, and 3 µg per cu m	Measured Background µg per cu m	Total µg per cu m	Minnesota Secondary Standard µg per cu m
Particulates				
Annual geometric mean	0.2	18	8.2	60
24-hr maximum	13.5	107	120.5	150
NO_x				
Annual arithmetic mean	0.5	14	14.5	100
SO_2				
Annual arithmetic mean	1	0.4	1.4	60
24-hr maximum	244	5	249	260
3-hr maximum	861	15	876	655

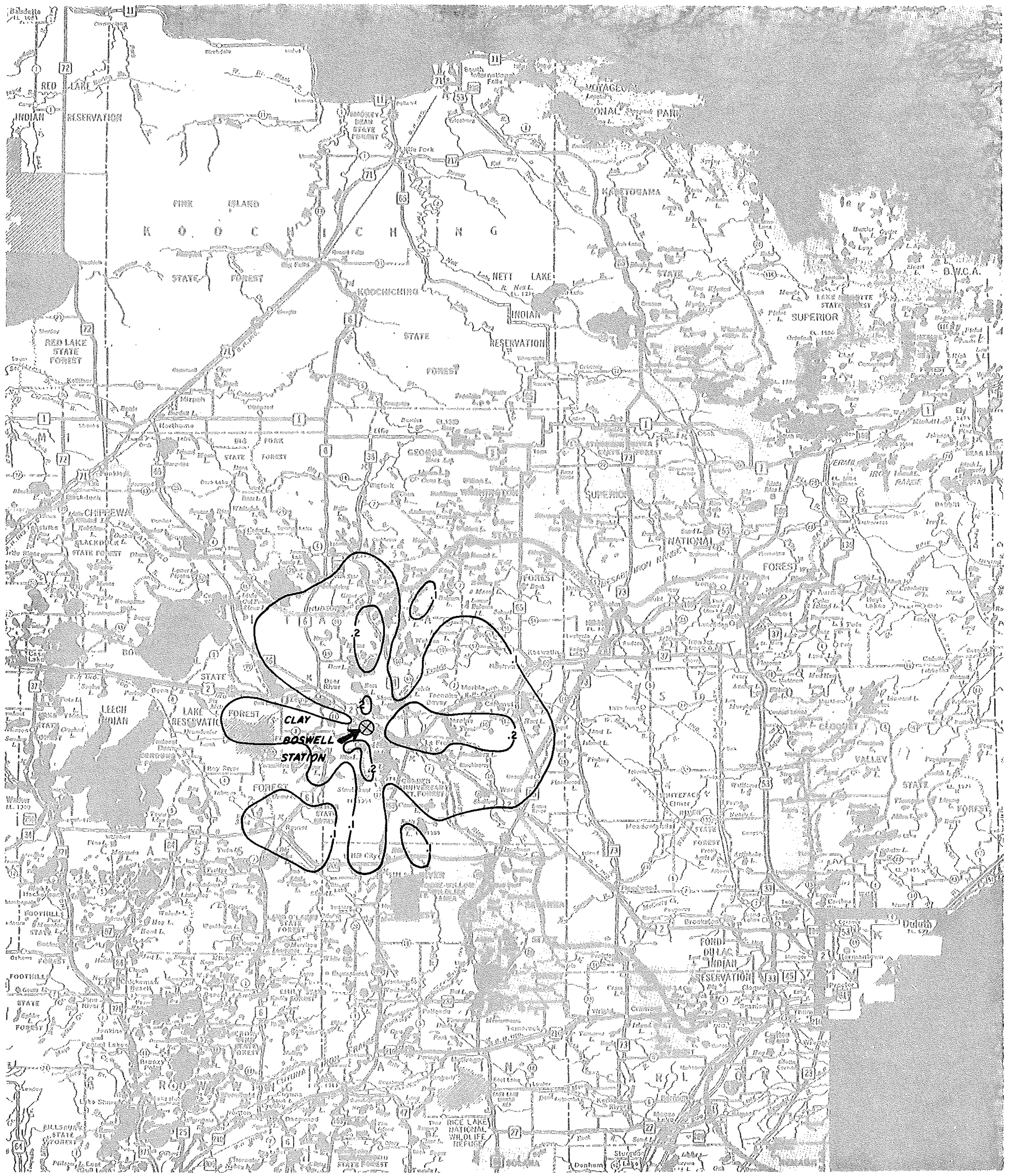
TABLE IV-67
SIZE DISTRIBUTION OF PARTICULATES EMITTED BY MODIFIED UNITS 1, 2, AND 3
CLAY BOSWELL STEAM ELECTRIC STATION

Particle Size (Microns)	Percent by Weight of Particles at Stack Outlet[a]		
	Units 1 and 2	Unit 3	Combined Total
0 to 5	100	72	90
5 to 10	0	17	6
10 to 20	0	11	4
20 to 40	0	0	0
40 and greater	0	0	0

[a] Modified Units 1, 2, and 3 will discharge through common 700 ft (213.4 m) stack.

Nitrogen oxides. Table IV-66 includes the annual arithmetic mean NO_x concentrations projected to be caused by emissions of the modified Units 1, 2, and 3. Figure IV-70 illustrates the annual arithmetic mean isopleths likely to be caused by the emissions of modified Units 1, 2, and 3.

Sulfur dioxide. The results of the diffusion modeling for the SO_2 emissions of modified Units 1, 2, and 3 are presented in Table IV-67 and Figures IV-71 through IV-73. Modified Units 1, 2, and 3 are projected to cause the ambient 3-hr maximum SO_2 concentration to exceed the AAQS by a factor of 1.31. The tall stack and other modifications being made pursuant to the air quality stipulation agreement should substantially reduce the ambient SO_2 concentrations relative to those caused by the pre-modified Units 1, 2, and 3. The diffusion modeling, however, indicates only a moderate decrease in SO_2 concentrations, e.g., 3-hr maximum concentration of 1,055 µg per cu m for the pre-modified Units 1, 2, and 3 versus 876 µg per cu m for the modified Units 1,



LEGEND

⊗ CLAY BOSWELL STATION

NOTE: ISOPLETHS IN MICROGRAMS PER CUBIC METER (μg per cu m)

FOR TOTAL WITH BACKGROUND, ADD 18 μg per cu m TO EACH ISOPLETH VALUE

BASE MAP LEGEND

INTERSTATE
MULTILANE DIVIDED HIGHWAY
MULTILANE UNDIVIDED HIGHWAY
INTERMEDIATE TYPE
GRAVEL SURFACED
SECONDARY ROAD-HARD SURFACED
SECONDARY ROAD-GRAVEL
NATIONAL FOREST
STATE FOREST
WILDLIFE MANAGEMENT AREA

N

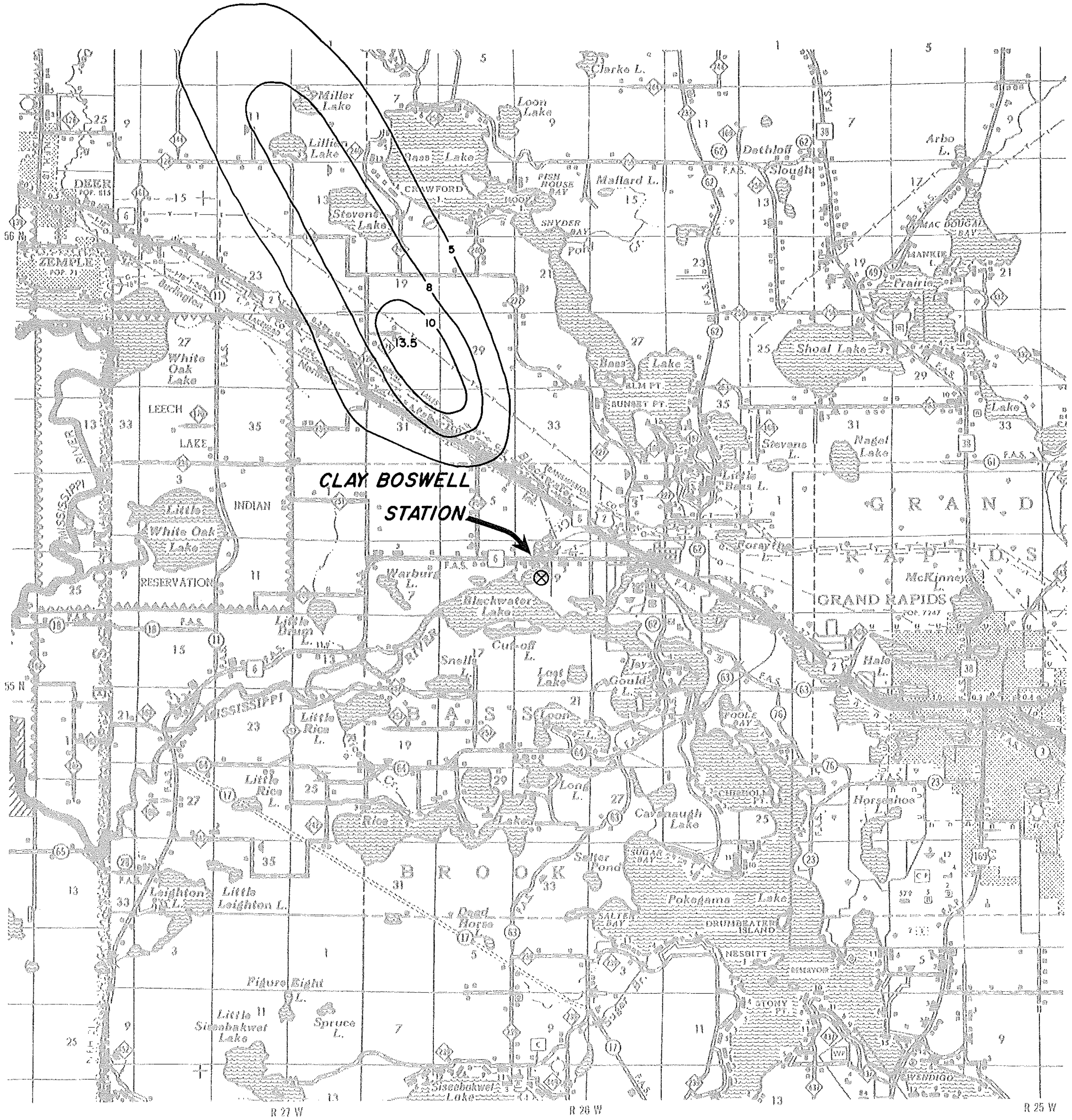
10 0 10 20
MILES

10 0 10 20
KILOMETERS

PROJECTED ISOPLETHS OF ANNUAL GEOMETRIC MEAN PARTICULATE CONCENTRATIONS

MODIFIED UNITS 1, 2, AND 3

FIGURE IV-68



LEGEND

⊗ CLAY BOSWELL STATION

NOTE: ISOPLETHS IN MICROGRAMS PER CUBIC METER (μg per cu m)

FOR TOTAL WITH BACKGROUND, ADD 107 μg per cu m TO EACH ISOPLETH VALUE

BASE MAP LEGEND

ROAD AND ROADWAY FEATURES

- PROJECTED ROAD
- GRADED AND DRAINED ROAD
- GRAVEL OR STONE ROAD
- BITUMINOUS ROAD
- PAVED ROAD

BOUNDARIES

- COUNTY
- CIVIL TOWNSHIP
- CONGRESSIONAL TOWNSHIP (U.S. LAND)
- SECTION LINE
- NATIONAL OR STATE PARK
- NATIONAL OR STATE FOREST
- NATIONAL INDIAN RESERVATION

DRAINAGE

- INTERMITTENT STREAM
- NARROW STREAM
- MARSH OR SWAMP LAND
- POND OR LAKE

PUBLIC SERVICE FACILITIES

- PIPE LINE, GAS
- PIPE LINE, OIL
- TRANSMISSION LINE (33 KV OR OVER)
- POWER PLANT

EDUCATIONAL AND CORRECTIONAL INSTITUTIONS

- SCHOOL HOUSE
- CONSOLIDATED OR LARGE SCHOOL

N

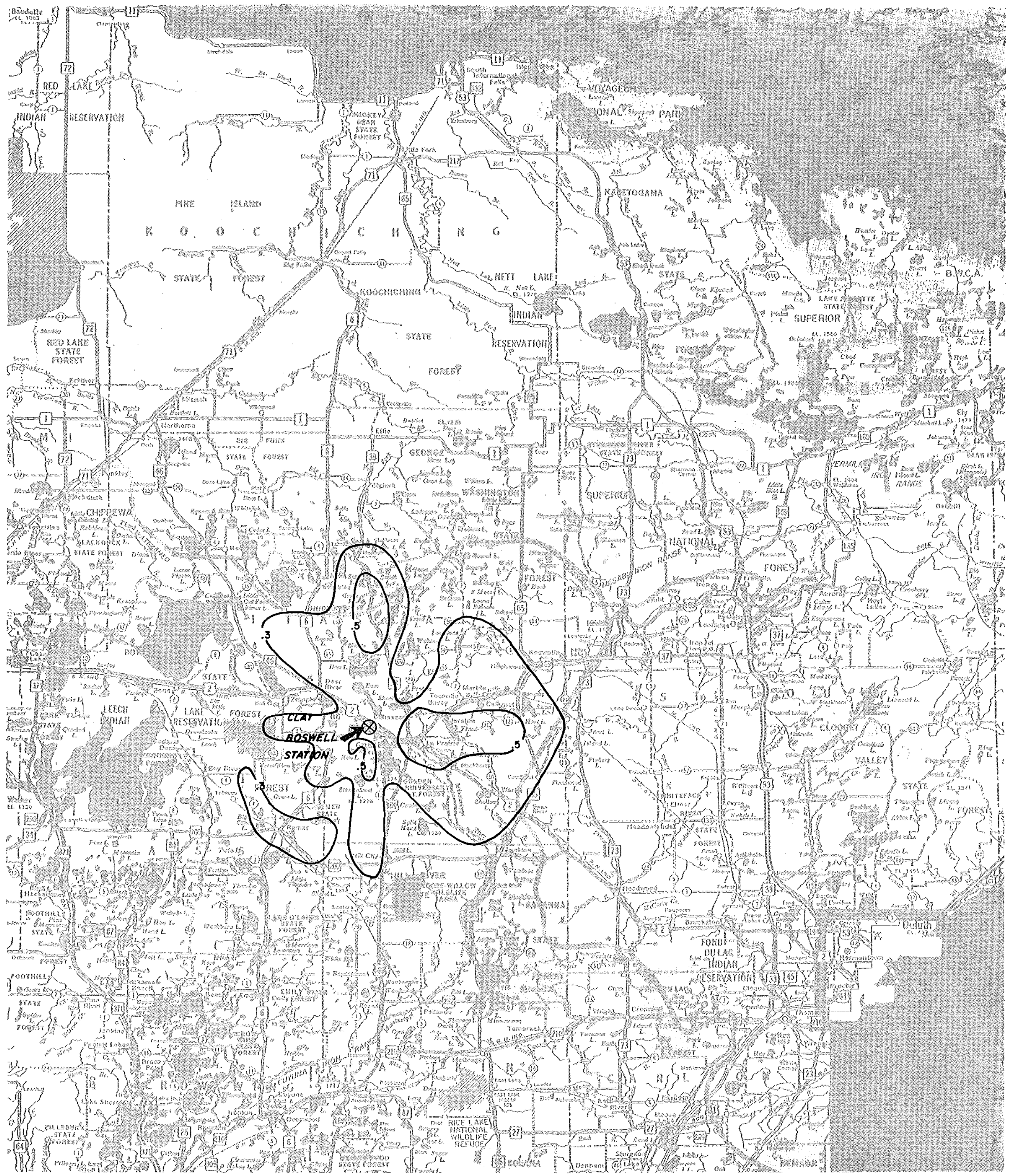
0 1 2 3
MILES

0 1 2 3
KILOMETERS

PROJECTED ISOPLETHS OF 24-HR MAXIMUM PARTICULATE CONCENTRATIONS

MODIFIED UNITS 1, 2, AND 3

FIGURE IV-69



LEGEND

⊗ CLAY BOSWELL STATION

NOTE: ISOPLETHS IN MICROGRAMS PER CUBIC METER (μg per cu m)

FOR TOTAL WITH BACKGROUND, ADD 14 μg per cu m TO EACH ISOPLETH VALUE

BASE MAP LEGEND

INTERSTATE	SECONDARY ROAD-HARD SURFACED
MULTILANE DIVIDED HIGHWAY	SECONDARY ROAD-GRAVEL
MULTILANE UNDIVIDED HIGHWAY	NATIONAL FOREST
INTERMEDIATE TYPE	STATE FOREST
GRAVEL SURFACED	WILDLIFE MANAGEMENT AREA

N

10 0 10 20
MILES

10 0 10 20
KILOMETERS

PROJECTED ISOPLETHS OF ANNUAL ARITHMETIC MEAN NO_x CONCENTRATIONS

MODIFIED UNITS 1, 2, AND 3

FIGURE IV-70

2, and 3. This apparent discrepancy is due to different coal analyses, and hence emission rates, being used for the diffusion modeling (Tables IV-55 and IV-57). The coal which was burned in the past in Units 1, 2, and 3 at the Clay Boswell Station was mined from an area of the Big Sky Mine where the sulfur content was low and relatively uniform throughout the deposit (average sulfur content of 0.91%, worst case of 2.00%) (130). The areas of the Big Sky Mine from which the fuel will be mined for the modified Units 1, 2, and 3 and for the proposed Unit 4 have coal deposits which are much more variable in sulfur content (average sulfur content of 1.03%, worst case of 4.55%) (refer to Chapter II). Refer to the Air Quality section of Chapter V for discussions of the projected violation of the SO_2 AAQS by the modified Units 1, 2, and 3.

Trace Elements. Table IV-68 presents the worst case trace element concentrations projected to be caused by modified Units 1, 2, and 3. Isopleths have not been plotted for the ambient concentrations of trace elements. Once again, the ambient concentrations of many of the trace elements probably will be distributed like the ambient particulates (Figures IV-68 and IV-69).

TABLE IV-68
PROJECTED TRACE ELEMENTS AND SULFATE CONCENTRATIONS RESULTING FROM EMISSIONS OF MODIFIED UNITS 1, 2, AND 3
CLAY BOSWELL STEAM ELECTRIC STATION

	Annual Arithmetic Mean µg per cu m			24-hr Maximum µg per cu m		
Pollutant	Units 1, 2, and 3	Measured Background	Total	Units 1, 2, and 3	Measured Background	Total
Arsenic	0.00003153	na[a]	0.00003153[b]	0.00166213	na	0.00166213[b]
Barium	0.00190000	na	0.00190000[b]	0.10025000	na	0.10025000[b]
Beryllium	0.00000310	0.00004	0.00004310	0.00021790	0.00100	0.00121790
Cadmium	0.00000360	0.00100	0.00100360	0.00019080	0.00400	0.00419080
Chromium	0.00004920	0.00378	0.00382920	0.00259340	0.06426	0.06685340
Cobalt	0.00000390	0.00076	0.00076390	0.00020420	0.01900	0.01920420
Copper	0.00007230	0.03250	0.03257230	0.00506410	0.19400	0.19906410
Fluorine	0.00207838	na	0.00207838b	0.10955902	na	0.10955902[b]
Gallium	0.00009820	na	0.00009820[b]	0.00517639	na	0.00517639[b]
Lead	0.00003520	0.06800	0.06803520	0.02040000	0.11900	0.13940000
Manganese	0.00027380	0.03830	0.03857380	0.01916670	0.22980	0.24896670
Mercury	0.00000360	na	0.00000360[b]	0.00018996	na	0.00018996[b]
Molybdenum	0.00009695	na	0.00009695[b]	0.00511051	na	0.00511051[b]
Nickel	0.00002930	0.00900	0.00902930	0.00205110	0.03200	0.03405110
Strontium	0.00072757	na	0.00072757[b]	0.03835234	na	0.03835234[b]
Titanium	0.00405410	0.03700	0.04105410	0.21370420	0.14800	0.36170420
Uranium	0.00000312	na	0.00000310[b]	0.00016470	na	0.00016470[b]
Vanadium	0.00013730	0.00280	0.00293730	0.00961540	0.07000	0.07961540
Zinc	0.00016739	na	0.00016739[b]	0.00882339	na	0.00882339[b]
Sulfates	2.0	5.0	7.0	49.0	10.0	59.0

[a] na means not available.

[b] Total concentration excludes background due to unavailable data.

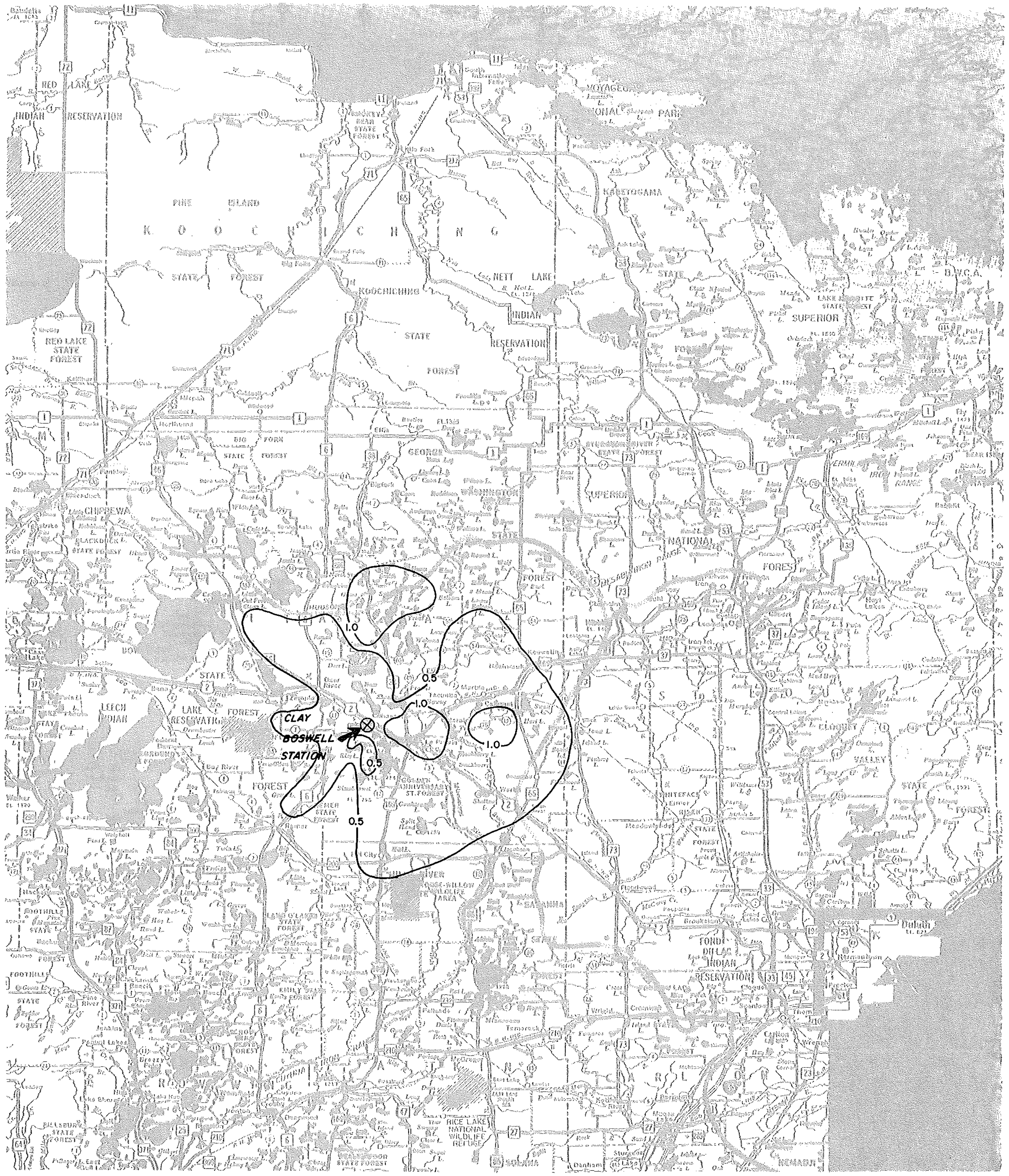
Trace element deposition rates have been calculated. The deposition rate analysis provides an index to the long-term soil loading of the trace elements. Table IV-69 presents the worst case annual average deposition rates for 19 trace elements which will be emitted by modified Units 1, 2, and 3. These rates were calculated by multiplying the annual average concentrations caused by Units 1, 2, and 3 (column 2 of Table IV-68) by an assumed fallout velocity of 0.01 m per sec. This fallout velocity has been verified as reasonable by use of Brigg's equation for settling velocity as a function of average particle size and density (131).

TABLE IV-69
PROJECTED MAXIMUM ANNUAL TRACE ELEMENT DEPOSITION RATES
MODIFIED UNITS 1, 2, AND 3
CLAY BOSWELL STEAM ELECTRIC STATION

Trace Element	Deposition Rate[a] μg per sq m per sec
Arsenic	10
Barium	599
Beryllium	1
Cadmium	1
Chromium	16
Cobalt	1
Copper	23
Fluorine	655
Gallium	31
Lead	110
Manganese	86
Mercury	1
Molybdenum	31
Nickel	9
Strontium	229
Titanium	1,278
Uranium	1
Vanadium	43
Zinc	53

[a] Fallout velocity of 0.01 m per sec assumed throughout. Deposition rates are for point of maximum ground level ambient concentrations only.

Figure IV-74 identifies the areas of maximum deposition. The values shown on Figure IV-74 are fractions of the maximum deposition rates given in Table IV-69. The deposition rate isopleths are based on the annual geometric mean particulate isopleths in Figure IV-68. This method is theoretically correct for all but the most volatile trace elements. The actual distribution of trace element deposition probably will be more widespread and less distinct than shown in Figure IV-74.



LEGEND

⊗ CLAY BOSWELL STATION

NOTE: ISOPLETHS IN MICROGRAMS PER CUBIC METER (μg per cu m)

FOR TOTAL WITH BACKGROUND, ADD 0.4 μg per cu m TO EACH ISOPLETH VALUE

BASE MAP LEGEND

- INTERSTATE
- MULTILANE DIVIDED HIGHWAY
- MULTILANE UNDIVIDED HIGHWAY
- INTERMEDIATE TYPE
- GRAVEL SURFACED
- SECONDARY ROAD-HARD SURFACED
- SECONDARY ROAD-GRAVEL
- NATIONAL FOREST
- STATE FOREST
- WILDLIFE MANAGEMENT AREA

N

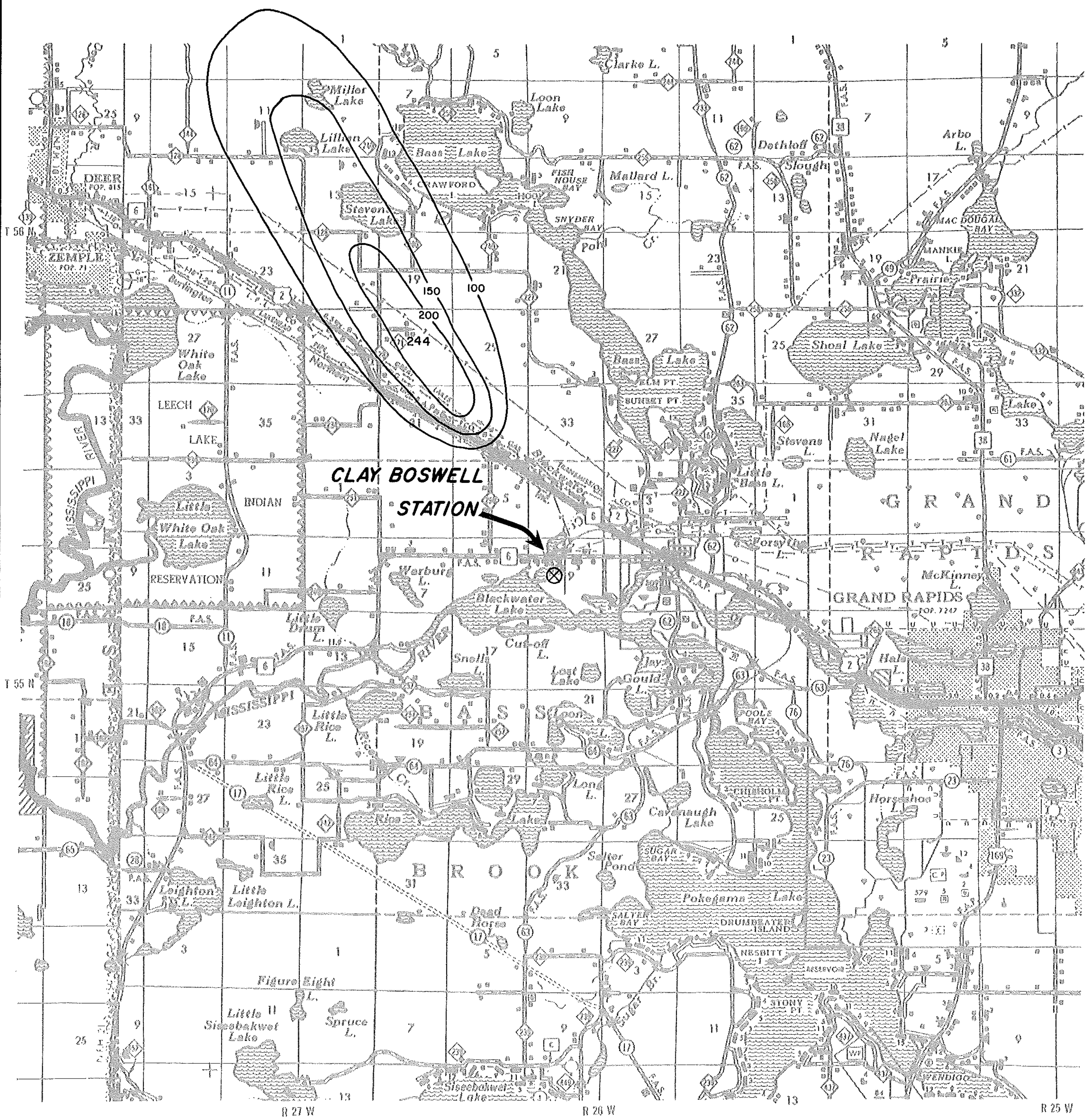
10 0 10 20
MILES

10 0 10 20
KILOMETERS

PROJECTED ISOPLETHS OF ANNUAL ARITHMETIC MEAN SO_2 CONCENTRATIONS

MODIFIED UNITS 1, 2, AND 3

FIGURE IV-71



LEGEND

⊗ CLAY BOSWELL STATION

NOTE: ISOPLETHS IN MICROGRAMS PER CUBIC METER (μg per cu m)

FOR TOTAL WITH BACKGROUND, ADD 5 μg per cu m TO EACH ISOPLETH VALUE

BASE MAP LEGEND

ROAD AND ROADWAY FEATURES

- PROJECTED ROAD
- GRADED AND DRAINED ROAD
- GRAVEL OR STONE ROAD
- BITUMINOUS ROAD
- PAVED ROAD

BOUNDARIES

- COUNTY
- CIVIL TOWNSHIP
- CONGRESSIONAL TOWNSHIP (U.S. LAND)
- SECTION LINE
- NATIONAL OR STATE PARK
- NATIONAL OR STATE FOREST
- NATIONAL INDIAN RESERVATION

DRAINAGE

- INTERMITTENT STREAM
- NARROW STREAM
- MARSH OR SWAMP LAND
- POND OR LAKE

PUBLIC SERVICE FACILITIES

- PIPE LINE, GAS
- PIPE LINE, OIL
- TRANSMISSION LINE (33 KV OR OVER)
- POWER PLANT

EDUCATIONAL AND CORRECTIONAL INSTITUTIONS

- SCHOOL HOUSE
- CONSOLIDATED OR LARGE SCHOOL

N

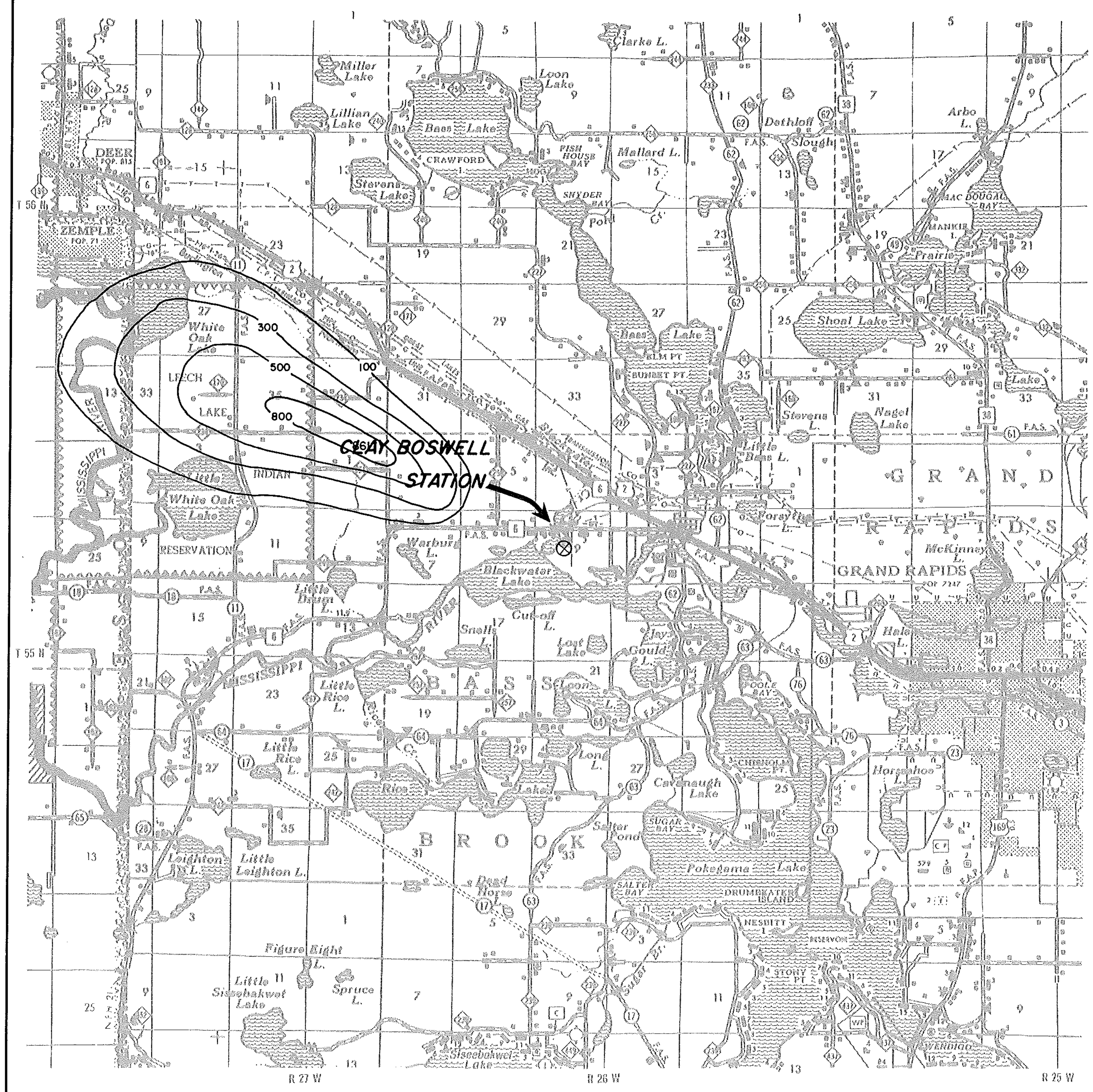
MILES: 0 1 2 3

KILOMETERS: 0 1 2 3

PROJECTED ISOPLETHS OF 24-HR MAXIMUM SO_2 CONCENTRATIONS

MODIFIED UNITS 1, 2, AND 3

FIGURE IV-72



LEGEND

⊗ CLAY BOSWELL STATION

NOTE: ISOPLETHS IN MICROGRAMS PER CUBIC METER (μg per cu m)

FOR TOTAL WITH BACKGROUND, ADD 15 μg per cu m TO EACH ISOPLETH VALUE

BASE MAP LEGEND

ROAD AND ROADWAY FEATURES

- PROJECTED ROAD
- GRADED AND DRAINED ROAD
- GRAVEL OR STONE ROAD
- BITUMINOUS ROAD
- PAVED ROAD

BOUNDARIES

- COUNTY
- CIVIL TOWNSHIP
- CONGRESSIONAL TOWNSHIP (U.S. LAND)
- SECTION LINE
- NATIONAL OR STATE PARK
- NATIONAL OR STATE FOREST
- NATIONAL INDIAN RESERVATION

DRAINAGE

- INTERMITTENT STREAM
- NARROW STREAM
- MARSH OR SWAMP LAND
- POND OR LAKE

PUBLIC SERVICE FACILITIES

- PIPE LINE, GAS
- PIPE LINE, OIL
- TRANSMISSION LINE (33 KV OR OVER)
- POWER PLANT

EDUCATIONAL AND CORRECTIONAL INSTITUTIONS

- SCHOOL HOUSE
- CONSOLIDATED OR LARGE SCHOOL

MILES 0 1 2 3

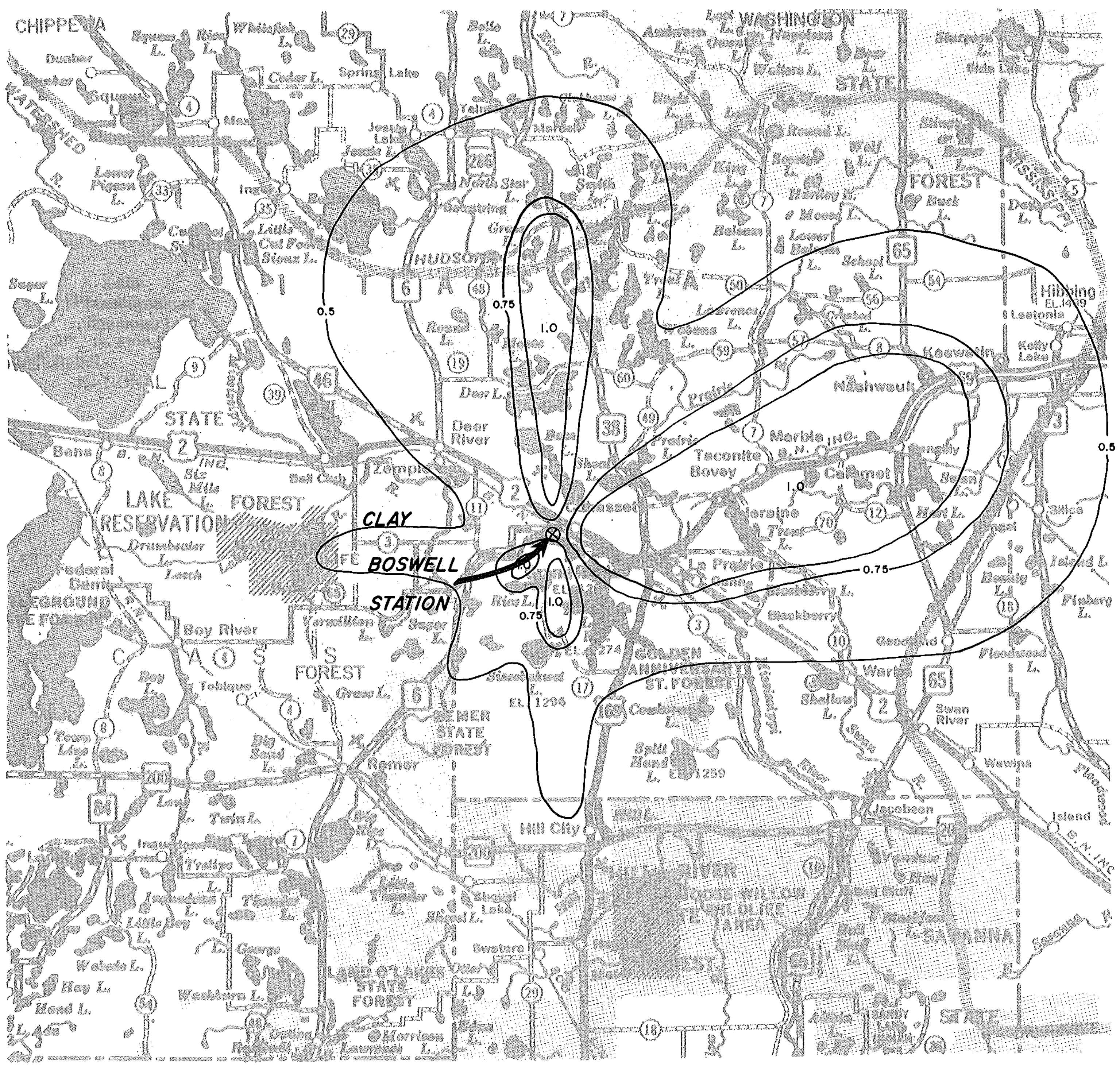
KILOMETERS 0 1 2 3

-N-

PROJECTED ISOPLETHS OF 3-HR MAXIMUM SO_2 CONCENTRATIONS

MODIFIED UNITS 1, 2, AND 3

FIGURE IV-73



LEGEND

⊗ CLAY BOSWELL STATION

NOTE: VALUES SHOWN ARE FRACTIONS OF MAXIMUM ANNUAL DEPOSITION RATES PRESENTED IN TABLE IV-69. FOR ACTUAL DEPOSITION RATE FOR EACH TRACE ELEMENT, MULTIPLY VALUES IN TABLE IV-69 BY THE FRACTIONS SHOWN IN THIS FIGURE

BASE MAP LEGEND

MULTILANE DIVIDED HIGHWAY
MULTILANE UNDIVIDED HIGHWAY
INTERMEDIATE TYPE
SECONDARY ROAD-HARD SURFACED
SECONDARY ROAD-GRAVEL
NATIONAL FOREST
STATE FOREST
WILDLIFE MANAGEMENT AREA

-N-

5 0 5 10
MILES

0 5 10
KILOMETERS

PROJECTED AREAS OF MAXIMUM TRACE ELEMENT DEPOSITION

MODIFIED UNITS 1, 2, AND 3

FIGURE IV-74

Sulfates. The SO_2 to sulfates conversion rates of 5% and 15% per year again were assumed for the annual average and 24-hr maximum sulfates concentrations resulting from the emission of modified Units 1, 2, and 3. The results of the sulfates diffusion modeling are given in Table IV-69. No isopleths were compiled for ambient sulfate concentrations. The sulfates will probably be distributed in a pattern similar to the ambient SO_2 concentrations (Figures IV-71 and IV-72).

Fogging, Icing, and Salt Deposition Caused by the Unit 3 Cooling Tower

Fogging and Icing. The potential for natural and man-induced fog is closely related to the local microclimate. The Clay Boswell Station is located in an area which is fairly susceptible to heavy, shallow fogs. Based on fogging data collected at the airports of Duluth, Minneapolis, and Alexandria, Minnesota and Fargo, North Dakota, the annual naturally occurring frequency of fog in hours per year in the vicinity of the Clay Boswell Station is estimated to be as follows (132):

light to moderate fogs; average (limit visibility to 10 km)	800 hr per year
dense fogs; average (limit visibility to 0.5 km)	100 hr per year
dense fogs; worst case (limit visibility to 0.8 km)	255 hr per year

These natural fogs generally occur in the mornings and persist for periods less than 3 hr during April through September and for periods of 4 to 5 hr during November through March.

The following analysis of the fogging caused by the Unit 3 cooling tower (note that there are no cooling towers for Units 1 and 2) is a conservative, worst case analysis. The 255 hr per year dense fog frequency was recorded at Duluth in 1955 (Duluth data for the period 1955 through 1964 were inspected to select the worst case) (132). The data for the Duluth saturation deficit conditions which caused this worst case frequency were used as inputs for the modeling of fog induced by the Unit 3 cooling tower. The International Falls wind roses and atmospheric stability data also were used as inputs (refer to Meteorology and Climatology section of Chapter IV). The cooling tower engineering and emission factors which were used as modeling inputs are given in Table IV-70.

The saturation deficit is the difference between the amount (mass) of water vapor required to saturate a given air volume and the ambient amount of water vapor naturally occurring in that air volume. The calculated downwind concentrations of dispersed water vapor caused by the cooling tower emissions were compared with the saturation deficit to determine the fogging frequency and extent. The modeling of the fogging was further based on the following assumptions.

TABLE IV-70
UNIT 3 COOLING TOWER PARAMETERS USED FOR FOGGING, ICING, AND SALT DRIFT ANALYSES
CLAY BOSWELL STEAM ELECTRIC STATION

Design Parameter	Design Condition
Heat rejection rate	
Btu per hr	1.7×10^9
kg-cal per hr	0.43×10^9
Dry bulb temperature	
°F	82.0
°C	27.8
Wet bulb temperature	
°F	71.0
°C	21.7
Approach to wet bulb temperature	
°F	14.0
°C	7.7
Vertical velocity of plume at exit	
fps	33.2
m per sec	10.1
Circulating water flow	
lb per hr	6.0×10^7
kg per hr	2.7×10^7
Salt concentration of circulating water, (ppm)	1,400
Drift rate (% of circulating water)	0.01
Fan air volume	
cu ft per hr	5.88×10^8
cu m per hr	0.166×10^8
Fan radius	
ft	14.0
m	4.27
Assumed unit capacity factor (%)	100
Tower height	
ft	42.0
m	12.8
Tower width	
ft	75.0
m	22.9
Tower length	
ft	289.0
m	88.09
Number of cooling cells	8
Tower orientation (long axis)	north-south

- The cooling system was assumed to saturate the air which is drawn through the tower.

- The height at which the water emissions become sufficiently dispersed to cause fog was assumed to be a function of the cooling tower height and the buoyancy of the cooling tower plume. The analysis of the plume buoyancy took into consideration the effect of the latent heat of vaporization (133).

- The spread of the cooling tower plume was assumed to follow a Gaussian distribution in both the horizontal and vertical planes.

- Naturally occurring dense fogs which limit visibility to 0.8 km are not counted as cooling tower induced fog.

- Periods with 100% relative humidity are counted as periods of cooling tower induced fogs even though visibility may be greater than 0.8 km.

- Downwash was assumed to occur when the exit velocity of the plume was less than 1.5 times the wind speed.

- The magnitude of the effect of terrain on plume rise was assumed to be influenced by atmospheric stability.

- Cooling tower induced icing of roads and other surfaces was assumed to occur each time the model predicted fogging and the temperature was 32°F (0°C) or less.

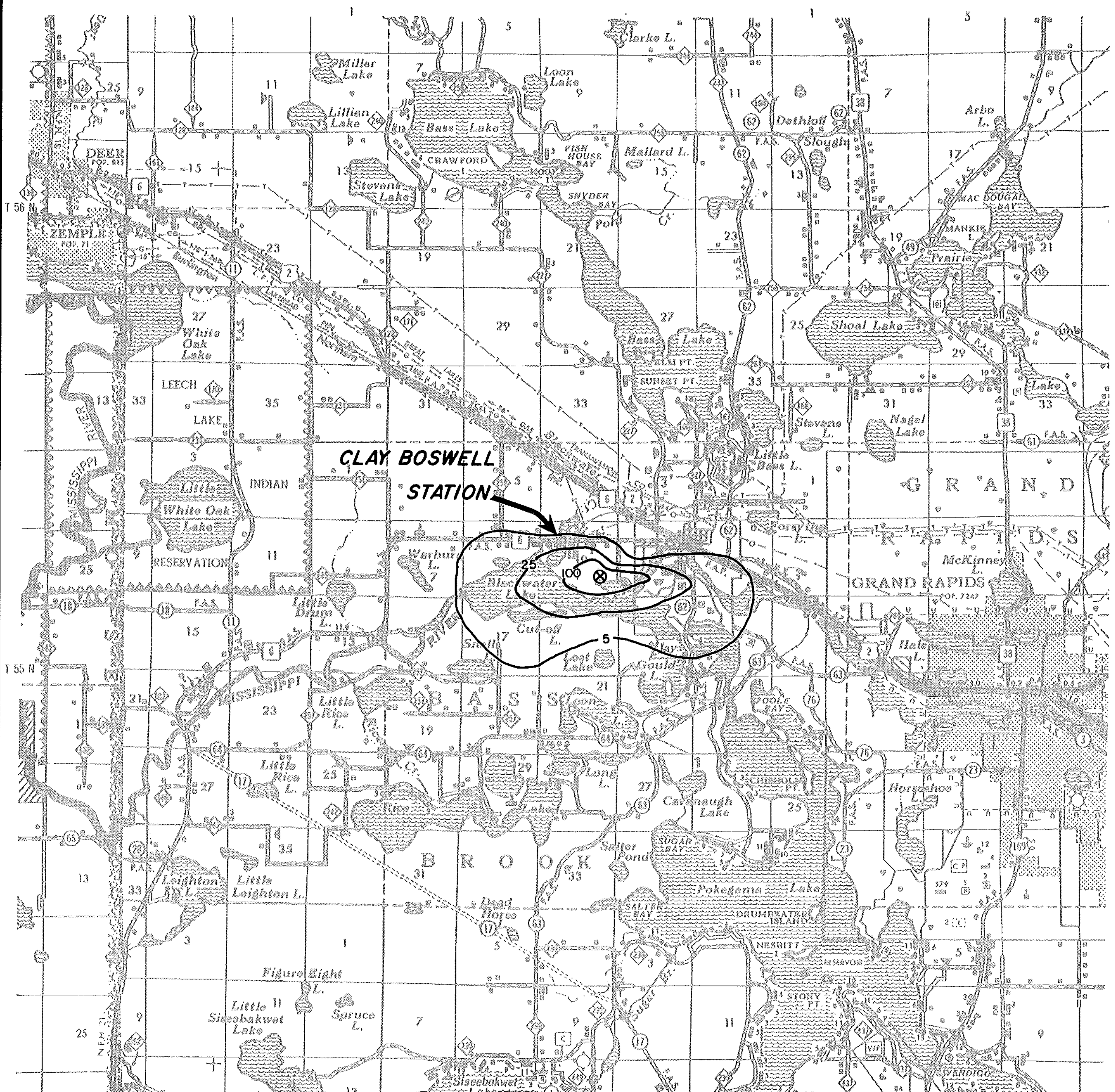
The fogging model predicted the number of hours per season during which a visible, ground level cooling tower induced fog would occur at each point on a grid consisting of 20 points spaced at 500 m intervals along each of 16 compass directions (i.e., 320 receptor points, total). The frequency of cooling tower induced icing and naturally occurring fogs also were calculated by the model. Table IV-71 presents the results of the fogging analysis. The frequencies given in Table IV-71 are the average number of hours per season during which ground level fog will be visible at any point on a circle with a radius equal to the given distance from the cooling tower. Maximum cooling tower induced fogging frequencies are predicted to occur during spring and fall. Minimum fogging frequencies probably will occur during summer. Cooling tower induced fogs will occur more frequently close to the tower (e.g., about 82 hr per year for any point 0.5 km from the cooling tower) then at greater distances (e.g. negligible frequency at a distance of 5.0 km). Figure IV-75 illustrates the locations where the maximum fogging frequencies are predicted to occur, based on the above analysis and the International Falls wind data.

TABLE IV-71
CALCULATED AVERAGE FREQUENCY OF FOGS INDUCED BY UNIT 3 COOLING TOWER
CLAY BOSWELL STEAM ELECTRIC STATION (130)

	Average Frequency in Hr per Season or Year				
Distance from Tower	Winter	Spring	Summer	Fall	Annual
0.5 km	19.7	28.2	6.3	27.4	81.6
1.0 km	9.0	11.7	2.3	12.3	35.3
3.0 km	0.88	1.60	0.0	0.87	3.55
5.0 km	0.0	0.0	0.0	0.0	0.0
10.0 km	0.0	0.0	0.0	0.0	0.0
Naturally occuring fog frequency (hr per season or year)	15.0	82.0	87.0	71.0	255.0

Icing induced by the Unit 3 cooling tower is predicted to occur during 50 hr per year at a radius of 0.5 km (132). Icing at a radius of 5 km is predicted to be negligible (refer to Air Quality section of Chapter V). Because of the orientation of the cooling tower and the prevalence of northwest winds during severe winter conditions, the icing frequency will be highest southeast of the cooling tower.

Salt Deposition. Water vapor and droplet drift from the Unit 3 cooling tower is controlled by drift eliminators. The drift which does escape has the same chemical composition as the circulating cooling water (see Chapter II). The worst case annual maximum salt deposition rate resulting from the Unit 3 cooling tower drift has been estimated to be less than 10 lbs per acre (11.2 kg per hectare) at a distance of 0.5 km from the tower, and negligible at a distance of 5 km (134). The distribution of the salt-containing drift around the Unit 3 cooling tower will approximately follow the same pattern as the induced fogging illustrated in Figure IV-75.



LEGEND

⊗ LOCATION OF COOLING TOWER

NOTE: ANNUAL FREQUENCY IN HOURS PER YR

BASE MAP LEGEND

ROAD AND ROADWAY FEATURES
- PROJECTED ROAD
- GRADED AND DRAINED ROAD
- GRAVEL OR STONE ROAD
- BITUMINOUS ROAD
- PAVED ROAD

BOUNDARIES
- COUNTY
- CIVIL TOWNSHIP
- CONGRESSIONAL TOWNSHIP (U.S. LAND)
- SECTION LINE
- NATIONAL OR STATE PARK
- NATIONAL OR STATE FOREST
- NATIONAL INDIAN RESERVATION

DRAINAGE
- INTERMITTENT STREAM
- NARROW STREAM
- MARSH OR SWAMP LAND
- POND OR LAKE

PUBLIC SERVICE FACILITIES
- PIPE LINE, GAS
- PIPE LINE, OIL
- TRANSMISSION LINE (33 KV OR OVER)
- POWER PLANT

EDUCATIONAL AND CORRECTIONAL INSTITUTIONS
- SCHOOL HOUSE
- CONSOLIDATED OR LARGE SCHOOL

N

0 1 2 3
MILES

0 1 2 3
KILOMETERS

CALCULATED LOCATION OF MAXIMUM GROUND-LEVEL FOGGING

UNIT 3 COOLING TOWERS

FIGURE IV-75

NOISE

Noise is generated by a number of sources at the Clay Boswell Steam Electric Station. In addition to equipment inside the generating facility, external sources such as coal trains and delivery trucks generate noise.

Sound levels at the Clay Boswell Station were examined using an on-site survey conducted on October 8 and 9, 1975 (135). Ambient sound levels were measured both inside and outside the boundaries of the Station during both daytime 7 a.m. to 10 p.m. and nighttime 10 p.m. to 7 a.m. During the survey, informal observations of traffic patterns, railway movements, and human activities were made in an attempt to define the acoustical region around the Station. U. S. Highway 2 and Minnesota Trunk Highway (T.H.) 6 were found to generate the most noise in the vicinity of the Clay Boswell Station. Occasional trains and aircraft caused temporary increases in noise levels.

Sound levels were measured utilizing one precision sound level meter and analyzer, General Radio Company type 1933 (ANSI-type 1), serial No. 620, with Electret-Condenser microphone type 1962-9601, serial No. 1367. Immediately before and after taking sound measurements, this instrument was calibrated with a sound level calibrator, General Radio Company type 1562-a, serial No. 8710. A microphone windscreen was used for all measurements to reduce wind effects.

Figure IV-76 depicts the ambient sound survey measurement locations and Table IV-72 describes the value and sampling time at each location. Because environmental sound often is a dynamic phenomenon which varies continuously at a fixed location, a statistical approach is required to properly describe the environmental sound. A method known as manual statistics was used to obtain the L_{10}, L_{50}, and L_{90} which describe the existing ambient sound levels, supplemented by measurements which approximated the L_{90}, which is often considered the "residual sound level". The "L_n" values refer to the percentage of time the specified value is exceeded. Thus, a daytime (L_{50}) limit of 60 dB(A) means that a sound pressure level of 60 dB(A) may be exceeded no more than 50% of the time.

Sound measurements were also taken in 10 preferred center frequency bands (31.5 Hz to 16,000 Hz) to obtain baseline data to be used as the engineering acoustic design criteria for MP&L's proposed Unit 4 at the Clay Boswell Station. Nighttime residual octave band sound levels (equivalent to 37 dB(A) obtained in the community of Cohasset on October 9, 1975, about 500 ft (152.4 m) east of the property line, provided data which indicated that this site (Location No. 5) typified the most sensitive receptor. Review of the aerial photographs and USGS 7 1/2 minute quadrangle maps (136) shows this residential area to be the nearest to the Clay Boswell Station. In addition, this location has the greatest population density near the generating facility.

Minnesota Noise Standards

Minnesota noise standards adopted September 17, 1974 describe the limiting levels of sound that may enter various noise-sensitive areas, according to land use activity at the receiver. Noise Area Classification I (NAC 1), which includes household units, has a daytime L_{50} limit of 60 dB(A) and a L_{10} limit of 65 dB(A), and a nighttime L_{50} limit of 50 dB(A) and a L_{10} limit of 55 dB(A) (138).

TABLE IV-72

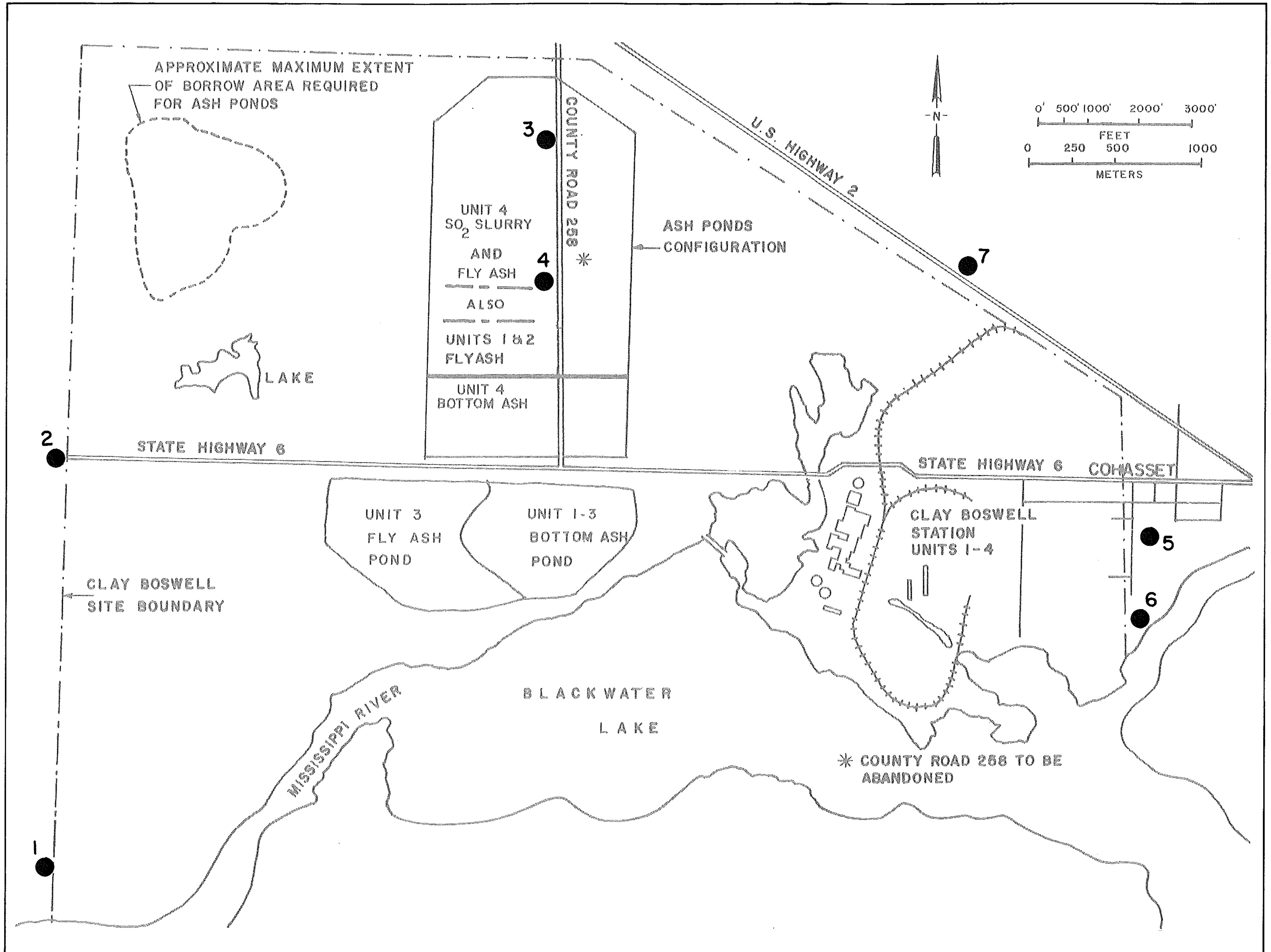
AMBIENT SOUND LEVEL OBSERVATIONS - CLAY BOSWELL STEAM ELECTRIC STATION (137)

Measurement Location	Measurement Time	L_{10} dB(A)	L_{50} dB(A)	L_{90} dB(A)	Residual dB(A)
October 8, 1975 Daytime Hours (7 a.m. to 10 p.m.)					
Location No. 1 western property line WSW corner near T.H. 6	12:40 p.m.	53	47	41	43
Location No. 2 western property line near T.H. 6	1:45 p.m.	51	49	45	49
Location No. 3 inside property line near County Road 258	2:10 p.m.	47	45	43	44
Location No. 5 in Cohasset about 500 ft (152.4m) east of property line	2:50 p.m.	49	47	43	-
Location No. 6 in Cohasset at the edge of the Mississippi River	3:20 p.m.	51	49	45	46
October 9, 1975 Nighttime Hours (10 p.m. to 7 a.m.)					
Location No. 4 inside property line west of County Road 258	6:35 a.m.	49	37	35	36
Location No. 5 Cohasset about 500 ft (152.4m) east of property line	5:10 a.m.	43	41	39	37
In Cohasset about 1½ mi (2.4 km) east of Station	5:50 a.m.	41	39	37	41
Location No. 7 on U.S. Highway 2 at northern property line	6:10 a.m.				41[a]

[a] Sound levels increased intermittently up to 61dB(A) due to nearby traffic.

Results of Noise Measurement

Table IV-72 indicates that at no time during the nighttime ambient sound level observations at any of the sampling locations did the L_{50} value exceed 41 dB(A). None of the daytime observations showed an L_{50} value which exceeded 49 dB(A). It should be noted that the noise measurements taken did not include coal train unloading operations. This causes some uncertainty in determining the maximum ambient level. The data indicated in Table IV-72 present an approximate description of the noise setting. Compliance with Minnesota noise regulations cannot be determined since the test procedures were not consistent with those approved by the MPCA, and since coal train operations were not included.



AMBIENT SOUND MEASUREMENT LOCATIONS
CLAY BOSWELL STATION SITE

SOURCE: ADAPTED FROM, "MINNESOTA POWER AND LIGHT COMPANY, CLAY BOSWELL UNIT 4, ENVIRONMENTAL SOUND IMPACT", (REVISED) 1977, FIGURE 1

FIGURE IV-76

TERRESTRIAL VEGETATION AND SOILS

The description of the terrestrial vegetation communities and soils in the vicinity ot the Clay Boswell Steam Electric Station is divided into regional, local, and site-specific discussions. At the end of this section, special attention is given, in a separate discussion and listing, to rare and endangered plant species likely to be found in the vicinity of the Clay Boswell Station. Also included is a description of the supplemental terrestrial ecology and plant pathology study which will be conducted in summer 1977.

Regional

Terrestrial Vegetation

A large portion of northeastern Minnesota lies within the mixed conifer-hardwood forest of the Great Lakes region (139). In Minnesota, this region is is characterized by the prevalance of pines (*Pinus strobus*, *P. resinosa* , and *P. banksiana*) on the drier soils of the uplands and the dominance of northern conifers (*Larix laricina*, *Picea mariana*, and *Thuja occidentalis*) and black ash (*Fraxinus nigra*) in poorly-drained depressions (140). Forests composed largely of quaking aspen (*Populus tremuloides*) and paper birch (*Betula papyrifera*) are widespread throughout the region and represent early seral communities that follow periodic fires or timber cutting. Shade tolerant hardwoods (*Acer saccharum*, *Tilia americana* , and *Betula lutea*) are common to upland sites that have escaped disturbance for some time, but these species decrease in importance toward the north. In contrast, shade tolerant conifers (*Abies balsamea* and *Picea glauca*) of the uplands are only of local distribution in the southern portion of this region, but become more widespread to the north (140).

A review of the literature pertaining to the description and classification of the mixed conifer-hardwood forest may be found in Curtis (141), Heinselman (142), and Maycock and Curtis (143). They conclude that the vegetation of this region varies continuously in both time and space to produce a series of communities with slightly differing floristic composition. The floristic composition of these stands may change in space along an environmental gradient that corresponds most noticeably with gross differences in moisture. This pattern is explained by the fact that no 2 species have exactly the same ecological tolerance so that the major dominants reach their greatest importance at different points along the environmental gradient. Floristic changes also occur in time due to the process of succession and also the past history of disturbance, plant migrations, and climatic change. As a result of these factors, no 2 stands will have exactly the same floristic composition although gross patterns in the vegetation are often recognizable.

To facilitate the description of the vegetation in northern Wisconsin (141), Curtis arranged the plant communities into orderly groupings on the basis of 3 criteria: 1) the physiognomy or gross appearance of a community, 2) the dominant species of the canopy layer, and 3) the range of soil-moisture conditions divided into 5 separate segments. No comparable work presently exists that describes the regional vegetation of Minnesota. Thus, Curtis' work provides the only complete survey of a regional vegetation from an area sufficiently close to Minnesota both geographically and ecologically (142). Therefore, Curtis' classification of vegetation will be used for a discussion of the vegetation within a 30 mile (48.28 km) radius of the Clay Boswell Station.

The forested land in the Clay Boswell Station region may be divided into the following forest types:

- Northern Mesic Forest
- Northern Xeric Forest; Dry-Mesic Segment
- Northern Lowland Forest; Wet-Mesic Segment
- Northern Lowland Forest; Wet Segment

Non-forested areas of natural vegetation are interspersed throughout this region and include:

- Open Bog
- Tall Shrub Community
- Lesser Communities

The following is a discussion of the plant communities of the Clay Boswell Station region.

Northern Mesic Forest

The major dominants of the northern mesic forests are sugar maple (*Acer saccharum*), basswood (*Tilia americana*), and yellow birch (*Betula lutea*). Sugar maple has the greatest tolerance to shading and eventually would replace all other species in the canopy were it not for periodic disturbances such as fired, windthrow, or lumbering. Quaking aspen, paper birch, and bigtooth aspen (*Populus grandidentata*) also may occur in the canopy layer but are found only rarely as seedlings or saplings. These species are very intolerant to shading and would be expected to disappear from a stand during the normal course of succession.

Northern mesic forests are common on sites with moderate topography and deep loam soils (141). However, this forest type also may develop on coarser grained soils because of the soil improving qualities of sugar maple-basswood litter and the moist nature of the climate (141).

The thick, rich humic layer which is so characteristic of the northern mesic stands provides a very favorable growing medium for a wide variety of both vascular and non-vascular plants. The prevalent shrub and herbaceous species in these stands include mountain maple (*Acer spicatum*), twisted stalk (*Streptopus roseus*), wild sarsaparilla (*Aralia nudicaulis*), and the Pennsylvania sedge (*Carex pensylvanica*) (141). The ground layer in these stands also include a wide variety of saprophytic seed plants, fungi, and slime molds. The epiphytic lichens which are found quite commonly in the northern mesic forests are *Cladonia coniocraea*, *Parmelia aurulenta* , *Physcia grisea*, *P. orbicularis* , and *Graphis scripta* (141).

Northern Xeric Forest; Dry-Mesic Segment. The major dominants of this vegetation type are red pine (*Pinus resinosa*), jack pine (*P. banksiana*), and white pine (*P. strobus*), as well as quaking aspen and paper birch. Except for white pine, all these species are considered as intolerant to shading and, along with white pine, would gradually be replaced by more shade-tolerant hardwoods. The presence of xeric forests in this area then can be attributed to forest fires and other disturbances that check the normal course of succession. Xeric forests are typical of sandy soils that are poor in nutrients and subject to drought (141). However, periodic disturbances such as fire are required to maintain xeric forests on these sites and thus prevent the development of more mesic forests.

The shrub and herbaceous species most prevalent in the northern xeric forests include beaked hazelnut (*Corylus cornuta*), bracken fern (*Pteridium aquilinum*), false lily-of-the-valley (*Maianthemum canadense*), dwarf blackberry (*Rubus pubescens*), and the blueberries (*Vaccinium angustifolium* and *V. myrtilloides*) (141). Also very characteristic of the ground layer in these xeric forests are the ericads (such as *Chimaphila umbellata* , *Gaultheria procumbens*, and *Epigaea repens*) and club mosses (*Lycopodium complanatum* and *L. clavatum*) that tend to form numerous small colonies owing to their spread by long-running stolons or rhizomes (141). The lichens of the pine forests are 1) *Alectroia nidulifera*, *Baridia chlorococca*, and *Evernia mesomorpha* which are found on all pines, but reach peak frequencies on jack pine; 2) *Cetraria atlantica*, *Lepraria aeruginosa* , *Lecanora subfusca*, and *Parmelia caperata* which are also found on all pines but reach optimum levels on white pine; and 3) *Caloplaca aurantiaca* , *Physica aipolia*, *P. ciliata* , and *Xanthoria polycarpa* which reach high populations on aspen (141).

Northern Lowland Forest; Wet Segment. The northern lowland forest can be divided into 2 community types: 1) the wet-mesic segment which includes white cedar, balsam fir, and black ash and 2) the wet segment which is dominated by black spruce and tamarack with white cedar and balsam fir as other important associates. The wet-mesic segment of the northern lowland forests is dominated by white cedar and balsam fir with black ash, American elm, and yellow birch as important associates. Wet areas dominated by black ash are often distinctive and are different floristically from conifer swamps. Lowland forests of the wet-mesic segment are typically found on peaty soils with a much lower water content than peats occupied by black spruce-tamarack swamps. The peat of the wet-mesic forests also is distinguished by a higher pH and by moderate levels of oxygen which may help to oxidize the surface layer (141).

The most prevalent shrub and ground layer species in this vegetation type include red-berried elder (*Sambucus pubens*), wild sarsaparilla, spotted jewelweed (*Impatiens biflora*), enchanter's nightshade (*Circaea alpina*), goldthread (*Coptis groenlandica*), bishop's cap (*Mitella nuda*), and the soft-leaved sedge (*Carex disperma*) (141).

The ground layer in these stands also include such saprophytic seed plants as the smaller coralroot (*Corallorhiza trifida*) and the striped coralroot (*C. striata*), as well as several species of bryophytes.

The canopy of the wet segment forest consists primarily of black spruce and tamarack. Black spruce tends to be found on the firmer peat or more completely filled lake basins, while the tamarack is found more often in areas where an open bog mat still is advancing over open water (141). The peat is composed largely of sphagnum moss which is interwoven with branchlets, wood, and rootlets. It is highly acidic, very wet, and very low in oxygen (141).

The prevalent shrub and ground layer species of the black spruce-tamarack swamps include balsam willow (*Salix pyrifolia*), Labrador tea (*Ledum groenlandicum*), three-leaved false Solomon's Seal (*Smilacina trifolia*), and the three-fruited sedge (*Carex trisperma*). Lichens such as *Cladonia cristatella* and *C. chlorophaea* also are abundent in this vegetation type.

Open Bog. The open bog is a soil-vegetation complex that consists of a distinctive assemblage of shrubs (most of which are ericads) and herbs growing on a mat of sphagnum peat. This vegetation type may be quite stable or may gradually succeed to a wet conifer swamp.

Along with various sphagnum species, open bogs chiefly are characterized by 2 important plant groups, the heath and sedge families. Members of the heath family, such as leather-leaf (*Chamaedaphne calyculata*), Labrador tea, bog laurel (*Kalmia polifolia*), and bog Rosemary (*Andromeda glaucophylla*), form an almost continuous canopy over the surface of the bog, with the other species of the community growing beneath or in rare openings between them (141).

The cranberries (*Vaccinium macrocarpon* and *V. oxycoccas*), as well as the insectivorous pitcher plant (*Sarracenia purpurea*) and sundews (*Drosera rotundifolia* and *D. intermedia*), are also very characteristic members of this community type. The sedges most commonly found in open bogs are represented by a number of genera, including *Carex* , *Eriophorum Rhynchospora* , *Cladium* , *Scirpus*, and *Dulichium* (141).

Although never growing in great abundance, orchids such as rose pogonia (*Pogonia ophioglossoides*), grass pink (*Calopogon pulchellus*), and the pink moccasin flower (*Cypripedium acaule*) also are often present (141).

Tall Shrub Community and Lesser Communities. One type of tall shrub community found in the region is the alder thicket. The lesser communities are predominantly sedge meadows and fens.

When a bog basin becomes partially drained by the down-cutting of the outlet stream, the surface layer of the peat begins to oxidize and turn to muck (141). These muck soils are very favorable places for the growth of speckled alder (*Alnus rugosa*) (141). Therefore, the alder thicket is a common community along streams, lakes and bogs, and where soil water is in movement.

Speckled, alder, long-beaked willow (*Salix bebbiana*) autumn willow (*S. serissima*), meadow-sweet (*Spiraea alba*), red-osier dogwood (*Cornus stolonifera*), and skunk currant (*Ribes glandulosum*) are the major dominants in alder thickets. The most prevalent ground layer species include panicled aster (*Aster simplex*), wild calla (*Calla palustris*), marsh fern (*Thelypteris palustris*), Joe-Pye weed (*Eupatorium maculatum*), and blue-joint grass (*Calamagrostis canadensis*). Alder thickets, as a general rule, are very stable plant communities. They have been known, to be succeeded by northern lowland forests of black ash (141).

The sedge meadows are most often found along shores of lakes or streams where the soil or peat is at or just above the water level. They are open communities of wet soils, predominantly covered by sedges rather than grasses (141). Three sedges that often are found dominating these communities are the tussock sedge (*Carex stricta*), lake-bank sedge (*C. lacustris*), and the yellow-sheathed sedge (*C. prairea*). In wetter conditions, the sedge meadow leads into cattail reed marshes, or other emergent aquatic groups (141). Following the sedge meadow, as the distance above the water table increases, is the alder thicket community. The soil of sedge meadows usually is a raw sedge peat, or a muck produced by the decomposition of such peat (141). Often the soil includes mineral matter which is deposited by overwash from the surrounding uplands. These northern sedge meadows are relatively acid (141). Species highly characteristic of northern sedge meadows include red-stalked aster (*Aster puniceus*), rattlesnake grass (*Glyceria canadensis*), and bushy goldenrod (*Solidago graminifolia*) (141).

Fens. Fens differ from sedge meadows in being dominated by grasses (*Poaceae*) instead of sedges (*Cyperaceae*). This community type is found on soils that have a pH of 7 or slightly above.

Soils of the Region

The soil "geomorphic regions" found within a 30 mile (48.28 km) radius of the Clay Boswell Station have been classified and defined by the Agricultural Experiment Station, University of Minnesota. Complete descriptions and the corresponding soils map can be found in the "Minnesota Soil Atlas; Hibbing Sheet" (144).

There are 9 major geomorphic regions found within 30 miles (48.28 km) of the Clay Boswell Station. These are shown in Figure IV-77. More detailed descriptions are presented below under Local Soils.

Mesabi Range. This geomorphic region (No. 16 on Figure IV-77) is covered with stony drift with textures ranging from loamy sand to sandy-loam. The topography is gently rolling where not disturbed by mines and dumps. The dominant soil type is a reddish clayey till with inclusions of brownish sandy loam and clay loam till. The original forest was primarily northern hardwoods. Presently, the forest consists mainly of aspen associated with black spruce, white birch, and jack pine. In addition, pasture and meadow lands are scattered throughout.

Prairie River Plain, Sandy. The Prairie River Plain (No. 20 on Figure IV-77) has gently rolling to nearly level topography with steeper slopes bordering lakes and streams. Sediments in this soil type generally are water deposited, deep brownish-colored, acid, and fine to medium sands. Many small and a few relatively large bogs occur in this geomorphic region. Soils located in higher positions are excessively drained. In contrast, soils in the lower positions have a water table within 2 to 3 ft (0.61 to 0.91 m) of the surface.

Original vegetation was predominantly pines on the sand plain and swamp conifers on the bogs. The geomorphic region now is forested primarily with aspen, white birch, and several species of pine. A small portion of the geomorphic region consists of crop and pasture land, with timothy and oats being the major crop species.

Nashwauk-Warba, Brown. This geomorphic region (No. 21 on Figure IV-77) has generally rolling topography with a few areas which are gently rolling to steep. A thick deposit of brown colored calcareous, clay loam glacial till covers the area. Stones are common throughout and intermixed till, sand, and gravel are found south of the Mesabi Range geomorphic region.

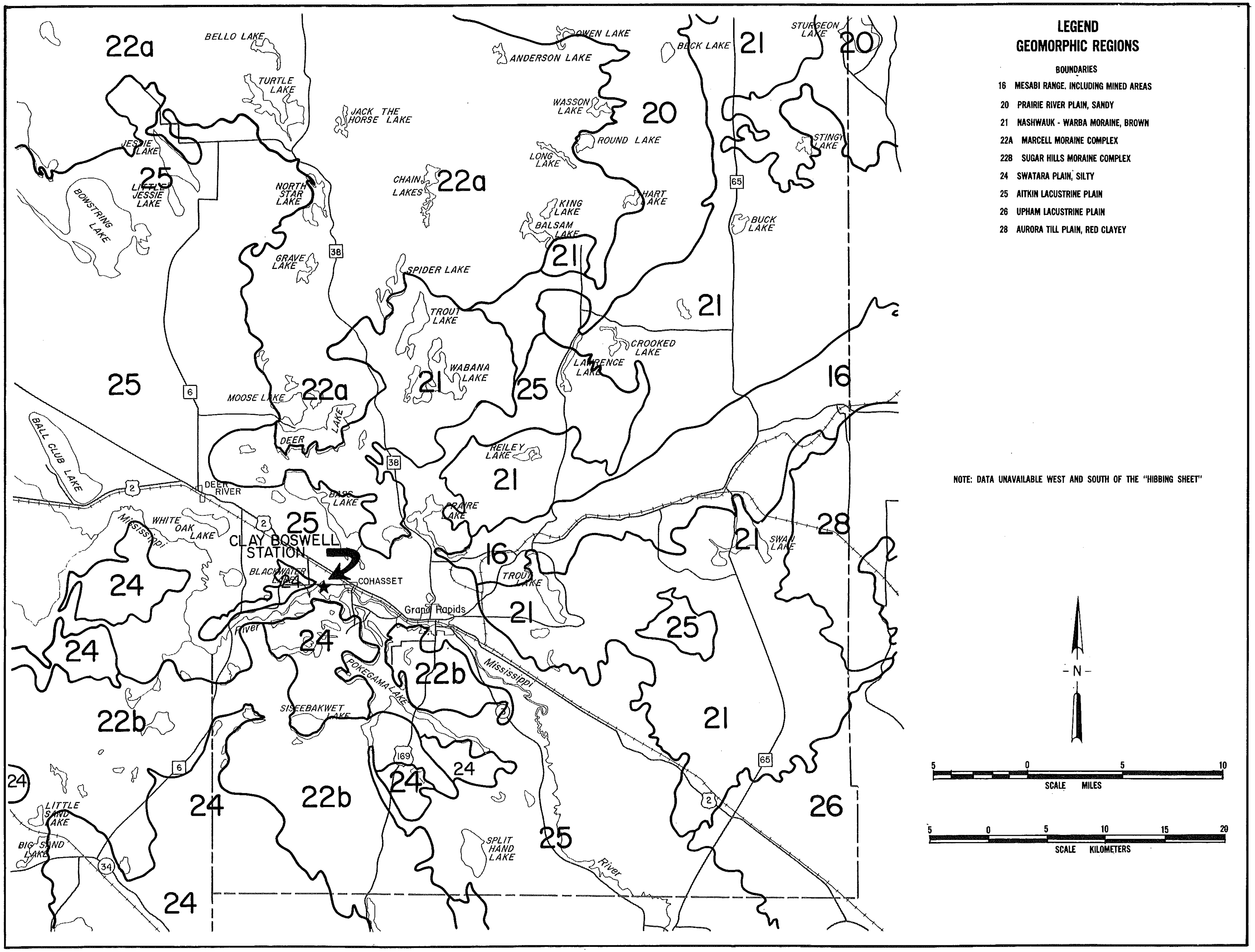
Originally, vegetation was red and white pines with small areas of northern hardwoods. Now, the major three species include aspen, pine, maple, and balsam fir. Some of the area is crop and pasture land with principal crops consisting of oats, timothy, brome, and some alfalfa.

Marcell Moraine Complex. This complex (No. 22a on Figure IV-77) is a prominent moraine with rolling to steep topography. Small bogs and potholes are common. Covering this geomorphic region are brown-colored, calcareous clay loam till, in places intermixed with deep sands and gravels. Much of the till is covered with a sand cap less than 1 ft (0.30 m) thick. These soils are well to moderately well-drained. The original vegetation consisted of white and red pine with a few northern hardwoods. Presently, the land is forested with aspen, pine, balsam fir, and maple. This geomorphic region is economically significant to the logging industry. A small portion of the geomorphic region is pasture and cropland; the latter largely timothy meadows.

Sugar Hills Moraine Complex. This complex (No. 22b on Figure IV-77) is a prominent moraine characterized by rolling to steep, irregular topography. Small bogs, potholes, and lakes are prevalent.

A thick layer of glacial drift which is brown-colored, weakly calcareous, loamy and high in silt content, covers this geomorphic region. Pockets of sands and gravels and silt loam and clay loam materials are common. In the northern portion of this geomorphic region, the till, which is mostly calcareous, is mixed with sands and gravels. The percentage of lime in this till and the depth at which it occurs is variable. The depth to lime normally is 3 to 6 ft (0.91 to 1.83 m). However, in some places, the till is non-calcareous, which indicates that some mixing of brown acid and calcareous till has occurred.

Originally, this complex was covered by white and red pines and northern hardwoods. Aspen, balsam fir, and maple are the principal canopy species now. Skiing is a very important recreation in this geomorphic region.



GEOMORPHIC REGIONS WITHIN 30 MILES (48.3 KM) OF THE CLAY BOSWELL STEAM ELECTRIC STATION

SOURCE: "MINNESOTA SOILS ATLAS; HIBBING SHEET", MISCELLANEOUS REPORT 110-1971, 1971, AGRICULTURAL EXPERIMENT STATION, UNIVERSITY OF MINNESOTA

FIGURE IV-77

Swatara Plain, Silty. The topography of this geomorphic region (No. 24 on Figure IV-77) is gently rolling to rolling irregular with small areas of steeper slopes. Potholes and bogs are common.

The glacial till, which is gray-brown, calcareous loam and clay loam, is capped with silt. In Itasca County, pockets of sandy and gravelly drift are common. Soils in localized areas of Cass County are more clayey.

The forest conopy originally was white and red pines with some northern hardwoods. Now, aspen and upland hardwoods are more common.

Aitkin Lacustrine Plain. This plain (No. 25 on Figure IV-77) is nearly level, with widely interspersed gently rolling areas and occasional discontinuous beach ridges. The water table is near the surface in lower positions and 3 to 6 ft (0.91 to 1.83 m) below the surface in the higher positions.

The mineral soils in this region range from fine sand to silty clay. The sandy soils are moderately well to poorly drained and commonly occur along the Mississippi River north of Ball Club Lake. The fine-textured soils are most prevalent west of the community of Cohasset and northward to Bowstring Lake. Most of these soils are poorly drained and often sandy to silty in the first 6 to 10 in. (15.4 to 25.4 cm). The sandy soils are acid throughout, whereas the silty and clayey soils are calcareous within 30 in. (76.2 cm).

Many small peat bogs and a few large ones are found in this geomorphic region. Two types of peat-sedge and woody bogs have a thin surface layer of sphagnum moss peat. Vegetation on the bog was, and still is, swamp conifers and sedges. Original vegetation on the mineral soils was primarily white and red pines. Presently, aspen, balsam fir, and pine are the dominant tree species on the mineral soils.

Upham Lacustrine Plain. This Plain (No. 26 on Figure IV-77) is a largely level basin which once was occupied by glacial Lake Upham. Extensive peat bogs are found here, along with occasional beach ridges and a few gently rolling areas.

The mineral soils are usually poorly drained. Along the west side of the geomorphic region, the soils are largely fine and very fine sand. The water table usually is 2 to 6 ft (0.61 to 1.83 m) below the surface.

The bog soils are mostly sedge and woody peats. There are some raised bogs scattered throughout the region. The original vegetation on the mineral soils was primarily red and white pines and balsam fir. Much of the land now is used for farming and pasture.

Vegetation on the peat bogs is mostly swamp conifers and sedges. The organic soils have a potential for vegetables, some small grains, and special crops. Some peat from this geomorphic region is being marketed as a soil conditioner for gardens and lawns.

Aurora Till Plain, Red Clayey. The topography of this geomorphic region (No. 28 on Figure IV-77) is rolling to hilly with short irregular slopes and several potholes and small peat bogs.

The till in this geomorphic region is a reddish-brown clacareous silty clay. In some areas, the till is capped with silt loam or loam 6 to 12 in. (15.2 to 30.5 cm) thick. The original forest in this geomorphic region was red and white pines but presently it is aspen, balsam fir, and red pine. Some of this land is cultivated.

Local

Because the field data available for the local (within a 12 mile (19.3 km) radius of the Clay Boswell Station) and site-specific areas are very limited, the following descriptions are judged to be inadequate to describe and assess properly the possible environmental impacts. More complete field data will be gathered during the field study scheduled for the summer of 1977. This additional information then will be presented in a supplemental document. A brief description of the summer study can be found following the local and site-specific descriptions.

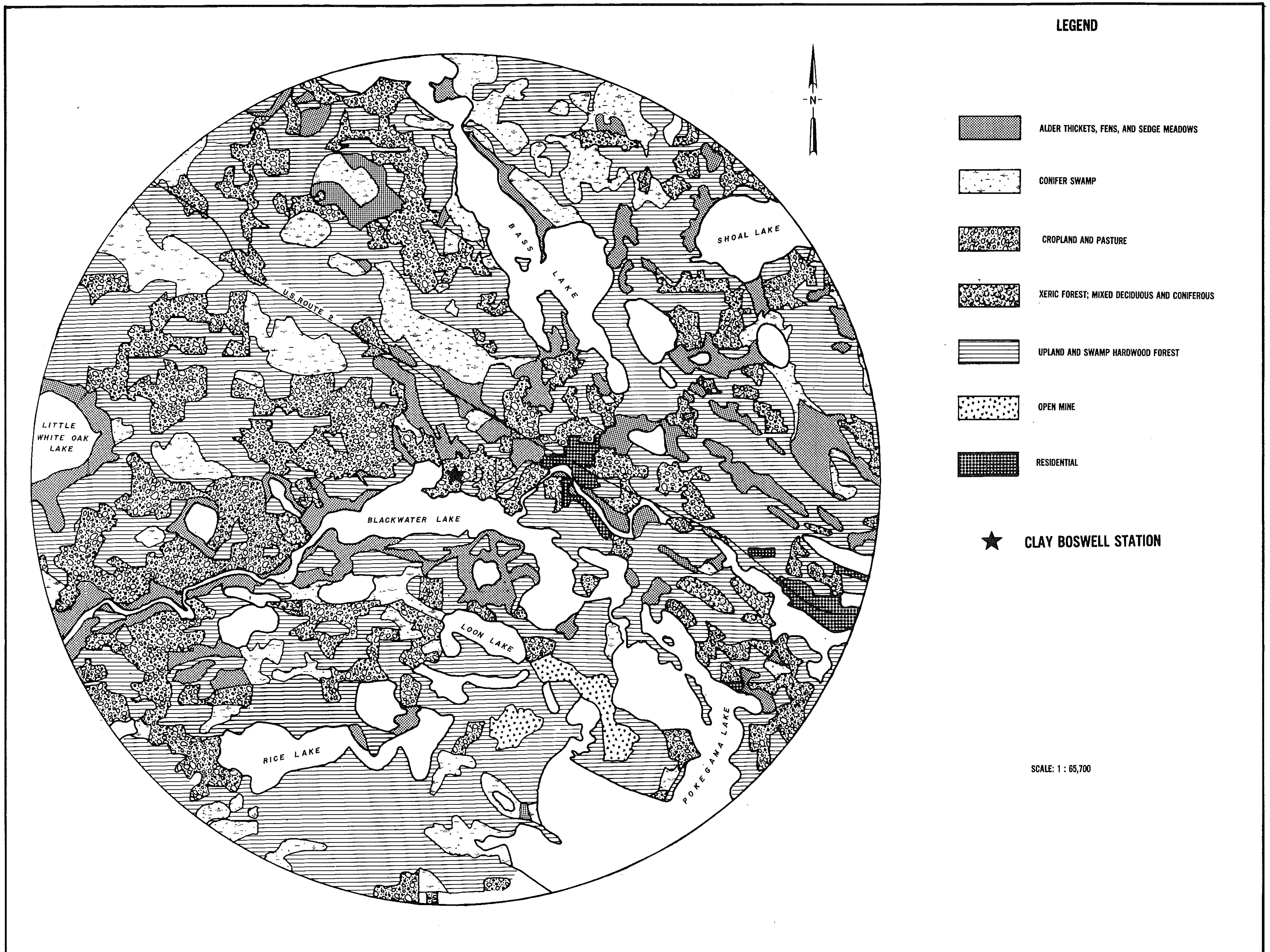
Terrestrial Vegetation

Figure IV-78 is a vegetation map of the area within 8 km of the Clay Boswell Station. This map was constructed from aerial photography flown in 1966. The most recent aerial photographs available for the vicinity near the Clay Bowell Station were flown in 1975 and will be used for the detailed field studies planned for the summer of 1977. A brief discussion of each vegetative type found within the local area is given below.

Harwood Forest. Nearly one half of the 8 km radius area is covered by hardwood forest (145). Although the area is delineated as a single type (Figure IV-78), it actually consists of a mosaic of forest stands, each representing a different set of environmental conditions (soil properties, topography, etc.) and a different history of natural and man-caused disturbances. The major factor determining the distribution of various hardwoods is soil drainage. There are at least 2 distinct forest types within the area delineated as hardwood forest: 1) northern lowland forest, wet-mesic segment and 2) the northern mesic forest. The locations and distribution of these 2 types of hardwood forest will be studied in greater detail during the summer of 1977.

The northern mesic forest type is found on the higher elevation, slightly drier sites of the hardwood forest. Sugar maple, basswood, paper birch, and aspen are the major canopy species.

Northern Xeric Forest; Dry-Mesic Segment. The area in Figure IV-78 typed as northern xeric is considered to be the dry-mesic segment because the major canopy species include red pine, white pine, jack pine, red oak, paper birch, and quaking aspen. Less than 1% of the 8 km radius area is covered with the northern xeric type of forest (145).



TERRESTRIAL VEGETATION COMMUNITIES-VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION

SOURCE: ADAPTED FROM MP&L, "ENVIRONMENTAL REPORT", EXHIBIT III-G-2

FIGURE IV-78

The northern lowland forest; wet-mesic segment is more commonly termed hardwood swamp forest because of its canopy of black ash, paper birch, and American elm (145). The hardwood swamp community is found in the low elevation, poorly drained sites of the hardwood forest.

Northern Lowland Forest; Wet Segment. The conifer swamp covers approximately 9% of the 8 km radius area (145). The canopy of this community consists primarily of black spruce and tamarack.

Open Bog. The area of open bog in the 8 km radius area has not yet been determined. This will be accomplished during the 1977 summer field studies for the area within a 12 mile (19.3 km) radius of the Clay Boswell Station site.

Tall Shrub Community and Lesser Communities. Nearly 10% of the area within 8 km of the Clay Boswell Station is classified as tall shrub community (alder thickets) or lesser communities (sedge meadows and fens) (145). To date, however, these types have not been distinguished from each other. Alder thickets, sedge meadows, and fens are mapped as a single type on Figure IV-78.

Untyped Areas. The remainder of the 8 km radius area either is cropland and pasture (20%) or non-vegetated areas, such as residential sites, mines, or open water. The non-vegetated areas comprise approximately 15% of the area within 8 km of the Clay Boswell Station (145).

Soils

Six of the geomorphic regions described above under regional soils occur within 12 miles (19.3 km) of the Clay Boswell Station. These are the Mesabi Range; Nashwauk-Warba, Brown; Marcell Moraine Complex; Sugar Hills Moraine Complex; Swatara Plain, Silty; and the Aitkin Lacustrine Plain geomorphic regions (Figure IV-77). Figure IV-79 maps the more detailed "soil landscape units" of the Minnesota Soil Atlas; Hibbing Sheet (144) which occur within 12 miles (19.3 km) of the Clay Boswell Station. Table IV-73 summarizes some selected features and characteristics of these "soil landscape units". More detailed data on the chemistry of the local soils will be collected during the summer 1977 supplemental field study. In addition, the U.S. Soil Conservation Service will be conducting extensive and detailed soil mapping in Itasca County during the spring and summer of 1977. In cooperation with the MPCA, the U.S. Soil Conservation Service has agreed to give a high priority to the soils in the locality of the Clay Boswell Station (146). These data should be available by late summer or early fall of 1977.

Existing Stresses and Disturbances

Naturally Occurring Stresses. Most bogs and lowland communities are very sensitive to fluctuations in the water table (147). Naturally occurring droughts or artifical drainage can lower the water table in these delicate communities sufficiently to stunt plant growth, kill seedlings, and halt germination (148). Alternatively, small but prolonged rises in the water table can saturate the critical rooting zone and reduce growth or kill the vegetation.

These water table fluctuations occur naturally in the bogs and lowland communities throughout Minnesota (149), but they have not been studied in the Clay Boswell locality.

Forest insects and diseases represent an additional natural stress which affects vegetation in the Clay Boswell locality. Common plant pathogens occurring throughout northern Minnesota forests include rusts, gal-forming insects, and outbreaks of sawfly damage on spruce trees, (145) and Hypoxylan Canker on aspen (150). The occurrence and prevalence of plant pathogens in the vicinity of the Clay Boswell Station will be documented in detail this summer during the supplemental field study.

Man-caused Disturbances. According to MP&L, the "principal" man-caused disturbances to the terrestrial vegetation in the Clay Boswell locality are grazing and logging (145). Evidence of logging was noted during the field studies of 1975 in all forest types around the site. Grazing was noted primarily in the hardwood forest communities.

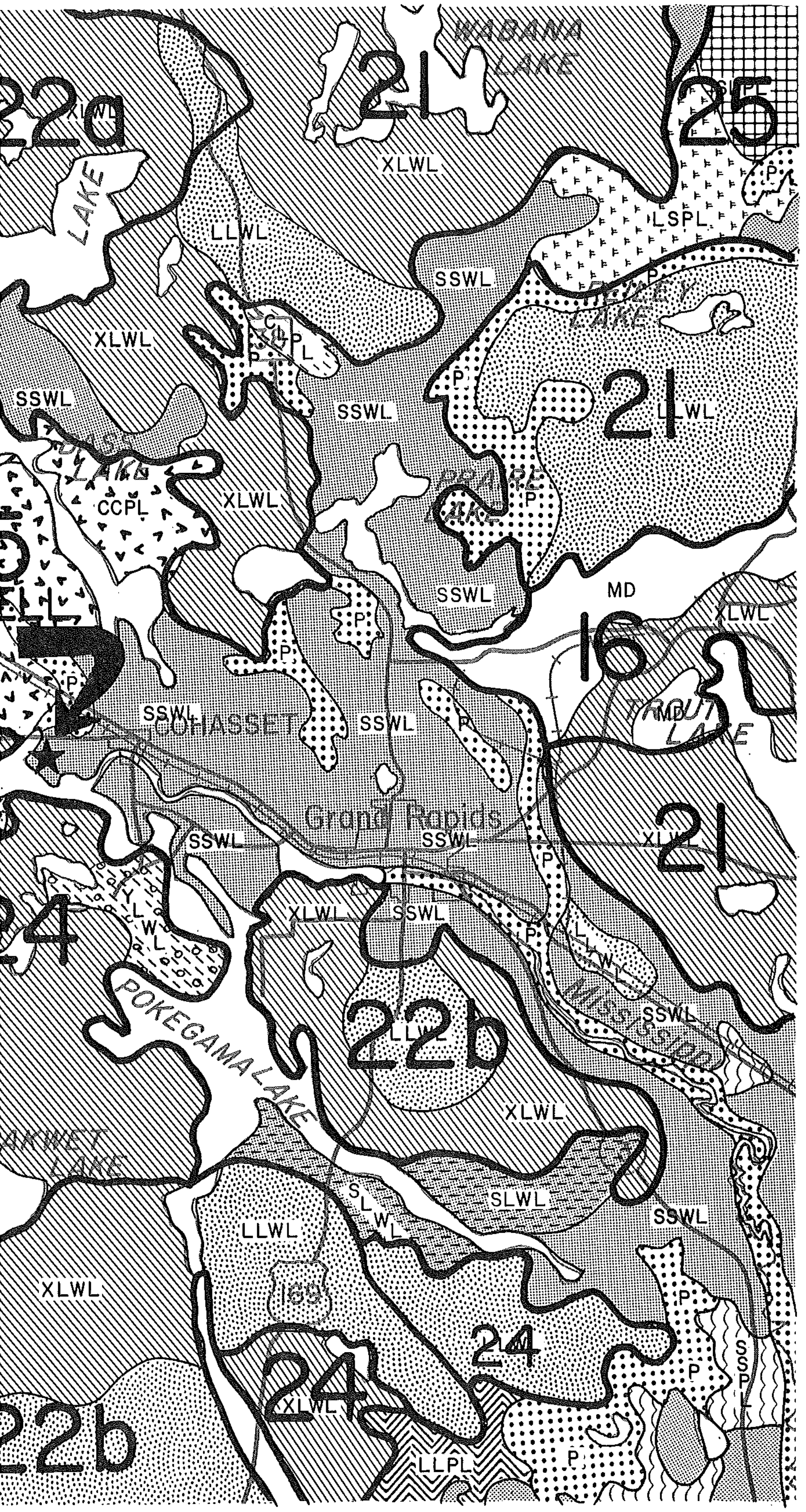
MP&L observations notwithstanding, the impacts of the Clay Boswell Station itself also have been highly significant in the past. A preliminary plant pathology survey conducted near the Station on September 9, 1974 by Professor Sagar V. Krupa, Department of Plant Pathology, University of Minnesota, found severe air pollution damage to vegetation from the existing Units 1, 2 and 3 within an approximate 4 mile (6.44 km) radius of the Clay Boswell Station (151). This brief survey was conducted at the request of MP&L, but a 2 year, detailed study proposed by the plant pathologists was rejected by MP&L. Professor Krupa and Professor F. A. Wood, (Head), Department of Plant Pathology, University of Minnesota summarized the findings of the 1974 survey as follows (151).

Preliminary observations indicate the problem to be composed of 2 parts:

- Visible deposition of a macronucleus (particulate matter + aqueous phase) on the foliage to a distance of roughly 1 mile (1.6 km) in radius from the stack. The direction from the source in which the deposition was observed on the foliage was closely related to the prevailing winds.

- Damage or injury to the foliage by deposition of possibly an aerosal - fine mist - extending roughly to a radius of 4 miles (6.4 km) from the stack. This was also closely related to the direction of the prevailing winds.

The complete 1974 field notes and written report and proposal submitted to MP&L by Professors Krupa and Wood may be found on file at the MPCA. The 1974 survey was very cursory. It merely indicates that there have been significant terrestrial impacts in the past from Units 1, 2, and 3. MP&L rejected the extended study proposal because they felt that new air emission control measures (Chapter II) taken pursuant to the air quality Stipulation Agreement would greatly reduce the toxic emissions and obviate the environmental concerns (151). The scope and severity of present and past phytotoxic and soils impacts will be measured during the summer 1977 field study. In addition, long-term terrestrial ecology studies may be required of MP&L to determine the long-term impacts of the entire Clay Boswell Station. For more complete, albeit general, discussion of the effects of air pollution on vegetation and soils, refer to Chapter V.



LEGEND

★ **CLAY BOSWELL STATION**

SOIL LANDSCAPE UNITS

- SSWL — SANDY OVER SANDY, WELL DRAINED, LIGHT COLORED SOILS
- SSPL — SANDY OVER SANDY, POORLY DRAINED, LIGHT COLORED SOILS
- SLWL — LOAMY OVER SANDY, WELL DRAINED, LIGHT COLORED SOILS
- SLPL — LOAMY OVER SANDY, POORLY DRAINED, LIGHT COLORED SOILS
- LLWL — DEEP SILTY OR LOAMY, WELL DRAINED, LIGHT COLORED SOILS
- LLPL — DEEP SILTY OR LOAMY, POORLY DRAINED, LIGHT COLORED SOILS
- LSPL — SANDY OVER LOAMY, POORLY DRAINED, LIGHT COLORED SOILS
- CSWL — SANDY OVER CLAYEY, WELL DRAINED, LIGHT COLORED SOILS
- CSPL — SANDY OVER CLAYEY, POORLY DRAINED, LIGHT COLORED SOILS
- CLWL — SILTY OR LOAMY OVER CLAYEY, WELL DRAINED, LIGHT COLORED SOILS
- CLPL — SILTY OR LOAMY OVER CLAYEY, POORLY DRAINED, LIGHT COLORED SOILS
- CCWL — CLAYEY OVER CLAYEY, WELL DRAINED, LIGHT COLORED SOILS
- CCPL — CLAYEY OVER CLAYEY, POORLY DRAINED, LIGHT COLORED SOILS
- XLWL — LOAMY OVER MIXED SANDY, AND LOAMY, WELL DRAINED, LIGHT COLORED SOILS
- YLWL — LOAMY OR SILTY OVER MIXED SILTY AND CLAYEY, WELL DRAINED, LIGHT COLORED SOILS
- P — ORGANIC SOILS
- A — ALLUVIAL SOILS UNDIFFERENTIATED
- MD — MINES OR DUMPS

NOTE: DATA UNAVAILABLE WEST AND SOUTH OF THE "HIBBING SHEET"

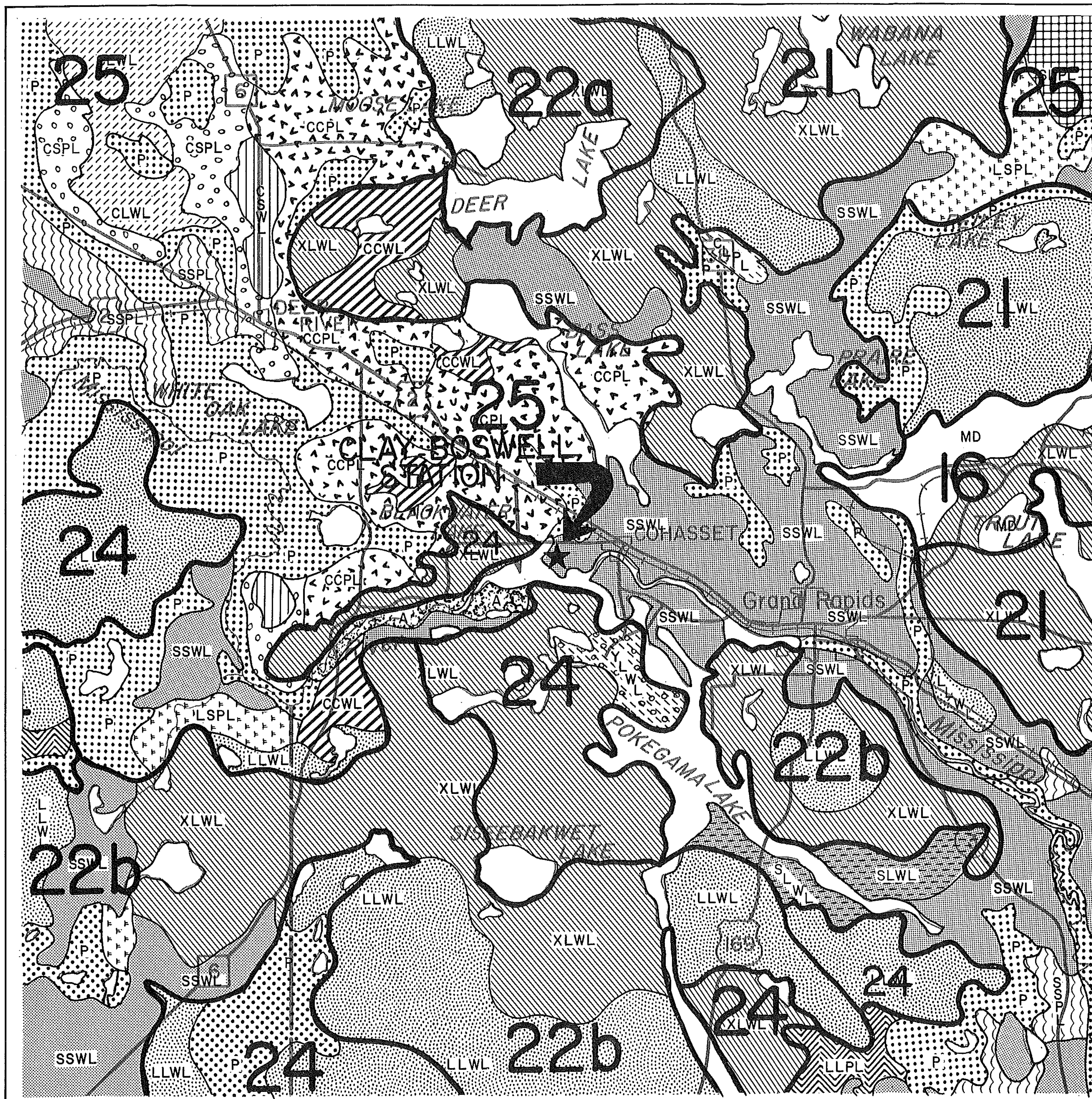
SCALE MILES: 5 0 5 10 15

SCALE KILOMETERS: 5 0 5 10 15 20

SOIL LANDSCAPE UNITS WITHIN 12 MILES (19.3KM) OF CLAY BOSWELL STEAM ELECTRIC STATION

SOURCE: "MINNESOTA SOILS ATLAS; HIBBING SHEET", MISCELLANEOUS REPORT 110-1971, 1971, AGRICULTURAL EXPERIMENT STATION, UNIVERSITY OF MINNESOTA

FIGURE IV-79



LEGEND

★ CLAY BOSWELL STATION

SOIL LANDSCAPE UNITS

- SSWL — SANDY OVER SANDY, WELL DRAINED, LIGHT COLORED SOILS
- SSPL — SANDY OVER SANDY, POORLY DRAINED, LIGHT COLORED SOILS
- SLWL — LOAMY OVER SANDY, WELL DRAINED, LIGHT COLORED SOILS
- SLPL — LOAMY OVER SANDY, POORLY DRAINED, LIGHT COLORED SOILS
- LLWL — DEEP SILTY OR LOAMY, WELL DRAINED, LIGHT COLORED SOILS
- LLPL — DEEP SILTY OR LOAMY, POORLY DRAINED, LIGHT COLORED SOILS
- LSPL — SANDY OVER LOAMY, POORLY DRAINED, LIGHT COLORED SOILS
- CSWL — SANDY OVER CLAYEY, WELL DRAINED, LIGHT COLORED SOILS
- CSPL — SANDY OVER CLAYEY, POORLY DRAINED, LIGHT COLORED SOILS
- CLWL — SILTY OR LOAMY OVER CLAYEY, WELL DRAINED, LIGHT COLORED SOILS
- CLPL — SILTY OR LOAMY OVER CLAYEY, POORLY DRAINED, LIGHT COLORED SOILS
- CCWL — CLAYEY OVER CLAYEY, WELL DRAINED, LIGHT COLORED SOILS
- CCPL — CLAYEY OVER CLAYEY, POORLY DRAINED, LIGHT COLORED SOILS
- XLWL — LOAMY OVER MIXED SANDY, AND LOAMY, WELL DRAINED, LIGHT COLORED SOILS
- YLWL — LOAMY OR SILTY OVER MIXED SILTY AND CLAYEY, WELL DRAINED, LIGHT COLORED SOILS
- P — ORGANIC SOILS
- A — ALLUVIAL SOILS UNDIFFERENTIATED
- MD — MINES OR DUMPS

NOTE: DATA UNAVAILABLE WEST AND SOUTH OF THE "HIBBING SHEET"

5 0 5 10 15
SCALE MILES

5 0 5 10 15 20
SCALE KILOMETERS

TABLE IV-73
SOIL LANDSCAPE UNIT FEATURES AND CHARACTERISTICS WITHIN 12 MILES (19.312 KM) OF CLAY BOSWELL STEAM ELECTRIC STATION (145)

Soil Landscape Unit	Geomorphic Region	Topography and Landscape Position	Most Common Texture and Thickness feet (meter): Rooting Zone	Most Common Texture and Thickness feet (meter): Substratum	Available Water to 5 ft (1.52 m)	Drainage Class	pH	Approximate Fertility in Rooting Zone: P	Approximate Fertility in Rooting Zone: K
SSWL - sandy over sandy, well drained, light colored soils	No. 21	gently rolling to rolling outwash	loamy sand to sand 1 to 4 ft (0.30 to 1.22 m)	sand and gravel 4 to 20+ ft (1.22 to 6.10+ m)	< 4 in. (< 10.2 cm)	excessively drained	5.5 to 6.2	low	low
	No. 22b	rolling outwash	loamy sand 1 to 3 ft (0.30 to 0.91 m)	sand and gravel 3 to 20+ ft (0.91 to 6.10+ m)	< 4 in. (< 10.2 cm)	well to excessively drained	5.5 to 6.0	high	low
	No. 25	nearly level to gently rolling lake plain	loam very fine sand to fine sand 2 to 4 ft (0.61 to 1.22 m)	fine and very finé sand 4+ ft (1.22+ m)	< 4 in. (< 10.2 cm)	well to moderately well drained	< 6.0	high	low
SSPL - sandy over sandy, poorly drained, light colored soils	No. 25	nearly level lake plain	loamy very fine sand to fine sand 2 to 4 ft (0.61 to 1.22 m)	fine and very fine sand 4+ ft (1.22+ m)	< 4 in. (< 10.2 cm)	poorly to very poorly drained	< 6.0	medium	low
SLWL - loamy over sandy, well drained, light colored soils	No. 25	nearly level to gently rolling lake plain	loam 1 to 2 ft (0.30 to 0.61 m)	sand 2 to 5+ ft (0.61 to 1.52+ m)	< 12 in. (< 30.5 cm)	moderately well drained	5.5 to 6.2	medium	low
LSPL - sandy over loamy, poorly drained, light colored soils	No. 25	nearly level to depressional lake plain	loamy fine sand to fine sand 1 to 3 ft (0.30 to 0.91 m)	stratified silts, clays, and very fine sand 3 to 20+ ft (0.91 to 6.10+ m)	4 to 8 in. (10.2 to 20.3 cm)	poorly to very poorly drained	5.5 to 6.2	medium	low
LLWL - deep silty or loamy, well drained, light colored soils	No. 21	rolling to hilly moraine	loamy and clay loam 4 ft (1.22 m)	clay loam 4 to 20+ ft (1.22 to 6.10+ m)	8 to 12 in. (20.3 to 30.5 cm)	moderately well to well drained	5.5 to 6.2	medium	low
	No. 22a	rolling to hilly moraine	loam and clay loam 4 ft (1.22 m)	loam and clay loam 4 to 20+ ft (1.22 to 6.10+ m)	8 to 12 in. (20.3 to 30.5 cm)	moderately well to well drained	5.5 to 6.2	medium	medium
	No. 22b	rolling to hilly moraine	loam and silt loam 1 to 4 ft (0.30 to 1.22 m)	loam 4 to 20+ ft (1.22 to 6.10+ m)	8 to 12 in. (20.3 to 30.5 cm)	well drained	5.5 to 6.0	medium to high	low
	No. 24	gently rolling to rolling till plain	loam and silt loam 4 ft (1.22 m)	loam 4 to 20+ ft (1.22 to 6.10+ m)	8 to 12 in. (20.3 to 30.5 cm)	well to moderately well drained	5.5 to 6.2	medium	medium
	No. 25	nearly level to gently sloping lake plain	silt loam and very fine sandy loam 2 to 4 ft (0.61 to 1.22 m)	stratified silts and very fine sands 4+ ft (1.22+ m)	8 to 12 in. (20.3 to 30.5 cm)	moderately well drained	5.5 to 6.0	medium	medium
LLPL - deep silty or loamy, poorly drained, light colored soils	No. 24	nearly level to depressional	loam and clay loam 4 ft (1.22 m)	loam and clay loam 4 to 20+ ft (1.22 to 6.10+ m)	8 to 12 in. (20.3 to 30.5 cm)	somewhat poorly to very poorly drained	5.5 to 6.0	medium	low
	No. 25	nearly level lake plain	silt loam 4 ft (1.22 m)	stratified silts, clays, and very fine sands 4+ ft (1.22+ m)	8 to 12 in. (20.3 to 30.5 cm)	poorly to very poorly drained	7.4 to 7.8	low	low
CSWL - sandy over clayey, well drained, light colored soils	No. 25	nearly level to gently rolling lake plain	loamy fine sand to fine sand 1 to 3 ft (0.30 to 0.91 m)	clay 3 to 20+ ft (0.91 to 6.10+ m)	4 to 8 in. (10.2 to 20.3 cm)	moderately well to poorly drained	5.5 to 6.2	medium	low
CSPL - sandy over clayey, poorly drained, light colored soils	No. 25	nearly level lake plain	sand and loamy sand 1 to 3 ft (0.30 to 0.91 m)	silty clay and clay 3 to 5+ ft (0.91 to 1.52+ m)	4 to 8 in. (10.2 to 20.3 cm)	very poorly drained	5.5 to 6.2	medium	medium

TABLE IV-73 (continued)
SOIL LANDSCAPE UNIT FEATURES AND CHARACTERISTICS WITHIN 12 MILES (19.312 KM) OF CLAY BOSWELL STEAM ELECTRIC STATION (145)

Soil Sandscape Unit	Geomorphic Region	Topography and Landscape Position	Most Common Texture and Thickness feet (meter): Rooting Zone	Most Common Texture and Thickness feet (meter): Substratum	Available Water to 5 ft (1.52)	Drainage Class	pH	Approximate Fertility in Rooting Zone: P	Approximate Fertility in Rooting Zone: K
CLWL - silty or loamy over clayey, well drained, light colored soils	No. 25	nearly level to gently sloping lake plain	silt loam 1 to 3 ft (0.30 to 0.91 m)	clay 3 to 5+ ft (0.91 to 1.52+ m)	8 to 12 in. (20.3 to 30.5 cm)	moderately well and somewhat poorly drained	5.5 to 6.2	medium	low
CLPL - silty or loamy over clayey, poorly drained, light colored soils	No. 25	nearly level lake plain	silt loam 1 to 3 ft (0.30 to 0.91 m)	clay 3 to 5+ ft (0.91 to 1.52+ m)	8 to 12 in. (20.3 to 30.5 cm)	poorly to very poorly drained	5.5 to 6.2	medium	low
CCWL - clayey over clayey, well drained, light colored soils	No. 21	gently rolling to rolling till plain	silty clay 3 ft (0.91 m)	clay 3 to 20+ ft (0.91 to 6.10+ m)	8 to 12 in. (20.3 to 30.5 cm)	moderately well drained	6.0 to 6.5	medium	high
	No. 25	nearly level to gently rolling lake plain	silty clay 3 ft (0.91 m)	clay 3 to 20+ ft (0.91 to 6.10+ m)	8 to 12 in (20.3 to 30.5 cm)	moderately well to poorly drained	5.5 to 6.2	medium	low
CCPL - clayey over clayey, poorly drained, light colored soils	No. 25	nearly level lake plain	silty clay loam and silty clay 1 to 3 ft (0.30 to 0.91 m)	clay 3 to 5+ ft (0.91 to 1.52+ m)	8 to 12 in. (20.3 to 30.5 cm)	poorly to very poorly drained	5.5 to 6.2	medium	low
XLWL - loamy over mixed sandy, and loamy, well drained, light colored soils	No. 16	rolling, mixed till and outwash	clay loam and loamy sand 1 to 4 ft (0.30 to 1.22 m)	clay loam, sand, and gravel 3 to 20+ ft (0.91 to 6.10+ m)	< 12 in. (< 30.5 cm)	well drained	5.5 to 6.2	low	low
	No. 21	rolling to steep mixed till and outwash	clay loam, loam, sand, and gravel 1 to 4 ft (0.30 to 1.22 m)	clay loam, sand, and gravel 4 to 20+ ft (1.22 to 6.10+ m)	< 12 in. (< 30.5 cm)	moderately well to excessively drained	5.5 to 6.2	medium	low
	No. 22a	rolling to hilly moraine	clay loam, loam, sand, and gravel 1 to 4 ft (0.30 to 1.22 m)	clay loam, sand, and gravel 4 to 20+ ft (1.22 to 6.10+ m)	< 12 in. (< 30.5 cm)	moderately well to excessively drained	5.5 to 6.0	medium	low
	No. 22b	rolling to steep moraine	loam, sand, and gravel 1 to 4 ft (0.30 to 1.22 m)	loam, sand, and gravel 4 to 20+ ft (1.22 to 6.10+ m)	< 12 in. (< 30.5 cm)	well to excessively drained	5.5 to 6.0	medium to high	low
	No. 24	rolling mixed till and outwash	loam, silt loam, and loamy sand 1 to 4 ft (0.30 to 1.22 m)	loam, sand, and gravel 4 to 20+ ft (1.22 to 6.10+ m)	< 12 in. (< 30.5 cm)	well to excessively drained	5.5 to 6.0	high to medium	low
YLWL - loamy or silty over mixed silty and clayey, well drained, light colored soils	No. 24	gently rolling to rolling mixed loam and clay till	loam and silty clay 4 ft (1.22 m)	loam and clay 4 to 20+ ft (1.22 to 6.10+ m)	8 to 12 in. (20.3 to 30.5 cm)	well to moderately well drained	5.5 to 6.2	medium	medium
P - organic soils	No. 21	level to depressional	peat 1 to 3 ft (0.30 to 0.91 m)	peat 3+ ft (0.91+ m)	12+ in. (30.5+ cm)	very poorly drained	< 6.0	low	low
	No. 24	level to depressional	peat 1 to 3 ft (0.30 to 0.91 m)	peat 3+ ft (0.91+ m)	12+ in. (30.5+ cm)	very poorly drained	< 6.0	low	low
	No. 25	low level to depressional	peat 1 to 3 ft (0.30 to 0.91 m)	peat 3+ ft (0.91+ m)	12+ in. (30.5+ cm)	very poorly drained to marshy	< 6.0	low	low
A - alluvial soils undifferentiated	No. 25	narrow stream bottoms	loam 2 to 4 ft (0.61 to 1.22 m)	loam 4+ ft (1.22+ m)	4 to 12 in. (10.2 to 30.5 cm)	poorly drained	< 6.0	variable	variable
MD - mines	No. 16	deep open pit mines and high mine dumps	b	b	b	b	b	b	b

[a] The location of the soil landscape units and geomorphic regions are shown on Figure IV-79.

[b] means not applicable.

Site-Specific

The Clay Boswell site as used here is the 3,599 acres (1,457 hectares) surrounding the Clay Boswell Station which is owned, or is in the process of being acquired, by MP&L. The following decriptions, taken from the Environmental Report (145), are once again incomplete and possibly erroneous. They will be supplemented by the summer 1977 field study.

Terrestrial Vegetation

The terrestrial vegetation communities of the Clay Boswell Station site can be divided into 8 types using Curtis' terminology (140). Figure IV-80 illustrates this division.

In addition, Table IV-74 gives a list of the plant species recorded during the 1975 terrestrial field study (145).

Hardwood Forest. Approximately 333 hectares (22.9%) of the site is covered with upland and lowland hardwood forests (Table IV-75). Black ash, paper birch, and quaking aspen are the dominant canopy trees of the hardwood stands (145). Of the 19 woody plants found in the shrub layer of these stands, beaked hazel and mountain maple dominated (145). Several genera of herbs were found, but not all of the species were identified. Of the herbaceous zone, 51 to 75% was found to be bare gound, indicating limited penetration of sunlight. The hardwood forests showed signs of past logging activities (145).

Northern Xeric Forest; Dry-Mesic Segment. Paper birch, jack pine, and quaking aspen dominate the canopy of these mixed deciduous forests on the Clay Boswell site (145). Beaked hazel and mountain maple dominated the shrub layer, while false lily-of-the-valley, blueberry (*Vaccinium* sp.), and violets were found in the herb layer (145). These mixed stands cover only 44 hectares (3.0%) of the Clay Boswell Station site.

Northern Lowland Forest; Wet Segment. Conifer swamps cover approximately 82 hactares of the Clay Boswell Station site. Black spruce and tamarack dominate the canopy of these stands while tree seedlings and bog birch (*Betula pumila*) were found in the shrub layer. The herbaceous stratum was dominated by leather-leaf (*Chamaedaphne calyculata*), Labrador tea, blueberry, and other acid tolerant species, as well as by unidentified bryophytes (mosses and liverworts) (145).

Tall Shrub Communities. Alder thickets, mixed with willow, occupied about 61 hectares (4.5%) of the site and were situated on the borders of streams, lakes, and swamps. The herbaceous flora of these thickets was dominated by unidentified grasses and sedges.

Fens and Sedge Meadows. At the Clay Boswell Station site, 165 hectares were typed as fens, sedge-meadows, or areas of emergent vegetation. Most of these areas are near the existing ash pond. The species found in these areas included horsetail, hazelnut (*Corylus americana*), grasses, sedges, and a variety of other species normal for such communities (145).

TABLE IV-74
PLANT SPECIES RECORDED - CLAY BOSWELL STEAM ELECTRIC STATION AREA
July and August 1975 (145)

Species
Balsam fir *(Abies balsamea)*
Red maple *(Acer rubrum)*
Sugar maple *(Acer saccharum)*
Mountain maple *(Acer spicatum)*
Common yarrow *(Achillea millefolium)*
Baneberry *(Actaea* sp.*)*
Crested quackgrass *(Agropyron cristatum)*
Red top *(Agrostis* sp. and *Agrostis alba)*
Slender hairgrass *(Agrostis perennans)*
Hairy alder *(Alnus rugosa)*
Bog-rosemary *(Andromeda glaucophylla)*
Wild sarsaparilla *(Aralia nudicaulis)*
Wild ginger *(Asarum canadense)*
Wild aster *(Aster* sp.*)*
Large-leaf northern aster *(Aster macrophyllus)*
Lady fern *(Athyrium filix-femina)*
Canoe or paper birch *(Betula papyrifera)*
Dwarf birch *(Betula pumila)*
Common grape fern *(Botrychium virginianum)*
Bromegrass *(Bromus* sp.*)*
Smooth brome *(Bromus inermis)*
Mosses *(Bryophyta)*
Sedge *(Carex* sp.*)*
Leather-leaf *(Chamaedaphne calyculata)*
Lamb's-quarters *(Chenopodium album)*
Northern Enchanter's nightshade *(Circaea alpina)*
Bull-thistle *(Cirsium vulgare)*
Clinton's lily *(Clintonia borealis)*
Dogwood *(Cornus* sp.*)*
Alternate-leaved dogwood *(Cornus alternifolia)*
Round-leaved dogwood *(Cornus rugosa)*
American hazel *(Corylus americana)*
Beaked hazel *(Corylus cornuta)*
Shield fern *(Dryopteris* sp.*)*
Fireweed *(Epilobium angustifolium)*
Horsetail, scouring rush *(Equisetum* sp.*)*
Horsetail *(Equisetum litorale)*
Meadow strawberry *(Fragaria virginiana)*
Black ash *(Fraxinus nigra)*
White evening-primrose *(Oenothera nuttallii)*
Rough evening-primrose *(Oenothera parviflora)*
Downy sweet cicely *(Osmorhiza claytoni)*
Virginia creeper *(Parthenocissus quinquefolia)*
Timothy *(Phleum pratense)*
Black spruce *(Picea mariana)*
Jack pine *(Pinus banksiana)*
Red pine *(Pinus resinosa)*
White pine *(Pinus strobus)*
Bluegrass *(Poa* sp.*)*
Common bindweed *(Polygonum convolvulus)*
Polypody family *(Polypodiaceae)*
Balsam poplar *(Populus balsamifera)*
Trembling aspen *(Populus tremuloides)*
Chokecherry *(Prunus virginiana)*
Common bracken *(Pteridium aquilinum)*
Wintergreen *(Pyrola* sp.*)*
Pink shinleaf *(Pyrola asarifolia)*
Pyrola *(Pyrola virens)*
American mountain ash *(Sorbus americana)*
Oak *(Quercus* sp.*)*
Bur oak *(Quercus macrocarpa)*
Northern red oak *(Quercus rubra)*
Buttercup *(Ranunculus* sp.*)*
Small-flowered buttercup *(Ranunculus abortivus)*
Poison ivy *(Rhus radicans)*
Currant, gooseberry *(Ribes* sp.*)*
Skunk currant *(Ribes glandulosum)*
Prickly rose *(Rosa acicularis)*
Raspberry, blackberry *(Rubus* sp.*)*
Dewberry *(Rubus pubescens)*
Sheep sorrel *(Rumex acetosella)*
Willow *(Salix* sp.*)*
Red-berried elder *(Sambucus pubens)*
False Solomon's seal *(Smilacina trifolia)*
Goldenrod *(Solidago* sp.*)*
Perennial sow-thistle *(Sonchus arvensis)*
Common twisted stalk *(Streptopus roseus)*
Common tansy *(Tanacetum vulgare)*
Common dandelion *(Taraxacum officinale)*

TABLE IV-74 (continued)
PLANT SPECIES RECORDED - CLAY BOSWELL STEAM ELECTRIC STATION AREA
July and August 1975 (145)

Species	
Bedstraw *(Galium* sp.*)*	Early meadow rue *(Thalictrum dioicum)*
Wild geranium *(Geranium maculatum)*	Basswood *(Tilia americana)*
Common avens *(Geum aleppicum)*	Northern starflower *(Trientalis borealis)*
Grass family *(Gramineae)*	Red clover *(Trifolium pratense)*
Sunflower *(Helianthus* sp.*)*	Hop-clover *(Trifolium procumbens)*
Hepatica *(Hepatica americana)*	Wake-robin, trillium *(Trillium* sp.*)*
Spotted jewel-weed *(Impatiens capensis)*	Elm *(Ulmus* sp.*)*
Soft rush *(Juncus effusus)*	Slippery elm *(Ulmus rubra)*
Bog laurel *(Kalmia polifolia)*	Yellow bellwort *(Uvularia grandiflora)*
Mint family (Labiatae)	Blueberry, cranberry *(Vaccinium* sp.*)*
American larch or tamarack *(Larix laricina)*	Late sweet blueberry *(Vaccinium angustifolium)*
Sweet pea *(Lathyrus* sp.*)*	Velvet-leaf blueberry *(Vaccinium myrtilloides)*
Labrador-tea *(Ledum groenlandicum)*	Small cranberry *(Vaccinium oxycoccos)*
Fly-honeysuckle *(Lonicera canadensis)*	Black-haw *(Viburnum lentago)*
Smooth-climbing honeysuckle *(Lonicera dioica)*	Highbush cranberry *(Viburnum trilobum)*
Fringed loosestrife *(Lysimachia ciliata)*	Vetch *(Vicia* sp.*)*
False lily-of-the-valley *(Maianthemum canadense)*	Tufted vetch *(Vicia cracca)*
Alfalfa *(Medicago sativa)*	Violet *(Viola* sp.*)*
White sweet clover *(Melilotus alba)*	Soft violet *(Viola blanda)*
Sweet mint *(Mentha arvensis)*	Kidney-leaved white violet *(Viola renifolia)*
Northern miterwort *(Mitella nuda)*	

TABLE IV-75
VEGETATIVE COMPOSITION - CLAY BOSWELL STEAM ELECTRIC STATION SITE (143)

Community Type	Area hectare	Percent of Site
Upland and swamp hardwood forest	333	22.9
Xeric forest; mixed deciduous and coniferous	44	3.0
Conifer swamp	82	5.6
Alder thicket	61	4.2
Fens and sedge meadow	165	11.3
Open bog	29	2.0
Conifer plantation	6	0.4
Cropland	416	28.6
Pasture	89	6.1
Residential	38	2.6
Industrial	160	11.0
Open water	34	2.3

Open Bog. Open bog occupies 29 hectares on the Clay Boswell site, occurring mostly in association with conifer swamps. The prevalent species found in this plant community include Labrador tea, leatherleaf, blueberry, and several species of bryophytes. Although free of canopy trees, scattered individuals of quaking aspen and willow can be found (145).

Conifer Plantations. Two conifer plantations, totalling approximately 6 hectares, are located near the southeastern border of MP&L's property. These communities are characterized by evenly spaced rows of red pine and white pine (145).

Cropland and Pasture. Approximately 505 hectares (34.7%) of the Clay Boswell Station site is in cropland or pasture. Some of this area is mowed periodically by local farmers for hay. Much of it is being allowed to revert to native vegetation. The portions which have not yet been acquired by MP&L still may be planted with annual crops. Most of the crop and pasture land is covered by timothy (*Phleum pratense*), redtop (*Agrostis alba*), and other forage grasses. Beaked hazel, smooth sumac (*Rhus glabra*), staghorn sumac (*Rhus typhina*), and many native herbs are encroaching onto some of the abandoned fields (145).

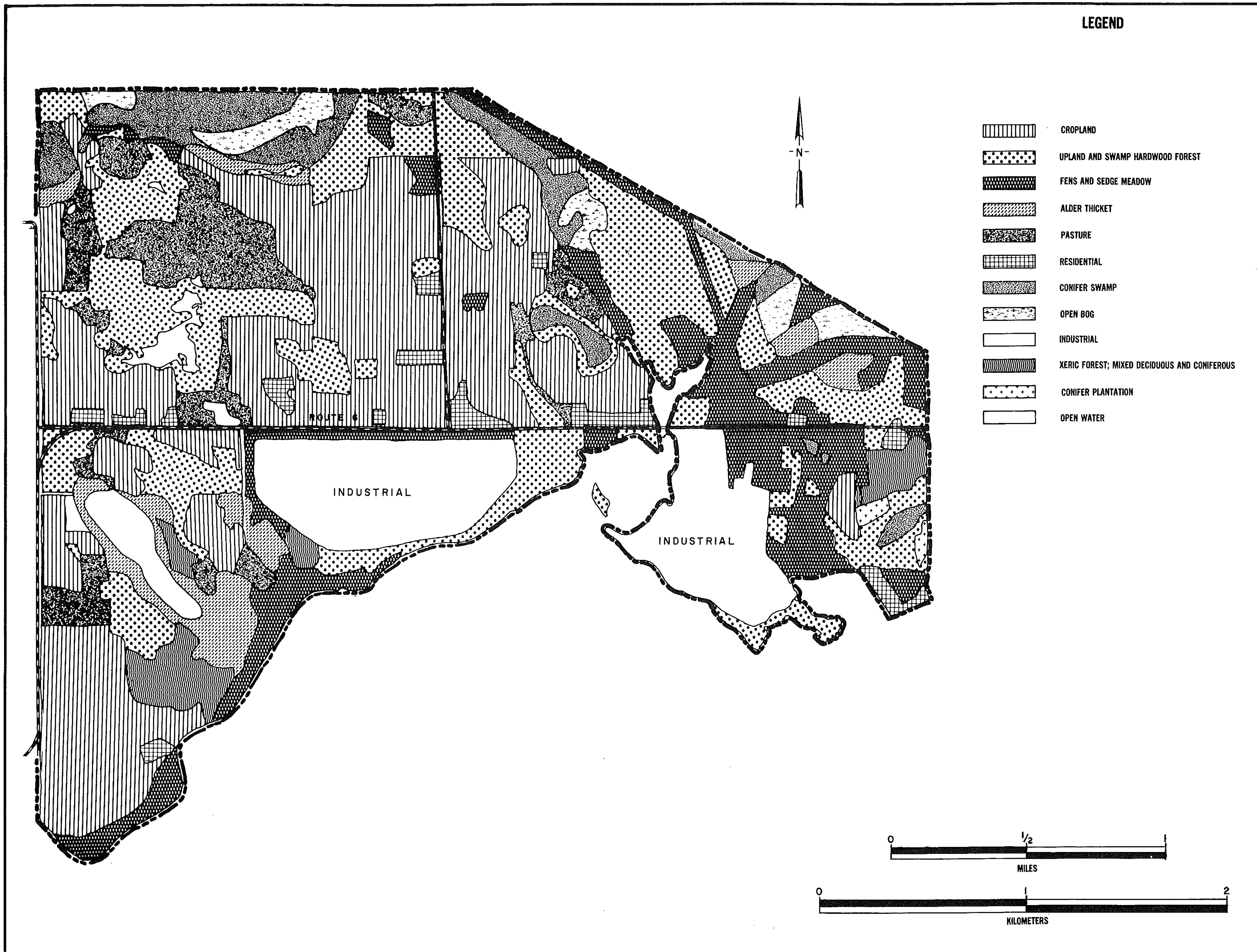
Soils

The available soil information for the Clay Boswell Station site is very general. The site is located within the Aitkin Lacustrine Plain geomorphic region. The MP&L property covers portions of 3 soil landscape units (Figure IV-79): "P", peat soils; "SSWL", loamy over sandy, well-drained, light-colored soils; and CCPL", clayey over clayey, poorly drained, light-colored soils. Refer to Table IV-73 for other characteristics and features of these soils. Once again, this information will be supplemented by the summer 1977 field study and by the spring and summer work of the U.S. Soil Conservation Service.

Rare and Endangered Plants

The Minnesota Environmental Policy Act, and regulations promulgated pursuant thereto, require that special attention be given in State actions and in environmental impact statements to preserving rare and endangered species of plants (152). The legal standing of some plant species is also enhanced by specific Minnesota laws which provide for the protection of certain wild flowers native to Minnesota (153). The Minnesota DNR has published a list of plants and animals which it deems in need of special consideration and protection, but most of the species listed are not legally protected (154). To date, 2 Minnesota wild plants have been afforded Federal Protection under the Endangered and Threatened Species Preservation Act of 1973 (155). These are the prairie bush-clover (*Lespedeza leptostachya*) and the Jacob's ladder (*Polemonium occidentale lacustre*). Because the Jacob's ladder has been recorded for St. Louis County (156), a very high priority of the 1977 summer field study will be given to a detailed search for this plant.

Minnesota is located in a biologically unique area, in that it forms a transition between 3 major vegetation regions; the eastern deciduous forests, the western plains and prairies, and the northern coniferous forests. Because



TERRESTRIAL VEGETATION COMMUNITIES OF THE SITE CLAY BOSWELL STEAM ELECTRIC STATION

SOURCE: ADAPTED FROM MP&L, "ENVIRONMENTAL REPORT", EXHIBIT III-G-3

FIGURE IV-80

of this, Minnesota provides a wide variety of ecological niches for flora and fauna. The vascular plants which thrive without care in Minnesota total approximately as follows (154):

Ferns and fern allies	69
Gymnosperms (pines and relatives)	13
Angiosperms (flowering plants, native)	1,500
Angiosperms, introduced	200

Of these roughly 1,800 wild plants, 256 species or varieties have been listed by Professor Thomas Morley of the Botany Department at the University of Minnesota as plants rare or endangered in Minnesota (157). All but 4 of the 256 species listed by Morley are adequately represented in regions adjacent to Minnesota and not in imminent danger of complete extinction nation-wide. Table IV-76 presents those rare or endangered plants which Morley lists as occurring in Itasca County and the 5 counties surrounding Itasca County (Aitkin, Beltrami, Cass, Koochiching, and St. Louis). The indication of counties where each species has been found may often be unreliable since the level of effort of field searches for each species varies widely from county to county. However, the 6 counties are sufficiently similar ecologically so that the recorded presence in any of Aitkin, Beltrami, Cass, Koochiching, or St. Louis Counties implies a likelihood that the species might also be found in Itasca County and further implies that the species may possibly be growing in areas which will be affected by the Clay Boswell Station.

Professor Morley's classification of "rare or endangered" species is based either on limited presence documented in the University of Minnesota herbarium, or on occurrence in only small geographical areas of Minnesota (157). Morley's list has yet to be given legal significance. The Minnesota Wild Flower Conservation Law (153) gives limited legal protection to the trailing arbutus (*Epigaea repens*) and the lotus lily (*Nelumbo lutea*), to all members of the genera *Lilium*, *Trillium*, and *Gentiana*, and to all members of the orchid family (*Orchidaceae*). The distribution of most of these plants is not given in Morley's list, but those which have been observed in Itasca County and the 5 surrounding counties, based on University of Minnesota herbarium specimens, have been included in Table IV-76.

A detailed search for the 87 plant species or varieties listed in Table IV-76 and other uncommon wild plants is a high priority objective of the 1977 summer field study being conducted by Ronald M. Hays and Associates. When uncommon species are found, the habitat of each also will be studied and recorded.

Summer 1977 Field Studies

To correct the inadequacies in the available field data on the terrestrial communities in the vicinity of the Clay Boswell Station, the MPCA has contracted with Ronald M. Hays and Associates to conduct a detailed field study in the summer of 1977. This study will gather data on the terrestrial vegetation and wildlife within a 12 mile (19.3 km) radius of the Clay Boswell Station, as well

TABLE IV-76
RARE AND ENDANGERED PLANT SPECIES FOUND IN ITASCA, AITKIN, BELTRAMI, CASS, KOOCHICHING, OR ST. LOUIS COUNTIES, MINNESOTA (154) (156) (157)

Plant Species	Status[a]				Documented Occurrence					
	N	P	R	U	Itasca	Aitkin	Beltrami	Cass	Koochiching	St. Louis
<u>Ferns and Fern Allies</u>										
<u>Ophioglossaceae</u>										
Adder's tongue *(Ophioglossum vulgatum* var. *pseudopodum)*	x		x							x
<u>Gymnosperms</u>										
<u>Pinaceae</u>										
Hemlock *(Tsuga canadensis)*	x		x							x
<u>Angiosperms</u>										
<u>Alismataceae</u>										
Grass-leaved arrowhead *(Sagittaria graminia)*	x		x							x
<u>Araceae</u>										
Fluted Jack-in-the-pulpit *(Arisaema atrorubens* var. *Stewardsonii)*	x		x		x				x	
<u>Boraginaceae</u>										
Bay forget-me-not *(Myosotis laxa)*	x		x					x		
<u>Caryophyllaceae</u>										
Procumbent pearlwort *(Sagina procumbens)*[b]	x		x							x
<u>Chenopodiaceae</u>										
Shining bug-seed *(Corispermum nitidum)*	x		x							x
<u>Compositae</u>										
Tall aster *(Aster prealtus)*	x		x							x
Small beggar-ticks *(Bidens discoidea)*	x		x							x
Western tarweed *(Madia glomerata)*	x		x							x
<u>Cruciferae</u>										
Marsh bitter cress *(Cardamine pratensis)*	x		x							x
Awlwort *(Subularia aquatica)*	x		x							x
<u>Cyperaceae</u>										
Carex cephalantha[b]	x		x							x
Carex katahdinensis[b]	x		x							x
Carex ormostachya	x		x							x
Carex pallescens var. *neogaea*	x		x							x
Carex paupercula var. *irrigua*[b]	x		x							x
Houghton's cyperus *(Cyperus houghtonii)*	x		x				x			
Sooty beaked-rush *(Rhynchospora fusca)*	x		x							x
Pedicelled bulrush *(Scirpus pedicellatus)*[b]	x		x							x

TABLE IV-76 (continued)
RARE AND ENDANGERED PLANT SPECIES FOUND IN ITASCA, AITKIN, BELTRAMI, CASS, KOOCHICHING, OR ST. LOUIS COUNTIES, MINNESOTA (154) (156) (157)

Plant Species	Status [a]				Documented Occurrence					
	N	P	R	U	Itasca	Aitkin	Beltrami	Cass	Koochiching	St. Louis
<u>Ericaceae</u>										
Trailing arbutus *(Epigaea repens)*		x		x	x		x	x		x
Lingen berry *(Vaccinium Vitus-idaea* var. *minus)*	x		x				x		x	x
<u>Fumariaceae</u>										
Mountain fringe *(Adlumia fungosa)*[b]	x		x							x
<u>Gentianaceae</u>										
Closed gentian *(Gentiana Andrewsii)*		x		x						x
Redstem gentian *(Gentiana rubricaulis)*		x		x	x	x				x
<u>Gramineae</u>										
Tickle grass *(Agrostis hyemalis)*	x		x							x
American beach grass *(Ammophila breviligulata)*[b]	x		x							x
Wavy hair grass *(Deschampsia flexuosa)*	x		x							x
One-flowered muhly grass *(Muhlenbergia uniflora)*	x		x							x
Prairie spear grass *(Poa arida)*	x		x						x	
Chaix's speargrass *(Poa chaixii)*[b] possibly introduced	x		x							x
Sylvan spear grass *(Poa sylvestris)*	x		x							x
Rough-stalked meadow grass *(Poa trivialis)*	x		x							x
<u>Juncaceae</u>										
Small-headed rush *(Juncus brachycephalus)*	x		x							x
Moor rush *(Juncus stygius)*	x		x							x
<u>Lentibulariaceae</u>										
Humped bladderwort *(Utricularia gibba)*	x		x							x
<u>Liliaceae</u>										
Meadow lily *(Lilium michiganse)*		x		x	x			x		x
Plains lily *(Lilium philadelphicum)*		x		x			x	x		x
Trillium cernum var. *macranthum*		x		x	x	x	x	x	x	x
Trillium grandiflorum		x		x	x	x		x		x
<u>Nymphaeaceae</u>										
Small white water lily *(Nymphaea tetragona)*	x		x				x			
<u>Orchidaceae</u>										
Swamp-pink *(Arethusa bulbosa)*		x		x	x	x	x	x		x
Grass-pink *(Calopogon pulchellus)*		x		x	x	x	x	x		x

TABLE IV-76 (continued)
RARE AND ENDANGERED PLANT SPECIES FOUND IN ITASCA, AITKIN, BELTRAMI, CASS, KOOCHICHING, OR ST. LOUIS COUNTIES, MINNESOTA (154) (156) (157)

Plant Species	Status[a]				Documented Occurrence					
	N	P	R	U	Itasca	Aitkin	Beltrami	Cass	Koochiching	St. Louis
<u>Orchidaceae (continued)</u>										
Fairy slipper *(Calypso bulbosa)*		x		x			x	x	x	x
Spotted coral-root *(Corallorhiza maculata* var. *maculata)*		x		x						x
Striped coral-root *(Corallorhiza striata)*		x		x	x	x				x
Early coral-root *(Corallorhiza trifida* var. *verna)*		x		x	x			x		x
Moccasin flower *(Cypripedium acaule)*		x		x	x	x		x		x
Ram's head orchid *(Cypripedium arietinum)*		x		x		x				
Lesser yellow lady-slipper *(Cypripedium Calceolus* var. *parviflorum)*		x		x	x					x
Large yellow lady-slipper *(Cypripedium Calceolus* var. *pubescens)*		x		x		x		x		x
Pink and white, or showy, lady-slipper *(Cypripedium reginae)*, Minnesota state flower		x		x	x		x	x		x
Creeping lattice-leaf *(Goodyera repens)*		x		x	x			x		x
Greater lattice-leaf *(Goodyera tesselata)*		x		x	x	x		x		x
Small wood orchid *(Habenaria clavellata)*		x		x		x				x
White bog orchid *(Habenaria dilatata* var. *dilatata)*		x		x	x		x			x
White bog orchid *(Habenaria dilatata* var. *media)*		x		x	x					x
Hooker's orchid *(Cypripedium arietinum)*		x		x				x	x	x
Northern rein-orchid *(Habenaria hyperborea* var. *huronensis)*		x		x	x	x	x	x	x	x
Ragged fringed orchid *(Habenaria lacera)*		x		x		x	x			x
Small rein-orchid *(Habenaria obtusata)*		x		x	x	x		x		x
Round-leaved rein-orchid *(Habenaria orbiculata)*		x		x	x	x	x	x		x
Fringed pink orchid *(Habenaria psycodes)*		x		x		x	x	x		x
Bracted green orchid *(Habenaria viridis* var. *bracteata)*		x		x		x		x		x
Shiny twayblade *(Liparis Loeselii)*		x		x						x
Auricled twayblade *(Listera auriculata)*		x	x							x
Heart-leaf twayblade *(Listera cordata)*		x		x	x			x		x
Malaxis brachypoda		x		x						x
Green malaxis *(Malaxis unifolia)*		x		x			x	x		x
Round-leaved orchis *(Orchis rotundifolia)*		x		x			x			x

TABLE IV-76 (continued)
RARE AND ENDANGERED PLANT SPECIES FOUND IN ITASCA, AITKIN, BELTRAMI, CASS, KOOCHICHING, OR ST. LOUIS COUNTIES, MINNESOTA (154) (156) (157)

Plant Species	Status[a]				Documented Occurrence					
	N	P	R	U	Itasca	Aitkin	Beltrami	Cass	Koochiching	St. Louis
Orchidaceae (continued)										
Rose pogonia *(Pogonia ophioglossoides)*		x		x		x	x	x		x
Nodding ladies' tresses *(Spiranthes cernua)*		x		x	x					x
Slender ladies' tresses *(Spiranthes lacera)*		x		x	x		x	x	x	x
Northern ladies' tresses *(Spiranthes Romanzoffiana)*		x		x						x
Polygonaceae										
Bushy knotweed *(Polygonum ramosissimum)*	x		x					x	x	x
Ranunculaceae										
Floating marsh marigold *(Caltha natans)*	x		x							x
Yellow water-crowfoot *(Ranunculus Gmelini)*	x		x			x				x
Lapland buttercup *(Ranunculus lapponicus)*	x		x		x	x				x
Rosaceae										
Laciniate avens *(Geum laciniatum)*	x		x							x
Fan-leaved cinquefoil *(Potentilla flabelliformis)*	x		x							x
Blackberry *(Rubus folioflorus)*	x		x							x
Barren strawberry *(Waldsteinia fragarioides)*	x		x							x
Rubiaceae										
Yellow bedstraw *(Galium verum)*	x		x							x
Salicaceae										
Bloom willow *(Salix pellita)*	x		x							x
Scrophulariaceae										
Pale penstemon *(Penstemon pallidus)*	x		x							x
Sparganiaceae										
Northern bur-reed *(Sparganium glomeratum)*	x		x							x
Xyridaceae										
Mountain yellow-eyed grass *(Xyris montana)*	x		x							x

[a] N means no legal status, not protected by law.

P means protected by Minnesota law, Minn. Stat. §17.23.

R means rare in Minnesota but adequately represented in adjacent regions of United States or Canada.

U means status unspecified in adjacent regions of United States or Canada.

[b] Occurs only in very localized areas.

as on control areas located at least 30 miles (48.3 km) from the Station. The field work is divided into 3 parts:

- Description of the terrestrial vegetation including a search for rare and endangered species;
- Identification of possible air pollution damage and other types of diseases and stresses currently existing in terrestrial vegetation; and
- Description of terrestrial wildlife including a search for rare and endangered species.

The objectives for the part of the study describing the terrestrial vegetation are threefold:

- Describe the vegetational setting of the study area using the relevé method:
- Search for rare and endangered species throughout the study area and describe their habitats using the relevé method; and
- Compile a flora (plant list) of the vascular plants found within the terrestrial habitats of the study area and document each listing with at least one voucher specimen. In addition, soil samples and specific plants (mossess and lichens) will be collected as archive material for possible future reference.

Identification of possible air pollution damage and other currently existing vegetation diseases and stresses will require 4 steps:

- Survey for air pollution injury and other types of stresses (disease) problems on the vegetation in the area;
- Foliar analysis for total sulfur in selected sensitive vegetation;
- Soil analysis for pH and available sulfur; and
- Lichen study and perhaps limited sampling for sulfur analysis.

The objectives for the part of the study describing the terrestrial wildlife are:

- Describe the wildlife setting of the study area using the relevés established for describing the vegetation setting;
- Search for rare and endangered species throughout the study area and describe their habitat; and
- Compile a species list for large mammals, small mammals, large birds, song birds, reptiles, and amphibians found within the terrestrial habitats of the study area and collect small mammal samples for use as archives.

The final report on the terrestrial vegetation and wildlife studies will be prepared and submitted to the MPCA by the end of Spetember 1977. This supplemental report will consist of a detailed description of the terresrial environmental setting and finalized projections of the probable terrestrial impacts of MP&L's proposed Unit 4 and other reasonable alternatives.

TERRESTRIAL WILDLIFE

Introduction

Because of the mobile nature of most wildlife species, it is not appropriate to divide the discussion of wildlife into "regional", local", and "site-specific" subsections. Rather, the following description is divided according to the major vegetation community types found in the vicinity (i.e. within 30 miles (48.28 km)) of the Clay Boswell Steam Electric Generating Station. These 9 communities are described in the preceeding section on terrestrial vegetation and soils. The radius of 30 miles (48.28 km) is thought to encompass the area of probable significant impact of the Clay Boswell Station. Most of the following information is taken from available literature. Where appropriate, wildlife observations made by MP&L are included. Table IV-77 contains a listing of the terrestrial vertebrates which may occur as residents or migrants in the vicinity of the Clay Boswell Station. At the end of this section special attention is given to rare and endangered species of wildlife. A search for resident species of wildlife within 12 miles (19.312 km) will be made during the summer 1977 field study to be conducted by Ronald M. Hays and Associates. The habitat of the resident endangered species will also be studied and described at that time, and a limited amount of song bird census data will be collected. In addition, small mammals will be collected, and their tissues will be appropriately stored to permit future analysis for heavy metals and other indices of environmental contaimination (refer to Terrestrial Vegetation and Soils section of Chapter IV for a more complete discussion of the objectives of the summer study).

At one time, wildlife species such as the fisher (*Martes americana*), timber wolf (*Canis lupus*), Canada lynx (*Lynx canadensis*), and spruce grouse (*Canachites canadensis*) were common in north central Minnesota (172). However, the cutting of forests, draining of swamps, and plowing of land destroyed or altered many of the original habitats and created new ones. Some wildlife species may be restricted to very specific habitat types, and when these habitats are removed, the animals may move elsewhere. But, as one type of habitat is destroyed another is created. Geographic ranges of wildlife are thus alternately restricted or expanded by man's activities. Human activities have provided new habitats for such animals as the white-tailed deer (*Odocoileus virginianus*), coyote (*Canis latrans*), raccoon (*Procyon lotor*), badger (*Taxidea taxus*), and other mammals and a variety of birds (172).

Notable species currently found in the vicinity of the Clay Boswell Station include the timber wolf and the bald eagle (*Haliatus leucocephalus*). The largest remaining concentrations of bald eagles nesting in the continental United States is centered in the Chippewa National Forest, the eastern border of which is only 9 km west of the Clay Boswell Station.

Vegetation of the region governs habitat types and in turn determines wildlife species distribution and populations. Three important components of the plant community influence the suitability of habitat for wildlife species: age, species composition, and dispersion (172). Some forms of wildlife require a young forest, others require old forest. Some need a predominantly coniferous forest type, while others thrive only in hardwood types. Still others require a combination of wetlands and forested or open uplands. Most species of wildlife,

TABLE IV-77
TERRESTRIAL VERTEBRATES WHICH MAY OCCUR IN VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION (158-171)

Species[a]	Habitat	Breeding Range in Minnesota	Relative Abundance[b]	Comments[c]
(C) Amphibia				
Mudpuppy *(Necturus maculosus)*	permanent bodies of water	probably statewide except southwest corner	present	
Central newt *(Diemictylus viridescens louisianensis)*	semi-permanent ponds or lakes bordered by forest lands with heavy leaf mold and fallen logs	Mississippi River valley to its headwaters plus the northeast	present	
Jefferson salamander *(Ambystoma jeffersonianum)*	heavy, undisturbed hardwood or mixed forests with many rotting logs and semi-permanent water	from Twin Cities north to northeast and north central part of State	present	
Tiger salamander *(Ambystoma tigrinum)*	hide in moist, covered, protected, undisturbed situations	all but the northeast quarter	present	
Red-backed salamander *(Plethodon cinereus)*	wooded areas, sometimes in dry, but usually in moist, situations	heavily wooded part of state	possible	
American toad *(Bufo americanus)*	city backyards to wilderness where there is shallow water	statewide	regular	observed on site
Spring peeper *(Hyla crucifer)*	brushy, second growth woodlots near semi-permanent water	eastern half (and wooded portions) of state	present	
Eastern gray treefrog *(Hyla versicolor versicolor)*	in trees or shrubs, usually near shallow bodies of water	most of state except southwest and Lake of the Woods area	present	
Boreal chorus frog *(Pseudacris triseriata maculata)*	marshy environs of ponds, lakes, and meadows	statewide except the southeastern corner	present	
Mink frog *(Rana septentrionalis)*	bogs	northeastern and northcentral Minnesota	present	
Northern leopard frog *(Rana pipiens pipiens)*	meadows, ponds	statewide	present	observed on site
Green frog *(Rana clamitans melanota)*	found wherever there is shallow water in wooded areas	eastern half (wooded portion) of state	present	
Wood frog *(Rana sylvatica)*	moist wooded areas	northern two-thirds (except western portion) of state	present	observed on site
(C) Reptilia				
Common snapping turtle *(Chelydra serpentina)*	any permanent body of water	statewide	regular	observed on site
Western painted turtle *(Chrysemys picta bellii)*	ponds and lakes with abundant aquatic vegetation	statewide	present	observed on site
Black-banded skink *(Eumeces septentrionalis septentrionalis)*	dry, soft, sandy soils with vegetation to afford cover and food	all but northeast quarter, is along St. Croix River and in Beltrami County	possible	
Northern red-bellied snake *(Storeria occipitomaculata occipitomaculata)*	open woodlands, also near sphagnum bogs	all but southwest part of state	present	
Eastern garter snake *(Thamnophis sirtalis sirtalis)*	moist woodlands	eastern half of state, mostly east of Mississippi River	common	observed on site
Eastern hognose snake *(Heterodon platyrhinus)*	loose, sandy soils	eastern half of state, especially along St. Croix and Mississippi River	possible	
Smooth green snake *(Opheodrys vernalis vernalis)*	glades and rocky or grassy meadows	from the northwest through the Mississippi River Headwaters Region to St. Croix River	possible	

TABLE IV-77 (continued)
TERRESTRIAL VERTEBRATES WHICH MAY OCCUR IN VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION (158-171)

Species[a]	Habitat	Breeding Range in Minnesota	Relative Abundance[b]	Comments[c]
(C) Aves				
(O) Gaviiformes				
Common loon *(Gavia immer)*	nests along lakes and rivers; common		common migrant	observed on site
Red-throated loon *(Gavia stellata)*			uncommon migrant	
(O) Podicipediformes				
Red-necked grebe *(Podiceps grisegena)*	nests in reeds and rushes on edges of deep water lakes; rare		common spring migrant, uncommon fall migrant	
Horned grebe *(Podiceps auritus)*			common migrant	
Pied-billed grebe *(Podilymbus podiceps)*	abundant; nests along sloughs, open and reedy marshy shores		common migrant	observed on site
(O) Pelecaniformes				
White pelican *(Pelecanus erythrorhynchos)*			rare migrant	
Double-crested cormorant *(Phalacrocorax auritus)*	rare; colonial nester in tops of trees		common migrant	
(O) Anseriformes				
Whistling swan *(Olor columbianus)*			common migrant	
Canada goose *(Branta canadensis)*	nests in marshes, bogs, or dry ground		common migrant	observed on site
White-fronted goose *(Anser albifrons)*			rare migrant	
Snow goose *(Chen caerulescens)*			common migrant	
Mallard *(Anas platyrhynchos)*	nests on ground in thick grass, bushes in meadows, swamps, or upland		common migrant	observed on site
Black duck *(Anas rubripes)*	nests in meadows and marshes or upland		common migrant	
Pintail *(Anas acuta)*	nests on low dry uplands in grass or under bushes, often far from water		common migrant	
Green-winged teal *(Anas crecca)*	nests on dry ground in grasses or bushes near a lake or marsh; rare		common migrant	observed on site
Blue-winged teal *(Anas discors)*	nests in marsh or meadow or adjacent upland; abundant		common migrant	observed on site
Gadwall *(Anas strepera)*			common migrant	obseıved on site
American wigeon *(Anas americana)*	nests on dry ground some distance from water; common		common migrant	
Northern shoveler *(Anas clypeata)*			uncommon migrant in spring rare in fall	
Wood duck *(Aix sponsa)*	nests in cavity of tree near or far from water from water; common		common migrant	observed on site
Redhead *(Aythya americana)*			comomon migrant	observed on site

TABLE IV-77 (continued)
TERRESTRIAL VERTEBRATES WHICH MAY OCCUR IN VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION (158-171)

Species[a]	Habitat	Breeding Range in Minnesota	Relative Abundance[b]	Comments[c]
(C) Aves				
(O) Anseriformes (continued)				
Ring-necked duck *(Aythya collaris)*	nests on shores of marshy lakes; common		common migrant	observed on site
Canvasback *(Aythya valisineria)*			common migrant	
Greater scaup *(Aythya marila)*			uncommon migrant	
Lesser scaup *(Aythya affinis)*			abundant migrant	
Common goldeneye *(Bucephala clangula)*	nests on wooded lakes and streams		common migrant; winter visitant where there is open water along the Mississippi	
Oldsquaw *(Clangula hyemalis)*			rare migrant	
Bufflehead *(Bucephala albeola)*			common migrant	
White-winged scoter *(Melanitta deglandi)*			rare migrant	
Surf scoter *(Melanitta perspicillata)*			rare migrant	
Black scoter *(Melanitta nigra)*			rare migrant in fall	
Ruddy duck *(Oxyura jamaicensis)*			rare migrant	
Hooded merganser *(Lophodytes cucullatus)*	nests in holes in trees in woodland swamps and ponds		common migrant	
Common merganser *(Mergus merganser)*	nests on ground under logs, boulders, branches or in dense woods or brush		common migrant	
Red-breasted merganser *(Mergus serrator)*			common migrant	
(O) Falconiformes				
Turkey vulture *(Cathartes aura)*	nests on ground by logs, brush, rocks, or on rocky ledges		uncommon migrant	
Goshawk *(Accipiter gentilis)*	nests in tree tops in forested regions		rare migrant	
Cooper's hawk *(Accipiter cooperii)*	nests in trees 15 to 20 ft up in wooded areas		uncommon migrant	
Sharp shinned hawk *(Accipiter striatus)*	nests in forested areas, nests in trees 25 to 50 ft from ground		uncommon migrant	
Red-tailed hawk *(Buteo jamaicensis)*	usually nests in trees, but can also nest on rock ledges; common		common migrant abundant on peak days of spring migration along major rivers	observed on site
Broad-winged hawk *(Buteo platypterus)*	nests 12 to 40 ft up in trees; common		common migrant	
Rough-legged hawk *(Buteo lagopus)*			common migrant	observed on site

TABLE IV-77 (continued)
TERRESTRIAL VERTEBRATES WHICH MAY OCCUR IN VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION (158-171)

Species[a]	Habitat	Breeding Range in Minnesota	Relative Abundance[b]	Comments[c]
(C) Aves				
(O) Falconiformes (continued)				
Golden eagle *(Aquila chrysaëtos)*			uncommon migrant in fall, rare in spring	
Bald eagle *(Haliaeetus leucocephalus)*	nests in forested area, in tree tops and near open water		uncommon migrant	observed on site
Marsh hawk *(Circus cyaneus)*	nests on ground in open or bushy meadow; common		common migrant	observed on site
Osprey *(Pandion haliaetus)*	nests in tops of dead trees not far from water		uncommon migrant	observed on site
Peregrine falcon *(Falco peregrinus)*			rare migrant	
Merlin *(Falco columbarius)*	nests, hollow trees, on cliffs,river bluff; rare		rare migrant	
American Kestral *(Falco sparverius)*	nests in hole in tree or cavity; common		common migrant	observed on site
(O) Galliformes				
Spruce grouse *(Canachites canadensis)*	nests in conifer forest		permanent resident	
Ruffed grouse *(Bonasa umbellus)*	nests in deciduous woods, usually near aspen		permanent resident	observed on site
Sharp-tailed grouse *(Pedioecetes phasianellus)*	nests in prairies, brushlands, and open bogs		permanent resident	
(O) Ciconiiformes				
Great blue heron *(Ardea herodias)*	colonial tree top nester, often on islands in lakes and rivers		common migrant	observed on site
Green heron *(Butorides virescens)*			rare to casual migrant	
American bittern *(Botaurus lentiginosus)*	nests in marshes, bogs, and lakes, fringed with cattails and/or bulrushes		common migrant	
(O) Gruiformes				
Sandhill crane *(Grus canadensis)*			rare migrant	
Virginia rail *(Rallus limicola)*	nests in a marsh or slough		rare migrant	observed on site
Sora *(Porzana carolina)*	nests in marshes and sloughs		common migrant in spring, uncommon in fall	
Yellow rail *(Coturnicops noveboracensis)*	nests in marshes and wet meadows several inches above the water; rare		rare migrant	
American coot *(Fulica americana)*	resident throughout state, main nesting range west of the Mississippi		abundant migrant	observed on site
(O) Charadriiformes				
Semipalmated plover *(Charadrius semipalmatus)*			uncommon migrant	

TABLE IV-77 (continued)

TERRESTRIAL VERTEBRATES WHICH MAY OCCUR IN VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION (158-171)

Species [a]	Habitat	Breeding Range in Minnesota	Relative Abundance [b]	Comments [c]
(C) Aves				
(O) Charadriiformes (continued)				
Piping plover *(Charadrius melodus)*			rare migrant	
Killdeer *(Charadrius vociferus)*	nests in shallow depression on ground; common		common migrant	observed on site
American golden plover *(Pluvialis dominica)*			common migrant	
Black-bellied plover *(Pluvialis squatarola)*			uncommon migrant	
Ruddy turnstone *(Arenaria interpres)*			uncommon migrant in spring, rare in fall	
American woodcock *(Philohela minor)*	nests on ground under wooded thicket near wet lowland		common to uncommon migrant	observed on site
Common snipe *(Capella gallinago)*	nests on hummock in dry grass in a bog or swamp		common migrant	
Upland sandpiper *(Bartramia longicauda)*	nests in depression on ground in grass of prairies or areas of some woods; scarce		local and rare migrant	
Solitary sandpiper *(Tringa solitaria)*			uncommon migrant	
Spotted sandpiper *(Actitis macularia)*	nests in depression on ground usually near beaches or sand-bars; most numerous in state in northern Minnesota and along the Mississippi		common migrant	observed on site
Greater yellowlegs *(Tringa melanoleucus)*			uncommon migrant	observed on site
Lesser yellowlegs *(Tringa flavipes)*			common migrant	
Willet *(Catoptrophorus semipalmatus)*			rare migrant	
Pectoral sandpiper *(Calidris melanotos)*			common migrant	
White-rumped sandpiper *(Calidris fuscicollis)*			uncommon migrant in spring, rare in fall	
Baird's sandpiper *(Calidris bairdii)*			uncommon migrant	
Least sandpiper *(Calidris minutilla)*			uncommon migrant in spring, common in fall	
Dunlin *(Calidris alpina)*			uncommon migrant in spring, rare in fall	
Semipalmated sandpiper *(Calidris pusillus)*			common migrant	

TABLE IV-77 (continued)
TERRESTRIAL VERTEBRATES WHICH MAY OCCUR IN VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION (158-171)

Species[a]	Habitat	Breeding Range in Minnesota	Relative Abundance[b]	Comments[c]
(C) Aves				
(O) Charadriiformes (continued)				
Sanderling *(Calidris alba)*			common to uncommon migrant	observed on site
Short-billed dowitcher *(Limnodromus griseus)*			rare migrant	
Long-billed dowitcher *(Limnodromus scolopaceus)*			uncommon migrant in spring, rare in fall	
Stilt sandpiper *(Micropalama himantopus)*			rare migrant in fall	
Buff-breasted sandpiper *(Tryngites subruficollis)*			rare migrant in fall	
Marbled godwit *(Limosa fedoa)*			rare migrant in spring	
Hudsonian godwit *(Limosa haemastica)*			rare migrant in spring	
Herring gull *(Larus argentatus)*			common to locally abundant migrant around lakes and rivers	
Ring-billed gull *(Larus delawarensis)*			abundant migrant	
Franklin's gull *(Larus pipixcan)*			rare migrant	
Bonaparte's gull *(Larus philadelphia)*	rare visitant in summer		common migrant	observed on site
Common tern *(Sterna hirundo)*	nests in colonies, on large lakes in depression on sandy or gravel beaches or islands		common to uncommon migrant	
Caspian tern *(Hydroprogne caspia)*	rare to locally uncommon summer visitant around large lakes		common migrant	
Black tern *(Chlidonias niger)*	nests in marshes or sloughs and on floating debris or muskrat houses		abundant migrant in spring, common in fall	
(O) Columbiformes				
Rock dove *(Columba livia)*	nests on buildings		permanent resident	observed on site
Mourning dove *(Zenaida macroura)*	resident except in heavily wooded parts of Itasca County; nests in lower limbs of trees		uncommon migrant	observed on site
(O) Cuculiformes				
Yellow-billed cuckoo *(Coccyzus americanus)*			rare migrant in spring	
Black-billed cuckoo *(Coccyzus erythropthalmus)*	nests 2 to 3 ft from ground in tangled undergrowth or limbs of trees		uncommon migrant	

TABLE IV-77 (continued)
TERRESTRIAL VERTEBRATES WHICH MAY OCCUR IN VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION (158-171)

Species[a]	Habitat	Breeding Range in Minnesota	Relative Abundance[b]	Comments[c]
(C) Aves				
(O) Strigiformes				
Great horned owl *(Bubo virginianus)*	nests in tree hollow or old hawk or crow nest		permanent resident	observed on site
Snowy owl *(Nyctea scandiaca)*			rare to uncommon migrant in fall, rare in spring, varies sharply year to year	
Hawk owl *(Surnia ulula)*			rare winter visitant	
Barred owl *(Strix varia)*	nests near swamps and river bottoms		permanent resident	
Great gray owl *(Strix nebulosa)*			rare winter visitant	
Long-eared owl *(Asio otus)*	nests fairly commonly in deciduous or coniferous woods near open spaces		rare migrant	
Short-eared owl *(Asio flammeus)*	common in open countrv over plains, sloughs, marshes, and wet meadows		uncommon migrant	
Boreal owl *(Aegolius funereus)*			regular but rare winter vistant	
Sa.. whet owl *(Aegolius acadicus)*	roosts in dense young evergreens and thickets		rare migrant	
(O) Caprimulgiformes				
Whip-poor-will *(Caprimulgus vociferus)*			rare spring migrant	
Common nighthawk *(Chordeiles minor)*	common; nesting in rocky openings in the woods		abundant migrant	observed on site
(O) Apodiformes				
Chimney swift *(Chaetura pelagica)*	most abundant around human habitation; in heavily forested area, nests in hollow trees		abundant migrant	
Ruby-throated hummingbird *(Archilochus colubris)*	common near tubular flowers, gardens, woods		common migrant	observed on site
(O) Coraciiformes				
Belted kingfisher *(Megaceryle alcyon)*	common along streams and ponds		common migrant	observed on site
(O) Piciformes				
Common flicker *(Colaptes auratus)*	common in open country near large trees		abundant migrant	observed on site
Pileated woodpecker *(Dryocopus pileatus)*	found in extensive deciduous or mixed forests; uncommon		permanent resident	
Red-headed woodpecker *(Melanerpes erythrocephalus)*	open, deciduous woods; uncommon		common to uncommon migrant	observed on site

TABLE IV-77 (continued)
TERRESTRIAL VERTEBRATES WHICH MAY OCCUR IN VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION (158-171)

Species[a]	Habitat	Breeding Range in Minnesota	Relative Abundance[b]	Comments[c]
(C) Aves				
(O) Piciformes (continued)				
Yellow-bellied sapsucker *(Sphyrapicus varius)*	common in woods and orchards		uncommon migrant	observed on site
Hairy woodpecker *(Dendrocopos villosus)*	nests in deciduous or mixed forests in hole in dead or living tree; common		permanent resident	observed on site
Downy woodpecker *(Dendrocopos pubescens)*	nests in dead or living trees in woods, orchards, suburbs		permanent resident	observed on site
Black-backed three-toed woodpecker *(Picoïdes arcticus)*	nests in coniferous forest, usually in holes of living trees		rare migrant, rare winter visitant	
(O) Passeriformes				
(F) Tyrannidae				
Eastern kingbird *(Tyrannus tyrannus)*	nests in open to semi-open country, usually on horizontal limb of tree		common migrant	observed on site
Great crested flycatcher *(Myiarchus crinitus)*	nests in cavity in dead limb of tree or rotten stub or in river valleys		uncommon migrant	
Eastern phoebe *(Sayornis phoebe)*	nests in old buildings, under eaves, under bridges		uncommon migrant	observed on site
Yellow-bellied flycatcher *(Empidonax flaviventris)*	nests on ground or in a mossy hummock or moss covered roots		uncommon migrant	
Willow flycatcher *(Empidonax traillii)*			uncommon migrant	observed on site
Alder flycatcher *(Empidonax alnorum)*	nests in boreal forest		uncommon migrant	
Least flycatcher *(Empidonax minimus)*	nests in scrub growth, wood margin, on limb or crotch of tree		common migrant	observed on site
Eastern wood pewee *(Contopus virens)*	nests in deciduous or mixed woods on a horizontal limb, often on dead tree		uncommon migrant	observed on site
Olive-sided flycatcher *(Nuttallornis borealis)*	nests in coniferous forests, usually far out on limb		uncommon migrant	
(F) Alaudidae				
Horned lark *(Eremophila alpestris)*	scarce; in semi-open to open fields		common migrant	
(F) Hirundinidae				
Barn swallow *(Hirundo rustica)*	common near farms, buildings		common migrant	observed on site
Cliff swallow *(Petrochelidon pyrrhonota)*	bulb shaped nests of mud built under eaves, or in shelter of cliffs, dams, or bridges		common to abundant migrant	observed on site
Tree swallow *(Iridoprocne bicolor)*	nests in hole in tree, fence, rotten stub, etc.; common		abundant migrant	observed on site
Rough-winged swallow *(Stelgidopteryx ruficollis)*	common, especially near water, nests on bank of river or lake		common migrant	
Purple martin *(Progne subis)*	most common along Mississippi river		abundant migrant	
Bank swallow *(Riparia riparia)*	common near steep river banks, gravel pits		uncommon migrant usually	

TABLE IV-77 (continued)
TERRESTRIAL VERTEBRATES WHICH MAY OCCUR IN VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION (158-171)

Species[a]	Habitat	Breeding Range in Minnesota	Relative Abundance[b]	Comments[c]
(C) Aves				
(O) Passeriformes (continued)				
(F) Corvidae				
Gray jay *(Perisoreus canadensis)*	common in coniferous forests		permanent resident	observed on site
Blue jay *(Cyanocitta cristata)*	common in oak, pine woods		common to abundant migrant, winter resident as well	observed on site
Black-billed magpie *(Pica pica)*			common to rare migrant	
Common raven *(Corvus corax)*	common in heavy timber		permanent resident	
Common crow *(Corvus brachyrhynchos)*	in woodlots, near crops and streams and variety of habitats		permanent resident	observed on site
(F) Paridae				
Black-capped chickadee *(Parus atricapillus)*	common in all wooded areas		permanent resident	observed on site
Boreal chickadee *(Parus hudsonicus)*	coniferous forests		permanent resident	
(F) Sittidae				
White-breasted nuthatch *(Sitta carolinensis)*	deciduous woodlands		permanent resident	observed on site
Red-breasted nuthatch *(Sitta canadensis)*	common in conifers		permanent resident	
(F) Certhiidae				
Brown creeper *(Certhia familiaris)*	woodlands		common migrant, winter resident	
(F) Troglodytidae				
House wren *(Troglodytes aedon)*	common in shrubbery and brush		common migrant	
Winter wren *(Troglodytes troglodytes)*	brush piles, thick undergrowth in moist forests, spruce, cedar, dense pine		uncommon migrant	
Long-billed marsh wren *(Telmatodytes palustris)*	scarce, needs reeds or cattails over water for nesting		uncommon migrant	
Short-billed marsh wren *(Cistothorus platensis)*	nests in damp meadows a few inches above water		common migrant	observed on site
(F) Mimidae				
Gray catbird *(Dumetella carolinensis)*	nests in bushes and vine tangles near ground, common except in coniferous forests		common migrant	observed on site
Mockingbird *(Mimus polyglottos)*	nests in bushes or trees in semi-open areas, regular but rare		rare migrant	
Brown thrasher *(Toxostoma rufum)*	nests in thick bushes, small trees, or tangled vines, absent from dense mixed conifer forests		common migrant	

TABLE IV-77 (continued)
TERRESTRIAL VERTEBRATES WHICH MAY OCCUR IN VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION (158-171)

Species[a]	Habitat	Breeding Range in Minnesota	Relative Abundance[b]	Comments[c]
(C) Aves				
(O) Passeriformes (continued)				
(F) Turdidae				
Robin *(Turdus migratorius)*	nests in woodland, parks, orchards, and cities in trees		abundant migrant	observed on site
Eastern bluebird *(Sialia sialis)*	nests throughout state in suitable habitat; in cavity in tree, fence, post, etc.; absent from dense northern forests		uncommon migrant	
Gray-cheeked thrush *(Catharus minimus)*			uncommon migrant	
Wood thrush *(Hylocichla mustelina)*	nests in crotch of small tree, absent in heavy coniferous forests		rare migrant	observed on site
Hermit thrush *(Catharus guttatus)*	usually nests on ground in moist woods		common to uncommon migrant	
Swainson's thrush *(Catharus ustulatus)*	nests in small tree or bushes in evergreen forests		common migrant	
Veery *(Catharus fuscescens)*	nests on or near ground in moist deciduous woods		common migrant in spring, uncommon in fall	observed on site
(F) Sylviidae				
Golden-crowned kinglet *(Regulus satrapa)*	nests in coniferous forests		common migrant	
Ruby-crowned kinglet *(Regulus calendula)*	common in conifers		common migrant	observed on site
(F) Motacillidae				
Water pipit *(Anthus spinoletta)*			uncommon migrant in spring, common in fall	
(F) Bombycillidae				
Bohemian waxwing *(Bombycilla garrulus)*			erratic in abundance and distribution	
Cedar waxwing *(Bombycilla cedrorum)*			common to abundant migrant	observed on site
(F) Laniidae				
Northern shrike *(Lanius excubitor)*			uncommon migrant, uncommon winter visitant	
Loggerhead shrike *(Lanius ludovicianus)*	very rare; on tree tops, poles		rare migrant	
(F) Sturnidae				
Starling *(Sturnus vulgaris)*	abundant around cities, parks, suburbs, farms		permanent resident	observed on site

TABLE IV-77 (continued)
TERRESTRIAL VERTEBRATES WHICH MAY OCCUR IN VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION (158-171)

Species[a]	Habitats	Breeding Range in Minnesota	Relative Abundance[b]	Comments[c]
(C) Aves				
(O) Passeriformes (continued)				
(F) Vireonidae				
Solitary vireo *(Vireo solitarius)*	faily common in mixed coniferous deciduous forests		uncommon migrant	observed on site
Red-eyed vireo *(Vireo olivaceus)*	common in deciduous forests		common migrant	observed on site
Philadelphia vireo *(Vireo philadelphicus)*	uncommon; wood margin of deciduous scrub		uncommon migrant	
Warbling vireo *(Vireo gilvus)*	scarce; resident of tall deciduous shade trees		uncommon to rare migrant	
(F) Parulidae				
Black-and-white warbler *Mniotilta varia)*	deciduous woods		common migrant	
Golden-winged warbler *(Vermivora chrysoptera)*	in birch and other young deciduous growth and in abandoned pastures		rare migrant	
Tennessee warbler *(Vermivora peregrina)*	scarce; in aspen and spruce woods		abundant migrant	
Orange-crowned warbler *(Vermivora celata)*			common migrant	
Nashville warbler *(Vermivora ruficapilla)*	nests on ground in sphagnum moss in wooded swamps, also common in second growth deciduous forests		abundant migrant	observed on site
Northern parula *(Parula americana)*	in mature deciduous and coniferous forests, builds nest from lichens		rare migrant	
Yellow warbler *(Dendroica petechia)*	nests in willow thickets, orchards, and shrubbery		common migrant in spring, uncommon in fall	observed on site
Magnolia warbler *(Dendroica magnolia)*	common in hemlock and conifer forests		common migrant	
Cape May warbler *(Dendroica tigrina)*	nests in spruce and fir		rare migrant	
Black-throated blue warbler *Dendroica caerulescens)*	nests up to three ft from ground in brush, deciduous or coniferous		rare migrant	
Yellow-rumped warbler *(Dendroica coronata)*	nests in trees of coniferous forests		abundant migrant	observed on site
Black-throated green warbler *(Dendroica virens)*	nests high in conifers or oaks		uncommon migrant	
Blackburnian warbler *(Dendroica fusca)*	treetops of spruce-fir forests		common migrant in spring, uncommon in fall	observed on site
Chestnut-sided warbler *(Dendroica pensylvanica)*	common in deciduous brush, nests two to three ft from ground		common migrant	observed on site
Bay-breasted warbler *(Dendroica castanea)*	scarce; in conifer forests		uncommon migrant in spring, common in fall	

TABLE IV-77 (continued)
TERRESTRIAL VERTEBRATES WHICH MAY OCCUR IN VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION (158-171)

Species[a]	Habitat	Breeding Range in Minnesota	Relative Abundance[b]	Comments[c]
(C) Aves				
(O) Passeriformes (continued)				
(F) Parulidae (continued)				
Blackpoll warbler *(Dendroica striata)*			common migrant	
Pine warbler *(Dendroica pinus)*	most numerous in mature pines		rare to uncommon migrant	
Palm warbler *(Dendroica palmarum)*	common only in open bogs, where it nests on the ground		abundant migrant	
Ovenbird *(Seiurus aurocapillus)*	resident of wooded, usually deciduous, areas		common migrant	observed on site
Northern waterthrush *(Seiurus noveboracensis)*	common in northern bogs		uncommon migrant	
Connecticut warbler *(Oporornis agilis)*	found in tamarack-black spruce bogs and upland jack pine and aspen		rare migrant	
Mourning warbler *(Oporornis philadelphia)*	heavy underbrush of wooded areas		common migrant	
Common yellowthroat *(Geothlypis trichas)*	abundant in most grassy or shrubby areas		common migrant	observed on site
Wilson's warbler *(Wilsonia pusilla)*			common migrant	
Canada warbler *(Wilsonia canadensis)*	northern forest underbrush		uncommon migrant	
American Redstart *(Setophaga ruticilla)*	deciduous forest understory		common migrant	observed on site
(F) Ploceidae				
House sparrow *(Passer domesticus)*			permanent resident around settled areas	
(F) Icteridae				
Bobolink *(Dolichonyx oryzivorus)*	present wherever suitable grassy lowlands habitat is present		uncommon migrant	observed on site
Eastern meadowlark *(Sturnella magna)*	in fields and on fences		common to rare migrant	
Western meadowlark *(Sturnella neglecta)*	locally numerous in open fields		common migrant	
Yellow-headed blackbird *(Xanthocephalus xanthocephalus)*			rare migrant	
Red-winged blackbird *(Agelaius phoeniceus)*	abundant in fields and marshes		abundant migrant	observed on site
Northern oriole *(Icterus galbula)*	in tall deciduous trees		common migrant in spring, uncommon in fall	observed on site
Rusty blackbird *(Euphagus carolinus)*			common migrant in spring, abundant in fall	

TABLE IV-77 (continued)
TERRESTRIAL VERTEBRATES WHICH MAY OCCUR IN VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION (158-171)

Species[a]	Habitat	Breeding Range in Minnesota	Relative Abundance[b]	Comments[c]
(C) Aves				
(O) Passeriformes (continued)				
(F) Icteridae (continued)				
Brewer's blackbird *(Euphagus cyanocephalus)*	nest in colonies on ground in meadows and fields		common migrant	observed on site
Common grackle *(Quiscalus quiscula)*	abundant on farmland, nests in conifer if possible		abundant migrant	observed on site
Brown-headed cowbird *(Molothrus ater)*	parasitises on other birds' nests; openings, uplands, and fields		abundant migrant in spring, uncommon in fall	observed on site
(F) Thraupidae				
Scarlet tanager *(Piranga olivacea)*	nests in deciduous or pine-oak forests		uncommon migrant	
(F) Fringillidae				
Cardinal *(Cardinalis cardinalis)*			possible resident	
Rose-breasted grosbeak *(Pheucticus ludovicianus)*	nests in trees or bushes of deciduous woods or old orchards		common migrant	observed on site
Indigo bunting *(passerina cyanea)*	nests in bushes or hedgerows, along wood margins		common migrant	observed on site
Evening grosbeak *(Hesperiphona vespertina)*	locally abundant in conifers		common but erratic migrant	
Purple finch *(Carpodacus purpureus)*	usually nests in evergreen in open woods		common migrant	observed on site
Pine grosbeak *(Pinicola enucleator)*	nests in conifer forests, on lower branches of trees		common migrant, also common winter visitant	
Hoary redpoll *(Acanthis hornemanni)*			rare migrant, rare winter visitant	
Common redpoll *(Acanthis flammea)*			common migrant, common winter visitant	
Pine sisken *(Spinus pinus)*	irregularly common in conifers		common migrant, erratic winter visitant	
American goldfinch *(Spinus tristis)*	weedy fields, bushes, seed-bearing trees		common to abundant migrant	observed on site
Red crossbill *(Loxia curvirostra)*	irregular nesting in coniferous forests		erratic migrant, erratic winter visitant	
White-winged crossbill *(Loxia leucoptera)*			varying from rare to abundant migrant, winter visitant	
Rufous-sided towhee *(Pipilo erythrophthalmus)*	brush, heavy undergrowth, wood margins, hedgerows		uncommon migrant	

TABLE IV-77 (continued)
TERRESTRIAL VERTEBRATES WHICH MAY OCCUR IN VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION (158-171)

Species[a]	Habitat	Breeding Range in Minnesota	Relative Abundance[b]	Comments[c]
(C) Aves				
(O) Passeriformes (continued)				
(F) Fringillidae (continued)				
Savannah sparrow *(Passerculus sandwichensis)*	numerous in low-lying grass fields		common migrant	observed on site
Grasshopper sparrow *(Ammodramus savannarum)*			rare migrant	observed on site
Le Conte's sparrow *(Ammospiza leconteii)*	tall marsh grass		uncommon to rare migrant	
Vesper sparrow *(Pooecetes gramineus)*	meadows, pastures, fields		common migrant	
Dark-eyed junco *(Junco hyemalis)*	brushy clearings and borders of coniferous forests		abundant migrant	
Sharp-tailed sparrow *(Ammospiza caudacuta)*			rare to uncommon migrant	
Tree sparrow *(Spizella arborea)*			abundant migrant, rare winter visitant	
Chipping sparrow *(Spizella passerina)*	sparse grass under scattered trees		common migrant	
Clay-colored sparrow *(Spizella pallida)*	open brushland		uncommon migrant	
Field sparrow *(Spizella pusilla)*			very rare migrant	observed on site
Harris' sparrow *(Zonotrichia querula)*			uncommon migrant	
White-crowned sparrow *(Zonotrichia leucophrys)*	thickets, hedgerows, or wood margins adjacent to fields or open areas		uncommon migrant	
White-throated sparrow *(Zonotrichia albicollis)*	dense undergrowth and brush		abundant migrant, very rare winter visitant	observed on site
Fox sparrow *(Passerella iliaca)*			uncommon migrant	
Lincoln's sparrow *(Melospiza lincolnii)*			uncommon migrant	observed on site
Swamp sparrow *(Melospiza georgiana)*	bogs and marshes, but not heavily wooded swamps		common to uncommon migrant	
Song sparrow *(Melospiza melodia)*	common; in moist areas with bushes, hedgerows, and wood margins		common migrant	observed on site
Lapland longspur *(Calcarius lapponicus)*			common migrant	
Snow bunting *(Plectrophenax nivalis)*			common migrant, common winter visitant	observed on site

TABLE IV-77 (continued)

TERRESTRIAL VERTEBRATES WHICH MAY OCCUR IN VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION (158-171)

Species[a]	Habitat	Breeding Range in Minnesota	Relative Abundance[b]	Comments[c]
(C) Mammalia				
(O) Marsupialia				
Virginia opossum *(Didelphis marsupialis virgiana)*	farming area preferred, also found in woodlands and along streams	from Twin Cities south, and in smaller numbers further north	possible	
(O) Insectivora				
Masked Shrew *(Sorex cinereus)*	moist situations, in forests, brush-land and open country, prefer conifer swamps and marshy areas with abundance of sedges and grasses	statewide	common	observed on site
Arctic shrew *(Sorex arcticus)*	tamarack and spruce bogs, moist open areas	northern half and to Twin Cities in eastern half	present	
Water shrew *(Sorex palustris)*	found in proximity to water, in bogs and covered banks	northeastern and north central to Twin Cities	present	
Pigmy shrew *(Microsorex hoyi)*	wooded and open areas, wet or dry	eastern half, plus the north-west	possible	
Short-tailed shrew *(Blarina brevicauda)*	common in all habitats, especially aspen-birch community, low-lying white cedar forests, and marshes	statewide	common	observed on site
Star-nosed mole *(Condylura cristata)*	swamps, bogs, wet meadows, in proximity to water	northeast and north central part of state, north of Twin Cities	possible	
(O) Chiroptera				
Little brown bat *(Myotis lucifugus)*	variety of habitats, utilizes caves, hollow trees, and buildings for daytime retreat	statewide	present	
Keen's myotis *(Myotis keenii)*	variety of habitats, utilizes caves, hollow trees, and buildings for daytime retreat	probably statewide	present	observed on site
Silver-haired bat *(Lasionycteris noctivagans)*	forested regions in vicinity of water	statewide	present	
Big brown bat *(Eptesicus fuscus)*	wooded areas near water, caves, tunnels, buildings	probably statewide	possible	
Red bat *(Lasiurus borealis)*	wooded areas near water, solitary	probably statewide	possible	
Hoary bat *(Lasiurus cinereus)*	wooded areas, solitary	probably statewide	possible	
(O) Lagomorpha				
Eastern cottontail *(Sylvilagus floridanus)*	broken, deciduous forests and heavy brush	most of state, excluding the northeast section	possible	
Snowshoe hare *(Lepus americanus)*	conifer forests, swamps, thickets	northern half of state	common	observed on site
(O) Rodentia				
Woodchuck *(Marmota monax)*	edges of clearings, prefers brushy area for cover and open areas for feeding	statewide except perhaps southwest corner	regular	
Thirteen-lined ground squirrel *(Spermophilus tridecemlineatus)*	shortgrass pairies, open areas, pasture lands	all but northeast corner	present	observed on site

TABLE IV-77 (continued)
TERRESTRIAL VERTEBRATES WHICH MAY OCCUR IN VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION (158-171)

Species[a]	Habitat	Breeding Range in Minnesota	Relative Abundance[b]	Comments[c]
(C) Mammalia				
(O) Rodentia (continued)				
Franklin's ground squirrel *(Spermophilus franklinii)*	brushy fields, edges of woods	all but northeast and southern corner of state	present	observed on site
Eastern chipmunk *(Tamias striatus)*	brushlands, mixed hardwoods	statewide except southwest corner	common	observed on site
Least chipmunk *(Eutamias minimus)*	disturbed, open areas, early successional stages	northern third of state	present	
Eastern gray squirrel *(Sciurus carolinensis)*	hardwood forests with nut trees	statewide	present	
Fox squirrel *(Sciurus niger)*	open hardwood forests, woodlots	all except northeastern part of state	possible	
Red squirrel *(Tamiasciurus hudsonicus)*	pine and spruce-balsam fir forests, climax forests, swamps, mixed hardwoods	statewide except southwest quarter	common	observed on site
Southern flying squirrel *(Glaucomys volans)*	woodlots and forests of deciduous or mixed deciduous-conifer forests	southern half of state plus Mississippi headwaters	possible	
Northern flying squirrel *(Glaucomys sabrinus)*	conifer forests	northern half of state	regular	observed on site
Plains pocket gopher *(Geomys bursarius)*	loose soils in open areas, grass-lands, roadsides, pastures	all but northeast quarter of state	possible	
Deer mouse *(Peromyscus maniculatus)*	common in most habitat types	statewide	common	observed on site
White-footed mouse *(Peromyscus leucopus)*	wooded or brushy areas preferred	all but northeast part of state	present	
Southern bog lemming *(Synaptomys cooperi)*	low, damp, bogs or meadows	northeast and north central part of state	regular	
Southern red-backed vole *(Clethrionomys gapperi)*	coniferous, deciduous, or mixed forests, preferring damp places	all but southern portion of state	common	observed on site
Meadow vole *(Microtus pennsylvanicus)*	prefers mesic habitats, with dense stands of grass and sedges	statewide	common	observed on site
House mouse *(Mus musculus)*	buildings and sometimes fields, where people concentrate	statewide (in urban areas)	common	
Norway rat			common	
Woodland jumping mouse *(Napaeozapus insignis)*	forested or brushy areas near water	northeast and north central part of state	regular	
Meadow jumping mouse *(Zapus hudsonius)*	found in variety of habitats, usually associated with wet marshes or low-lying areas	statewide	common	observed on site
Beaver *(Castor canadensis)*	streams, rivers and lakes, with deciduous trees on banks; alder, aspen, paper birch	statewide	regular	
Muskrat *(Ondatra zibethicus)*	marshes, ponds, lakes, streams	statewide	common	observed on site
Porcupine *(Erethizon dorsatum)*	forested areas	northern third of state	regular	sign observed on site

TABLE IV-77 (continued)
TERRESTRIAL VERTEBRATES WHICH MAY OCCUR IN VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION (158-171)

Species[a]	Habitat	Breeding Range in Minnesota	Relative Abundance[b]	Comments[c]
(C) Mammalia				
(O) Carnivora				
Black bear *(Ursus americanus)*	forested areas, concentrate around dumps	northern half	present	sign observed on site
Raccoon *(Procyon lotor)*	along streams and lake borders where there are wooded areas	statewide	present	sign observed on site
Fisher *(Martes pennanti)*	large, climax, conifer or mixed forests	northeastern and north central part of state	present	
Ermine *(Mustela erminea)*	variety of habitat types	statewide	probably common	observed on site
Long-tailed weasel *(Mustela frenata)*	found in variety of habitats, usually near water	statewide except in north-east corner of state	present	observed on site
Least weasel *(Mustela rixosa)*	meadows, fields, brushy areas and open woods	statewide	present	
Mink *(Mustela vison)*	along streams and lakes	statewide	common	
River otter *(Lutra canadensis)*	along rivers and streams	statewide	present	
Badger *(Taxidea taxus)*	open grasslands and forests where there is open area	statewide except in north-eastern part of state	possible	
Eastern spotted skunk *(Spilogale putorius)*	open and broken, sparsely wooded areas	southern half and occasionally in northwest and north central	possible	
Striped skunk *(Mephitis mephitis)*	semi-open country, mixed woods, brushland	statewide	common	observed on site
Coyote *(Canis latrans)*	prairies, open woodlands	statewide	fairly common	observed on site
Timber wolf *(Canis lupus)*	wilderness forests	northern third of state	present	sign observed on site
Red fox *(Vulpes fulva)*	mixture of forests and open country	statewide	uncommon	
Gray fox *(Urocyon cinereoargenteus)*	shrub, pioneer, and brush	southern half and occasionally in north	possible	
Lynx *(Lynx canadensis)*	boreal forests	northern part of state	possible	
Bobcat *(Lynx rufus)*	subclimax forests and brush	northern half of state	probably present	
(O) Artiodactyla				
White-tailed deer *(Odocoileus virginianus)*	swamp, open brush, and near shrub, pioneer, and climax forest stages	statewide	regular	observed on site
Moose *(Alces alces)*	forested regions with many lakes, usually sub	northeastern and north central part of state	possible	

[a] C = Class, O = Order, F = Family.

[b] Relative abundance is a subjective valuation based upon the literature and refers to the area within 30 miles (48 km) of the Clay Boswell Steam Electric Station. For Amphibia, Reptilia, and Mammalia:

Common - species well established and relatively abundant in the vicinity of the Clay Boswell Station.

Regular - species can be found in the vicinity of the Clay Boswell Station in the proper habitat on a regular basis, but is not common.

Uncommon - species is found in the vicinity of the Clay Boswell Station, but in low numbers.

Present - species is probably found in the vicinity of the Clay Boswell Station, but its status is unknown; this category makes no statement concerning relative abundance.

Possible - species could occur in the vicinity of the Clay Boswell Station but its presence in the area has never been documented.

For Aves, the relative abundance of migrants refers to Itasca, Aitkin, Beltrami, Cass, Clearwater, Hubbard, Koochiching, Lake of the Woods, and Wadena Counties, and follows Green and Janssen (161).

Abundant - daily counts of as many as 50 birds, season counts of 250 or more, by an active observer.

Common - daily counts of 6 to 50 birds, season counts of as many as 250, by an active observer.

Uncommon - daily counts of 1 to 5 birds, season counts of 5 to 25, by an active observer.

Rare - season counts of no more than 5 birds by an active observer.

[c] Observations are for the 3,599 acre (1,457 hectare) Clay Boswell Station site owned or being acquired by MP&L. The observations are reported in "Environmental Report, Clay Boswell Steam Electric Station Unit No. 4," 1976, Envirosphere Company, MP&L, New York, N.Y.

therefore, inhabit distinct vegetative types. A few species, such as the larger herbivores and carnivores, range over several vegetative types. There are 7 major naturally occurring vegetative types and 2 distinct kinds of disturbed habitats in the vicinity of the Clay Boswell Station. A brief discussion of each vegetative type and disturbed area and the habitat they provide for various wildlife species is given below. For a more detailed wildlife species list and their specific preferred habitat, refer to Table IV-77.

Hardwood Forest

The northern hardwood forest provides a diverse habitat for wildlife. Diversity of vegetation in age, species, and distribution all contribute to make the northern hardwood forest host to a great many wildlife species. The 2 types of northern hardwood forest (the northern lowland forest; wet-mesic segment and the northern mesic forest) each provide distinctly different habitats because of the different types of browse species and cover afforded by each.

The black ash and hazelnut present in the northern lowland forest; wet-mesic segment (i.e. hardwood swamp), provide winter food for the red-backed vole (*Clethrionomys gapperi*) and the deer mouse (*Peromyscus maniculatus*), the 2 species found to be the most abundant of the small mammals on the Clay Boswell Station site (Figure IV-81) (Table IV-78). Both species are important as consumers of insects, mast (acorns, etc.), seeds, and green vegetation. Among the seeds and fruits eaten by them are beaked and American hazelnut, juneberry, basswood, pin cherry, blueberry, and wintergreen (173). Both the deer mouse and the red-backed vole prefer moist conifer for deciduous stands of trees, especially where underlain by mossy logs and downed timber (174).

Another rodent common in hardwood forests and most other forest communities is the red squirrel (*Tamiasciurus hudsonicus*) (175). The main diet of the red squirrel is mast, but the soft inner bark and buds of maples, aspens, and birches are also consumed (174). The red squirrel also eats strawberries, wintergreen berries, blueberries, hazelnuts, and acorns (174). Fungi of many varieties are also eaten (174). The red squirrel is occasionally predatory upon birds and vertebrate animals, especially their eggs and young (174).

The third most abundant mammal found in the hardwood forest is the eastern chipmunk (*Tamias striatus*) (Table IV-78). This species prefers the upland hardwood forest rather than the hardwood swamp. Seeds and nuts of maple, oak, and basswood are the eastern chipmunk's principal foods (173).

Two important carnivores of the hardwood forests are the ermine (*Mustela erminea*) and the long-tailed weasel (*Mustela frenata*). The diet of the ermine includes deer mice, redbacked voles, and shrews. Consequently, the ermine will be found where these prey species are available (172). The long-tailed weasel feeds on slightly larger mammals, such as young snowshoe hares (*Lepus americanus*) and chipmunks, but it also feeds heavily upon mice (173).

The snowshoe hare often resides in hardwood forests where the forest floor is covered with dense thickets, brush, and fallen logs (173). Many species of herbaceous plants, such as clover, grasses, dandelion, strawberry, and ferns,

TABLE IV-78

MAMMAL LIVE TRAPPING DATA - CLAY BOSWELL STEAM ELECTRIC STATION SITE - AUGUST 18 TO 29, 1975[a] (176)

Habitat and Species	Number of Individuals Captured	Total Captured[b]	Estimated Mean Density individuals per hectare	Number of Trap Nights	Total Captures per 100 Trap Nights
Hardwood Forest[c]					
Shorttail shrew *(Blarina brevicauda)*	1	1	0.5	392	0.2
Deer mouse *(Peromyscus maniculatus)*	19	42	8.0	392	10.7
Boreal redback vole *(Clethrionomys gapperi)*	25	44	5.9	392	11.2
Eastern chipmunk *(Tamias striatus)*	27	39	2.4	d	d
Red squirrel *(Tamiasciurus hudsonicus)*	5[e]	d	0.5	d	d
Northern flying squirrel *(Glaucomys sabrinus)*	1	1	0.1	d	d
Snowshoe hare *(Lepus americanus)*	1	1	0.1	d	d
Ermine *(Mustela erminea)*	2	3	0.2	d	d
Longtail weasel *(Mustela frenata)*	4	4	0.4	d	d
Conifer Swamp[f]					
Shorttail shrew *(Blarina brevicauda)*	1	1	0.9	343	0.3
Masked shrew *(Sorex cinereus)*	4	5	3.6	343	1.4
Boreal redback vole *(Clethrionomys gapperi)*	7	15	2.1	343	4.4
Red squirrel *(Tamiasciurus hudsonicus)*	3[e]	1	0.8	d	d
Snowshoe hare *(Lepus americanus)*	2	4	0.5	d	d
Ermine *(Mustela erminea)*	3	4	0.8	d	d
Longtail weasel *(Mustela frenata)*	1	1	0.3	d	d
Grass Meadow[g]					
Shorttail shrew *(Blarina brevicauda)*	5	6	10.6	126	12.7
Meadow vole *(Microtus pennsylvanicus)*	11	16	12.8	126	12.7
Meadow jumping mouse *(Zapus hudsonicus)*	20	34	48.1	126	27.0
Franklin ground squirrel *(Spermophilus Franklini)*	1	1	0.5	d	d
Ermine *(Mustela erminea)*	3	3	1.4	d	d
Striped skunk *(Mephitus mephitus)*	1	1	0.5	d	d
Pasture (0.63 hectare plot)[h]					
Masked shrew *(Sorex cinereus)*	1	1	1.6	112	0.9
Meadow vole *(Microtus pennsylvanicus*	10	10	15.9	112	8.9
Hay Field[i]	none	none	none	112	0.0

a Mammal field plots are illustrated on Figure IV-81.

b Total capture includes recaptures.

c 1.96 hectare plot for small mammals, 9.64 hectare plot for medium size mammals.

d Means not applicable.

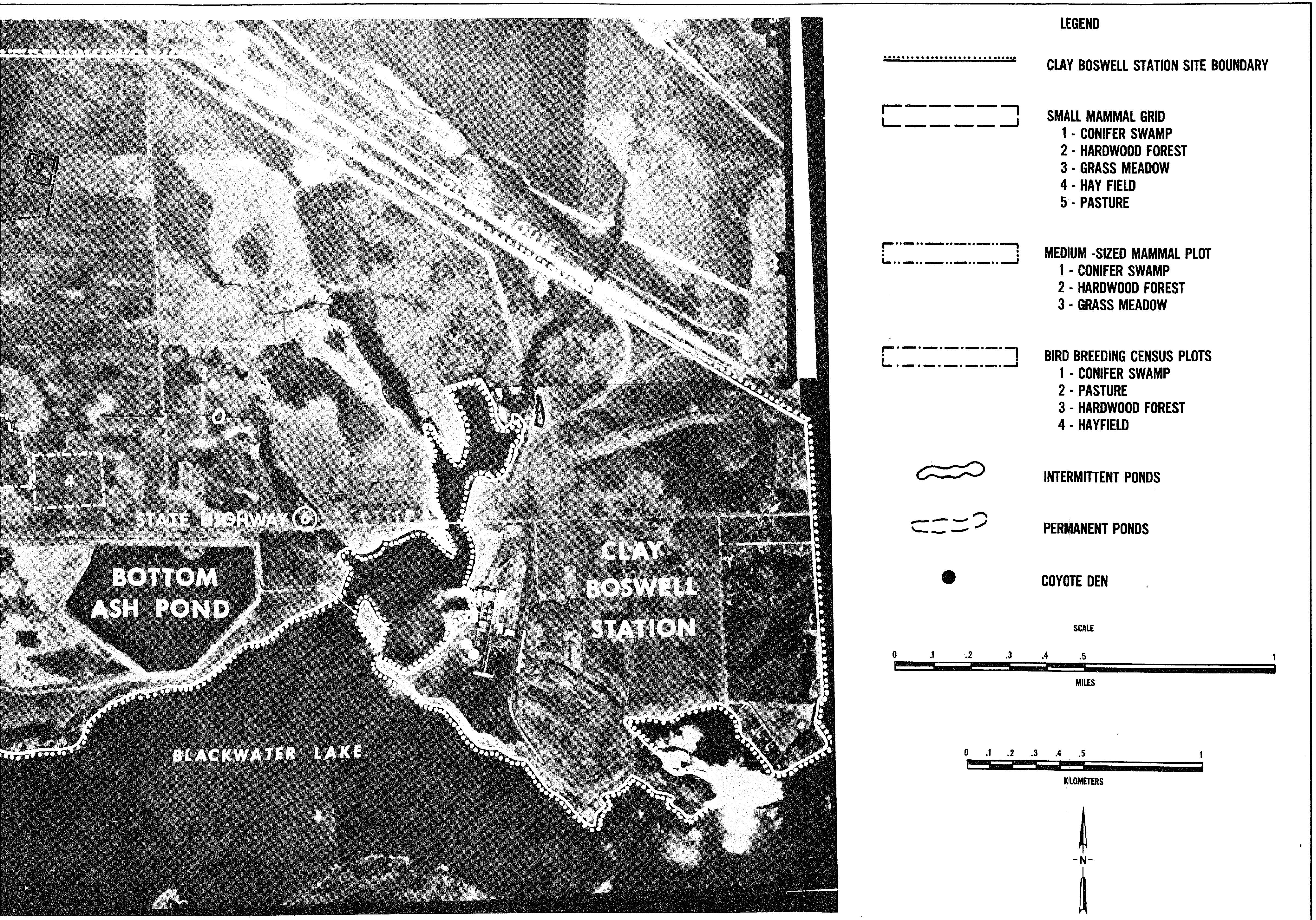
e Captures and/or observations.

f 1.10 hectare plot for small mammals, 4.0 hectare plot for medium size mammals.

g 0.47 hectare plot for small mammals, 2.21 hectare plot for medium size mammals.

h 0.63 hectare plot for small mammals, medium size mammals not sampled.

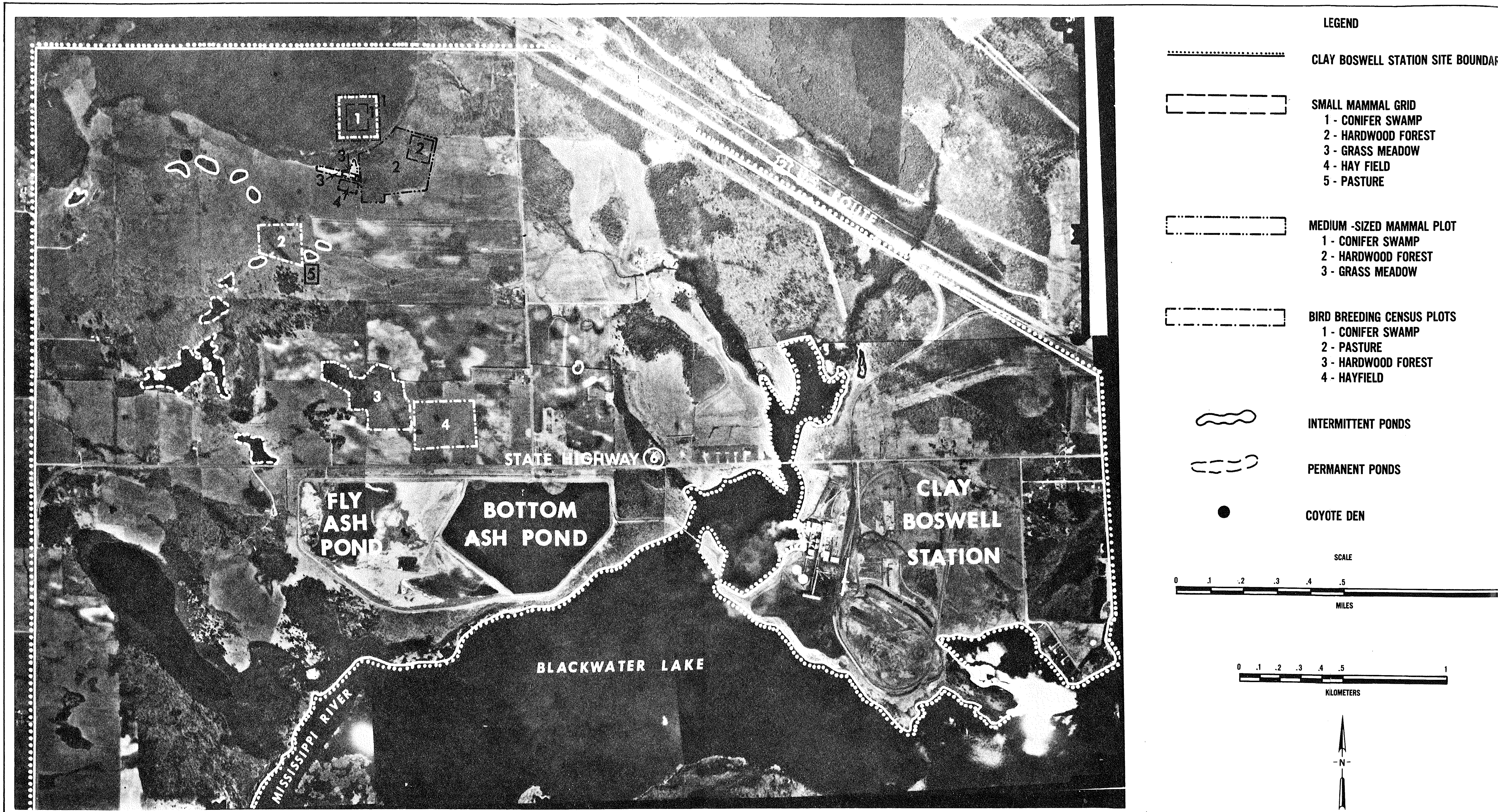
i 0.63 hectare plot for small mammals, medium size mammals not sampled.



LOCATION OF MAMMAL AND BIRD CENSUS PLOTS OF THE SITE CLAY BOSWELL STEAM ELECTRIC STATION

SOURCE: ADAPTED FROM MP&L, "ENVIRONMENTAL REPORT", EXHIBITS III-G-6 AND III-G-7

FIGURE IV-81


LEGEND
CLAY BOSWELL STATION SITE BOUNDAR
SMALL MAMMAL GRID
1 - CONIFER SWAMP
2 - HARDWOOD FOREST
3 - GRASS MEADOW
4 - HAY FIELD
5 - PASTURE
MEDIUM -SIZED MAMMAL PLOT
1 - CONIFER SWAMP
2 - HARDWOOD FOREST
3 - GRASS MEADOW
BIRD BREEDING CENSUS PLOTS
1 - CONIFER SWAMP
2 - PASTURE
3 - HARDWOOD FOREST
4 - HAYFIELD
INTERMITTENT PONDS
PERMANENT PONDS
COYOTE DEN
SCALE
0 .1 .2 .3 .4 .5
MILES
0 .1 .2 .3 .4 .5 1
KILOMETERS
N
STATE HIGHWAY 6
FLY ASH POND
BOTTOM ASH POND
CLAY BOSWELL STATION
BLACKWATER LAKE
MISSISSIPPI RIVER

along with the tender and succulent parts of aspen, willow, alder, hazelnut, and paper birch, make up the bulk of the snowshoe hare's diet (173).

The white-tailed deer is primarily a browsing animal and uses the northern mesic forest and disturbed areas (cutovers, plantations, and fields) for the most of its feeding during the summer months. They browse primarily on the leaves, buds, and current year's growth of red maple, hazel, quaking aspen, willow, and paper birch found within 3 ft (0.91 m) of the ground (177). During the winter months, critical habitat for the white-tailed deer becomes the conifer swamp forest where snow depths and temperatures are less severe (177).

Other mammals found in the hardwood forests include the porcupine (*Erethizon dorsatum*), racoon, and several species of bats and shrews. The beaver (*Castor canadensis*) utilizes young aspen stands which are near the water for food and shelter. Signs of black bear (*Ursus americanua*) and timber wolf have been observed in the vicinity of the Clay Boswell Station. (175).

The highest density of breeding birds and the highest number of breeding bird species usually occurs in the hardwood forests (Table IV-79), because of the high index of diversity of vegetation offered by the hardwood forest. The small birds forage for insects, berries, and seeds on the ground and at all levels within the canopy.

The 4 most abundant breeding birds observed in the hardwood forest were the red-eyed vireo (*Vireo olivaceus*), veery (*Catharus fuscescens*), the ovenbird (*Seiurus aurocapillus*), and the wood thrush (*Hylocichla mustelina*) (175). These birds consume a variety of animal food including beetles, ants and other *Hymenoptera*, caterpillars, spiders, and grasshoppers (173). They also feed on some plant life such as bunchberry, juneberry, blueberry, dogwood, wild cherry, and Jack-in-the-pulpit (173), all of which are usually present in the hardwood forest.

Associated with the borders of the hardwood forest are other abundant birds such as the American robin (*Turdus migratorius*), yellow warbler (*Dendroica petechia*), chestnut-sided warbler (*Dendroica pensylvanica*), common yellowthroat (*Geothlypis trichas*), and indigo bunting (*Passerina cyanea*) (175). The American robin prefers clearings near hardwood forests and has a diet composed of caterpillars, beetles, earthworms, and the fruit of such plants as cherry, blackberry, and dogwood (173). The warblers and the indigo bunting prefer to forage for insects in the forest canopy (173).

Most of these birds migrate from northern Minnesota in late summer and fall. However, such birds as the downy woodpecker (*Dendrocopus pubescens*), black-capped chickadee (*Parus atricapillus*), white-breasted nuthatch (*Sitta carolenensis*), and the blue jay (*Cyanocitta cristata*), remain in northern Minnesota during the winter months. The downy woodpecker feeds on wood-boring larvae of beetles and moths, adult beetles, ants, poison ivy, and dogwood (173). The black-capped chickadee and white-breasted nuthatch feed on beetles, ants, spiders, and other insects and seeds (173). Acorns are the staple food for blue jays although they also feed on caterpillars, grasshoppers, and beetles (173). Flocks of seed eaters such as pine siskins (*Spinus pinus*), common redpolls (*Acanthis flammea*), American goldfinches (*Spinus tristis*), crossbills (*Loxia*

TABLE IV-79
SONG BIRD DENSITY ESTIMATES - CLAY BOSWELL STEAM ELECTRIC STATION SITE
June 18, 1975 and June 24 1975 (175)

Species	Number Territorial Male Birds per 100 hectare by Community			
	Hardwood Forest[a]	Conifer Swamp[b]	Pasture[c]	Hayfield[d]
Common flicker	11.6			
Yellow-bellied sapsucker	11.6			
Downy woodpecker	11.6			
Eastern kingbird			19.0	
Willow flycatcher	11.6			
Least flycatcher	11.6			
Eastern wood pewee	11.6			
Blue jay	11.6			
Gray jay		25.0		
White-breasted nuthatch	11.6			
Short-billed marsh wren			19.0	
Robin	34.9		19.0	
Wood thrush	23,2			
Veery	69.6			
Ruby-crowned kinglet		50.0		
Cedar waxwing	11.6			
Solitary vireo	11.6			
Red-eyed vireo	69.6			
Nashville warbler		25.0		
Yellow warbler	34.9			
Yellow-rumped warbler		25.0		
Blackburnian warbler		25.0		
Chestnut-sided warbler	23.2			
Ovenbird	34.9			
Common yellowthroat	34.9			
American redstart	23.2			
Bobolink			38.1	80.0
Red-winged blackbird			19.0	
Common grackle	11.6			
Brown-headed cowbird	11.6	25.0		
Northern oriole	11.6			
Scarlet tanager	11.6			
Rose-breasted grosbeak	11.6			
Indigo bunting	23.2			
American goldfinch	11.6			
Savannah sparrow		25.0	38.1	146.7
Grasshopper sparrow			38.1	66.7
White-throated sparrow		50.0		
Lincoln's sparrow		25.0		
Song sparrow	23.2	25.0	19.0	

[a] 8.6 hectare plot sampled.
[b] 4.0 hectare plot sampled.
[c] 5.3 hectare plot sampled.
[d] 7.5 hectare plot sampled.

curvirostra and *L. leucoptera*), and evening grossbeaks (*Hesperiphona vespertina*) occur erratically throughout the forested areas of northern Minnesota in response to the local abundance of tree seeds and berries.

The wood frog (*Rana sylvatica*) is a common amphibian in hardwood forests (175). It prefers the hardwood swamps. Two other amphibians which prefer moist wooded areas are the central newt (*Diemictylus viridescens louisianensis*) and the Jefferson salamander (*Ambystoma jeffersonianum*) (160). Of the reptiles, the eastern garter snake (*Thamnophis sirtalis sirtalis*) also prefers moist woodlands (160).

Northern Lowland Forest; Wet Segment (Conifer swamp)

The conifer swamp is not as diverse in terms of age, vegetation type, and dispersion when compared with the hardwood forest. Therefore, the number and variety of wildlife species is not as great.

The 3 most abundant small mammals which were found in the black spruce conifer swamp of the Clay Boswell Station site were the red-backed vole, masked shrew (*Sorex cinereus*), and the shorttail shrew (*Blarina brevicauda*) (Table IV-78). The red-backed vole often nests in fallen, mossy logs in the sphagnum of spruce-tamarack swamps or in relatively dry hummocks in black spruce swamps (174). It feeds primarily on vegetable matter (174). Insects, such as beetles, moths, flies, and caterpillers make up the majority of the masked shrew's diet (174). The masked shrew resides primarily in damp, mossy woods, such as spruce-tamarack sphagnum bogs (174). The shorttail shrew prefers much the same type of habitat, and feeds largely on various snails, voles, insects, worms, and beetles (174).

The medium-sized mammals found in the conifer swamp include the red squirrel, snowshoe hare, ermine, and the long-tail weasel. The preferred habitats of the snowshoe hare are bogs and swamps having growths of conifers, alders, and willows (174).

Of the large mammals, the white-tailed deer is the most prevalent in the conifer swamps. During the winter months, the conifer swamp constitutes a primary wintering habitat of the white-tailed deer (177). In times of severe winter conditions, deer will congregate in these dense stands, where snow depths and temperature are less severe (177). However, pressures of deer on limited food supplies, such as balsam fir and cedar, often become critical, resulting in mortality and reproductive failures from physiological stress (177).

The conifer swamp was found to have the second highest density of breeding birds (175). The 2 most abundant birds found during the spring were the ruby-crowned kinglet (*Regulus calendula*) and the white-throated sparrow (*Zonotrichia albicollis*) (Table IV-79). Insects and a variety of plant food make up their diet. Later in the year, the gray jay (*Perisoreus canadensis*) is more common. Warblers such as the Nashville warbler (*Vermivora ruficapilla*), blackburnian warbler (*Dendroica fusca*), and the yellow-rumped warbler (*Dendroica coronata*) are very abundant in the vicinity of the Clay Boswell Station, where they often forage for insects in the crowns of black spruce (175). Sparrows are also prominent in conifer swamps, where they forage for insects and plant food in the lower branches of black spruce or in the more open bog heath (175).

A reptile known to be present in the Clay Boswell area in open woodlands and sphagnum bog forests is the northern red-bellied snake (*Storeria occipitomaculata occipitomaculata*) (160). The mink frog (*Rana septentrionalis*) is an amphibian known to be present in bogs and bog forests in this region (160).

Northern Xeric Forest; Dry-Mesic Segment (Pine Forest)

This forest type contains a mixutre of hardwood and softwood tree species and is relatively dry. The red squirrel, red-backed vole, northern flying squirrel (*Glaucomys sabrinus*), and porcupine are all regular inhabitants of the northern dry-mesic forest.

The red squirrel prefers conifer stands, or mixed forests of coniferous and deciduous trees. When in the pine stands, they will feed chiefly on the seeds and cones of conifers and also on the diseased bark of pine (174). The northern flying squirrel feeds on hazelnuts and the seeds of spruce, balsam, and mapple (174). The porcupine feeds on the inner bark, branches, and leaves of many trees in the northern dry-mesic forest, such as white pine, red pine, jack pine, willow, maple, aspen, and birch (174).

The chestnut-sided warbler, indigo bunting, yellow-rumped warbler, and the common yellowthroat are typical passerine residents of dry-mesic forests (161). The ruffed grouse (*Bonasa umbellus*) and various raptors also use these forests, as will the leopard frog (*Rana pipiens*) and spring peeper (*Hyla crucifer*).

Open Bog

The open bogs of the Clay Boswell Station region provide habitat for a number of mammals, birds, reptiles, and amphibians. Small, open water pools provide an additional dimension in habitat type within the open bog (178).

Of the mammals, snow shoe hare, southern bog lemming (*Synaptomys cooperi*), muskrat (*Ondatra zibethicus*), meadow jumping mouse (*Zapus hudsonius*)., masked shrew, shorttail shrew, and the white-tailed deer are among those present in the open bog. The mink (*Mustela vison*) often frequent bogs which are near open water.

Birds common to open bog areas include the swamp sparrow (*Melospiza georgiana*), song sparrow (*Melospiza melodia*), and the red-winged blackbird (*Agelaius phoeniceus*) (178). The swamp sparrow primarily inhabits wet, brushy bogs, but will frequently forage for weed seeds and insects in adjoining fields (173). It feeds on several types of insects and some plants (173). The song sparrow feeds on similar foods, but prefers margins of open bog areas (173). The red-winged blackbird feeds on a variety of insect and plant foods. Although the red-winged blackbird nests in open bogs and marshes, it is more commonly seen near cultivated cropland.

The leopard frog, milk frog, American toad (*Bufo americanus*), and the eastern garter snake are all found in or near open bogs. The leopard frog is probably the most abundant, feeding on various kinds of insects and spiders (158). The mink frog is rarely found far from water, and feeds on a variety of insects.

Alder Thickets

Since alder thickets are a common community along streams, lakes, and bogs, wildlife from aquatic habitats are often seen in the alder thickets. Dense copses of alder provide very effective wildlife cover from predators and unfavorable weather (173).

Beaver and snowshoe hare feed on the wood and foliage of speckled alder (173). The beaver will also utilize the alder for building materials for its lodges and dams. The meadow jumping mouse is another common resident of alder thickets (159). It feeds almost exclusively on seeds, grasses and cultivated grains, and prefers moist thickets and grasslands near streams or lakes (174).

The white-tailed deer may feed on some shrub species in alder thickets, but alder habitat is not as highly preferred by the white-tailed deer as the upland aspen and birch forests (179).

Birds which occupy alder thickets include the American goldfinch, pine siskin, and the common redpoll (173). These species feed on the seeds of alder and on the seeds of nearby surrounding tree species.

Fens and Sedge Meadows

The small fens scattered throughout the Clay Boswell Region offer habitat to several small mammal and bird species. The meadow vole (*Microtus pennsylvanicus*), occupies moist habitats with dense stands of grasses, sedges, and grain crops. The shorttail shrew and the meadow jumping mouse also are residents of the fens. The woodchuck (*Marmota monax*), striped skunk (*Mephitis mephitis*), and the ermine often inhabit fens. Fens and sedge meadows provide good habitat for the skunk because it prefers a mixture of forest, brushland, and open grassland near water. Skunks are omnivorous and eat adult and larval insects as well as toads, frogs, mice, and eggs of turtles and birds (173). Muscrats frequently feed on the vegetation of fens and sedge meadows (173).

Birds which feed and nest in the fens are most often waterfowl, which utilize nearby aquatic habitats. Some of these include the mallard (*Anas platyrhynchos*), blue-winged teal (*Anas discors*), and the wood duck (*Aix sponsa*). These waterfowl feed primarily on the seeds of various grasses of the fens (173). Songbirds which feed on the seeds of fen grasses include the dark-eyed junco (*Junco hyemalis*), tree sparrow (*Spizella arborea*), and the chipping sparrow (*Spizella passerina*) (173).

Several species of *Carex* are an important vegetative component of the sedge meadows and provide habitat for numerous wildlife species. The meadow jumping mouse, short tailed shrew, and Franklin ground squirrel (*Spermophilus franklini*) commonly inhabit sedge meadows (175). Several species of waterfowl are common in sedge meadows because they feed almost exclusively on the seeds of plants such as *Carex stricta*, *Poa palustris*, and *Scirpus atrovirens*(173). The American coot (*Fulica americana*), lesser scaup (*Aythya affinis*), canvasback (*Aythya valisneria*), blue-winged teal and the ring-necked duck (*Aythya collaris*) are some characteristic waterfowl species in the region that feed and nest in the sedge meadows (173).

The common snapping turtle (*Chelydra serpentina*) is present when the sedge meadows are near permanent bodies of water. They feed on fish, water plants, insects, crayfishes, snails, and clams (158). The western painted turtle (*Chrysemys picta belli*) may also be present in sedge meadows (160).

Amphibians which utilize fens, sedge meadows, and adjoining water bodies include the mudpuppy (*Necturus maculosus*), boreal chorus frog (*Pseudacris triseriata maculata*), and the leopard frog. The mudpuppy prefers permanent bodies of water, its diet comprising aquatic animals such as crayfish, water insects, small fish, worms, and frogs (158). The boreal chorus frog prefers temporary or permanent marshy ponds in the sedge meadows and elsewhere (158).

Pasture

Pasture and croplands are important components of the habitat mosaic in the vicinity of the Clay Boswell Station. A small mammal known to be quite abundant in the pastures of the Clay Boswell Station site is the meadow vole (Table IV-78). It feeds heavily on fresh grasses and sedges and the seeds of redtop and timothy (174).

A coyote (*Canis latrans*) has made its den in a pasture on the Clay Boswell Station site (175). The Clay Boswell Station site is typical coyote habitat, with its mixture of forest and farmland. The food of coyotes consists of mammals such as the meadow vole, porcupine, snowshoe hare, red squirrel, skunk, raccoon, and muskrat (173).

The woody species invading abandoned pastures provide cover and food for many wildlife species. Mammals which feed on the leaves and nuts of beaked hazelnut (*Corylus cornuta*), young bur oak (*Quercus macrocarpa*), etc. include the raccoon, snowshoe hare, red squirrel, white-tailed deer, and the eastern chipmunk (173). Young quaking aspen is another important food source for the beaver, snowshoe hare, porcupine, and white-tailed deer. Weed species such as yarrow (*Achillea millefolium*), *Aster macrophyllus* , and horsetail (*Equisetum* sp.) provide food sources for other small mammals.

The birds which feed on the pasture weed species include the ruffed grouse, snow bunting (*Plectrophenax nivalis*), red-winged blackbird, common redpoll, and many sparrows (Table IV-78).

The common tree frog (*Hyla versicolor*) and the American toad are common in pastures near the Clay Boswell Station (175). Field depressions where water collects, and roadside ditches contain the greatest density of resident amphibians in the spring (175). When these areas dry up in the summer, amphibians are most common in the idle grassland, lowland forest, and in alder thickets where open surface water occurs (175).

Cropland

Small mammals which use croplands of the Clay Boswell Station site for habitat include the meadow vole and the thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*) (175). Mammals which occasionally pass through hay fields and other croplands include white-tailed deer, coyote, and bobcat (*Lynx rufus*). Although idle fields and meadows comprise a small percentage of the area in north central Minnesota, they are important ecotonal areas (175).

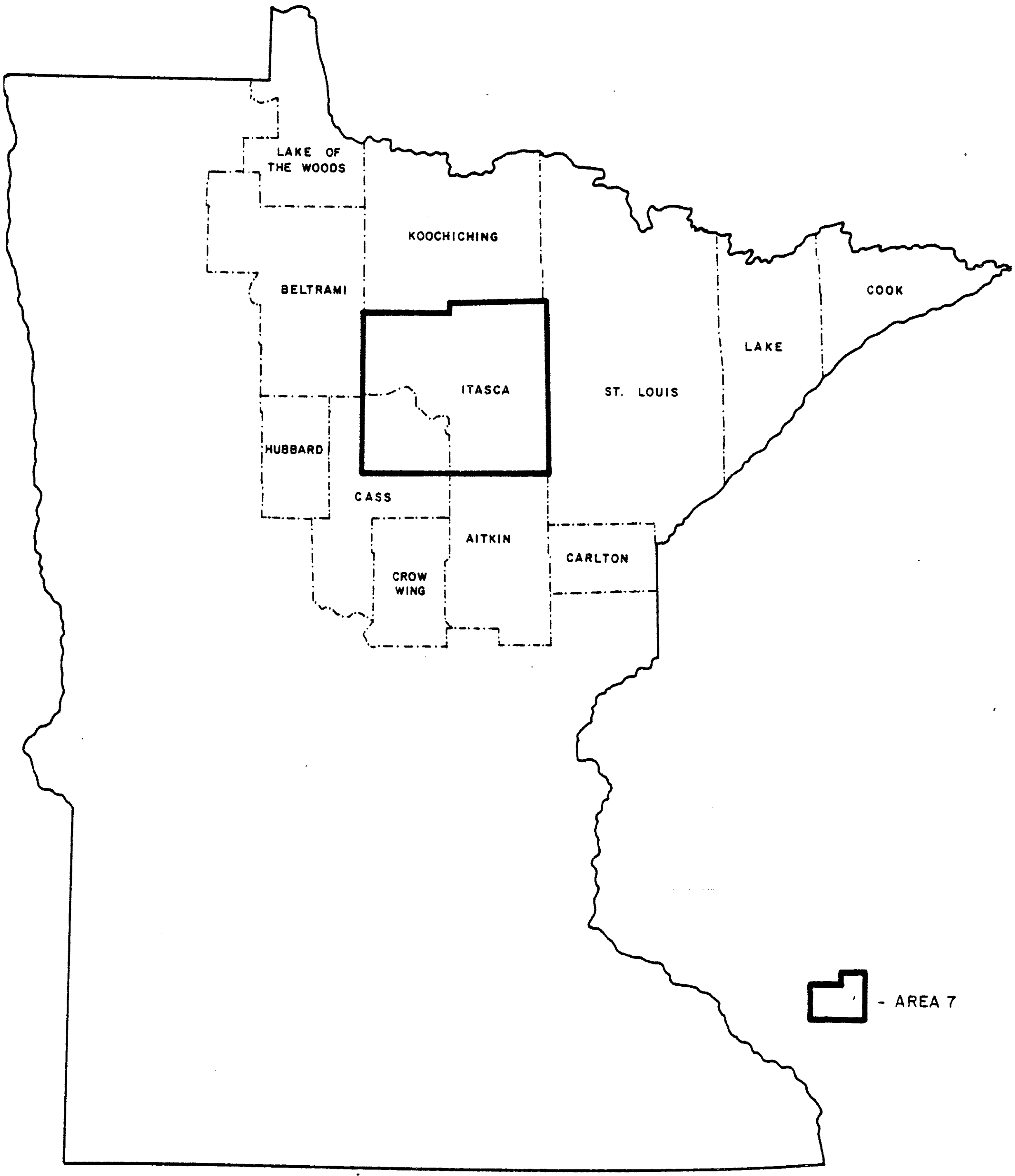
Some unusual bird species observed associated with the croplands on the Clay Boswell Station site include the bobolink (*Dolichonyx oryzivorus*) and the grasshopper sparrow (*Ammodramus savannarum*) (175). The savannah sparrow (*Passerculus sandwichensis*) is quite common in the croplands near the Clay Boswell Station, as are red-winged blackbirds, Brewer's blackbird (*Euphagus cyanocephalus*) and the common grackle (*Quiscalus quiscula*) (175). These species forage for grain and insects in grain and hay fields. Sections of pasture and cropland which contain trees provide habitat for the eastern kingbird (*Tyrannus tyrannus*) and the red-headed woodpecker (*Melanerpes erythrocephalus*) (175). The cropland and pasture of the site has also been used by a resident pair of red-tailed hawks (*Buteo jamaicensis*) and several pair of American kestrels (*Falco sparverius*) (175). In late summer, other birds of prey, such as the marsh hawk (*Circus cyaneus*) and roughlegged hawk (*Buteo lagopus*) have been observed preying upon small mammals in the croplands on the Clay Boswell Station site (175).

Game Resources of the Clay Boswell Station Area

Hunting and trapping are important sources of recreation and tourist income in north central Minnesota. The Clay Boswell Station is located in what was Area No. 7 of Game Management Region No. V of the Minnesota DNR (Figure IV-82) (the boundaries of the Minnesota DNR regions were recently changed). Figure IV-83 illustrates some important wildlife resource areas located within approximately 10 km of the Clay Boswell Station. Table IV-80 lists the principal game species and their relative abundances for Game Management Area No. 7.

The mallard, blue-winged teal, wood duck, ring-necked duck, American wigeon (*Anas americana*), and common goldeneye (*Bucephala clangula*) are the principal duck species nesting in the vicinity of the Clay Boswell Station (175). Table IV-81 presents brood count data for these species collected by the Minnesota DNR in spring 1972 on White Oak Lake, Little White Oak Lake, and the Mississippi River. Little White Oak Lake, Shoal Lake, Rice Lake, Little Drum Lake, Bass Lake, and Blackwater Lake are important waterfowl areas within 10 km of the Clay Boswell Station (180). The Mississippi River and Blackwater, Bass, and Little Drum Lakes contain important wild rice beds (175). Blackwater Lake produces more than half of the duck broods in Game Management Area No. 7 (175). Current (e.g. 1972 through 1976) waterfowl harvest data are not available for Itasca County (181)(182).

Presently, the deer population of Game Management Area No. 7 is approximately 13 deer per square mile (0.05 per hectare) (180). This density is probably slightly lower than average because of severe winters in the past 5 years (175). Approximately 5,000 to 6,000 deer were harvested by firearms in Itasca County in the 1972, 1973, and 1974 hunting seasons (1.7 to 2.1 per sq mi) (0.65 to 0.78 per sq km) (175). The Itasca County firearm deer harvest during these years constituted 7.5 to 8.8% of the total Minnesota harvest (175). Figure IV-83 shows one major winter deer yarding area east of Bass Lake along

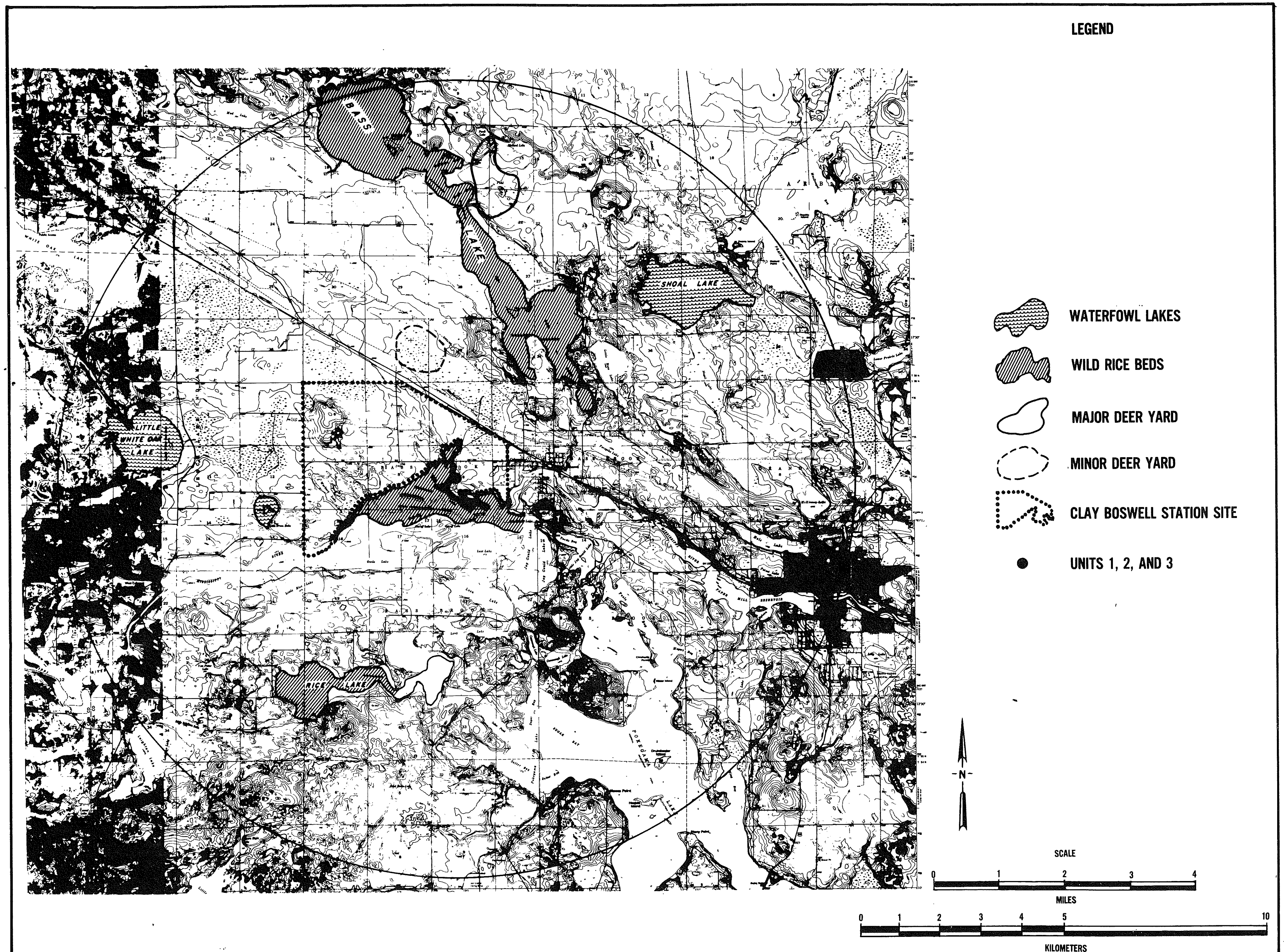


MINNESOTA'S DEPARTMENT OF NATURAL RESOURCES

GAME MANAGEMENT REGION V - AREA 7

SOURCE: MP&L, "ENVIRONMENTAL REPORT", EXHIBIT III-G-4

FIGURE IV-82



IMPORTANT WILDLIFE RESOURCE AREAS IN VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION

SOURCE: ADAPTED FROM MP&L, "ENVIRONMENTAL REPORT", EXHIBIT III-G-5

FIGURE IV-83

TABLE IV-80
RELATIVE ABUNDANCE - PRINCIPAL GAME SPECIES - GAME MANAGEMENT AREA 7
NORTH CENTRAL MINNESOTA

Species	Relative Abundance[a]
Whitetail deer	Common
Black bear	Occasional
Moose	Scarce
Mule deer	Rare
Snowshoe hare	Common
Cottontail rabbit	Occasional
Gray squirrel	Scarce
Beaver	Common
Muskrat	Common
Mink	Common
Raccoon	Common
Skunk	Common
Coyote	Common
Weasel	Common
Red fox	Common
Otter	Occasional
Fisher	Occasional
Bobcat	Occasional
Timber wolf	Scarce
Gray fox	Rare
Lynx	Rare
Ruffed grouse	Common
American woodcock	Common
Common snipe	Common
Rails	Common
Spruce grouse	Occasional
Mourning dove	Occasional
Sharp-tailed grouse	Scarce

[a] As observed by Minnesota Department of Natural Resources personnel:
Common - animal or sign seen more than half of trips in field per year
Occasional - animal or sign seen a quarter to half trips in field per year
Scarce - animal or sign seen not more than on one dozen trips in field per year
Rare - animal or sign seen on one or less trips in field per year.

TABLE IV-81
MINNESOTA DNR WATERFOWL BROOD COUNT DATA
FOR WHITE OAK LAKE, LITTLE WHITE OAK LAKE,
AND THE MISSISSIPPI RIVER, 1972[a] (175)

Species	No. of Broods	No. of Adults	No. of Young	Total Ducks
Mallard	9	14	65	79
American wigeon	6	49	32	81
Ring-necked duck	6	15	34	49
Blue-winged teal	2	5	17	22
Common goldeneye	1	1	4	5
Wood duck	0	20	0	20
Unidentified	3	5	9	14

[a] Census performed along a total of 21 miles (34 km) of shoreline.

Pohl Creek. This deer yard is approximately 260 hectares in area (175). Another less important yarding area is situated just north of U.S. Highway 2 south of Bass Lake (175).

The moose population in Game Management Area No. 7 is low (about 60 in 1974) and restricted to the northeast and southeast corners of Itasca County (175). Moose hunting was not permitted in Itasca County in 1975 or 1976 (183). Black bears are somewhat more abundant. The bear harvest in Itasca County totaled 112 in 1974, the highest in the State for that year (175).

Game Management Area No. 7 provides excellant habitat for the American woodcock (*Philohela*), which prefers semi-open low brush communities associated with pastures and hayfields (175). Ruffed grouse are similarly well distributed in the Area, though the population may be less than optimal because of a relative lack of extensive, young stands of quaking aspen (175).

The annual harvest of beaver and otter (*Lutra canadensis*) in Game Management Area No. 7 averages approximately 2,000 and 90 animals, respectively (182). This is about 9% of the total annual Minnesota harvest of beaver and about 20% of the total annual Minnesota harvest of otter (182). Muskrat and mink are also common in Game Management Area No. 7, as are coyote, raccoon, skunk, red fox (*Vulpes fulva*) and the weasels. No trapping data are available for these furbearers in Itasca County (183). The remaining furbearers listed in Table IV-80 are found only occasionally or rarely in the vicinity of the Clay Boswell Station (175).

Rare, Threatened, and Endangered Terrestrial Vertebrates

The Minnesota Environmental Policy Act and accompanying regulations require that special attention be given in State actions and in environmental impact statements to preserving rare and endangered species of wildlife (184). As with the flora, Minnesota provides a tremendous variety of ecological niches for terrestrial and aquatic vertebrates. The species of wild animals which breed and thrive without care in Minnesota total approximately as follows (185):

Fish	144
Amphibians	18
Reptiles	26
Birds	
regular	292
occasional	23
accidental	44
Hypothetical	12
extinct (Passenger Pigeon)	1
Mammals	77

Of the 493 species of terrestrial vertebrates, only the timber wolf and the peregrine falcon (*Falco perigrinus*) are listed as threatened or endangered (186) pursuant to the Endangered and Threatened Species Preservation Act of 1973 (187) and its Minnesota counterpart (188). Most migratory species are protected under various Federal and state migratory bird treaties and statutes (186). The bald eagle is given special protection by the Bald Eagle Protection Act of 1940, as amended, 1972 (187).

The Minnesota DNR publication "The Uncommon Ones" (185), lists as needing special consideration 13 terrestrial vertebrate species which could be present in the vicinity of the Clay Boswell Station. The following briefly discusses the legal status, habits, and relative abundance of each of these species. The terminology follows that of Moyle, and the symbols E, P, U, N, or R listed after each species refer to the following key (185):

E Classified under federal regulations as endangered for the United States as a whole (186).

P Afforded some degree of protection under Minnesota laws, the amount and kind of protection varying with the species.

U Specifically listed as "unprotected" under Minnesota laws.

N Status not specified under Minnesota laws; not legally designated either "protected" or "unprotected".

R Probably have always been rare or uncommon in Minnesota. Some of these are peripheral species.

Endangered Species

This category includes species in danger of extinction in Minnesota within the immediate future. All are protected at present.

Peregrine Falcon, *Falco peregrinus* (E, P, R). There are two subspecies of the peregrine falcon which are considered endangered by the Federal Government (186). Both occur in Minnesota only very rarely during migration. The arctic peregrine falcon (*Falco peregrinus tundriur*) breeds primarily in northern Canada and Alaska (161). It is unlikely that this race would pass through the Clay Boswell Station vicinity during migratory periods. The other subspecies, the American peregrine falcon (*Falco peregrinus anatum*), was at one time a relatively common nesting bird in Minnesota. There has been little or no nesting activity in recent years within the State. Efforts are presently being made under the direction of the University of Minnesota to re-establish the species by hand raising the young at former nesting sites along the Mississippi River in southern Minnesota.

Threatened Species

This category includes species which could become endangered in Minnesota in the foreseeable future but not necessarily throughout their entire natural range.

Bald Eagle, *Haliaeetus leucocephalus Alascanus* (P). Only the southern bald eagle, *Haliaeetus leucocephalus leucocephalus* is considered endangered by the Federal Government (186). The bald eagles in the vicinity of the Clay Boswell Station are members of the northern subspecies, *Haliaeetus leucocephalus Alascanus*. Both subspecies are protected by the Bald Eagle Protection Act (190), which provides penalties for anyone killing bald eagles or molesting their nests or eggs or bartering in their parts, nests, or eggs.

Minnesota contains the highest breeding population of northern bald eagles in the lower 48 states. This population is principally centered in the Chippewa National Forest just west of the Clay Boswell Station site (191). The total number of eagle nests in the Chippewa National Forest in 1976 was 176 (192). The number of breeding pairs associated with these nests was 94. Of these, the total number of breeding pairs which began nesting activities was 77 in 1976, or 82% of the total breeding pairs, present. Seventy-two percent of the territories containing incubating birds were successful in 1976 in raising at least one young (192).

There are 3 known eagle nesting sites within 15 miles (24.1 km) of the Clay Boswell Station (193). The farthest is approximately 14 miles (22.5 km) due west of the Clay Boswell Station at the north end of Mud Lake. Another nest is approximately 10 miles (16.1 km) south-southwest of the Clay Boswell Station at the south end of Siseebakwet Lake. At the third site, there are 2 nests, apparently within the same territory and associated with the same pair of birds (193). These nests are located approximately 12 miles (19.3 km) east of the Clay Boswell Station. One of the nests is located on the southern end of the west side of Trout Lake. The second nest is further north on the south half and east side of Trout Lake. The information on eagle nesting sites is considered complete for this area (193); it is unlikely that there are other unknown nesting sites in the vicinity of the Clay Boswell Station. All 3 of these territories are known to be active. Eagles have been sighted, apparently migrating, within 2 miles of the Clay Boswell Station (193), and 2 adults were observed on the south side of Blackwater Lake, about one kilometer from the Station in August, 1975 (175).

It is known that smoke is an irritant to raptors (194). One of the factors associated with nest site selection by eagles is visibility, and it is likely that areas where there is a constant emission of smoke will be avoided as nesting sites. Eagles are disturbed easily during nesting. If the plume-caused disturbance came at a critical time during incubation or early brooding when the eggs or young require the protection and warmth of the adult, the embryo or eaglets could die. However, John Mathisen, Wildlife Biologist for the Chippewa National Forest, feels that it is unlikely that the Clay Boswell Station constitutes a negative impact on breeding eagles (195).

Greater Sandhill Crane, *Grus canadensis tabida* (P). This race of species was formerly more abundant and widespread, nesting in swamps and muskeg throughout most of Minnesota (164). The principal cause for its decline in Minnesota has been the drainage of marshes and wetlands (185), though hunting also took a very significant portion of the population in the past (196).

The greater sandhill crane now nests primarily in the northwestern portion of Minnesota and in a few localities in the central part of the State. The Minnesota population is only a small portion of the United States breeding population. The greater sandhill crane is a rare migrant in the north central part of the State, and could possibly move through the Clay Boswell Station vicinity (161).

Eastern Timber Wolf, *Canis lupus lycaon* (E,P). The eastern timber wolf is currently listed as an endangered species by the Federal Government (186). It is not, however, considered endangered or threatened by the Minnesota DNR. The U.S. Fish and Wildlife Service has recently proposed a recovery plan for the eastern timber wolf in Minnesota which includes a recommended change in status of the subspecies from "endangered", as it is currently listed, to "threatened" (197). This change in status would simplify the management of wolves by allowing controlled killing of individuals where the presence of wolves directly conflicts with human needs.

The recovery plan divides Minnesota into 5 zones, with differing management plans in each. The Grand Rapids and Clay Boswell Station area is part of the 2,100 sq mi (5,450 sq km), zone 4, where it is recommended by the recovery plan that the average wolf density be maintained at its 1975-1976 level; i.e., about 1 wolf per 50 sq mi (129 sq km). This recommendation, if adopted, would require limited taking of wolves each year in zone 4 (197).

There are no established wolf packs within 15 km of the Clay Boswell Station (193). There are, however, established pack territories within 25 km to the northwest, southwest, south, and southeast. These packs are small and seldom wander within 15 km of the Clay Boswell Station (193). On occasion, radio-collared wolves have passed within 15 km of the Clay Boswell Station. These animals were either part of the Hill City pack, or wolves transplanted as part of the U.S. Fish and Wilflife Service nuisance wolf removal program (193).

Coyote densities, in comparison to wolves, are quite high in the Clay Boswell Station area, at about 5 to 8 per sq km (190). The primary reasons wolves are not found in the 15 to 20 km radius area around the Clay Boswell Station is the human habitation disturbance from the Grand Rapids area. Coyotes are much more tolerant of human distrubances, and have therefore been more successful at inhabiting the area around the Clay Boswell Station (193).

Species of Changing or Uncertain Status

This category includes species which are uncommon or local in Minnesota. These species are not presently endangered or threatened, but they could become threatened. Conversely, they may increase under favorable circumstances.

White Pelican, *Pelecanus erythrorhyncus* (P). This species is only a rare migrant in north central Minnesota. It deserves special consideration where it nests, since the colonies which are formed are particularly vulnerable to disturbance. There have been no recent breeding records for Itasca County, nor for the north central part of the State (161).

Double-crested Cormorant, *Phalacrocorax auritus auritus* (U). This bird is a common spring and fall migrant throughout most of Minnesota. Until the early 1950's the species was considered abundant as a migrant, and flocks of 1,000 to 5,000 were often observed. Currently, peak flock size in Minnesota ranges from 300 to 500 birds (161). There are no active colonies of cormorants in Itasca County, but there are records of it breeding occasionally in north central Minnesota (161).

Cooper's Hawk, *Accipiter cooperii* (P). The Cooper's hawk is probably more rare now than in the past, although its abundance is difficult to determine because it is secretive and can easily be confused with the sharp-shinned hawk (*Accipiter striatus*). Population studies have shown that there were declines in numbers of Cooper's hawks in the earlier part of the century due to hunting, and more recently because of low nesting success rates caused by pesticides and other man-caused stresses (198).

Marsh Hawk, *Circus cyaneus* (P). This species has recently been declining in numbers in Minnesota (199). Loss of habitat and use of pesticides are probably the main causes of its decline (185). March hawks are probably present in significant numbers in the vicinity of the Clay Boswell Station.

Osprey, *Pandion haliaetus* (P). The osprey, like the bald eagle, is a bird closely associated with open water and undisturbed wooded areas. This raptor was once more common in Minnesota than it is at present. Its decline is probably most closely tied to the wide use of pesticides. With the present, more controlled use of pesticides, osprey are beginning to show signs of recovery (185). Like eagles, excessive smoke is probably an irritation to ospreys and could have an effect during critical periods of the nesting season.

The Chippewa National Forest is an important area for nesting ospreys. There are approximately 138 known nest sites on the Chippewa National Forest as of 1976, with many more unaccounted for (192). Due to frequent blowdown and relocation of nesting sites, osprey populations are more difficult to measure than are eagles. A sampling of 58 nests was used to assess reproductive success for 1976 on the Chippewa National Forest. Of the 58 nests, 50 were active, and of these 24 were successful in fledging at least one young (192). The total number of young osprey reared on the Chippewa National Forest in 1976 was 43 (192).

There is an osprey nest located approximately 13 miles to the southeast of the Clay Boswell Station on the east side of Split Hand Lake (193). There probably are other osprey nests unaccounted for in this area (193).

Franklin's Gull, *Larus pipixcan* (P). The Franklin's gull is a rare migrant in north central Minnesota. Though it probably does not nest in this part of the State, it is known to range throughout the central regions of Minnesota during the summer (161).

Common Tern, *Sterna hirundo hirundo* (P). The common tern is a colonial nester on large lakes in north central and northeastern Minnesota, with the largest colonies on Lake of the Woods, Leech Lake, and Mille Lacs Lake (161). Because the common tern nests in colonies, it is particularily susceptible to disruption by human interference (185).

Fisher, *Martes pennanti* (P). The fisher was originally found throughout the forested region of Minnesota, but for the past centry has been limited to the northern part of the State (185). Presently, the species is completely protected by Minnesota law. Because of the increase in its numbers, a bill has recently been passed by the Minnesota legislature which changes the fisher's status to that of a game animal.

Canada Lynx, *Lynx canadensis canadensis* (U). Though this large wilderness cat was probably not uncommon in the past, it is considered to be a rare animal in Minnesota now. The lynx is less abundant than the bobcat, with which it is probably in competition for habitat. The maturing of northern forests favors the lynx. The lynx has never had the status of a game animal in Minnesota and is presenly classed as an unprotected predator (185).

SOCIO-ECONOMICS

Regional

For the existing socio-economic conditions, the Arrowhead Region was the largest area examined for the following reasons: 1) It was assumed that any new permanent employees for the Clay Boswell Station would be distributed in approximately the same pattern as existing employees. Most of the population of the region surrounding the Clay Boswell Station is concentrated in cities along the Mesabi Iron Range, and in the Duluth metropolitan area. The population in Cass County, to the southwest of the Clay Boswell Station, is very dispersed. In addition, only 2 employees for the Clay Boswell Station live outside the Arrowhead Region; 2) Any new permanent employees for the Clay Boswell Station would be attracted primarily from existing population centers in the area; 3) Changes in public service demands will primarily affect those counties, school districts, and cities where significant changes in population occur.

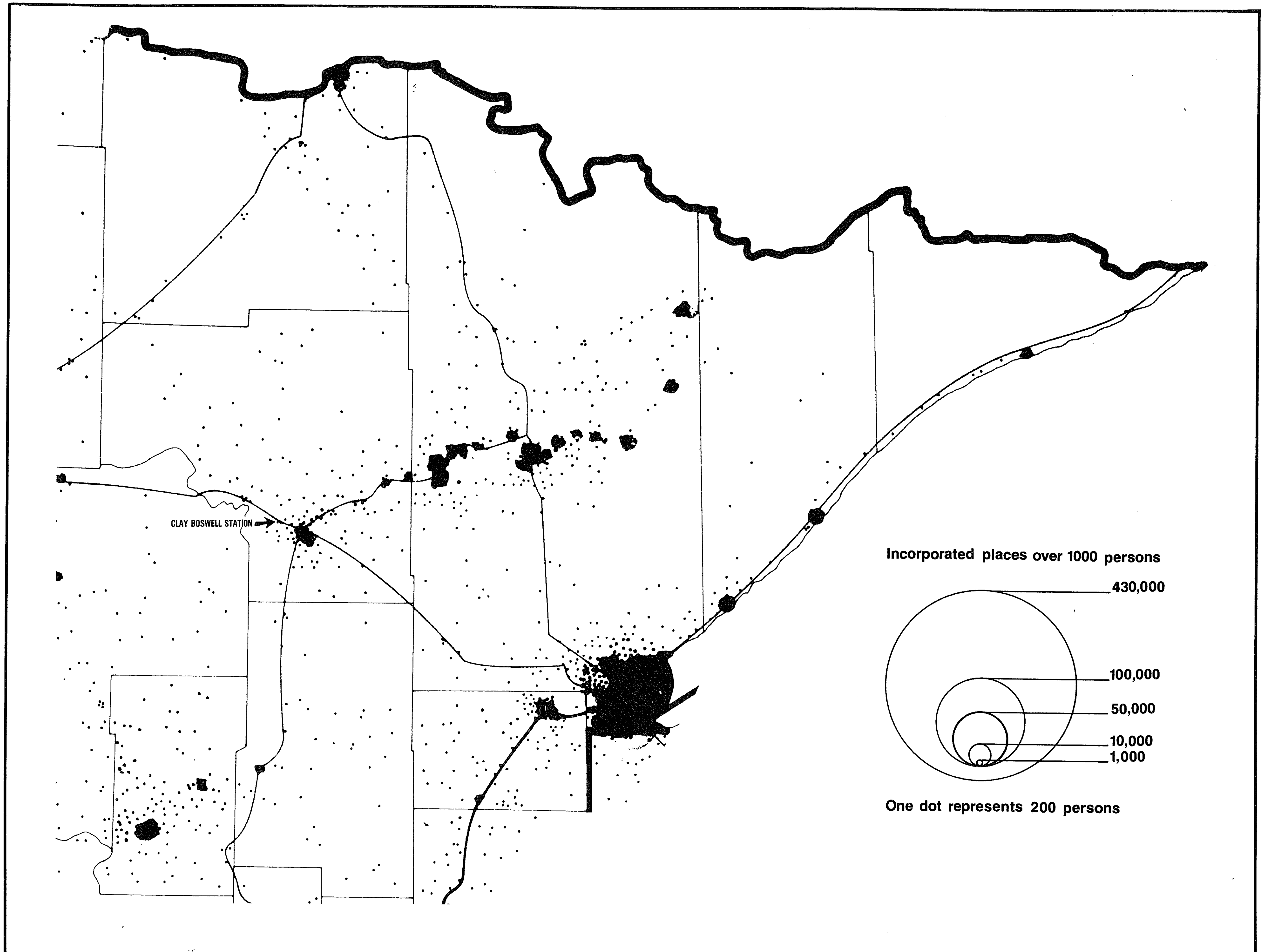
Population

Distribution. The population of the Arrowhead Region in 1970 was approximately 330,000. About two-thirds of the population reside in St. Louis County. Duluth, located in the southeastern portion of St. Louis County, is the largest city in the Region and in 1970 had a population of over 100,000. The metropolitan area of Duluth accounts for approximately one-third of the population of the Arrowhead Region. Another one-third of the Region's residents live in the small cities and townships located along the Mesabi Iron Range running through St. Louis and Itasca Counties. The remaining one-third of the Region's population is dispersed throughout the area. With the exception of the Duluth metropolitan area and a few smaller communities including Grand Rapids, the Region is comprised of a large number of very small rural communities. Population Distribution for the Arrowhead Region is illustrated in Figure IV-84.

The Arrowhead Region has experienced dramatic shifts in population over the last 35 years. Between 1940 and 1950, the population of the Arrowhead Region declined slightly. However, between 1950 and 1960, the Region experienced a dramatic population increase. This increase was at least partially related to the fact that employment in the mining industry in the Region was peaking during that period. Between 1960 and 1970, the Region experienced a decrease in population of approximately 4% while total State population increased by 11%, as shown in Table IV-82. Total State population increased by 36% between 1940 and 1970, while population for the Region increased 7%.

All counties in the Arrowhead Region except Aitkin County experienced increases in population between 1940 and 1970. Lake County experienced the largest increase in population (92%) while Aitkin County experienced the only decline (minus 36%), Compared to other counties in the Region, Itasca County had a relatively moderate 8% increase in population between 1940 and 1970. All counties in the Region except Carlton and Cook Counties experienced declines in population of 3 to 6% between 1960 and 1970. The population of Cook and Carlton Counties increased by 1% during that period.

Projections. Both the State Demographer and the Arrowhead Regional Development Commission (ARDC) have found it difficult to project future



POPULATION DISTRIBUTION-ARROWHEAD REGION - 1970

SOURCE: "PUBLIC PROGRAMS IN MINNESOTA DEVELOPMENT REGIONS, PART II, MANUAL FOR THE USE OF THE ATLAS IN DEVELOPING REGIONAL AGENDAS", 1974, PREPARED FOR THE MINNESOTA STATE PLANNING AGENCY BY THE CENTER FOR URBAN AND REGIONAL AFFAIRS, UNIVERSITY OF MINNESOTA

FIGURE IV-84

populations of the Arrowhead Region. Projections vary from slight decreases to major population increases. The population of the Arrowhead Region is strongly influenced by trends in St. Louis County. Because St. Louis County has experienced dramatic changes in population over recent years and because of current volatile economic conditions, it is anticipated that its population could change dramatically again in the future. Three population projections are

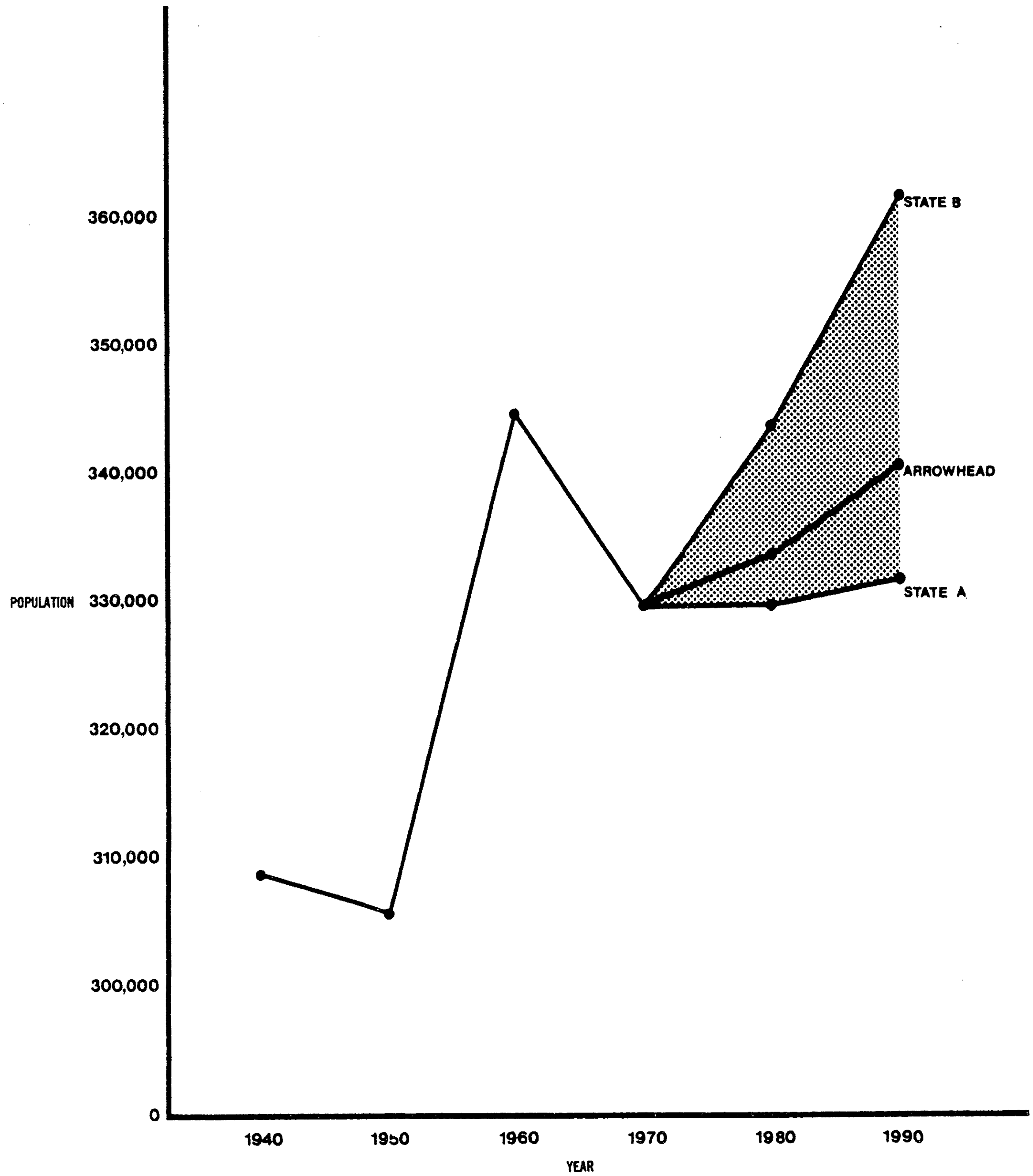
TABLE IV-82
HISTORIC TRENDS IN POPULATION - ARROWHEAD REGION - 1940 to 1970 (200)

Area	Population				Percent Change	
	1940	1950	1960	1970	1940 to 1970	1960 to 1970
Arrowhead Region						
Aitkin	17,865	14,327	12,162	11,403	-36	- 6
Carlton	24,212	24,584	27,932	28,072	+16	+ 1
Cook	3,030	2,900	3,377	3,423	+13	+ 1
Itasca	32,996	33,321	38,006	35,530	+ 8	- 6
Koochiching	16,930	16,910	18,190	17,131	+12	- 6
Lake	6,956	7,781	13,702	13,351	+92	- 3
St. Louis	206,917	206,062	231,588	220,693	+ 7	- 5
Total	308,906	305,885	344,957	329,603	+ 7	- 4
State of Minnesota	2,792,300	2,982,483	3,413,864	3,804,971	+36	+11

available for the Region. As illustrated in Figure IV-85, population projections for 1990 range from 332,000 to 362,000. The most recent projection available from ARDC estimates the Region's population in 1990 to be just over 340,000. Assuming this projection is appropriate, it is estimated that population will increase within the Region by approximately 1% by 1980 and approximately 3% by 1990. It is anticipated that Carlton, Koochiching, and St. Louis Counties will experience population increases by 1980 ranging from 3 to 4%. Aitkin County is expected to continue to lose population at a dramatic rate (minus 18%) while the remaining counties are expected to show decreases of between 2 and 6%. All counties except Carlton, Koochiching, and St. Louis are expected to continue to lose population through 1990. The projected population of the Arrowhead Region is presented in Table IV-83. Given the economic conditions which exist in the Region at present, significant decreases in population are not anticipated unless significant economic changes occur during this time period. State population is expected to increase 7% by 1980 and 16% by 1990. Clearly, the Arrowhead Region and all counties within the Region are experiencing a much lower growth rate - if not a decline - than the State as a whole.

Economic Sectors

Mining Industry. Today, steel demands for the U.S. are being met largely from the production of taconite iron ore from the Arrowhead Region of Minnesota. Since the production of natural iron ore peaked in 1953, the total natural iron



POPULATION TRENDS AND PROJECTIONS - ARROWHEAD REGION - 1940 TO 1990

SOURCE: ARROWHEAD REGIONAL DEVELOPMENT COMMISSION POPULATION PROJECTIONS, 1973, AND MINNESOTA STATE PLANNING AGENCY, MINNESOTA POPULATION PROJECTIONS - 1970 to 2000, NOVEMBER 1975

FIGURE IV-85

ore shipments have declined while taconite iron ore shipments have steadily increased, as shown in Table IV-84. Between 1973 and 1984 direct employment in the mining industry in the Region is expected to increase by almost 4,000 new operational jobs and approximately 6,000 construction-related jobs, as shown in Table IV-85.

In addition to direct employment, the taconite industry produces 2 additional economic effects:

- o The purchase of goods and services from firms within the Region. It has been estimated that by 1984 goods and services for the taconite industry would amount to as much as $125 million.

- o The employee earning cycle created within the local economy. The taconite industry could create 1,950 secondary jobs within the Region (205). By 1980, taconite production could account for 663 secondary jobs in Itasca County.

Several companies are investigating the feasibility of copper-nickel mining operations. There are specific concerns which may delay mineral extraction. Some of these concerns are:

- o Proximity of deposits to the Boundary Water Canoe Area (BWCA).

- o Potential for surface and ground water contamination from waste production.

- o Waste disposal from the extraction process.

- o Potential stress on housing and public services within the Region from this additional mining operation.

At present, the State of Minnesota has established a task force to examine these issues.

TABLE IV-83
PROJECTED POPULATION - ARROWHEAD REGION - 1970 to 1990 (201) (202)

Area	Projected Population					Percent Change	
	1970	1975	1980	1985	1990	1970 to 1980	1970 to 1990
Arrowhead Region							
Aitkin	11,403	9,800	9,300	8,680	8,050	-18	-29
Carlton	28,702	27,970	28,870	29,620	30,370	+ 3	+ 8
Cook	3,423	3,330	3,220	3,120	3,020	- 6	-12
Itasca	35,530	34,390	34,720	34,600	34,460	- 2	- 3
Koochiching	17,131	17,670	17,760	17,860	17,950	+ 4	+ 5
Lake	13,351	13,150	12,950	12,750	12,550	- 3	- 6
St. Louis	220,693	223,230	226,880	230,595	234,250	+ 3	+ 6
Total	329,603	329,540	333,700	337,225	340,650	+ 1	+ 3
State of Minnesota	3,804,971	3,923,000	4,076,800	4,252,200	4,421,500	+ 7	+16

TABLE IV-84
IRON ORE SHIPMENTS FROM MINNESOTA (MILLIONS OF LONG TONS AND PERCENT OF TOTAL) (203) (204)

Year	Natural Ore			Taconite			Total[a]	
	tons	mt	percent	tons	mt	percent	tons	mt
1953	80.9	82.2	99.3	.6	.6	.7	81.5	82.8
1958	34.4	35.0	80.4	8.4	8.5	20.6	42.8	43.5
1961	30.3	30.8	61.8	14.5	14.7	38.2	44.9	45.6
1964	30.4	30.9	61.0	19.4	19.7	39.0	49.8	50.6
1967	25.6	26.0	51.5	24.1	24.5	48.5	49.7	50.5
1970	21.2	21.5	38.5	34.0	34.6	61.5	55.1	56.0
1973	19.0	19.3	30.4	43.9	44.6	69.6	62.9	63.9

Year	Mesabi			Vermilion			Cuyuna			Other			Total[a]	
	tons	mt	percent	tons	mt	percent	tons	mt	percent	tons	mt	percent	tons	mt
1958	40.04	40.68	93.5	1.08	1.10	2.5	1.48	1.50	3.4	.24	.24	.56	42.84	43.53
1961	42.20	42.88	94.0	.87	.88	1.9	1.32	1.34	2.9	.50	.51	1.10	44.88	45.60
1964	47.66	48.43	95.8	1.02	1.04	2.0	.69	.70	1.3	.41	.42	.80	49.78	50.58
1967	48.11	48.88	96.6	.29	.30	.58	1.08	1.10	2.2	.31	.32	.60	49.79	50.59
1970	54.68	55.56	99.1	-	-	-	.52	.53	.9	-	-	-	55.20	56.09
1973	62.59	63.59	99.5	-	-	-	.31	.32	.49	-	-	-	62.90	63.91

[a] Differences between totals and values added to obtain totals are due to rounding.

Timber Industry. The timber industry is one of the largest in Minnesota, providing not only the natural resource but also processing the raw wood product into pulp or paper. Of the Region's 10 million acres (4 million hectares) of forest, approximately 9.2 million acres (3.7 million hectares) are commercial forest. Within the Arrowhead Region, 6,108 people were employed in the timber industry in 1973. Of this number, 61% were employed in the processing of timber to paper, as shown in Table IV-86. A total of 35% of manufacturing employment in the Region was directly involved in the processing of wood products.

Agriculture. Similar to statewide trends, the number of farms in the Arrowhead Region has decreased from 6,638 in 1959 to 3,242 in 1969, a 51% decline, as shown in Table IV-87. The rate of decline was twice the State recorded rate for the same time period. While the absolute number of farms dropped drastically, the average farm size increased by 31%, decreasing the total amount of regional farm acreage by only a small proportion, as shown in Table IV-88.

The most dramatic change to occur in agricultural history is a steady drop in employment. In 1960, agricultural employment for the Region was 4,500. In 1970, this figure had declined to 1,945, a decrease of 57%, as shown in Table IV-89.

TABLE IV-85
PROJECTED GROWTH IN IRON MINING INDUSTRY[a] (205)

	Tonnage (Millions)						Employment			Capital Investments ($ Millions)		
	1973		1984		Change							
	ton	mt	ton	mt	ton	mt	1973	1974	Change	By 1973	By 1984	Change
Minntac (U.S. Steel)	12.5	12.7	18.5	18.8	6.0	6.0	3,250	4,100	850	325	525	200
Erie Mining (Bethlehem and Pickands-Mather)	10.5	10.7	10.7	10.9	0.2	0.2	2,850	3,000	150	650	655	5
Reserve (Armco and Republic)	10.8	11.0	10.8	11.0	-	-	3,000	3,000	-	560	630	70
National Steel (Hanna)	2.8	2.9	6.0	6.1	3.2	3.3	580	1,000	420	90	240	150
Eveleth Taconite (Oglebay-Norton)	2.4	2.4	6.0	6.1	3.6	3.7	475	900	425	45	155	110
Hibbing Taconite (Bethlehem and Pickands-Mather)	-	-	6.0	6.1	6.0	6.1	-	1,250	1,250	-	200	200
Minorca (Inland Steel)	-	-	2.6	2.6	2.6	2.6	-	500	500	-	90	90
Taconite Total[a]	39.0	39.6	60.6	61.6	21.6	22.0	10,155	13,750	3,595	1,670	2,495	825
Natural Ore - all companies	15.3	15.6	7.3	7.4	-8.0	-8.1	1,885	1,100	- 785	na[b]	na[b]	na
Total[a]	54.3	55.2	67.9	69.0	13.6	13.8	12,040	12,650	2,850			

[a] Columns may not always total due to rounding of numbers.

[b] na means not available.

TABLE IV-86

FOREST INDUSTRY MANUFACTURING AND EMPLOYMENT - ARROWHEAD REGION AND STATE OF MINNESOTA - 1973 (205)

	County							Arrowhead Region	State of Minnesota
	Aitkin	Carlton	Cook	Itasca	Koochiching	Lake	St. Louis		
Total manufacturing employment	356	3,248	151	1,500	2,405	402	9,077	17,139	313,862
Lumber and wood products	217	-	130	397	675	138	827	2,384	9.329
Paper and allied	-	1,962	-	888	874	-	-	3,724	15,637
Total forest products	217	1,962	130	1,285	1,549	138	827	6,108	24,966
% Forest products of total manufacturing	61.0	o0.4	86.0	85.6	64.4	34.0	9.1	35.6	7.9
Total employment	1,562	6,119	835	6,745	3,982	2,868	56,576	86,651	1,107,220
% Manufacturing of total	22.8	53.08	18.0	22.2	60.4	14.0	16.0	19.8	28.3
% Forest products of total	13.9	32.06	10.2	19.0	39.3	4.8	1.5	7.0	2.3

TABLE IV-87
NUMBER OF FARMS AND PERCENT PART TIME - ARROWHEAD REGION AND STATE OF MINNESOTA (205)
1949, 1959, and 1969

	County							Arrowhead Region	State of Minnesota
	Aitkin	Carlton	Cook	Itasca	Koochiching	Lake	St. Louis		
Number of farms[a] 1949	2,207	1,962	b	2,210	1,061	242	4,686	12,428	174,100
Number of farms 1959	1,367	1,232	b	1,208	561	92	2,153	6,638	145,660
Number of farms 1969	791	705	b	519	267	45	915	3,242	110,747
% Change, 1949 to 1959	-38	-37	b	-45	-47	-62	-54	-46	-19
% Change, 1959 to 1969	-42	-43	b	-43	-52	-31	-58	-51	-24
% Part-time farm 1949[c]	24	38	b	46	33	53	47	40	na[d]
% Part-time farm 1969[c]	24	34	b	38	32	69	44	36	12

[a] Less than 10 acres (4.04 hectares) selling $250 in products, or more than 10 acres (4.04 hectares) selling $50 in products.
[b] Data not available because of small number of farms.
[c] Selling more than $50 in products, and worked off farm at least 100 days a year.
[d] na means not available.

TABLE IV-88
ACRES (HECTARES) IN FARMING - ARROWHEAD REGION - 1959, 1969 (205)

	County							Arrowhead Region	State of Minnesota
	Aitkin	Carlton	Cook	Itasca	Koochiching	Lake	St. Louis		
1959									
acres	232,000	196,300	a	175,900	116,600	18,500	306,600	1,045,900	
hectares	93,887	79,439	a	71,184	47,186	7,487	124,076	423,260	
1969									
acres	180,660	139,100	a	120,100	75,300	6,700	181,100	702,960	
hectares	73,110	56,292	a	48,603	30,473	2,711	73,288	284,478	
% Change acres (hectares) 1959 to 1969	-22.0	-29.1	a	-31.7	-35.4	-64.0	-40.9	-32.8	
1959									
acres per farm	215	159	a	146	177	125	142	163	
hectares per farm	87	64	a	59	72	50	57	66	
1969									
acres per farm	228	197	a	231	282	147	198	214	
hectares per farm	92	80	a	93	114	59	80	86	
% Change acres (hectares) per farm 1959 to 1969	+6.0	+23.9	a	+58.2	+59.3	+17.6	+39.4	+31.3	
% Land in farming 1969	15.4	25	a	7.1	3.8	.5	4.6	6.1	56.8

[a] Data not available because of small number of farms.

Since 1970, worldwide demand for food has increased the price of agricultural products. This may have brought about a reversal in the decline of agricultural activity in the Region. Since 1970, hay production in the Region has increased by 6.4%, possibly indicating a stabilization in the trend toward the loss of farm acreage.

Industrial Development. Industrial development in the Region has been allied closely to the utilization of natural resources. The mining and timber industries have provided 90% of industrial employment in locations with populations of less than 2,500 (205).

Non-natural resource based industrial employment has been limited. Overall, it is estimated that 82.6% of new industry is dependent on the Region's natural resources. Thus, the national trend toward decentralization of industrial areas outside metropolitan areas has not occurred in the Region due to the resource orientation of major industries in the area.

Construction. The construction industry is inter-related with the other major economic sectors and provides employment opportunities for a skilled work force. In 1970, the Region had 6,099 employees in the construction industry. The majority of these were involved in mining-oriented construction projects. With the present expansion of taconite and paper plants, the Region's construction industry is estimated to now employ between 5,000 to 6,000 persons as shown in Table IV-90.

The construction industry can be characterized by 2 major factors:

- Mobility - Skilled construction laborers are attracted by the complexity and duration of a project. On the Mesabi Iron Range, taconite construction has attracted workers from as far away as Arizona.

- Stability - The construction industry is greatly affected by national economic cycles. When construction activity declines, workers seek out other jobs and pursuits, or go on unemployment compensation. When the industry expands, the potential to earn higher wages draws workers from other industries and produces an artificial swelling in construction ranks. These 2 characteristics produce a labor force which is highly mobile and unstable and, upon completion of major mining and paper construction projects, will greatly contract. Unemployment within the Region will increase slightly as the labor force shifts into other project locations or is absorbed into other industries.

Tourism and Recreation. Tourism is a major element of the Region's economy. Because the tourism industry consists of a variety of businesses which provide a specific service, such as lodging or transportation, employment is distributed among a variety of economic sectors. In addition, tourism within the Region is cyclical, increasing employment during the summer and winter months as tourists enter the Region.

The Region has unique natural features, such as remote wilderness, scenic water areas, abundant wildlife, and towering forests. The Region provides year around recreation, drawing people not only from Minnesota but from other parts of the midwest and Canada.

In a 1975 study conducted by Uel Bland, it was reported that an estimated 237,000 visitors a week travel through Duluth during the summer months, spending more than $2 million per week (206).

Trade and Service Industry. The trade and service industries comprise the largest economic sector in the Region, providing over 44,000 jobs in 1970. In 1972, employment centered in 6,428 establishments with gross sales and receipts of $1,326 million. Annual payrolls from these establishments were $142 million.

The Region provides 3 levels of trade centers:

- Regional Trade Center - Duluth is the major trade center, built upon a diversified economic base heavily dominated by export industries. This trade center provides a full range of specialized goods and services to the smaller communities within the Region.

- Sub-Regional Trade Center - Grand Rapids on the western edge of the Region provides a wider range of goods and services than the mining towns.

- Community Center - The Mesabi Iron Range towns serve the daily needs of households with limited general merchandising and convenience goods.

TABLE IV-89
TOTAL AGRICULTURAL EMPLOYMENT -
ARROWHEAD REGION AND STATE OF MINNESOTA
1950, 1960, AND 1970 (205)

	Arrowhead Region	State of Minnesota
Employment - 1950	11,640	260,000
Employment - 1960	4,480	177,000
Employment - 1970	1,945	104,000
% Change 1950 to 1960	-61.5	-31.9
% Change 1960 to 1970	-56.6	-41.2

Labor Force

Characteristics. The Regional labor force declined slightly from 121,790 to 121,585 between 1960 and 1970. Although the State's labor force increased by 20%, the slight decline in the Regional labor force indicates a steady level of economic activity. Table IV-91 presents data on labor force participation in the Arrowhead Region, the State, and the U.S.

From 1970 to 1974, when expansions in the taconite and timber industries first began, employment gains in the service industry have increased the Regional labor force to 132,630, an increase of 9%. However, during this period, unemployment in the Region and Itasca County exceeded the State figure of 5.2%. The unemployment rate was 8.1% for the Region from 1970 to 1974. Labor

TABLE IV-90
PROJECTED INCREASES IN MESABI IRON RANGE EMPLOYMENT FOR TACONITE AND CONSTRUCTION INDUSTRIES[a]

Construction Projects		1975				1976				1977				1978				1979
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1
United	Hibbing Taconite	812	1,250	1,800	1,300	1,300	1,400	1,300	1,900	1,400	1,450	1,500,	1,900	1,400	1,300	1,300	50	-
Bechtel	National Steel Plant	921	989	1,242	940	800	950	1,200	900	-	-	-	-	-	-	-	-	-
	Inland (Minorca)	50	300	340	320	260	600	780	800	650	800	700	-	-	-	-	-	-
	Butler Taconite	-	-	-	-	-	-	50	400	500	900	1,200	1,100	800	1,000	1,200	1,300	900
U.S. Steel	Minntac Phase III	40	40	500	880	800	1,500	2,000	1,800	1,800	1,100	1,300	700	50	-	-	-	-
American Builders Inc.	Fairlane (Eveleth Taconite)	344	450	600	750	800	800	200	40	-	-	-	-	-	-	-	-	-
	Thunderbird (Eveleth Taconite)	75	75	100	150	250	250	300	20	-	-	-	-	-	-	-	-	-
Sub-totals		2,242	3,104	4,582	4,340	4,210	5,500	5,830	5,860	4,550	4,250	4,700	3,700	2,250	2,300	2,500	1,350	900
Housing construction areawide		50	260	400	280	120	220	320	240	60	180	240	240	30	100	120	130	40
Other miscellaneous construction		35	96	125	120	35	95	125	120	30	200	300	400	120	200	260	320	100
Sub-totals		70	356	525	400	155	315	445	360	90	380	540	640	150	300	380	450	140
Total construction labor		2,317	3,460	5,107	4,470	4,365	5,815	6,275	6,220	4,640	4,630	5,240	4,340	2,400	2,600	2,880	1,800	1,040
Permanent taconite labor		-	-	-	100	250	300	1,100	1,500	1,800	2,100	2,200	2,400	2,900	3,150	3,200	3,450	3,450
Total		2,317	3,460	5,107	4,840	4,615	6,115	7,375	7,720	6,440	6,730	7,440	6,740	5,300	5,750	6,080	5,250	4,490

[a] Construction labor force consists of prime contractors' employees, plus supervisory personnel, plus sub-contractors. Quarterly summaries are based on peak employment during that period. Construction data obtained from primary contractors during April, 1975. Taconite labor verified by Lake Superior Industrial Bureau during April, 1975.

TABLE IV-91
LABOR FORCE PARTICIPATION OF POPULATION 14 YEARS OLD AND OVER (205)

Area	Population 14+ Years			Labor Force 14+ Years		
	Male	Female	Total	Male	Female	Total
Arrowhead Region						
Aitkin County						
1960	4,507	4,175	8,682	2,298	934	3,862
1970	4,322	4,305	8,627	2,587	1,315	3,902
Carlton County						
1960	9,701	9,294	18,995	7,117	2,904	10,021
1970	9,922	9,997	19,919	6,761	3,427	10,188
Cook County						
1960	1,221	1,058	2,279	912	403	1,315
1970	1,316	1,200	2,516	862	554	1,416
Itasca County						
1960	12,987	12,120	25,107	9,275	2,994	12,269
1970	12,792	12,849	25,641	8,294	3,789	12,083
Koochiching County						
1960	6,104	5,658	11,762	4,626	1,462	6,088
1970	6,175	6,062	12,237	4,226	2,072	6,298
Lake County						
1960	4,590	4,179	8,769	3,721	1,144	4,865
1970	4,714	4,576	9,290	3,349	1,451	4,800
St. Louis County						
1960	80,015	81,099	161,114	58,455	24,915	83,370
1970	78,781	84,481	163,262	53,059	29,839	82,898
Total 1960	119,125	117,583	236,708	87,034	34,756	121,790
1970	118,022	123,470	241,492	79,138	42,447	121,585
City of Duluth						
1960	36,825	39,911	76,736	26,801	13,815	40,616
1970	35,327	40,680	76,007	23,922	16,134	40,056
State of Minnesota						
1960	1,147,981	1,196,494	2,344,475	887,774	411,191	1,298,965
1970	1,317,587	1,418,152	2,735,739	963,315	592,214	1,555,529
United States						
1960	61,315,298	64,961,254	126,276,552	47,467,720	22,409,756	69,877,476
1970	71,492,364	77,914,869	149,407,233	52,076,663	30,820,770	82,897,433

force estimates for the Arrowhead Region and counties are presented in Table IV-92.

Income. Regionally, changes in median family income from 1959 to 1969 have not kept pace with State and national income averages. The State's change in income average of $4,358 is 23% higher than the Regional median family income change of $3,440.

The relatively static employment level experienced by the Region through 1969 is a major factor contributing to lower Regional income. Table IV-93 presents data on family income characteristics for the Region, the State, and the U.S.

Closer examination of regional per capita income figures from 1969 to 1973 indicates a lag in income growth compared with the State and national averages (Table IV-94). In 1973, the regional per capita income was 18% below the national average and 20% below the statewide average.

Public Services

Education. There are 38 school districts in the Arrowhead Region. Current and projected school age population in the Region is identified in Table IV-95. Total elementary age population in 1970, excluding kindergarten, was 42,443. Total secondary age population was 49,236. The State Demographer projects substantial decreases in both elementary and secondary age populations throughout the Region and the State by 1980. Elementary age population is expected to decrease by 40% in the Arrowhead Region by 1980. However, a mini babyboom is anticipated in the 1980's, increasing elementary age population slightly by 1990. Secondary enrollment will follow similar patterns with secondary school population decreases in the Region of 19% by 1980 and a decrease of 41% by 1990. In the future, counties in the Region are expected to show dramatic declines in school age population. This trend is occurring throughout Minnesota.

There are several post-secondary education institutions in the Region. There is one 4-year public college, the University of Minnesota at Duluth. In addition, there are at least three vocational-technical institutes, five junior colleges (one in Grand Rapids), one private trade school, and one private college. The locations of these institutions are identified in Figure IV-86.

Health Service. There presently are 384 practicing doctors in the Arrowhead Region or 1.2 doctors for each 1,000 people, as shown in Table IV-96. Only Cook County has coverage better than the State average of 1.6 doctors per 1,000 people. Aitkin has the least adequate coverage with 0.4 doctors per 1,000, while Carlton, Itasca and Koochiching all have 0.6 and Lake has 0.7 doctors per 1,000 people. Clearly, the Region and these counties appear to be understaffed compared to the statewide average.

There are at least 20 hospitals in the Arrowhead Region with a total of 1,972 beds. Three of these hospitals are located in Itasca County. Most other hospitals are located along the Iron Range or in the Duluth metropolitan area. Location of hospitals in the Arrowhead Region is illustrated in Figure IV-87.

TABLE IV-92
LABOR FORCE ESTIMATES - ARROWHEAD REGION AND COUNTIES (205)

Area	Total Work Force	Total Employed	Total Unemployed	Rate Unemployed
Arrowhead Region				
Aitkin County				
1974	4,600	4,000	520	11.3
1966	3,500	3,000	450	12.9
Carlton County				
1974	11,100	10,100	1,000	9.0
1966	9,500	9,100	370	3.9
Cook County				
1974	1,730	1,590	140	8.1
1966	1,460	1,390	70	4.8
Itasca County				
1974	14,300	12,700	1,560	10.9
1966	12,700	11,600	1,120	8.8
Koochiching County				
1974	6,700	6,200	540	8.1
1966	6,100	5,800	290	4.8
Lake County				
1974	4,600	4,200	330	7.2
1966	4,700	4,500	190	4.0
St. Louis County				
1974	89,600	82,900	6,700	7.5
1966	84,800	80,800	4,000	4.7
Total 1974	132,630	121,690	10,790	8.1
1966	122,760	116,190	6,490	5.3
State of Minnesota				
1974	1,866,400	1,769,700	96,700	5.2
1966	1,488,700	1,442,500	46,200	3.1
United States				
1974	na[a]	na	na	na
1966	na	na	na	na

[a] na means not available

TABLE IV-93
FAMILY INCOME CHARACTERISTICS - ARROWHEAD REGION (200)

Area	Number of Families		Median Family Income in current dollars		Median Family Income in constant dollars[a]		Families Below Poverty Level[b] number		Families Below Poverty Level[b] percent	
	1960	1970	1959	1969	1959	1969	1959	1969	1959	1969
Arrowhead Region										
Aitkin County	3,187	3,041	3,064	5,900	4,691	5,900	1,561	974	49.0	32.1
Carlton County	6,724	6,760	5,641	8,994	7,151	8,994	1,165	914	17.4	13.6
Cook County	796	914	5,188	8,000	6,361	8,000	130	128	16.4	14.0
Itasca County	9,303	9,003	4.546	7,985	6,349	7.985	2,473	1,692	26.6	18.8
Koochiching County	4,284	4,248	5,683	8 508	6,765	8,508	661	773	15.5	17.3
Lake County	3,355	3,292	5,584	8,803	6,999	8 803	396	338	11.8	10.3
St. Louis County	58,313	54,682	5,455	8,997	7,153	8,997	10,286	7,679	17.7	14.1
Total	85,962	81,940	5,334	8,774	6,976	8,774	16,672	12,458	19.4	15.2
City of Duluth	27,039	24,839	5,877	9,313	7,405	9,313	4,029	3.498	14.9	14.1
State of Minnesota	836,723	921,332	5,573	9,931	7,896	9,931	178,766	127,095	21.4	13.8
United States	45,128,393	51,168,599	5,660	9,590	7,265	9,590	9,650,239	7,770,735	21.4	15.2

[a] Constant dollars expressed in terms of constant 1969 dollars.

[b] Poverty level for non-farm family of 4 in 1969 was defined as $3,968.

TABLE IV-94
PER CAPITA PERSONAL INCOME - ARROWHEAD REGION - 1969 AND 1973 (207)

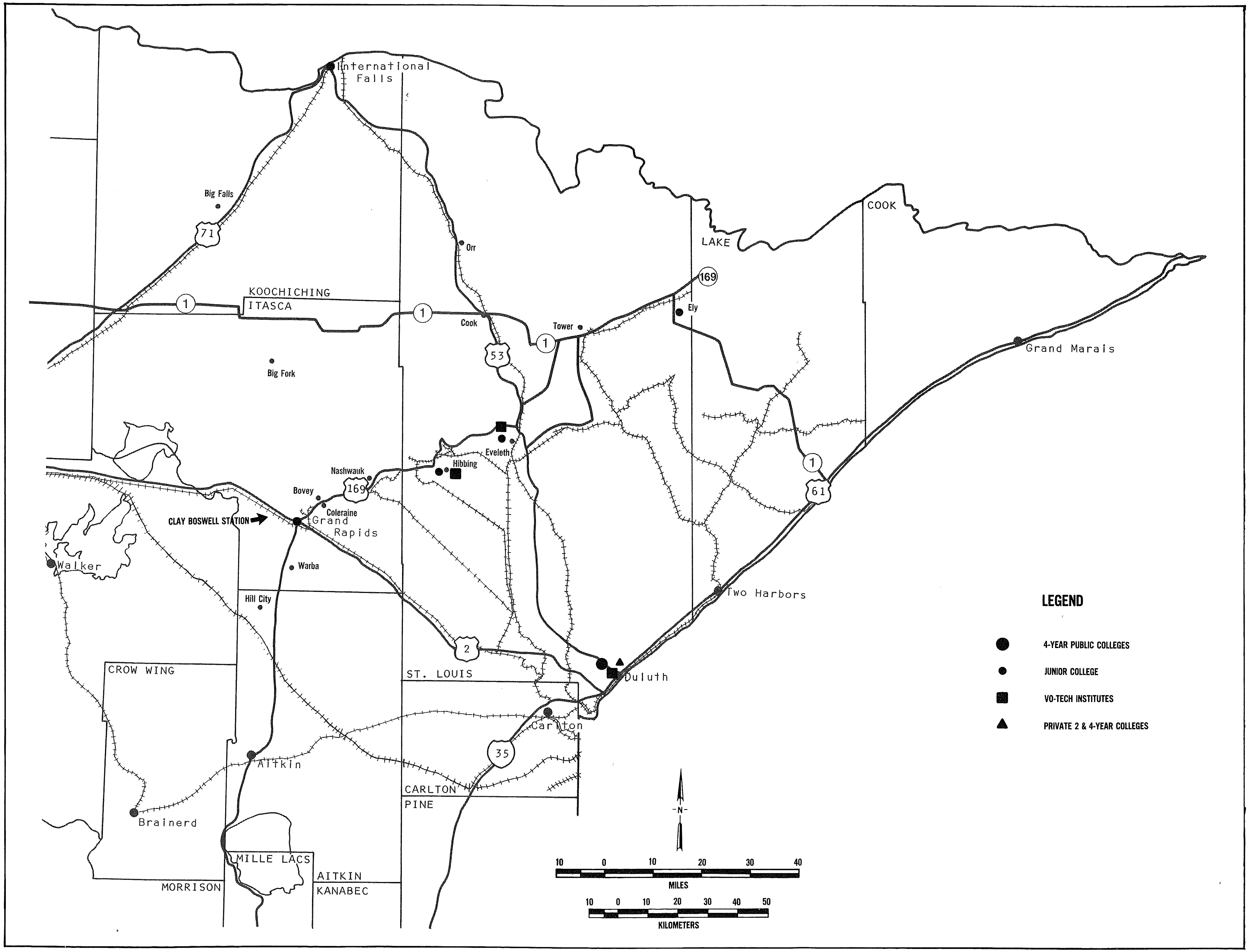
Area	1969	1973	Dollar Change	Percent Change	Rank[a] in State of Minnesota
Arrowhead Region					
Aitkin County	$ 1,999	$ 3,022	$ 1,023	51.2	85
Carlton County	2,685	3,827	1,142	42.5	67
Cook County	2,655	3,434	779	29.3	80
Itasca County	2,613	3,504	891	34.1	76
Koochiching County	2,602	3,582	980	37.7	71
Lake County	2,685	3,551	866	32.3	74
St. Louis County	3,207	4,447	1,240	38.7	54
Total	2,998	4,136	1,138	38.0	
State of Minnesota	3,571	5,144	1,573	44.0	
United States	3,733	5,041	1,308	35.0	

[a] Rank is based on total of 87 counties in State of Minnesota.

TABLE IV-95
PROJECTED SCHOOL ENROLLMENTS - ARROWHEAD REGION
1970 TO 1990 (208)

Area	Elementary Population[a] 1970	1980	1990	Percent Change in Elementary 1970-1980	1970-1990	Secondary Population 1970	1980	1990	Percent Change in Secondary 1970-1980	1970-1990
Arrowhead Region										
Aitkin County	1,385	741	965	-46	-30	1,537	1,350	899	-12	-42
Carlton County	3,934	2,257	2,739	-43	-30	4,161	3,835	2,832	- 8	-32
Cook County	435	231	244	-47	-44	460	409	227	-11	-51
Itasca County	4,803	2,756	3,462	-43	-28	5,723	4,523	3,161	-21	-45
Koochiching County	2,364	1,378	1,661	-42	-30	2,755	2,236	1,533	-19	-44
Lake County	2,003	1,045	1,294	-48	-35	2,128	1,770	1,149	-17	-46
St. Louis County	27,519	17,032	19,481	-38	-29	32,472	25,832	19,323	-20	-40
Total	42,443	25,440	29,846	-40	-30	49,236	39,955	29,124	-19	-41
State of Minnesota	500,645	348,837	416,623	-30	-17	546,234	523,994	421,402	- 4	-23

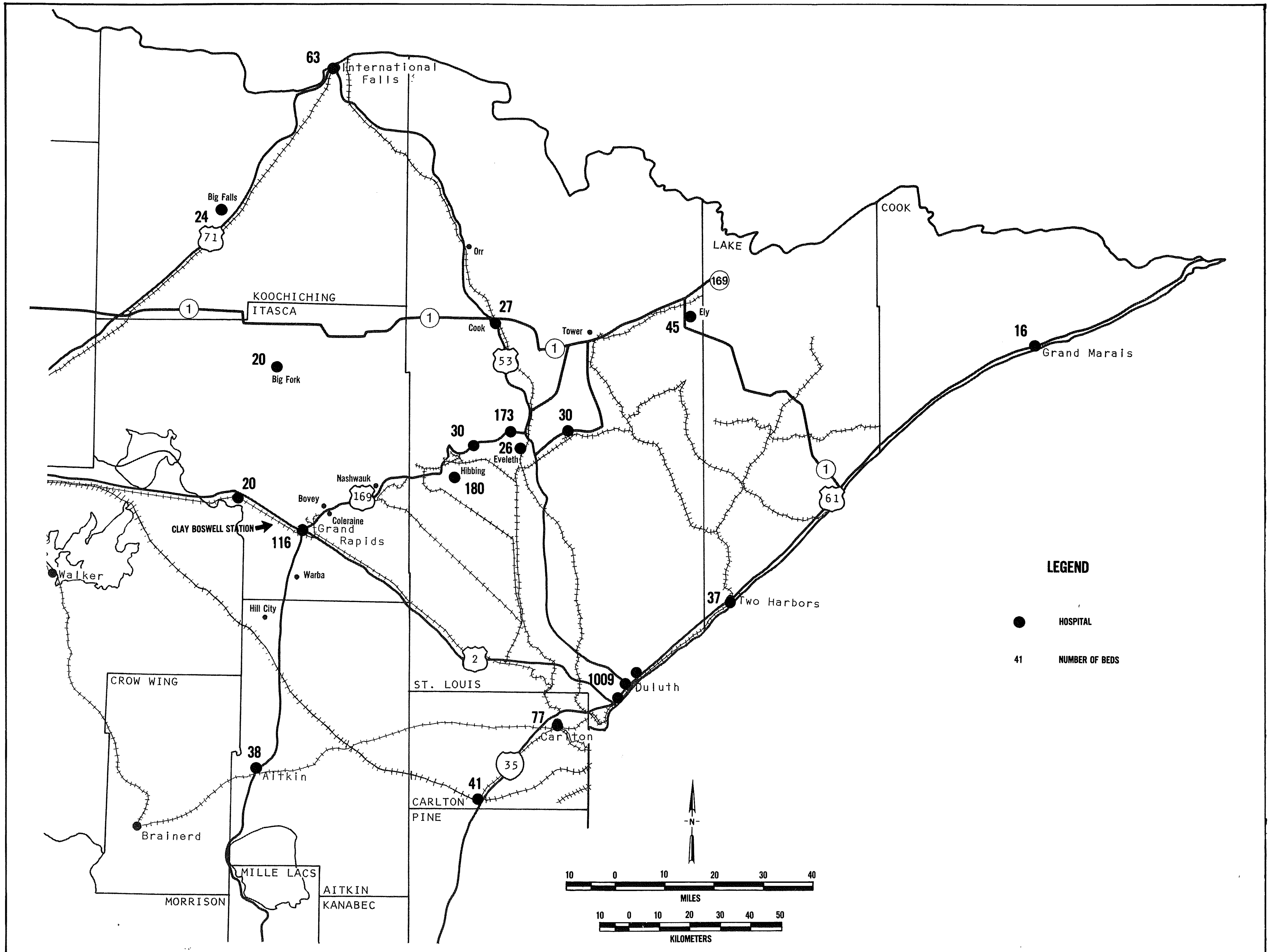
[a] Does not include kingergarten population.



POST-SECONDARY ARROWHEAD REGION EDUCATIONAL INSTITUTIONS

SOURCE: "INVENTORIES OF MINNESOTA POST-SECONDARY INSTRUCTIONAL PROGRAMS", MINNESOTA HIGHER EDUCATION COORDINATING COMMISSION, APRIL 1972

FIGURE IV-86



LOCATION OF HOSPITALS
ARROWHEAD REGION - 1973

SOURCE: "PUBLIC PROGRAMS IN MINNESOTA'S DEVELOPMENT REGIONS, PART I, ATLAS OF PROGRAMS AND SERVICE AREAS", 1973, PREPARED FOR THE MINNESOTA STATE PLANNING AGENCY BY THE CENTER FOR URBAN AND REGIONAL AFFAIRS, UNIVERSITY OF MINNESOTA

FIGURE IV-87

TABLE IV-96
PRACTICING DOCTORS PER CAPITA - ARROWHEAD REGION - 1977

Area	1970 Population	Number of Doctors	Doctors Per 1,000 Population
Arrowhead Region			
Aitkin County	11,403	5	0.4
Carlton County	28,072	17	0.6
Cook County	3,423	7	2.1
Itasca County	35,530	22	0.6
Koochiching County	17,131	10	0.6
Lake County	13,351	9	0.7
St. Louis County	220,693	314	1.4
Total	329,603	384	1.2
State of Minnesota	3,804,971	6,000	1.6

TABLE IV-97
HOSPITAL BEDS PER CAPITA - ARROWHEAD REGION (209)

Area	1970 Population	Number of Beds	Hospital Beds Per 1,000 Population
Arrowhead Region			
Aitkin County	11,403	38	3.3
Carlton County	28,072	118	4.2
Cook County	3,423	16	4.7
Itasca County	35,530	156	4.4
Koochiching County	17,131	87	5.1
Lake County	13,351	37	2.8
St. Louis County	220,693	1,520	6.9
Total	329,603	1,972	6.0
State of Minnesota	3,804,971	19,676	5.2

There are 6 hospital beds per 1,000 people in the Arrowhead Region. This compares favorably to the State average of 5.2 beds per 1,000 population as presented in Table IV-97. However, all counties except St. Louis County have a hospital capacity below the State average, with capacity ranging from 2.8 beds per 1,000 people in Lake County to 5.1 beds per 1,000 people in Koochiching County. There are 31 nursing homes with 2,700 beds in the Region (209).

Available ambulance service in the Arrowhead Region is illustrated in Figure IV-88. At least 31 different services are available. Most of these are located in St. Louis County along the Iron Range and in the Duluth metropolitan area. Three such services are located in Itasca County.

Law Enforcement. There are approximately 40 municipal police departments in the Arrowhead Region. However, data on police personnel were available only for the 7 county sheriff departments and the 25 departments in municipalities over 1,000 population. Since 1967, municipalities over 1,000 population must send police officers to a certified officer training program within one year from the date of employment.

There are at least 446 certified full-time police officers in the Arrowhead Region (Table IV-98). Of these, 142 are employed by county sheriff departments. The remainder serve municipalities over 1,000 population. This staffing is equivalent to a coverage of 1.4 certified police officers per 1,000 population in the region. Coverage by county ranges from 0.8 in Aitkin County to 1.7 in Lake County.

Three counties in the region employ a total of 40 civilian employees (34 are full-time). There are also 14 full-time officers in the Region who are not certified.

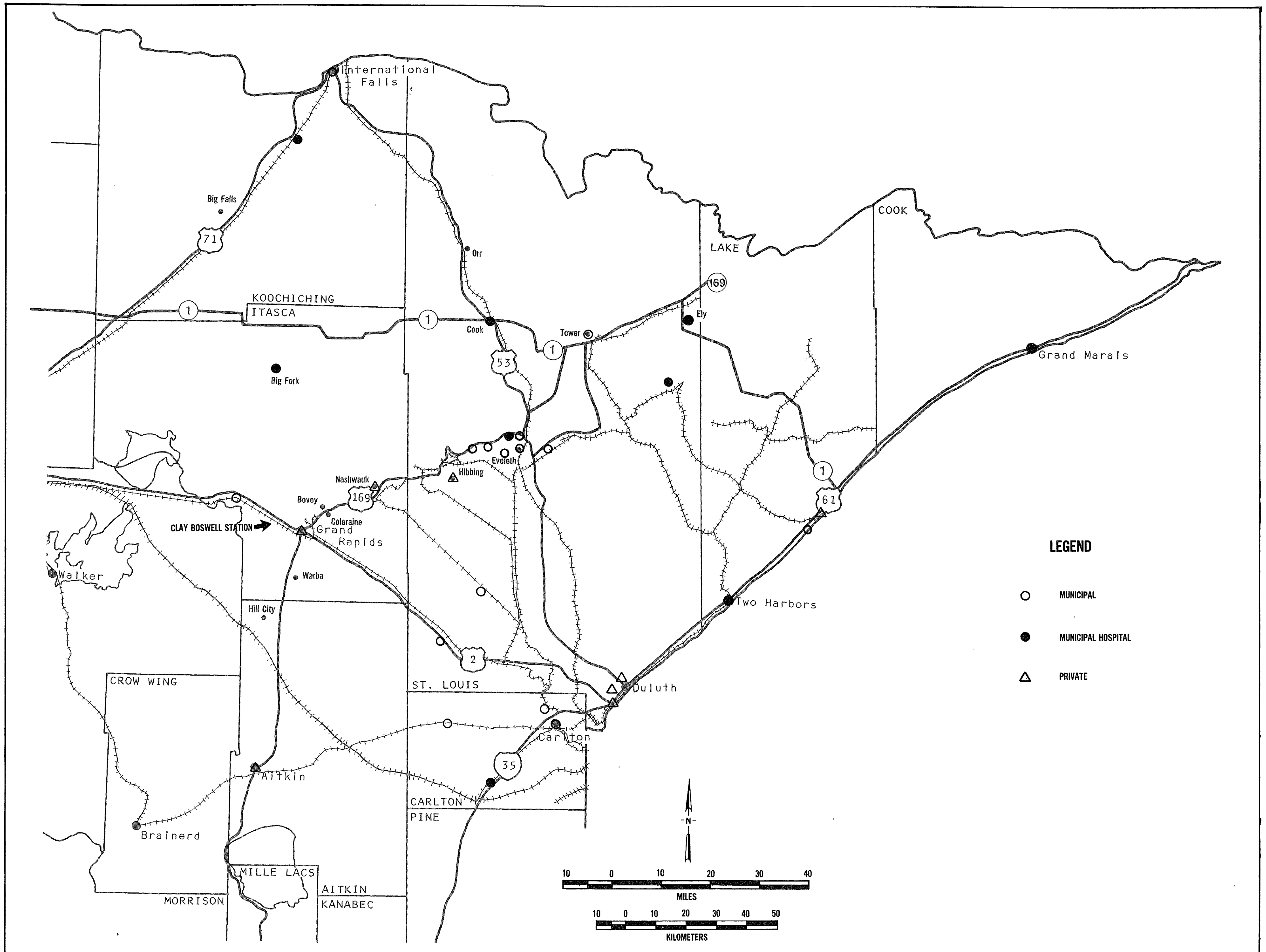
The condition of county jails and lockups in the Arrowhead Region is indicated in Figure IV-89. Cook County does not have a county jail and the Koochiching County Jail needs replacement. Only Itasca and St. Louis Counties have satisfactory county jail facilities at the present time.

Fire Protection. There are 73 fire departments in the Arrowhead Region. All of these are volunteer fire departments and 11 are located in Itasca County. The coverage in Minnesota as a whole is 4.8 fire fighters per 1,000 population. Information on the number of fire fighters in the Arrowhead Region is not available. The number of fire fighters in Itasca County and the State is indicated in Table IV-99.

Revenues and Expenditures

Revenues. County revenues in the Arrowhead Region for 1974 are indicated in Table IV-100. The primary sources of county revenues are property taxes, intergovernmental grants, fees, fines and other miscellaneous sources. Non-revenue receipts include borrowed funds, trust and agency funds (which are received by the counties for redistribution to other taxing districts), and miscellaneous transferred funds.

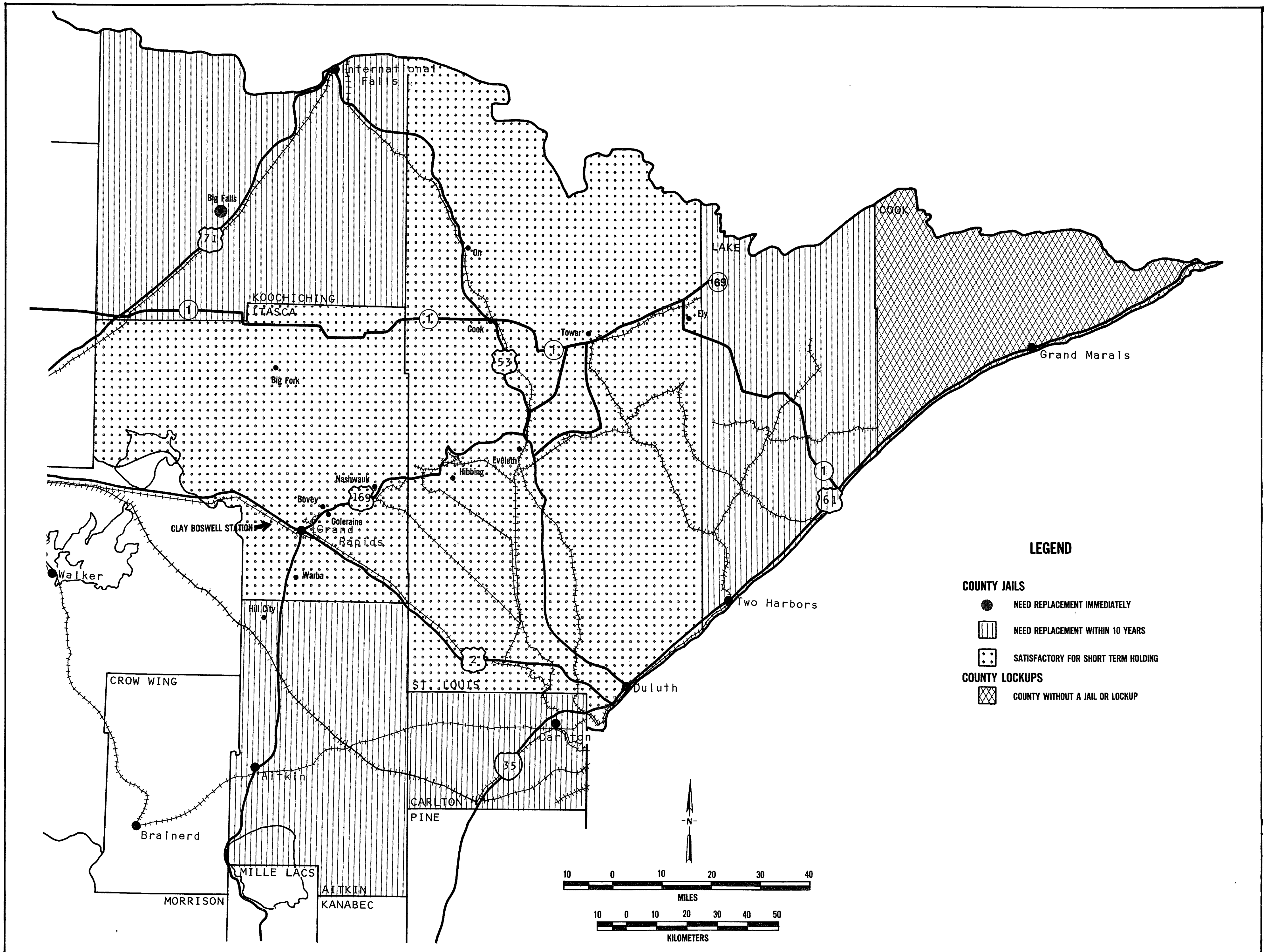
In 1974, property taxes accounted for 28% of county revenue receipts in the Arrowhead Region compared to 30% of county revenues throughout Minnesota.



LICENSED AMBULANCES ARROWHEAD REGION - 1973

SOURCE: "PUBLIC PROGRAMS IN MINNESOTA'S DEVELOPMENT REGIONS, PART I, ATLAS OF PROGRAMS AND SERVICE AREAS", 1973, PREPARED FOR THE MINNESOTA STATE PLANNING AGENCY BY THE CENTER FOR URBAN AND REGIONAL AFFAIRS, UNIVERSITY OF MINNESOTA

FIGURE IV-88



**COUNTY JAILS AND LOCKUPS
ARROWHEAD REGION - 1973**

SOURCE: "A COMPREHENSIVE PLAN FOR REGIONAL JAILING AND JUVENILE DETENTION IN MINNESOTA", MINNESOTA DEPARTMENT OF CORRECTIONS, 1971

FIGURE IV-89

County reliance on property taxes in the Region ranged from 17% in Cook County to 34% in Itasca County. The trend in both the Arrowhead Region and the State has been toward less reliance on property taxes as a source of revenue. State and Federal grants and aids have become an increasingly important aspect of local financing. In 1974, these funds accounted for 64% of county financing in the region compared to 60% of county revenues across the State. Intergovernmental grants and aids range from 55 to 78% of County revenues among the counties in the Arrowhead Region.

Expenditures. County expenditures in 1974 for the Arrowhead Region are identified in Table IV-101. Most county expenditures are for welfare and highways. In all cases, these expenditures accounted for over half of county expenses in 1974. In the entire region, welfare expenditures account for 49% of county expenses. This is slightly less than the statewide average of 53%. Highways in the region account for an above average 17% compared to the statewide expenditures of 14%. On a percentage basis, all other expenditures in the region are similar to the statewide average.

Outstanding Indebtedness. Outstanding indebtedness for local governments in the region is indicated in Table IV-102. Between 1966 and 1974, counties in the region decreased indebtedness by 7% while cities and townships increased indebtedness by over 50%. School districts decreased indebtedness by 11% between 1966 and 1972. Local governments in the Arrowhead Region increased indebtedness by 14% between 1966 and 1974. This compares very favorably to the statewide increase of 81%.

Local

Population

Distribution. Itasca County has the second largest population in the Arrowhead Region, with a 1970 population of approximately 36,000. The 1970 population distribution of the county is illustrated in Figure IV-90. The major city is Grand Rapids, located in the southwestern portion of the County. Grand Rapids has generally shown a steady increase in population over the past 3 decades and had a population of 7,200 in 1970. Considering the decreases in population experienced in Itasca County and the Arrowhead Region during the 1960's, this trend toward population increase illustrates the relative economic strength of the city of Grand Rapids compared to the surrounding areas.

The areas with populations over 1,000 tend to be townships located in close proximity to the City of Grand Rapids and communities along Highway 169 leading toward the Mesabi Iron Range. All remaining cites and townships in the county have populations of less than 1,000. A large percentage of the county land area is sparsely populated and is not organized into official townships. This land area, which accounts for approximately one-third of the total land area of the county, has a population of less than 4,000. Historic Trends in Itasca County's Population are presented in Table IV-103.

The urban/rural shifts in Itasca County population are illustrated in Figure IV-91. Rural cities in Itasca County have lost population since 1940 and showed particularly dramatic population losses during the 1960's. Unorganized

TABLE IV-98
CERTIFIED FULL-TIME POLICE OFFICERS - ARROWHEAD REGION

Area	1970 Population Served	Number of Officers	Officers Per 1,000 Population
Arrowhead Region			
Aitkin County			
County Sheriff	11,403	4	0.4
Municipal	1,553	5	3.1
Total	11,403	9	0.8
Carlton County			
County Sheriff	28,072	11	0.4
Municipal	11,231	12	1.1
Total	28,072	23	0.8
Cook County			
County Sheriff	3,423	2	0.6
Municipal	1,301	2	1.5
Total	3,423	4	1.2
Itasca County			
County Sheriff	35,530	12	0.3
Coleraine	1,086	1	0.9
Grand Rapids	7,247	11	1.5
Keewatin	1,382	3	2.1
Nashwauk	1,341	4	3.1
Total	35,530	31	0.9
Koochiching County			
County Sheriff	17,131	11	0.6
Municipal	6,439	13	2.0
Total	17,131	24	1.4
Lake County			
County Sheriff	13,351	10	.07
Municipal	7,941	13	1.6
Total	13,351	23	1.7
St. Louis County			
County Sheriff	220,693	92	0.4
Duluth	100,578	129	1.3
Other Municipal	60,696	111	1.8
Total	220,693	332	1.5
Region Total			
County Sheriffs	329,603	142	0.4
Municipal	200,795	304	1.5
Total	329,603	446	1.4
State of Minnesota			
County Sheriffs	3,804,971	1,435	0.4
Municipal	2,527,308	5,145	2.0
Total	3,804,971	6,580	1.7

TABLE IV-99
FIRE FIGHTERS - ITASCA COUNTY
AND STATE OF MINNESOTA - 1976

Area	1970 Population Served	Fire Fighters	Fire Fighters per 1,000 Population
Itasca County	33,510	249	7.4
State of Minnesota	3,804,971	18,264	4.8

TABLE IV-100
COUNTY REVENUES - ARROWHEAD REGION 1974

	Revenues				Percent of Revenues			
Area	Property Taxes (000)	Grants and Aids (000)	Other (000)	Total Revenues (000)	Property Taxes %	Grants and Aids %	Other %	Total %
Arrowhead Region								
Aitkin County	$ 849	$ 3,165	$ 301	$ 4,315	20	73	7	100
Carlton County	1,981	4,671	654	7,306	27	64	9	100
Cook County	225	987	100	1,312	17	75	8	100
Itasca County	4,166	6,627	1,324	12,117	34	55	11	101[a]
Koochiching County	940	3,253	340	4,533	21	72	8	100
Lake County	559	2,446	123	3,128	18	78	4	100
St. Louis County	16,466	36,263	3,860	56,589	29	64	7	100
Region Total	25,186	57,412	6,702	89,300	28	64	8	101[a]
State of Minnesota	234,904	474,476	76,355	785,735	30	60	10	100

[a] Columns will not always total due to rounding of numbers.

territories and townships also experienced population decline during the 1960's. The ARDC projects a general continuation of this trend (201). Some increase in township population is projected, principally for those townships located in close proximity to the City of Grand Rapids. Some municipalities located along the Iron Range are also expected to show increases in population. All remaining areas of the county are expected to lose population in the future, as shown in Figure IV-91.

Age Composition. The median age of the Itasca County population has been rising since 1940 as shown in Figure IV-92. More specifically, there has been a significant decrease in the 20 to 39 age group as a percentage of total population of the county. Since these individuals account for a fairly large portion of the labor force of the areas, it appears that there is a significant out-migration of individuals within the labor force of Itasca County. If this trend continues in the future, it may suggest a decrease in total population as well, since these age groups represent the prime childbearing age group of the population. The apparent loss of young adult population in Itasca County is further emphasized by comparing age composition in Itasca County to age composition of the entire State. As shown in Figure IV-93, Itasca County has a much lower percentage of young adults and very young children in its population than in Minnesota as a whole. The county also shows a larger number of teenagers and older adults in its population than in the State.

Projections. Itasca County has had a relatively stable population level over the last 35 years. In 1940, its population was approximately 33,000 and in 1970 its population was 36,000. The population projections of the State Demographer and the ARDC are illustrated in Figure IV-94. The ARDC projects a continuing gradual decrease of 3% between 1970 and 1990. The State Demographer projects a slight increase in population for Itasca County by 1990.

As shown in Table IV-104 and Figure IV-91, increases in population of 16% by 1980 and 28% by 1990 are projected for the City of Grand Rapids. All other communities in the County are projected to decrease significantly in population. Both townships and unorganized territories are also projected to decrease in population by 1980. However, townships are expected to increase in population between 1980 and 1990. It is anticipated that the majority of these increases will occur in those townships located near the City of Grand Rapids. Unorganized territories are expected to lose approximately half of their population by 1990.

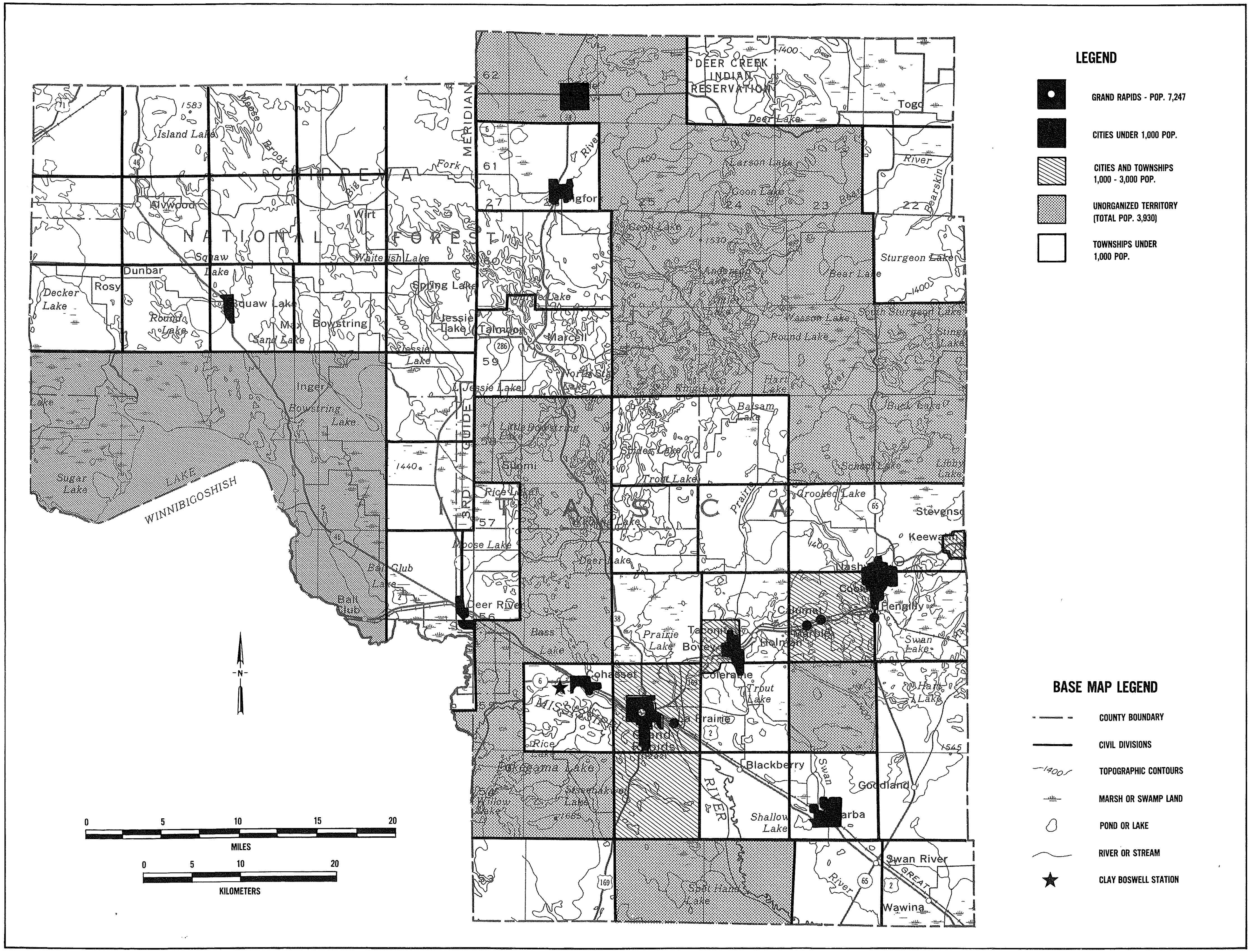
The State Demographer has made projections of age compositions in each of the counties in Minnesota, based on a number of assumptions with regard to birth rates and in and out-migration rates. Assuming a net migration rate of zero, the age composition of Itasca County can be expected to change dramatically by 1990 as shown in Figure IV-95. Assuming a net migration rate of zero, and normal aging of the population with average birth rates, the percent of population in the 20 to 39 age group is expected to increase significantly. The 0 to 19 age group is expected to decrease significantly and 40 to 59 age group is also expected to decrease. These projections are based on the current population mix, which involves a smaller percentage of individuals in the prime childbearing ages and a large percentage of individuals in the late teens. A continuing out-migration of young adults could significantly change this projection of age composition (200).

Economic Sectors

Itasca County is an integral part of an economic region comprising St. Louis, Koochiching, Carlton, Cook and Aitkin Counties. This Region serves as a major supplier of taconite ore to the steel industry, timber for the paper industry and provides a unique scenic environment which attracts many tourists.

Itasca County's relationship to the other counties within this Region is important for several reasons:

- The expansion of the taconite industry and other economic development activities is dependent upon the availability of electrical energy. The



POPULATION DISTRIBUTION
ITASCA COUNTY - 1970

FIGURE IV-90

TABLE IV-101

CLASSIFICATION OF COUNTY DISBURSEMENTS - ARROWHEAD REGION - CALENDAR YEAR ENDING DECEMBER 31, 1974

	County							Arrowhead Region	State of Minnesota
	Aitkin	Carlton	Cook	Itasca	Koochiching	Lake	St. Louis		
	(000)	(000)	(000)	(000)	(000)	(000)	(000)	(000)	(000)
Current Expenses									
General Government	$ 337	$ 967	$ 235	$ 998	$ 452	$ 469	$ 3,973	$ 7,431	$ 69,815
Public Safety	120	256	66	427	182	224	2,663	3,938	43,695
Natural Resources	2	16	15	127	0	17	296	473	7,542
Highways	1,496	513	291	1,800	1,163	1,285	7,212	13,760	97,576
Sanitation	-	73	61	92	51	1	574	852	1,844
Health	7	168	10	112	24	57	1,173	1,551	20,363
Hospitals - PSE[a]	0	0	67	433	0	0	1,985	2,485	19,503
Welfare	1,309	2,707	324	4,931	2,130	869	27,989	40,259	361,297
Schools	0	0	0	0	0	0	0	0	7
Libraries	11	18	0	21	0	27	120	197	8,037
Recreation	21	20	2	8	29	34	0	106	5,270
Interest	5	0	0	0	13	c	27	45	3,406
Miscellaneous	184	308	42	667	172	279	8,805	10,457	38,240
Total[b]	$ 3,491	$ 5,044	$1,115	$9,617	$ 4,216	$3,264	$54,902	$81,649	$678,226
Capital outlay	143	1,636	127	2,733	155	388	5,534	10,716	105,376
Other disbursements Trust and Agency payments	4,625	5,789	958	8,961	311	1,307	98,846	120,797	1,169,874
Total All Disbursements	$ 8,374	$12,498	$2,208	$21,311	$ 4,807	$5,388	$170,155	$224,741	$3,160,676
	%	%	%	%	%	%	%	%	%
Current Expenses									
General Government	10	19	21	10	11	14	7	9	10
Public Safety	3	5	6	4	4	7	5	5	6
Natural Resources	c	c	1	1	0	1	1	1	1
Highways	43	10	26	19	28	39	13	17	14
Sanitation	c	1	5	1	1	c	1	1	c
Health	c	3	1	1	1	2	2	2	3
Hospitals - PSE[a]	0	0	6	5	0	0	4	3	3
Welfare	37	54	29	51	51	27	51	49	53
Schools	0	0	0	0	0	0	0	0	c
Libraries	c	c	0	c	0	1	c	c	1
Recreation	1	c	c	0	1	1	0	c	1
Miscellaneous	5	6	4	7	4	9	16	13	6
Total[b]	99	98	99	99	101	101	100	100	98

[a] Public Service Enterprises - publicly owned services such as utilities, hospitals and nursing homes.

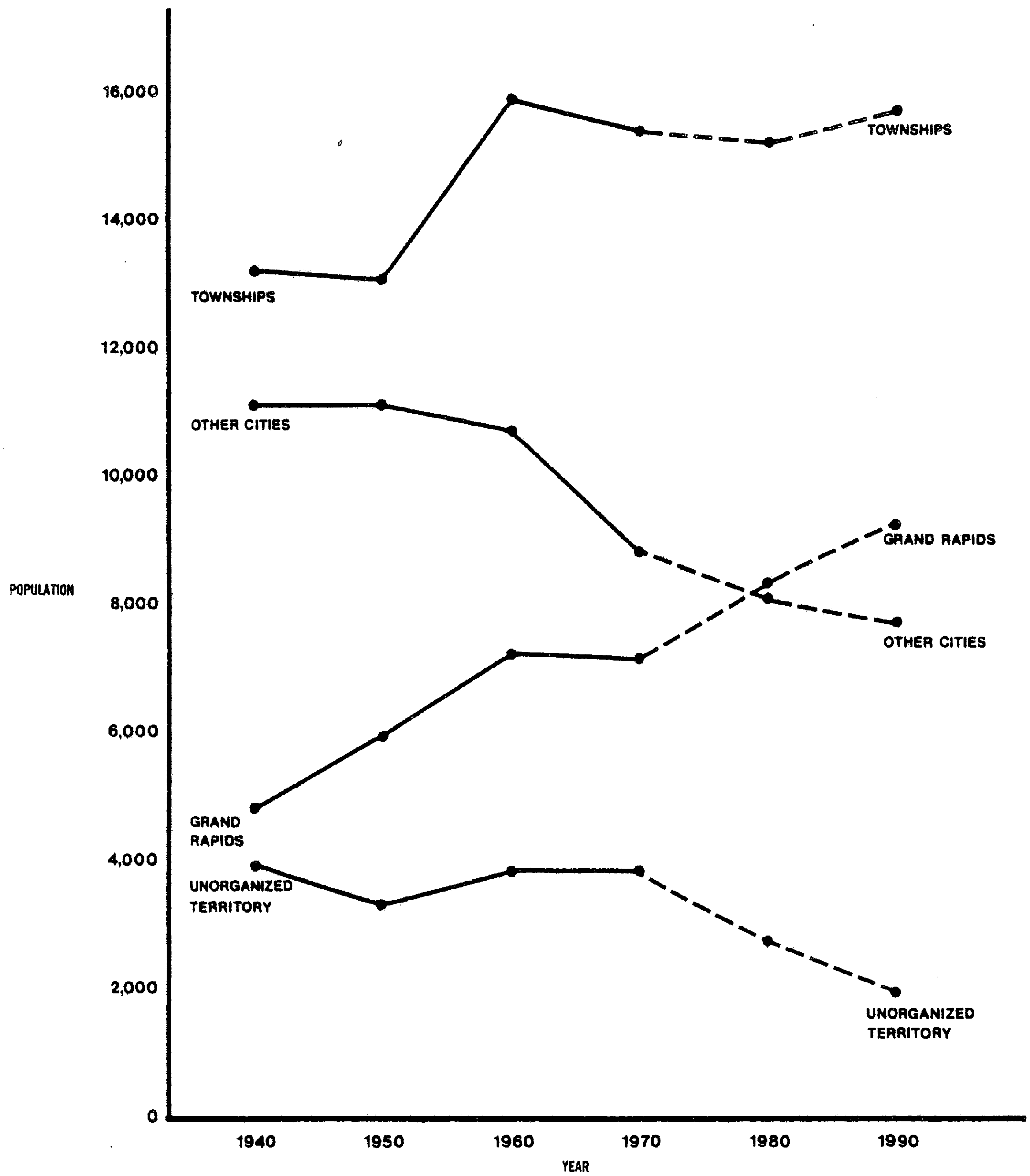
[b] Columns will not always total due to rounding of numbers.

[c] Less than 1%.

TABLE IV-102
OUTSTANDING INDEBTEDNESS FOR COUNTIES, CITIES, TOWNSHIPS AND SCHOOL DISTRICTS
ARROWHEAD REGION - 1966, 1972 and 1974 (205)

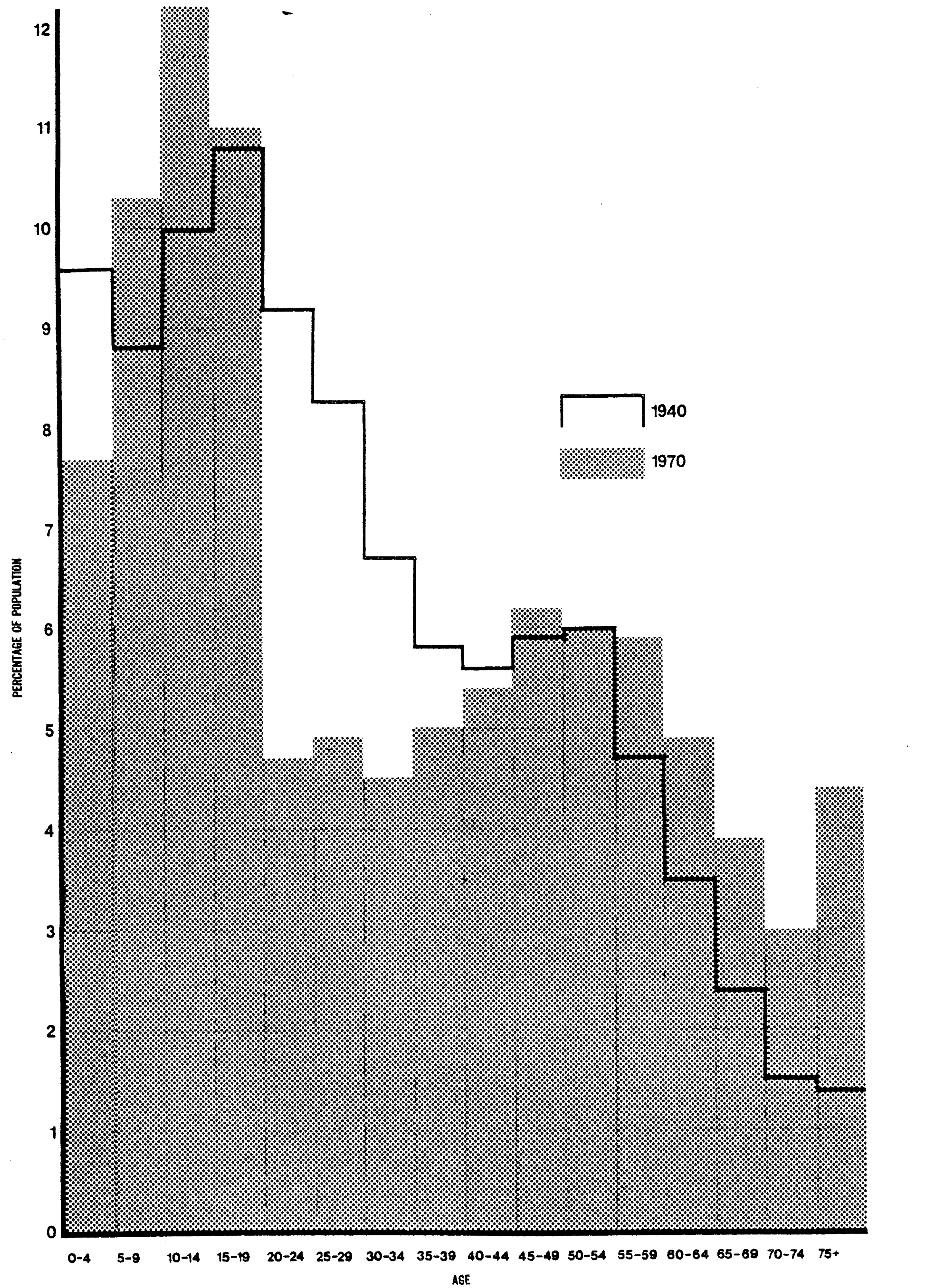
Level of Government	County							Arrowhead Region	State of Minnesota	% Region of State
	Aitkin	Carlton	Cook	Itasca	Koochiching	Lake	St. Louis			
Counties										
1966 ($000)	500	0	100	0	305	120	2,670	3,695	55,294	6.7
1974 ($000)	110	0	420	1,165	485	350	890	3,420	124,243	2.8
Absolute change ($000)	-390	-	320	1,165	180	230	-1,780	-275	68,949	a
% change	-78.0	-	320.0	a	59.0	191.7	-66.7	-7.4	124.7	a
Cities										
1966 ($000)	402	1,368	48	1,449	1,579	2,997	19,300	27,143	580,962	4.7
1974 ($000)	1,234	5,261	120	5,338	2,639	2,224	25,108	41,924	1,268,097	3.3
Absolute change ($000)	832	3,893	72	3,889	1,060	-773	5,808	14,781	687,135	2.2
% change	207.0	284.6	150.0	268.4	67.1	-25.8	30.1	54.5	118.3	a
Towns										
1966 ($000)	18	52	0	6	0	0	1,149	1,225	6,247	19.6
1974 ($000)	6	218	0	80	0	0	1,559	1,863	8,274	22.5
Absolute change ($000)	-12	166	-	74	-	-	410	638	2,027	31.5
% change	-66.7	319.2	-	1,233.3	-	-	35.7	52.1	32.4	a
School Districts										
1966 ($000)	1,366	8,110	550	3,867	3,442	2,835	22,050	42,220	755,052	5.6
1972 ($000)	1,896	7,982	935	5,955	3,110	510	17,017	37,405	1,132,195	3.3
Absolute change ($000)	530	-128	385	2,088	-332	-2,325	-5,033	-4,815	377,143	a
% change	38.8	-1.6	70.0	54.0	-9.6	-82.0	-22.8	-11.4	49.9	a
Summary										
1966 ($000)	2,286	9,530	698	5,322	5,326	5,952	45,169	74,283	1,397,555	5.3
1972 plus 1974 ($000)	3,246	13,461	1,475	12,538	6,234	3,084	44,574	84,612	2,532,809	3.3
Absolute change ($000)	960	3,931	777	7,216	908	-2,868	-559	10,329	1,135,254	0.9
% change	42.0	41.2	111.3	135.6	17.0	-48.2	-1.3	13.9	81.2	a

[a] not applicable.



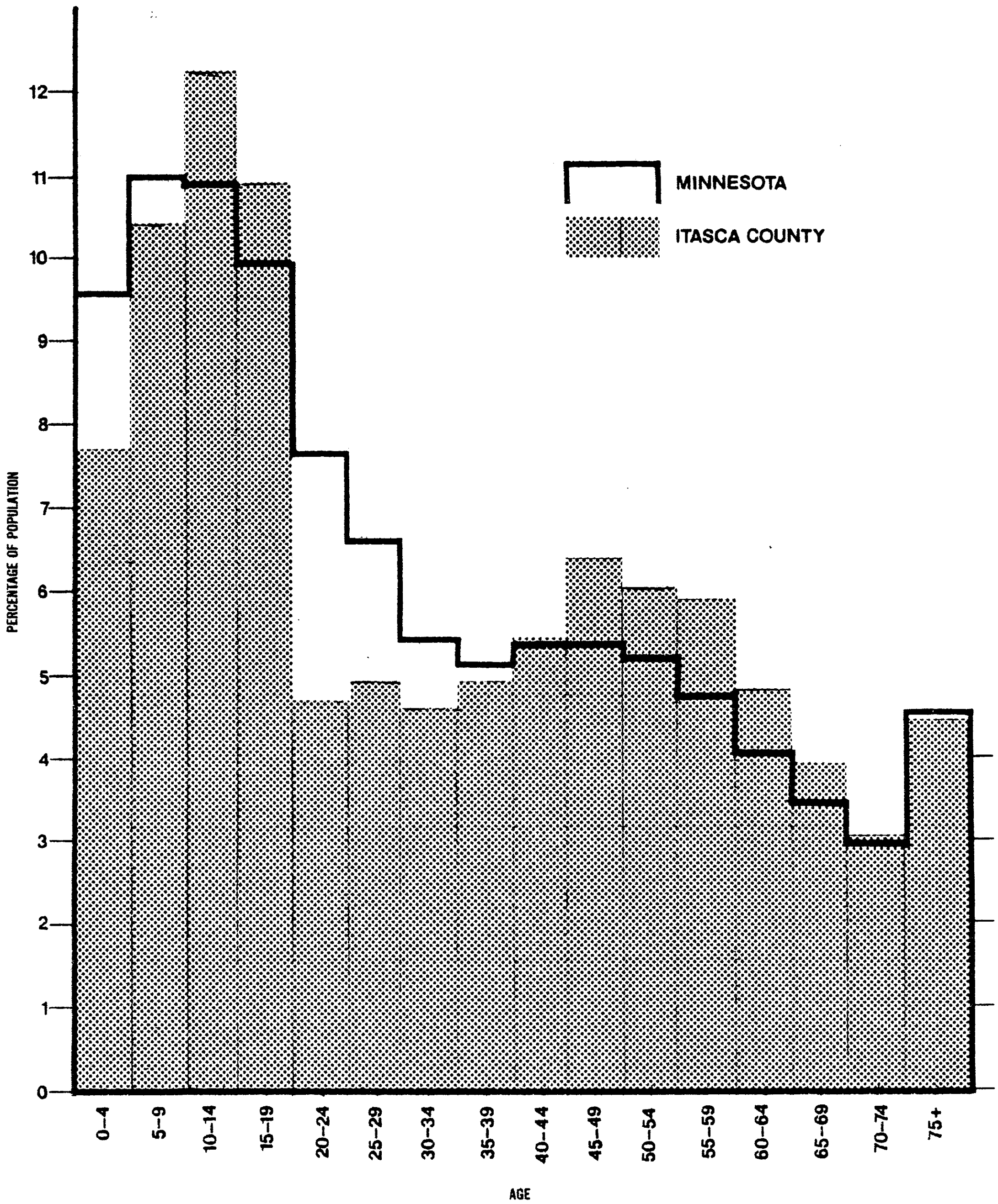
URBAN/RURAL POPULATION SHIFTS - ITASCA COUNTY - 1940 TO 1990

FIGURE IV-91



HISTORICAL COMPARISON OF AGE COMPOSITION - ITASCA COUNTY - 1940 TO 1970

FIGURE IV-92



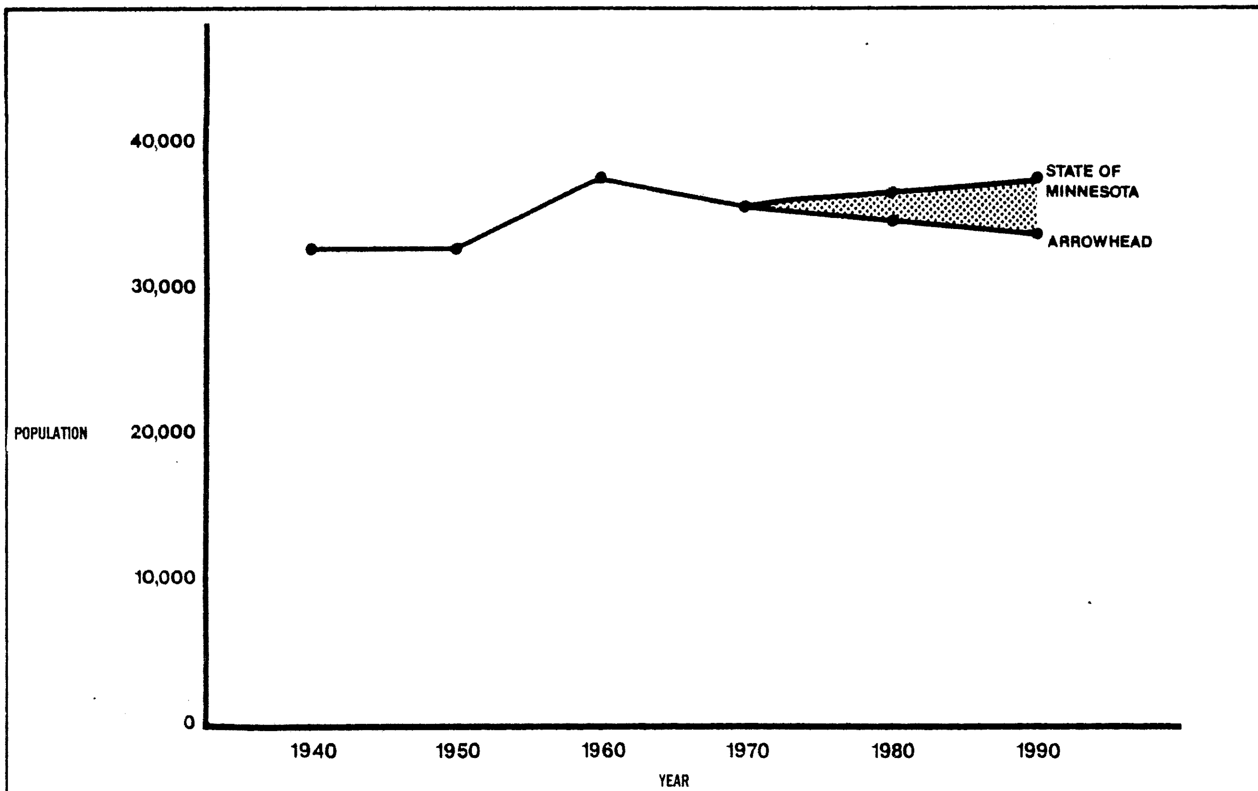
COMPARISON OF AGE COMPOSITION OF POPULATION -
MINNESOTA AND ITASCA COUNTY - 1970

FIGURE IV-93

TABLE IV-103
HISTORIC TRENDS IN POPULATION - ITASCA COUNTY - 1940 to 1970 (201)

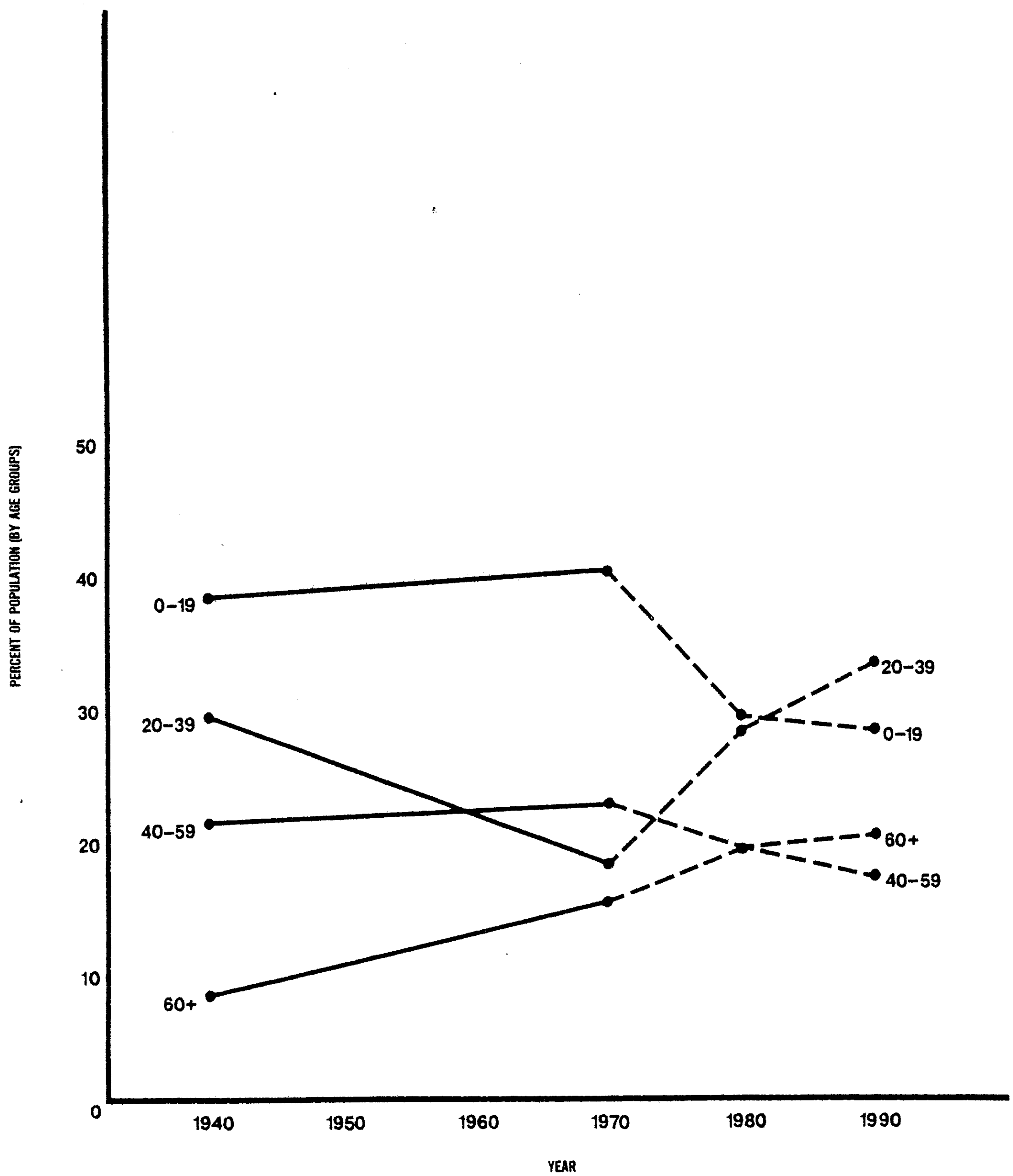
Area	Population				Percent Change	
	1940	1950	1960	1970	1940 to 1970	1960 to 1970
Itasca County						
Grand Rapids	4,875	6,019	7,265	7,247	+49	a
Other cities	11,238	11,247	10,808	8,854	-21	-18
Townships	13,280	13,223	16,031	15,499	+17	- 3
Unorganized territories	3,985	3,427	3,902	3,930	- 1	+ 1
Total	32,996	33,321	38,006	35,530	+ 8	- 6

[a] Change less than 0.5%.



POPULATION TRENDS AND PROJECTIONS
ITASCA COUNTY - 1940 TO 1990

FIGURE IV-94



PROJECTED AGE COMPOSITION OF POPULATION -
ITASCA COUNTY - 1940 TO 1990

FIGURE IV-95

expansion of the Clay Boswell Station is intended to provide additional electrical service to taconite processors within the Region.

- Grand Rapids serves as a major tourist point for people enjoying the lakes and National Forests within the County.

- Grand Rapids also serves as a retail and service center for the lower portion of the Mesabi Iron Range.

Itasca County supports a variety of potentially conflicting economic functions such as minerals extraction vs. tourism and recreation. However, the combination of a large physical area with extremely low and dispersed population centers reduces the opportunity for land-use conflict. In Itasca County there are 1.9 million acres (0.77 million hectares) of public and private land. The population of 36,000, centered in incorporated areas, provides a gross density of 0.02 persons per acre (0.05 persons per hectare). Despite this low population the conflicts between economic functions persist, resulting in structural changes in land prices, capital availability, and labor force.

Mining Industry. Contraction of the natural ore industry resulted in the loss of 1,185 jobs in Itasca County between 1960 and 1970. However, the mining industry still employs approximately 16% of the County's labor force in taconite production in plants centered in Keewatin and Cooley. These plants have announced expansions which will increase mining employment within the county by 1,560 people by 1984.

Although potential copper-nickel resources lie outside Itasca County, many of the indirect economic benefits arising from increased secondary employment logically could be expected to occur in Itasca County.

Timber Industry. In 1972, the Itasca County timber industry employed 1,285 people, as shown in Table IV-86. Pulp wood comprises the largest volume of forest products in the County. The major producer of pulp wood is the Blandin Paper Company in Grand Rapids. Blandin Paper Co. is the largest manufacturing

TABLE IV-104
PROJECTED POPULATION - ITASCA COUNTY - 1970 to 1990 (202)

Area	Projected Population					Percent Change	
	1970	1975	1980	1985	1990	1970 to 1980	1970 to 1990
Itasca County							
Grand Rapids	7,427	8,020	8,440	8,860	9,280	+16	+28
Other cities	8,854	8,600	8,250	7,760	7,270	- 7	-18
Townships	15,499	14,810	15,280	14,540	15,790	- 1	+ 2
Unorganized territories	3,930	2,960	2,750	2,440	2,120	-30	-46

employer in the County, providing approximately 1,100 jobs. At the present time, the Blandin plant is being expanded, and employment will increase.

Other major producers utilize Itasca County forest resources, including the Northwest Paper Company, Conway Corporation, and Diamond National Company in Cloquet; Boise Cascade Corporation in International Falls; Super Wood Corporation in Duluth; St. Regis Paper Company in Sartell; and the Mosinne Paper Company, Mosinne, Wisconsin.

Agriculture. In Itasca County, the number of farms decreased from 1,208 in 1959 to 519 in 1969, a 57% decline (Table IV-87). Farm acreage dropped from 175,900 acres (71,184 hectares) in 1959 to 120,100 acres (48,603 hectares) in 1969, which is a 32% reduction. The average Itasca County farm increased in size by 58%, from 146 to 231 acres. In 1969, there were an estimated 300 people employed in farming within the County.

Tourism and Recreation. With a vast number of lakes and forest areas in the County, Grand Rapids serves as a retail and service center for Itasca County tourists and those heading farther north. Examination of retail business indicators for Grand Rapids shows significant gains in the number of motels, service-oriented employment and per capita sales, and tourist-oriented commodities between 1967 and 1972, as shown in Table IV-105.

TABLE IV-105
TOURIST INDICATORS - ITASCA COUNTY, GRAND RAPIDS, AND STATE OF MINNESOTA (210) (211)

Indicator	Itasca County	Grand Rapids	State of Minnesota
Service employment increase (1967 to 1972)			
number	135	214	30,484
%	42.3	159.7	53.1
Motels (1967 to 1972)			
% change	-5.3	100.0	- 4.9
Per capita sales (1972)			
gasoline	$231	$796	$183
food and drink	$137	$354	$170

Note: Calculations by Beck and Associates, Duluth, Minnesota.

In a recent report issued by the Department of Economic Development, an estimate of tourist-related expenditures for 1974 was given. Of the $976 million in tourist-related expenditures in the State, the region captured $120 million (12%) and Itasca County $14 million (1.2%). The estimated tourist-related expenditures for Itasca County are presented in Table IV-106. With Minnesota' healthy tourism industry and the record increase in tourist-oriented services in Grand Rapids, it can be assumed that Itasca County and Grand Rapids will continue to benefit from the increased leisure time of the populace.

TABLE IV-106
TOURIST-RELATED EXPENDITURES - ITASCA COUNTY - 1974 (212)

Expenditure Category	1974 Estimated Expenditure (000)
Lodging	$ 3,239
Food and drink	4,858
Transportation	3,091
Entertainment	1,178
Retail purchases	2,355
Grand total	$14,721

Trade and Service Industry. Grand Rapids serves as the major economic focus for Itasca County, marketing to the tourist as well as providing the resident with durable goods, such as appliances and clothing. Grand Rapids has 2 commercial locations. The major location is the central business district from Second Avenue West to Second Avenue East and Second Avenue East to Fifth Street East. This area contains a diversified mixture of general merchandise and service establishments. A recent survey indicated that the area contained 52 retail and 38 service establishments. The second location is the commercial development along U.S. Highway 2. In addition, there are 40 acres (16 hectares) within industrial parks in Grand Rapids. Of these, only 6 acres (2.4 hectares) are occupied.

As shown in Table IV-107, the trade and service facilities in Grand Rapids increased sales from 1967 to 1972, with approximately the same number of business establishments. Total retail sales in Grand Rapids were $43.7 million in 1972 (213). While recorded sales increases in Grand Rapids were lower than statewide averages, the business community demonstrated stability although the number of families in Itasca County declined by about 3% from 1960 to 1970. A major factor of the growth in retail sales has been the inflationary increase in family income. In 1959, the median family income in Itasca County was $4,546, while in 1969 this figure had increased to $7,985, a 75% increase.

In 1972, Grand Rapids had 31 wholesale establishments which distributed products throughout the northeast and north central areas. During this period wholesaling generated $20 million in sales with an estimated employment of 200 people.

Labor Force

Labor Force Characteristics. Between 1960 and 1970 the County labor force contracted from 12,269 to 12,083 a decline of 1.5%. This slight decrease indicates a steady level of economic activity. An increase in female workers in the labor force was evident in both the region and Itasca County from 1960 to 1970 when the number of females in the Itasca County labor force increased from

TABLE IV-107
RETAIL SALES BY TYPE - GRAND RAPIDS AND STATE OF MINNESOTA - 1972 (210) (211)

Type	1972 Sales (000)	Percent Change 1967 to 1972 City %	Percent Change 1967 to 1972 State %	Per Capita Sales 1972 City	Per Capita Sales 1972 State
General merchandise	$ 3,600	45.7	51.3	$ 486	$ 310
Apparel	2,809	17.2	46.8	380	95
Other	4,321	58.6	93.6	583	273
Primary Total	10,730	41.3	64.9	1,449	678
Automotive	7,351	25.0	47.9	993	387
Furniture, etc.	1,706	128.1	43.8	230	98
Food and drink	2,262	47.4	52.4	354	170
Secondary Total	11,319	38.6	48.5	1,577	655
Food	10,628	19.4	38.4	1,436	408
	1,673	45.5	28.3	226	63
Hardware	3,488	53.7	112.5	471	320
Gasoline	5,892	49.6	52.0	796	183
Convenience Total	21,681	33.3	58.8	2,929	974
Total	43,730	36.6	57.5	5,955	2,307

24.7% to 29.5%, as shown in Table IV-108. Employment by industry in 1970 is shown in Table IV-109.

Since 1970, expansion in the taconite and timber industries in Itasca County have caused the labor force to increase from 12,083 to 14,300, an increase of 18%. This exceeds the State increase of 5.2%. The County unemployment rate from 1970 to 1974 was 10.9%. Itasca County employment data are shown in Table IV-92.

Recent data on employment by major industries for the Grand Rapids Area as presented in Table IV-110, indicates the impact of taconite expansion on the local economy. Mining shows a 70% increase, from 459 employees in 1974 to 780 employees in 1975. Related construction activities shows a 65% increase from 410 to 676 employees for the same time period. Both industries have dramatically increased their share of total industrial employment. The next largest gain has been made by public administration which recorded a 10% increase.

Employment in the retail sector had not paralleled the increase in employment in the mining and construction sectors. This lag in the retail sectors growth probably indicates an uncertainty among retail businesses over the long-term impacts of mining/construction expansion.

Comparison of the occupational composition of the employed labor force for the County versus the City of Grand Rapids shows that the County has a higher

TABLE IV-108
LABOR FORCE PARTICIPATION RATE OF POPULATION 14 YEARS OLD AND OVER (200)

Area	Participation Rate Male %	Female %	Total %
Arrowhead Region			
Aitkin County			
1960	65.0	22.4	44.5
1970	59.8	30.6	45.2
Carlton County			
1960	73.4	31.2	52.8
1970	68.1	34.3	51.1
Cook County			
1960	74.7	38.1	57.7
1970	65.5	46.2	56.3
Itasca County			
1960	71.4	24.7	48.9
1970	64.8	29.5	47.1
Koochiching County			
1960	75.8	25.8	51.8
1970	68.4	34.2	41.5
Lake County			
1960	81.1	27.4	55.5
1970	71.0	31.7	51.7
St. Louis County			
1960	73.1	30.7	51.7
1970	67.3	35.3	50.8
Total 1960	73.1	29.6	51.5
1970	67.1	34.4	50.3
City of Duluth			
1960	72.8	34.6	52.9
1970	67.7	39.7	52.7
State of Minnesota			
1960	77.3	34.4	55.4
1970	73.1	41.8	56.9
United States			
1960	77.4	34.5	55.3
1970	72.8	39.6	55.5

TABLE IV-109
1970 EMPLOYMENT BY INDUSTRY - ARROWHEAD REGION,
ITASCA COUNTY, AND GRAND RAPIDS

Economic Sector	Arrowhead Region	Itasca County	Grand Rapids	Percent Change 1960 - 1970 Itasca County	Grand Rapids
Agriculture, forestry	2,661	415	30	-47	-55
Mining	12,234	1,715	153	-40	-41
Construction	6,099	638	98	21	-17
Manufacturing	18,993	1,520	464	33	18
Transportation, Communications, and Utilities	8,626	530	106	-24	-37
Finance, Insurance, Real Estate	3,417	251	80	66	7
Trade	22,355	2,010	604	12	9
Services	22,539	2,901	786	32	18
Public administration	13,471	419	137	14	31
Not reported	-	173	-	-	-
Total	110,396	10,572	2,458	-1.5	2.1

TABLE IV-110
EMPLOYMENT BY MAJOR INDUSTRY - GRAND RAPIDS AREA
JULY 1974 AND 1975 (214)

Major Industry	1974 Number	1974 Percent	1975 Number	1975 Percent	Percent Increase 1974 - 1975
Mining	459	7	780	11	70
Construction	410	7	676	9	65
Utilities	281	4	269	4	-4
Manufacturing	1,243	20	1,335	18	7
Trade	1,387	22	1,396	19	0.6
Services	647	10	690	10	6
Finance, insurance	157	2	172	2	9
Public administration	1,721	27	1,907	26	10
Total[a]	6,305	100	7,225	100	

[a] Totals will not always total due to rounding of numbers.

percentage of craftsmen, laborers and operators than does the City of Grand Rapids. This is due to Grand Rapids' function as a sub-regional economic center. In contrast to the communities that support the mining and timber industry, Grand Rapids demonstrates a higher percentage of professional, managerial, sales and clerical workers, occupational activities closely allied with urban areas as shown in Table IV-111.

TABLE IV-111
OCCUPATIONAL COMPOSITION OF EMPLOYED LABOR FORCE
ITASCA COUNTY (200)

	Number		Percent of Total	
Occupation	Itasca County	Grand Rapids	Itasca County	Grand Rapids
Professional	1,398	434	13	18
Manager	904	244	9	10
Sales	528	182	5	7
Clerical	1,251	441	12	18
Craftsman	1,922	327	18	13
Operators	1,816	357	17	15
Laborers	696	100	7	4
Farm laborers	68	-	-	-
Service	1,465	373	14	15
Other, not reported	524	-	-	-
Total	10,572	2,458		

Employee Residence. A recent survey by the Copper-Nickel Study Team which examined place of residence for operational employees of taconite plants along the Mesabi Iron Range showed that:

- o The vast majority of taconite company employees live within 20 miles (32 km) of the operation.

- o In specific survey cases, a majority of workers at several plants reside within 10 miles (16 km), and 84 to 92% of the employees reside within 20 miles (16 km) of the plant. Undoubtedly, a major factor is the availability of affordable housing in these small communities along the Mesabi Iron Range as well as the feeling of association among families in this rural environment.

Income. Figures for Itasca County from 1959 to 1969 provides a median family income change of $3,439, quite similar to the regional change. The 1973 Itasca County per capita income of $3,500 was 32% below the State's level. From 1969 to 1973 the per capita change in income for Itasca County has been lower than statewide gains. After excluding inflation of 5.1%, which occurred during this period, the annual growth rate of 3.5% is reduced to 3.4%. This moderate growth in County per capita income represents a mild expansion in the County's economy during this period.

Clay Boswell Station Employment and Local Economic Impacts. Current employment at the Clay Boswell Station totals 102. Of this number, 47 are technical workers and 55 are employees involved in administrative, clerical and maintenance jobs. These employees earn approximately $1.3 million annually, spending $1.0 million in direct purchases within the local economy. The majority of employees reside in Grand Rapids, the community of Cohasset, and Deer River, as shown in Table IV-112.

TABLE IV-112
EMPLOYEE RESIDENCE, WAGES, AND TAXES
CLAY BOSWELL STEAM ELECTRIC STATION (215)

Place of Residence	Employees	Percent of Total	MP&L[a] Wages Paid	After Tax[b] Income
Grand Rapids	57	55	$ 729,600	$ 592,630
Cohasset	14	14	179,200	145,550
Deer River	12	12	153,600	124,760
Bovey	6	6	76,800	62,380
Coleraine	6	6	76,800	62,380
Remer	2	2	25,600	20,790
Duluth	1	1	12,800	10,390
Hill City	1	1	12,800	10,390
Marble	1	1	12,800	10,390
Pengilly	1	1	12,800	10,390
Warba	1	1	12,800	10,390
Totals	102	100	$1,305,600	$1,060,440

[a] Average wage of $12,800.

[b] Average taxes of $2,403.

With a taxable value of $29 million, the existing Clay Boswell Station annually generates $2.7 million in revenues to the County, the township, and the school district (Table IV-113). Employee earnings provide $176,000 in Federal taxes and $69,000 in State income taxes.

Besides the direct employment, the Clay Boswell Station creates a secondary employment impact, which involves 40 to 50 workers who provide services to the employees of the Station. Based upon an average wage of $9,000 per worker, the secondary employment generates an additional $360,000 to $450,000 in salaries and wages for the local economy. Assuming the same tax ratios as applied to the Clay Boswell employees, Federal tax payments would range between $58,000 to $61,000 and State income taxes between $19,000 and $24,000.

Direct and secondary employment of the facility provides an annual gross disposable income of between $1.3 and $1.36 million as shown in Table IV-114. Of this amount, 25% is allocated for fixed expenditures such as housing and

TABLE IV-113
PROPERTY TAXES PAID FOR
CLAY BOSWELL STEAM ELECTRIC STATION (216) (217)

Taxing Jurisdiction	1971	1975	% Total Taxes Paid for Clay Boswell Steam Electric Station
Itasca County	$202,987	$1,180,007	23.2
Bass Brook Township	49,476	176,112	90.5
School District No. 318	434,704	1,421,675	35.2
Total	$687,167	$2,777,794	29.8

insurance, resulting in a net disposable income of approximately $1 million. The total recorded retail sales in Itasca County in 1975 were $87.2 million. The Clay Boswell Station accounted for 1% of those sales.

Employee Commuting Characteristics. The current commuting patterns of employees at the Clay Boswell Station are presented in Table IV-115. The

TABLE IV-114
ESTIMATED CLAY BOSWELL STEAM ELECTRIC STATION IMPACT ON RETAIL SALES
ITASCA COUNTY

Sales Category	1975 Sales[a] Itasca County (thousands)	1975 Sales[b] Minus Tourist Expenditures	Per Capita Sales[c]	Sales Attributable to Clay Boswell		Total Sales
				Primary[d]	Secondary[e]	
Primary shopping goods[f]	$19,366	$17,011	$ 459	$164,000	$ 72,000	$236,000
Secondary shopping goods[g]	30,839	21,465	583	208,000	92,000	300,000
Convenience goods[h]	37,011	33,920	916	327,000	144,000	471,000
Total	$87,216	$72,495	$1,959	$699,000	$308,000	$1,007,000

a Based on county sales as recorded by Research Bulletin No. 19, Department of Economic Development, 1976.
b Tourist-Travel expenditure as recorded by Research Bulletin No. 6, Department of Economic Development, 1976.
c Assumed 1975 population of 37,000.
d Primary employment of 102 with an average family size of 3.5.
e Secondary employment average of 45 with an average family size of 3.5.
f Includes general merchandise, apparel, and other.
g Includes automotive, furniture, appliances, eating, and drinking.
h Includes food, drugs, hardware, and gasoline.

commuting characteristics of mining employees in the region are also indicated in this table. Of the existing employees at the Clay Boswell Station, 93% commute less than 20 miles (32 km) one-way to work. 60% of these employees live in the City of Grand Rapids. Only one employee commutes over 40 miles (64 km) one-way to the Clay Boswell Station and only 2 employees live outside the Arrowhead Region. This commuting pattern is supported by the data on other commuting patterns, shown in Table IV-115. In all cases, over half of employees

TABLE IV-115
COMMUTING CHARACTERISTICS - MINING AND CLAY BOSWELL STEAM ELECTRIC STATION EMPLOYEES
ARROWHEAD REGION

Plant	Number of Employees	Commuting Distance: Under 20 miles (32.19 km)	20 to 40 miles (32.19 to 64.37 km)	Over 40 miles (64.37 km)
Clay Boswell[a]	102	93%	6%	1%
Minntac[b]	3,000	84%	10%	6%
Erie[b]	3,000	67%	25%	8%
Eveleth Taconite[b]	624	57%	43%	-

[a] Source: Memo from B.E. Smith, Plant Superintendent, Clay Boswell Steam Electric Station, Minnesota Power & Light Company, September 15, 1976.

[b] Source: Letter from Alfred France, President, Lake Superior Industrial Bureau, to David Brostrom, Minnesota Department of Natural Resources, December 9, 1975.

commute less than 20 miles (32 km), and over 90% commute less than 40 miles to work. Figure IV-96 illustrates the commuting radius for employees of the Clay Boswell Station.

Housing

The 1970 census of housing indicated there were 14,944 units in Itasca County, housing 35,530 people. Of these units 82% were occupied year around and were located in rural areas. There are 4,479 units in Grand Rapids with 3,455 single family homes (77%), 522 units in structures of 2 or more units (12%), and 237 mobile homes (5%). The majority of these units are occupied.

There is no information on the number of housing units in the Arrowhead Region built especially for senior citizens, however, in 1974 ARDC projected the need for 760 housing units for the elderly within the Region and 100 units in Itasca County (218).

From 1970 to July 1975 a modest building boom occurred in the county. During that period 1,504 building permits were issued for year around residences and mobile homes. Due to the lower costs of development in non-urban areas, the majority of these permits were for areas immediately surrounding Grand Rapids. Assuming no demolition or conversion of existing units, the number of dwelling units increased by 9% to a mid-1975 figure of 16,448.

The ARDC has indicated there is an acute shortage of housing throughout the Mesabi Iron Range. To meet the housing needs for the expanded taconite and timber labor force, it is estimated that 3,800 units will be required (219). For Itasca County, the Commission has identified preliminary needs for 70 housing units, the majority of which will be in Grand Rapids. Very few units were found available for sale or rent in March 1977 in 13 communities in Itasca County, as shown in Table IV-116.

TABLE IV-116
HOUSING UNITS FOR SALE AND RENT - MARCH 1977

Location	Housing Units	
	For Sale	For Rent
Keewatin	6 to 8	a
Nashwauk	3 to 5	a
Bovey	2 or less	a
Bass Brook Township	1[a]	a
Coleraine	2[a]	a
Deer River	4	none
Grand Rapids	Less than 1% of total units	Less than 1% of total units
Marble	3	2 for sale units being rented
Warba	2	none
Zemple	none	none
Calumet	10	none
Taconite	none	none
La Prairie	3	none

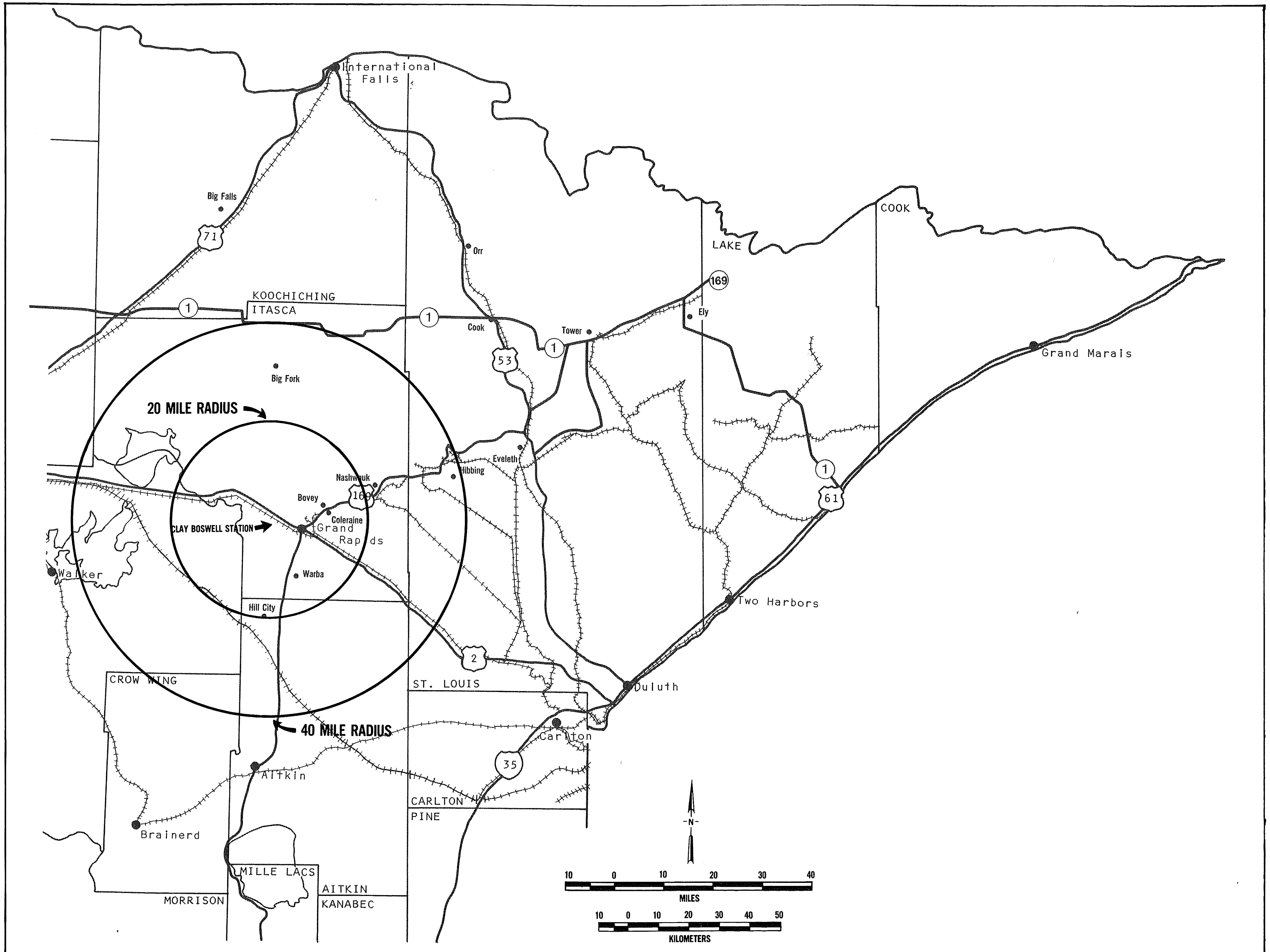
[a] Units for sale are also for rent.

Additional analyses conducted by ARDC indicate that modular housing units offer the greatest potential for meeting housing needs. The ARDC has estimated that a modular two bedroom 1,008 sq ft (93.6 sq m) home selling for $26,000 would require a monthly housing expenditure of $320 and would meet the requirements of approximately 30% of the population. The alternative is to continue the proliferation of 960 sq ft (89 sq m) mobile homes selling for approximately $10,000 and requiring $274 a month in housing payments. ARDC estimates that 58% of the area's population could afford mobile homes at present income levels, due to the mobile home's relatively low cost.

There are several issues affecting the housing situation in Itasca County and Mesabi Iron Range communities:

- The average cost for single family homes in Grand Rapids ranges from $27,000 to $28,000. To purchase a home of this price, annual household income should equal from $13,500 to $14,500. In 1977, the average salary in the taconite industry and at the Clay Boswell Station is expected to be approximately $12,500 annually. The gap between housing cost and income is a major problem limiting the increase of additional housing supply.

- The increase in construction employment is attracting workers from outside the region, and every available form of shelter is being utilized. Non-winterized cabins, motels and rooming houses are becoming sources of accommodations. Demand is increasing rental prices to record levels. The



COMMUTING RADIUS FOR EMPLOYEES
CLAY BOSWELL STEAM ELECTRIC STATION

FIGURE IV-96

TABLE IV-117
HOUSING DEVELOPMENT ON THE IRON RANGE[a]

Minor Civil Division	1974 Single Family	1974 Mobile Home	1974 Apartment	1975 Single Family	1975 Mobile Home	1975 Apartment	1976 Single Family	1976 Mobile Home	1976 Apartment	1977 Single Family	1977 Mobile Home	1977 Apartment
Grand Rapids	19	24	4	36	-	18	42	-	100	30	-	63
Nashwauk	1	-	-	3	-	-	1	-	-	1	-	-
Keewatin	2	-	-	2	-	-	2	-	-	1	-	-
Coleraine	4	-	-	6	-	-	2	-	-	2	-	-
5 Townships	23	9	-	42	36	-	36	40	-	24	32	-
Total[b]	49	33	4	89	36	18	83	40	100	58	32	63

[a] Based on building permits and mortgage applications as of January 1, 1976.

[b] Of the 605 total, 362 are in urban areas and 243 are in rural areas.

temporary housing demand created by the construction industry is resulting in a "wait and see" attitude by real estate investors.

- The housing industry on the Mesabi Iron Range consists of individual building contractors who construct a limited number of units each year. The ability to efficiently produce large numbers of units is restricted by lack of sufficient financing and other factors.

- Building materials continue to rapidly increase in price, resulting in costs which out-strip household incomes.

The results of these issues have been to create an extremely tight housing supply complemented by the use of marginal housing for shelter. Recently there has been an increase in apartment, mobile home, and single family home building permits but the problems affecting regional housing construction continue to influence the situation (Table IV-117).

TABLE IV-118
SCHOOLS - ITASCA COUNTY SCHOOL DISTRICTS (220)

District	Location	Number of Schools Elementary	Number of Schools Secondary
316	Bovey	1	1
	Coleraine	1	1
	Marble	1	-
	Taconite	1	-
	Subtotal	4	2
317	Dear River	1	1
	Spring Lake	1	-
	Subtotal	2	1
318	Balsum	1	-
	Big Fork	1	1
	Cohasset	1	-
	Effie	1	-
	Grand Rapids	4	2
	Squaw Lake	1	-
	Togo	1	-
	Warba	1	-
	Wendigo	1	-
	Subtotal	12	3
319	Keewatin	1	1
	Subtotal	1	1
	Total	19	7

Public Services

Education. There are 4 school districts in Itasca County, as shown in Figure IV-86. The Clay Boswell Station is located in District 318 which includes Grand Rapids and the community of Cohasset. The other school districts in Itasca County are 316, 317, and 319. As presented in Table IV-118, District 316 in Coleraine-Bovey has 4 elementary and 2 secondary schools; District 317 in Deer River has 2 elementary schools and one secondary school; Grand Rapids District 318 has one elementary school and 3 secondary schools; and District 319 has one elementary school and one secondary school. The locations of these school facilities are shown in Figure IV-97.

The number of teachers in each school district in Itasca County for 1974-75 is presented in Tables IV-119 and IV-120. There are 258 elementary teachers in the County with approximately 18 students per teacher. There are 309 secondary teachers, each teaching an average of 17 students.

There are 9,354 students enrolled in Itasca County schools. Of these 4,187 are elementary age and 5,167 are secondary school age. According to the State Demographer, Itasca County elementary age population is expected to decrease by 43% by 1980. Secondary age population will decrease by 21% by 1980.

Existing capacities for elementary and secondary schools are indicated in Tables IV-119 and IV-120. Among elementary schools, only the Deer River District is near capacity. Among secondary schools, both Deer River and Grand Rapids are currently above capacity.

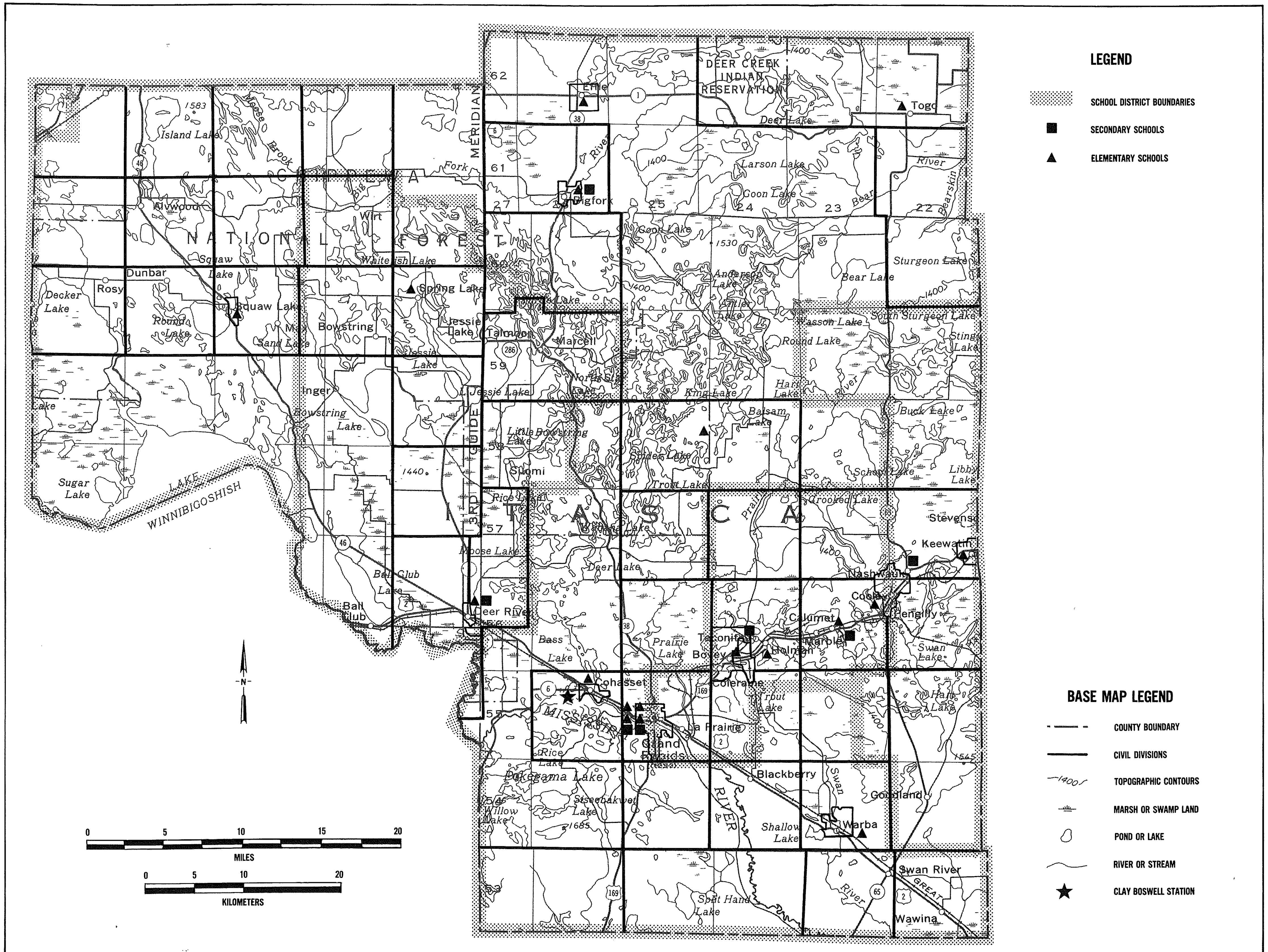
TABLE IV-119
ELEMENTARY SCHOOL CAPACITY - ITASCA COUNTY
1974-1975 (221)

	Enrollment 1974-1975 [a]	Capacity 1974-1975	Estimated Unused Capacity	Total Number Teaching Staff 1974-1975 [b]	Students per Teacher 1974-1975
Itasca County					
District 316	932	1,200	268	51	18.9
District 317	552	550	- 2	33	18.4
District 318	2,250	2,575	325	144	17.2
District 319	453	650	197	30	17.2
Total	4,187	4,975	788	258	17.7
Arrowhead Region	31,954	na [c]	na	na	17.6
State of Minnesota	417,503	na	na	17,963	23.2

[a] Does not include kindergarten enrollment.

[b] Source: Minnesota Department of Education, March 1977.

[c] na means not available.



PUBLIC SCHOOLS AND SCHOOL DISTRICTS
ITASCA COUNTY

FIGURE IV-97

TABLE IV-120
SECONDARY SCHOOL CAPACITY - ITASCA COUNTY
1974-1975 (221)

	Enrollment 1974-1975	Capacity 1974-1975	Estimated Unused Capacity	Total Number Teaching Staff 1974-1975[a]	Students per Teacher 1974-1975
Itasca County					
District 316	1,086	1,400	314	70	15.5
District 317	656	650	- 6	34	18.9
District 318	2,821	2,800	-21	164	17.3
District 319	604	650	46	41	15.2
Total	5,167	5,500	333	309	16.8
Arrowhead Region	32,252	na[b]	na	na	na
State of Minnesota	451,754	na	na	21,710	20.8

[a] Source: Minnesota Department of Education, March 1977.

[b] na means not available.

Health Services. There are 0.6 practicing doctors per 1,000 population in Itasca County; 3 hospitals in the County with a total of 156 beds, or an average of 4.4 beds per 1,000 population; 3 nursing homes with 268 beds; and 3 ambulance services in Itasca County.

Law Enforcement. Itasca County has 31 certified full-time police officers. There are 12 County Sheriff's Officers, Grand Rapids has 11 officers, Coleraine has one officer, Keewatin has 3 officers, and Nashwauk has 4 officers. Coverage ranges from 0.9 officers per 1,000 population in Coleraine to 3.1 officers per 1,000 population in Nashwauk. Grand Rapids has a coverage of 1.5 officers per 1,000 and Itasca County has a coverage of 0.9 officers per 1,000. On a countywide basis, coverage is less than the average for the Arrowhead Region.

Fire Departments. There are 11 volunteer fire departments in Itasca County. MP&L has an agreement with the Cohasset fire department to provide fire protection services to the existing Clay Boswell Station. An annual advance of $1,200 is paid for this service. Fire protection measures at the Station include fire extinguishers, fire pumps, hydrants, and hoses.

Fire Fighters. In Itasca County there are 7.4 fire fighters per 1,000 population, well above the statewide average. Individual department coverage in Itasca County ranges from 1.8 to 26.0 per 1,000 population. The service area for each department in Itasca County is shown in Figure IV-98.

Itasca County and the Arrowhead Region are protected against wildfires by the DNR, and the U.S. Forest Service provides protection on Federal lands. The Blandin Paper Company also has employees trained to fight fires. The U.S.

Forest Service, Minnesota DNR, and the Blandin Paper Company have a total of 30 full-time, 125 volunteer and 100 auxiliary trained personnel in Itasca County. The number of local fire fighters in Itasca County and the Arrowhead Region for 1976 is presented in Table IV-121.

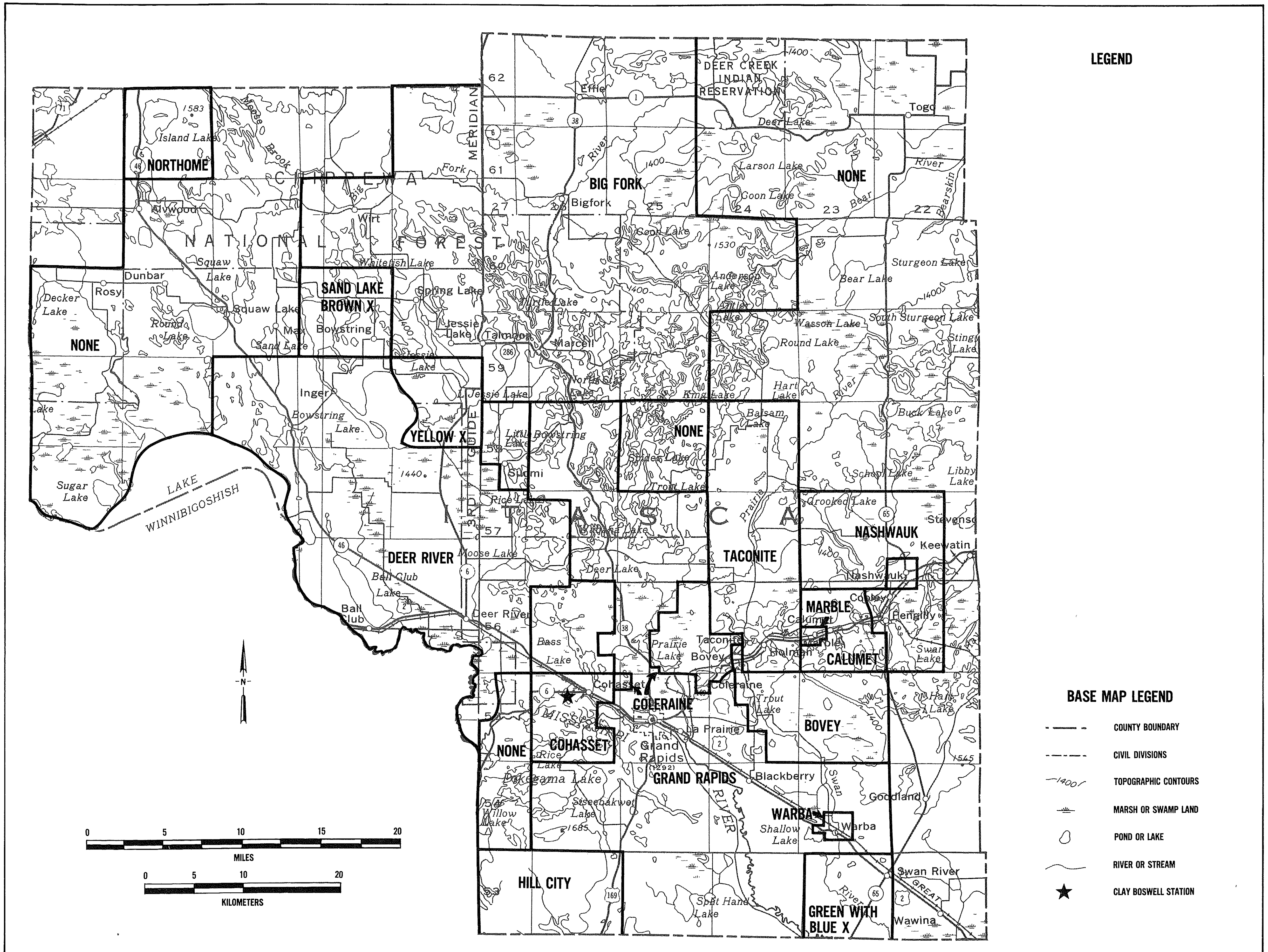
A measure of the adequacy of local fire protection is the fire insurance rating established by the Minnesota Insurance Service Office. These ratings are assigned on a scale of 10 to 1, with 1 having the highest rating. The rating takes into account such things as the type of fire department (volunteer or full-time), number of personnel, type, age, and condition of equipment, local water supplies, territory to be served, and a variety of other factors. The highest possible rating in Minnesota is 3. Of the 3 fire departments that serve the Clay Boswell Station area, Cohasset has a rating of 9; Deer River has a rating of 10; and Grand Rapids has a rating of 7. These ratings apply only to the area within the corporate limits of each community. All rural areas in the State of Minnesota are rated 10 (222).

Revenues and Expenditures

Revenues. The revenues for local units of government in Itasca County are presented in Table IV-122. Total revenues in 1974 were $39 million. The County had revenues of $12.1 million, school districts had revenues of $18.5 million, townships had revenues of $1.1 million, and the City of Grand Rapids had revenues of $5.4 million. Property taxes accounted for 34% of County revenues, 31% of township revenues, 13 to 37% of school district revenues, and from zero

TABLE IV-121
FIRE FIGHTERS - ITASCA COUNTY - 1976

Area	1970 Population Served	Fire Fighters	Fire Fighters per 1,000 Population
Itasca County			
Big Fork	2,740	22	8.1
Bovey	1,396	20	14.3
Calumet	1,177	20	17.0
Bass Brook	2.197	24	10.9
Coleraine	1,699	20	11.8
Deer River	3,084	25	8.1
Grand Rapids	13,976	25	1.8
Keewatin	1,650	19	11.5
Marble	770	20	26.0
Nashwauk	2,800	20	7.1
Taconite	670	14	20.9
Warba	1,351	20	14.8
Total	33,510	249	7.4
State of Minnesota	3,804,971	18,264	4.8



FIRE DEPARTMENT SERVICE AREA
ITASCA COUNTY

FIGURE IV-98

TABLE IV-122
LOCAL REVENUES IN ITASCA COUNTY - 1974

Unit of Government	Taxes Collected	Grants and Aid	Other Sources	Total Revenue	Percent of Revenue: Taxes	Grants	Other	Total
Cities over 2,500[a]								
Grand Rapids	$ 451,087	$ 4,138,952	$ 767,377	$ 5,357,416	8	77	14	99
Cities under 2,500[a]								
Big Fork	11,075	28,386	25,581	65,042	17	44	39	100
Bovey	61,353	125,608	25,208	212,169	29	59	12	100
Calumet	12,257	35,676	1,797	49,730	25	72	4	101
Cohasset	8,644	21,556	7,389	37,589	23	57	20	100
Coleraine	72,101	125,213	55,364	252,678	28	50	22	100
Cooley	--	1,052	300	1,352	--	78	22	100
Deer River	38,587	37,176	50,236	125,999	31	30	40	101
Effie	9	2,573	1,050	3,632	--	71	29	100
Keewatin	12,432	125,832	9,705	147,969	8	85	7	100
LaPrairie	3,746	13,735	6,401	23,882	16	58	27	101
Marble	74,210	113,790	7,453	195,453	38	58	4	100
Nashwauk	18,754	147,198	36,464	202,416	9	73	18	100
Squaw Lake	35	3,999	3,167	7,201	--	56	44	100
Taconite	53,410	42,460	22,745	118,615	45	36	19	100
Warba	1,226	4,855	4,978	11,059	11	44	45	100
Zemple	--	1,083	177	1,260	--	86	14	100
School Districts[b]								
Coleraine	1,043,842	2,167,779	188,649	3,400,270	31	64	6	101
Deer River	613,466	1,223,283	109,553	1,946,302	32	63	6	101
Grand Rapids	3,583,000	5,250,000	941,000	9,774,000	37	54	10	101
Nashwauk-Keewatin	450,000	1,060,000	1,901,000	3,411,000	13	31	56	100
Townships[a]	339,227	628,414	109,807	1,077,448	31	58	10	99
County[a]	4,166,275	6,626,781	1,373,876	12,166,932	34	54	11	99
TOTAL	$11,014,736	$21,925,401	$5,649,277	$38,839,414	28	56	15	99

[a] State Auditor Reports.

[b] Communications with individual school districts, May, 1977.

to 38% of municipal revenues. There is great local reliance on intergovernmental grants and aids which account for 55% of County revenues, 58% of township revenues, between 31 and 64% of school district revenues, and between 30 and 86% of municipal revenues. In the City of Grand Rapids, 77% of 1974 revenues were grants and aids, while only 8% of revenues were from property taxes.

Expenditures. Total 1974 expenditures in Itasca County were $28.6 million. Capital outlays of $8 million were also made in Itasca County during 1974 as shown in Table IV-123. $15.7 million (55%) was spent for education; $5 million (17%) was spent for health and welfare, $2.7 million (9%) was spent for highways, and $1.5 million (5%) was spent for general government costs. The City of Grand Rapids had expenses of $1.2 million and capital outlays of $3.5 million in 1974 as shown in Table IV-124. 55% of expenses are incurred by school districts, 34% by the county; 3% by townships, 4% by Grand Rapids, and the remaining 4% by other municipalities.

TABLE IV-123
CLASSIFICATION OF COUNTY DISBURSEMENTS - ARROWHEAD REGION
CALENDAR YEAR ENDING DECEMBER 31, 1974

	Itasca County	Arrowhead Region	State of Minnesota
	(000)	(000)	(000)
Current Expenses			
General Government	$ 998	$ 7,431	$ 69,185
Public Safety	427	3,938	43,695
Natural Resources	127	473	7,542
Highways	1,800	13,760	97,576
Sanitation	92	852	1,844
Health	122	1,551	20,363
Hospitals - PSE[a]	433	2,485	19,503
Welfare	4,931	40,259	361,297
Schools	0	0	7
Libraries	21	197	8,037
Recreation	8	106	5,270
Interest	5	45	3,406
Miscellaneous	667	10,457	38,240
Total[b]	$9,617	$81,649	$678,226
Capital outlay	2,733	10,716	105,376
Other disbursements Trust and Agency payments	8,961	120,797	1,169,874
Total All Disbursements	$21,311	$224,741	$3,160,676
	%	%	%
Current Expenses			
General Government	10	9	10
Public Safety	4	5	6
Natural Resources	1	1	1
Highways	19	17	14
Sanitation	1	1	c
Health	1	2	3
Hospitals - PSE[a]	5	3	3
Welfare	51	49	53
Schools	0	0	c
Libraries	c	c	1
Recreation	0	c	1
Miscellaneous	7	13	6
Total[b]	99	100	98

[a] Public Service Enterprises - publicly owned services such as utilities, hospitals and nursing homes.

[b] Columns will not always total due to rounding of numbers.

[c] Less than 1%.

TABLE IV-124
LOCAL EXPENDITURES - ITASCA COUNTY - 1974

Unit of Government	Expenditures: General Government	Safety	Highways	Sanitation	Education	Health and Welfare	Other	Total Expenses	Capital Outlay
Cities over 2,500									
Grand Rapids	$ 143,402	$198,517	$205,630	$98,326	$ -	$ 600	$ 545,301	$1,191,776	$3,496,132
Cities under 2,500									
Big Fork	12,316	9,390	3,319	-	-	-	44,806	69,831	3,260
Bovey	36,170	30,786	14,700	22,175	-	377	57,845	162,053	52,090
Calumet	7,942	7,397	19,536	5,010	-	-	12,459	52,344	3,075
Cohasset	5,318	4,459	6,526	2,218	-	-	7,746	26,267	7,467
Coleraine	9,943	30,218	62,783	21,005	-	-	52,626	176,575	81,186
Cooley	1,950	-	-	-	-	-	-	1,950	-
Deer River	13,960	28,201	19,902	5,830	-	-	25,756	93,649	33,963
Effie	1,344	100	1,000	-	-	-	672	3,116	609
Keewatin	25,403	51,364	31,233	21,883	-	-	43,014	172,897	7,000
La Prairie	15,953	1,085	3,916	-	-	-	2,411	23,365	950
Marble	23,684	25,267	28,678	10,899	-	-	63,722	152,250	32,835
Nashwauk	15,1 2	66,262	55,956	6,020	-	-	43,899	187,279	30,476
Squaw Lake	1,805	2,174	1,595	-	-	-	479	6,053	0
Taconite	9,498	11,301	12,524	11,753	-	-	20,242	65,318	0
Warba	1,826	611	1,544	319	-	-	3,543	7,843	2,403
Zemple	1,056	202	70	-	-	-	35	1,363	0
School Districts									
Coleraine	-	-	-	-	3,514,000	-	-	3,514,000	55,220
Deer River	-	-	-	-	1,809,570	-	-	1,809,570	44,100
Grand Rapids	-	-	-	-	8,378,253	-	-	8,378,253	1,129,437
Nashwauk-Keewatin	-	-	-	-	1,995,171	-	-	1,995,171	133,551
Townships	161,364	52,561	441,639	-	-	-	226,396	881,960	103,727
County	997,845	427,218	1,800,476	92,255	309	5,042,838	1,256,330	9,617,271	2,732,673
Total	$1,485,921	$947,113	$2,711,027	$297,693	$15,697,303	$5,043,815	$2,407,282	$28,590,154	$7,950,154

LAND USE AND RECREATION

Regional

The State of Minnesota is divided into 13 Planning and Development Regions for the purpose of facilitating statewide program planning and intergovernmental cooperation. These regions represent a grouping of counties based on natural, social, and economic factors. In the section on regional land use, the basic area which will be discussed is the Arrowhead Region (Region 3), and Cass County. The Arrowhead Region has been chosen because the electric energy generated by MP&L's proposed Unit 4 will be used principally within this area and because the 7 counties comprising the Arrowhead Region share common physical and social features which differ from the rest of the State. Cass County has been included due to its proximity to the site of the proposed action.

Because people tend to travel greater distances to enjoy recreational activities, Regions 2 and 5 will be included with the Arrowhead Region 3 in the discussion of regional recreational facilities and activities.

Land Use

The Arrowhead Region, with a land area of 20,662 sq. miles (33,252 sq km), is the largest of the 13 Planning and Development Regions in Minnesota. It borders Ontario, Canada, to the north and Lake Superior to the east. A large share of Minnesota's natural resource lands exist within the Arrowhead Region, including 56% of Minnesota's forests, 37% of the State's water surface area, and 20% of the State's marshlands (224).

The existing land use within the Arrowhead Region and Cass County is presented in Table IV-125. These data have been gathered from two principal sources: 1) the Minnesota Land Management Information System (MLMIS), and 2) the Minnesota Department of Natural Resources (DNR). Figure IV-99 illustrates major forests, rivers, lakes, roads, and cities in Regions 2, 3, and 5.

Forestry. The great majority (77%) of land in the Arrowhead Region and Cass County is forested. Within this classification, various preserve areas are included such as Voyageurs National Park with 130,000 acres (52,609 hectares) of forest, the Boundary Waters Canoe Area (BWCA) with 1,030,000 acres (416,826 hectares) of forest, and State Park land with 31,069 acres (12,573 hectares).

The latest statistics on the amount of land devoted to commercial forest production came from a 1962 survey conducted by the U.S. Forest Service (223). Within the Arrowhead Region, 9,222,000 acres (3,732,011 hectares) are available for commercial forestry activity. While there have been some changes in these totals since 1962, i.e., the establishment of the 130,000 acre (52,609 hectares) Voyageurs National Park, the vast majority of land in the 7 counties still is available to be harvested for forest products.

Cultivated, Pasture, or Open Land. Cultivated land accounts for approximately 279,640 acres (113,166 hectares) or 1.9% of the land in the Arrowhead Region and Cass County, while the pasture or open land classification in this region accounted for 782,760 acres (316,772 hectares) or 5.3% of the land.

Water, Marsh, and Swamps. While not a land use as such, water bodies are an important factor in the economy of the Arrowhead Region and Cass County. The MLMIS study reported over 1,551,720 acres (627,959 hectares) or 10.5% of the 8 county area were covered by water. A great majority of recreational facilities in this region, such as resorts and public recreation areas, are oriented to water-related activites. March or swamps accounted for over 429,960 acres (173,999 hectares) or 2.9% of this region.

Urban and Non-Residential or Mixed Residential. Urban land uses are divided into 2 categories in the MLMIS. Urban residential is that land which includes at least five residential building per 40 acre (16.2 hectare) parcel (including seasonal homes, resorts, mobile homes, etc.) and no commercial buildings. The urban and non-residential or mixed residential classification includes at least one commerical, industrial, or institutional development within the 40 acre (16.2 hectare) parcel. The urban residential land within the Arrowhead Region and Cass County occupies 156,880 acres (63,487 hectares) or 1.1% of the area. The urban and non-residential or mixed residential lands account for 75,120 acres (30,400 hectares) or approximately 0.5% of this region.

Extractive. Extractive land uses occupy 120,000 acres (48,562 hectares) or 0.1% of this region's 14,800,000 acres (5,989,347 hectares). While this area represents only a small fraction of the land in this region, it illustrates man's influence on this area. Extractive land uses are concentrated in St. Louis and Itasca Counties.

Transportation. The majority of the regional roadways radiate from the City of Grand Rapids as shown in Figure IV-100. Access to the area, on a regional scale, is provided by U.S. 169 and U.S. 2, both of which pass through Grand Rapids. U.S. 169 proceeds in a north-south direction providing access to the Minneapolis-St. Paul area and southern Minnesota as well as proceeding northeast to the cities of Virginia and Ely. U.S. 2 provides a regional route across the State in an east-west direction. This highway links Duluth to Grand Forks, North Dakota. Both of these roadways are under the jurisdiction of the State of Minnesota. The majority of population in the area is centered in communities along these 2 roadways.

Four commercial airports serve the Arrowhead Region and Cass County. Duluth is served by North Central Airlines, a commercial carrier. Non-stop flights provide service between Duluth and Chicago, Milwaukee, Minneapolis-St. Paul, Toronto, and Winnipeg. The Boeing 707 is the largest aircraft to serve the Duluth airport. Hibbing is served by North Central Airlines. Non-stop service is provided to Duluth, International Falls, and Minneapolis-St. Paul. The DC-9 is the largest aircraft serving the Hibbing airport. Bemidji is also served by North Central Airlines. Non-stop flights are scheduled daily to Brainerd, Grand Forks, N.D., and Thief River Falls. The largest aircraft serving the Bemidji airport is the Convair 580. Grand Rapids is served by Mesabi Airlines, a commuter airline. Non-stop service is available to Eveleth and Minneapolis-St. Paul. The Convair 580 is the largest aircraft serving Grand Rapids airport.

There are numerous other limited facility airports in the area that could be utilized by private airplanes.

The Arrowhead Region is served by the following railroads: The Duluth, Mesabi and Iron Range Railroad (D.M. and I.R.R.R.); the Duluth, Winnipeg and Pacific Railroad; the Burlington-Northern Railroad; the Soo Line Railroad; the Chicago, Milwaukee, St. Paul and Pacific Railroad; the Chicago and Northwestern Railroad. As shown in Figure IV-100, Duluth is the rail center for these lines. Reserve and Erie Mining Companies operate their own railroads for the transport of taconite iron ore to Lake Superior. The D.M. and I.R.R.R. transports taconite for mining companies and also provides a connection from Grand Rapids to Duluth.

Two bus companies serve the Region. Triangle Transportation Company provides daily service between Duluth and Grand Forks, N.D., and Greyhound Bus Lines provides service daily between Minneapolis and Hibbing. Both bus routes pass through Grand Rapids.

Land Ownership

An important factor in the use of land is its ownership. The Arrowhead Region and Cass County are unique in comparison with most development regions in the State, as much land is publicly owned. Based on avilable data, it is estimated that 64% of the land in the Arrowhead Region is owned by Federal or State Government (Table IV-126). When Cass County is included, the total land in public ownershiop for this region is 8,252,000 acres (3,339,466 hectares) or 63% of the 8 county area. The percent of public land in the individual counties ranges from a low of 40% in Carlton County to a high of 89% in Cook County.

The Federal Government owns and manages over 3 million acres (1.2 million hectares) of land in the 8 counties or 24% of the total land area. This land accounts for 37% of the public land. National forests account for 65% of Federal land in the 8 counties as indicated in Table IV-127. These lands represent 97% of National Forest land in the State. Major Federal land holdings in the area include the Boundary Waters Canoe Area with 858,560 acres (347,447 hectares) including the interior as well as the portal zone, Bureau of Indian Affairs lands with 140,000 acres (56,656 hectares), and Voyageurs National Park.

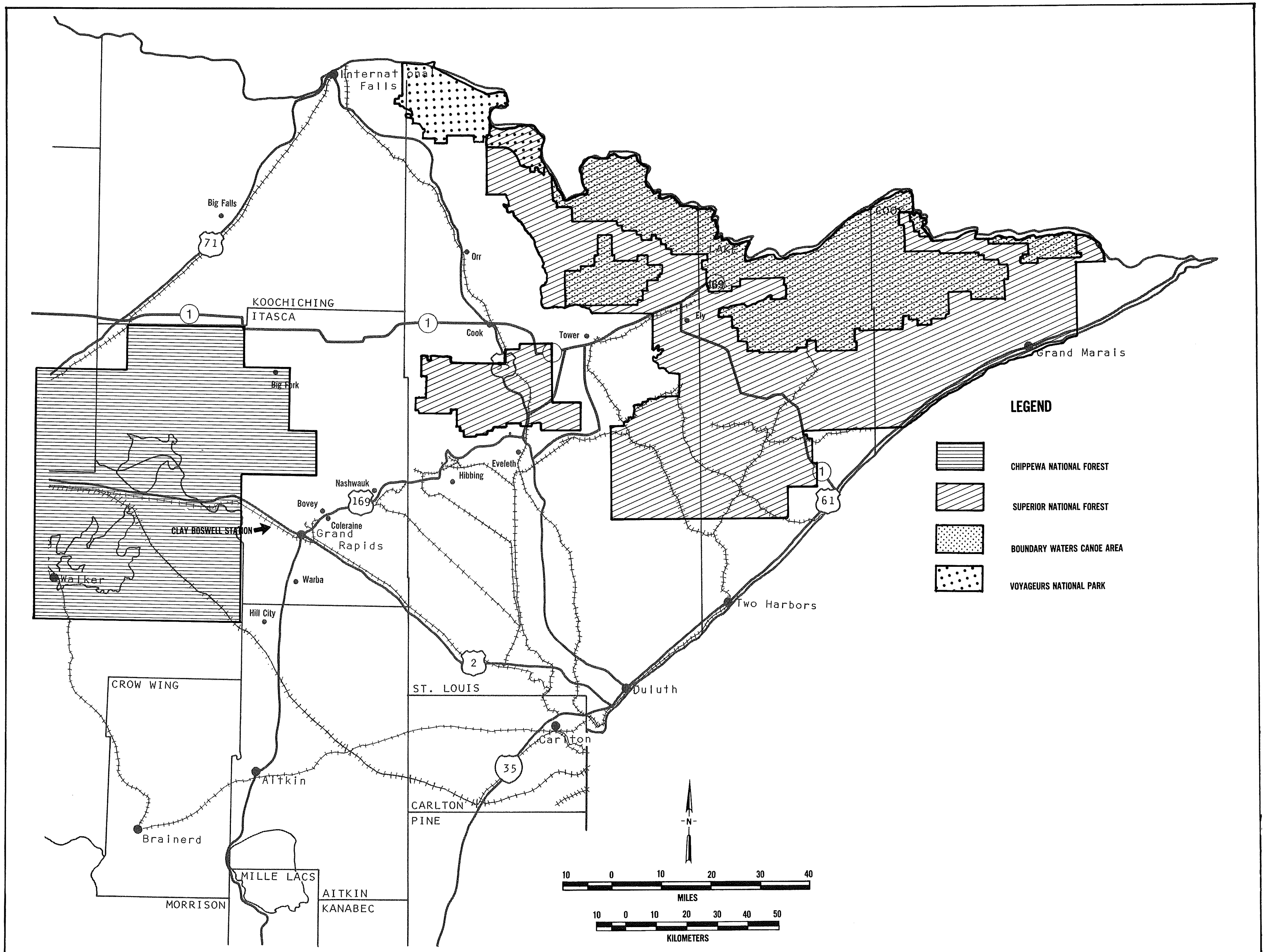
The State of Minnesota owns and manages approximately 2,960,000 acres (1,197,869 hectares) in the 8 counties, or 23% of the total land area. This represents 36% of the public land. The State also holds 2,258,000 acres (913,780 hectares) of land in trust for the taxing district. This is commonly known as tax-forfeited land. Within the 8 county region, 17% of the land is tax-forfeited, is managed by the counties, and accounts for 75% of all tax-forfeited land in the State.

TABLE IV-125
LAND USE - ARROWHEAD REGION AND CASS COUNTY (225) (226)

	Forested			Cultivated			Pasture and Open			Water			Marsh		
	acre	hectare	percent	acre	hectare	percent	acre	hectare	percent	acre	hectare	percent	acre	hectare	percent
Arrowhead Region															
Aitkin	838,640	339,385	66.2	67,720	27,405	5.3	134,760	54,535	10.5	105,920	42,864	8.2	120,760	48,870	9.4
Carlton	378,480	153,165	67.2	45,880	18,567	8.1	91,240	36,923	16.2	8,560	3,464	1.5	24,840	10,053	4.4
Cook	954,240	386,167	74.0	-	-	-	2,200	890	0.2	324,240	131,215	25.1	1,160	469	0.1
Itasca	1,518,120	614,361	79.4	24,920	10,085	1.3	102,920	41,650	5.4	172,440	69,784	9.0	26,040	10,538	1.4
Koochiching	1,759,240	711,939	85.5	17,960	7,268	0.9	87,920	35,580	4.3	33,640	13,614	1.6	148,200	59,974	7.2
Lake	1,354,760	548,252	81.5	1,720	696	0.1	7,000	2,833	0.4	280,360	113,458	16.9	4,760	1,926	0.3
St. Louis	3,571,360	1,445,278	80.2	80,560	32,601	1.8	184,960	74,850	4.1	381,080	154,218	8.5	49,160	19,894	1.1
Total	10,374,840	4,198,225	78.4	238,760	96,623	1.8	611,000	247,263	4.6	1,306,240	528,616	9.9	374,920	151,725	2.8
Cass County	1,022,240	413,686	65.1	40,880	16,543	2.6	171,760	69,509	10.9	245,480	99,342	25.6	55,040	22,274	3.5
Eight County Total	11,397,080	4,612,234	77.0	279,640	113,166	1.9	782,760	316,772	5.3	1,551,720	627,959	10.5	429,960	173,999	2.9

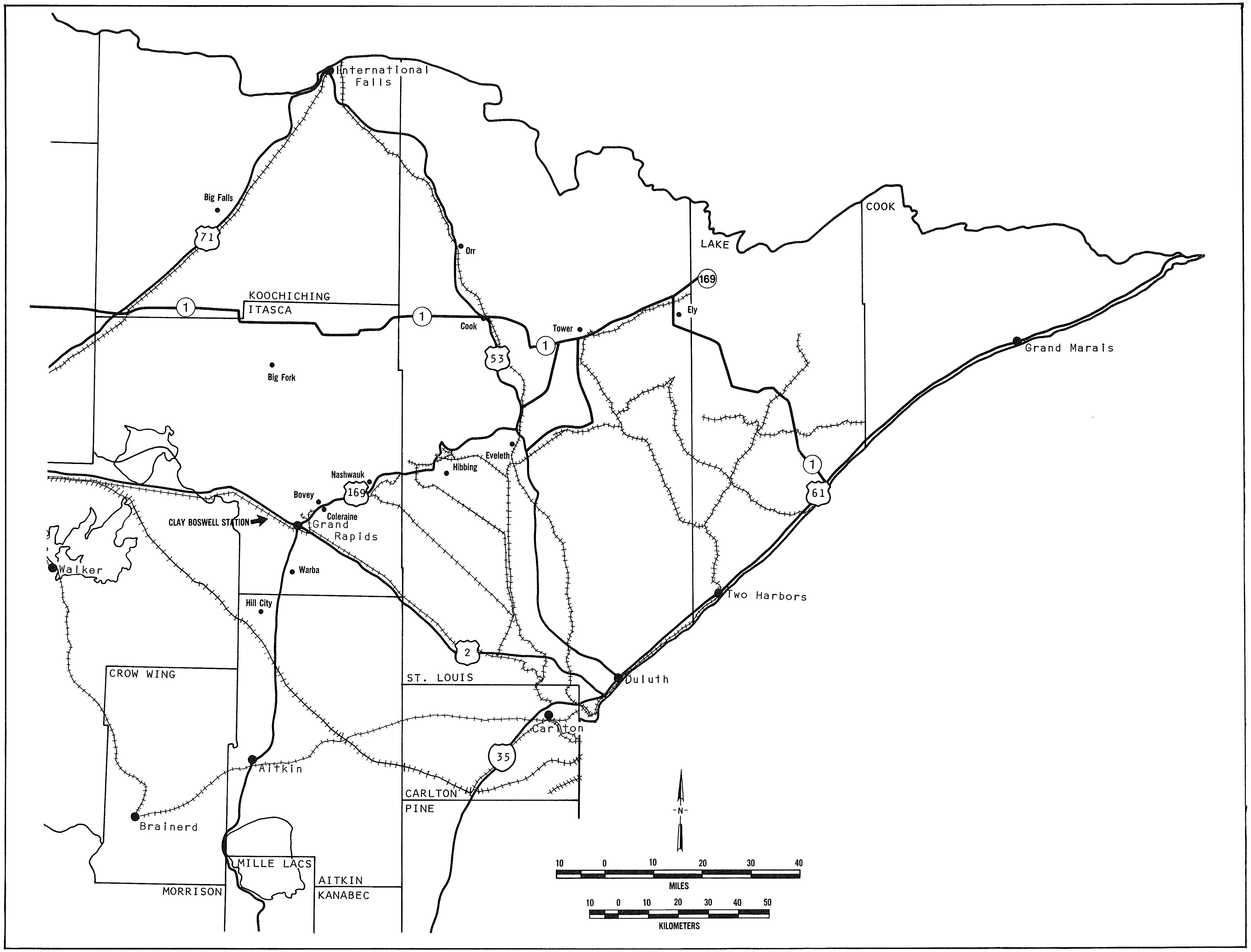
	Urban Residential			Urban, Non-Residential, or Mixed Residential			Extractive			Transportation			Total		
	acre	hectare	percent	acre	hectare	percent	acre	hectare	percent	acre	hectare	percent	acre	hectare	percent
Arrowhead Region															
Aitkin	14,280	5,779	1.1	3,480	1,408	0.3	40	16	-	120	48	0.1	1,285,720	520,312	9.72
Carlton	5,960	2,412	1.1	7,320	2,962	1.3	600	242	0.1	320	129	0.1	563,200	227,919	4.26
Cook	5,200	2,104	0.4	2,040	825	0.2	360[a]	146[a]	-	-	-	-	1,289,440	521,818	9.75
Itasca	24,400	9,874	1.3	10,440	4,225	0.5	32,800[a]	13,306[a]	1.7	240	97	-	1,912,400	773,921	14.46
Koochiching	5,240	2,120	0.2	3,560	1,441	0.2	160	65	-	560	226	-	2,056,480	832,195	15.55
Lake	8,200	3,318	0.5	3,920	1,586	0.2	1,000[a]	404[a]	-	280	113	-	1,662,000	672,587	12.57
St. Louis	64,680	26,175	1.4	39,320	15,912	0.9	79,520[a]	32,180[a]	1.8	4,120	1,167	0.1	4,454,760	1,802,777	33.69
Total	127,760	51,703	1.0	70,080	28,360	0.5	120,320	48,692	0.9	5,640	2,282	-	13,224,000	5,351,563	100.00
Cass County	29,120	11,784	1.9	5,040	2,040	0.3	-	-	-	160	165	-	1,569,720	635,243	-
Eight County Total	156,880	63,487	1.1	75,120	30,400	-	120,320	48,692	0.1	5,800	2,347	-	14,793,720	5,986,806	-

[a] These estimates have been reduced to account for higher estimates of extractive use based on DNR data.



LAND USE - ARROWHEAD REGION

FIGURE IV-99



ROADWAY AND RAILROADS
ARROWHEAD REGION

FIGURE IV-100

TABLE IV-126

ESTIMATED STATE AND FEDERALLY OWNED LAND - ARROWHEAD REGION AND CASS COUNTY[a] (227)

	Total Land Area		Public Land			Federal Land (228)		DNR Land (229)		Other State Land		Tax-Forfeited Land	
	acre	hectare	acre	hectare	percent	acre	hectare	acre	hectare	acre	hectare	acre	hectare
Arrowhead Region													
Aitkin	1,164,502	471,257	631,800	255,680	54	16,160	6,540	388,191	157,095	4,120	1,667	223,329	90,378
Carlton	550,092	222,614	220,971	89,424	40	9,160	3,707	75,385	30,507	8,768	3,548	127,658	51,661
Cook	936,426	378,958	835,306	338,036	89	694,600	281,095	132,725	53,712	1,481	599	6,500	2,630
Itasca	1,739,322	699,832	935,741	378,861	54	318,920	129,062	319,223	129,185	5,598	2,265	292,000	118,168
Koochiching	1,989,188	804,996	1,469,509	594,689	74	87,520	35,418	1,092,669	442,187	4,320	1,748	285,000	115,335
Lake	1,367,808	553,532	1,152,369	466,347	84	814,360	329,560	179,076	72,469	1,639	663	157,294	63,655
St. Louis	4,043,532	1,636,359	2,280,772	992,996	56	817,400	330,790	548,875	222,122	7,827	3,167	906,670	366,916
Total	11,780,870	4,767,549	7,526,468	3,045,854	64	2,758,120	1,116,171	2,736,144	1,107,278	33,753	13,659	1,998,451	808,744
Cass County	1,302,315	527,028	726,167	293,859	59	314,000	127,071	183,896	74,420	4,271	1,728	260,000	105,218
Eight County Total	13,083,185	5,294,577	8,252,635	3,339,723	63.1	3,072,120	1,243,343	2,920,040	1,181,698	38,024	15,388	2,258,451	913,963
State of Minnesota	51,033,677	20,652,596	12,796,948	5,178,741	25	4,311,560	1,744,826	5,199,612	2,104,208	281,040	113,733	3,004,376	1,215,828
Eight County Area as % of State	25.6		64.5		-	71.2		56.2		13.5		75.2	

[a] Total acreage in the counties recorded in this Table do not match those recorded in Table IV-125. This is due to errors in both sets of data which cannot be reconciled without additional original research.

TABLE IV-127
ESTIMATED FEDERAL LANDS - ARROWHEAD REGION AND CASS COUNTY

	U.S. Forest Service				Bureau of Land Management		U.S. Fish and Wildlife					
	BWCA		National Forests				National Wildlife Refuges		Waterfowl Fee Title		Easements and Flowage Rights	
	acre	hectare	acre	hectare	acre	hectare	acre	hectare	acre	hectare	acre	hectare
Arrowhead Region												
Aitkin	-	-	-	-	-	-	14,280	5,779	-	-	40	16
Carlton	-	-	1,280	518	-	-	-	-	-	-	-	-
Cook	273,280	110,593	373,280	151,061	-	-	-	-	-	-	-	-
Itasca	-	-	293,360	118,719	1,160	469	-	-	40	16	-	-
Koochiching	-	-	40	16	33,800	13,678	-	-	-	-	-	-
Lake	357,920	144,845	456,320	184,666	-	-	-	-	-	-	-	-
St. Louis	227,360	92,009	577,560	233,730	80	32	-	-	40	16	-	-
Total	858,560	347,447	1,701,840	688,710	35,040	14,180	14,280	5,779	80	32	40	16
Cass County	-	-	297,200	120,273	-	-	-	-	-	-	-	-
Eight County Total	858,560	347,447	1,999,040	808,983	35,040	14,180	14,280	5,779	80	32	40	16
State of Minnesota	858,560	347,447	2,063,160	834,931	43,680	17,677	152,920	61,885	186,400	75,433	132,440	53,597
Eight County Area as % of Federal Land in State	100		96.9		80.2		9		-		-	

	National Park Service		Corps of Engineers				Bureau of Indian Affairs		Other		Total Federal Lands	
			Fee Title		Easements							
	acre	hectare	acre	hectare	acre	hectare	acre	hectare	acre	hectare	acre	hectare
Arrowhead Region												
Aitkin	-	-	600	243	800	324	440	178	-	-	16,160	6,540
Carlton	-	-	-	-	-	-	6,960	2,816	920	372	9,160	3,707
Cook	1,320	534	-	-	-	-	46,680	18,891	40	16	694,600	281,095
Itasca	-	-	5,360	2,169	12,200	4,937	6,640	2,687	160	65	318,920	129,062
Koochiching	a		-	-	-	-	53,160	21,513	520	210	87,520	35,418
Lake	-	-	40	16	-	-	-	-	80	32	814,360	329,560
St. Louis	a		-	-	-	-	11,280	4,565	1,080	437	817,400	330,790
Total	1,320	534	6,000	2,428	13,000	5,261	125,160	50,651	2,800	1,133	2,758,120	1,116,172
Cass County	-	-	840	340	440	178	15,520	6,281	-	-	314,000	127,071
Eight County Total	1,320	534	6,840	2,768	13,440	5,439	140,680	56,931	2,800	1,133	3,072,120	1,243,243
State of Minnesota	1,560	631	51,320	20,769	47,680	19,295	769,640	311,462	4,200	1,700	4,311,560	1,744,826
Eight County Area as % of Federal Land in State	85		13.3		28.2		18.3		67		71.3	

[a] Voyageur National Park was not in existence when these data were collected.

TABLE IV-128

ESTIMATED STATE LANDS ADMINISTERED BY DEPARTMENT OF NATURAL RESOURCES - ARROWHEAD REGION AND CASS COUNTY (229)

	Forest Outside State Forest	Forest Inside State Forest	Game	Fisheries	Park	Water, Soils, and Minerals	Law Enforcement	Administration	DNR Total
Arrowhead Region									
Aitkin									
acre	105,682	255,710	16,176	591	9,989	-	43	-	388,191
hectare	42,768	103,482	6,546	239	4,042	-	17	-	157,095
Carlton									
acre	13,898	49,060	400	1,545	9,444	-	22	-	75,385
hectare	5,624	19,854	162	625	3,822	-	8.90	-	30,507
Cook									
acre	50,891	74,486	-	720	6,554	-	-	74	132,725
hectare	20,595	30,143	-	291	2,652	-	-	30	53,712
Itasca									
acre	83,665	233,733	369	348	807	276	25	-	319,223
hectare	33,858	94,588	149	141	326	112	10	-	129,185
Koochiching									
acre	212,596	879,948	-	-	118	-	7	-	1,092,669
hectare	86,035	356,102	-	-	48	-	2.8	-	442,187
Lake									
acre	53,495	108,601	-	11,346	5,627	-	6	-	179,076
hectare	21,649	43,949	-	4,592	2,277	-	2.4	-	72,469
St. Louis									
acre	236,318	301,484	1,958	3,460	4,157	1,322	35	140	548,875
hectare	95,634	122,006	792	1,400	1,682	535	14	57	222,122
Total									
acre	756,538	1,903,022	18,903	18,010	36,696	1,598	138	214	2,736,144
hectare	306,160	770,126	7,650	7,288	14,850	647	56	87	1,107,278
Cass County									
acre	45,706	133,653	2,116	2,171	126	-	124	-	183,896
hectare	18,497	54,087	856	878	51	-	50	-	74,420
Eight County Total									
acre	802,244	2,036,675	21,019	20,181	36,822	1,598	262	214	2,920,040
hectare	324,657	824,213	8,506	8,167	14,901	647	106	87	1,181,698
State of Minnesota									
acre	1,564,158	2,999,604	451,428	25,794	151,907	2,073	1,493	3,872	5,200,340
hectare	632,992	1,213,897	182,686	10,438	61,475	839	604	1,567	2,104,503
Percent of State	51.3	67.9	4.7	78.2	24.2	77	17.5	5.5	56.2

Minnesota Department of Natural Resources (DNR) administered land has been categorized and is administered by various divisions within the DNR as indicated in Table IV-128. Of the 2,920,040 acres (1,181,698 hectares) administered by the DNR, forest land in and outside of State Forests comprises 2,838,919 acres (1,148,870 hectares). The forest land represents 97% of all DNR land in the 8 county area. The forest land in the 8 counties represents 62% of all forest land owned and managed within the State by the DNR.

There are 9,222,000 acres (3,732,011 hectares) of commercial forest land in the Arrowhead Region. While over 6.3 million acres (2.55 million hectares) of this land is publicly owned, the forest industry and private individuals own 2.9 million acres (1.17 million hectares) of land available for commercial forest activity (230) (231).

Development Trends

Several development trends are evident in the Arrowhead Region and to some extent, are a function of existing land use and ownership. These trends, which include mining, forestry, agriculture, and tourism, will affect the region in numerous ways and produce an array of impacts. Information concerning these trends provides a wider view of land use changes than the specific land use resulting from MP&L's proposed action.

Mining. Extensive land use changes resulting from the mining industry will develop in the region during the coming centry. The expansion of the iron ore mining industry and the possible establishment of copper-nickel mining will change existing land uses. Natural iron ore, both direct ore and gravity concentrated, is declining in the percentage of total ore shipped out of Minnesota. While the active, inactive, and abandoned natural ore mines are an important aspect of present land use, mining of these will not increase greatly in the future. Therefore, the impact of mining on future land use will be restricted essentially to iron taconite and copper-nickel operations.

The iron taconite mining industry began in 1949 (232). Given the demand for iron ore and the amount of taconite in Minnesota, a long life is expected. Approximately 45 billion long tons (46.5 billion mt) of magnetic taconite, mineable by open pit methods, exist in the Mesabi Iron Range. This does not include nonmagnetic taconite, or taconite which may be recoverable by underground mining methods. Additionally, this does not assume technological change which will allow future mining of taconite which is uneconomical by today's technology. It is clear that this resource estimate of 45 billion long tons (46.5 billion mt) is conservative.

Mining and processing 45 billion long tons (64.5 billion mt) of taconite ore will produce 15 billion long tons (15.5 billion mt) of iron pellets and 30 billion long tons (31.0 billion mt) of tailings or waste. To date, approximately 0.5 billion long tons (0.52 billion mt) of pellets have been produced.

The existing land use associated with taconite mining and processing is approximately 40 sq miles (103 sq km) as indicated in Table IV-129. The

TABLE IV-129
EXISTING AND PROJECTED LAND USE ASSOCIATED WITH MINNESOTA TACONITE MINING AND PROCESSING

	Pit				Basin[a]				Stockpile			
	Existing[a]		Planned		Existing		Planned		Existing		Planned	
	sq mile	sq km	sq mile	sq km	sq mile	sq km	sq mile	sq km	sq mile	sq km	sq mile	sq km
U.S. Steel	2.53	6.55	b	b	4.37	11.32	22.0[c]	56.98	0.87[d]	2.25	b	b
Erie	8.19	21.21	b	b	4.19	10.85	14.1	36.52	2.92[e]	7.56	b	b
Reserve	5.19	13.44	b	b	-	-	-	-	1.82[f]	4.71	b	b
Inland Steel[g]	-	-	1.18	3.06	-	-	4.39	11.37	-	-	2.38	6.16
Hibbing Taconite	-	-	3.59[h]	9.30	-	-	11.6	30.04	-	-	b	b
Eveleth Taconite[i]	1.78	4.61	2.0	5.18	1.22	3.16	5.12	13.26	1.87	4.84	2.73	7.07
Jones & Laughlin	-	-	2.62	6.78	-	-	7.2	18.65	-	-	b	b
National Steel	0.98	2.54	b	b	4.5	11.65	32.6	84.43	0.86	2.22	b	b
Total	18.67	48.35	9.39	24.32	14.28	36.98	97.01	251.25	8.34	21.60	5.11	13.23

[a] Department of Natural Resources, Working Map, January, 1973.

[b] Not available.

[c] Pollution Control Agency Permit #WPC 5055.

[d] U.S. Steel, 1975, Reclamation Map.

[e] Erie Mining Company, 1975, Reclamation Map.

[f] Reserve Mining Company, 1975, Reclamation Map.

[g] Final Environmental Impact Statement: Proposed Inland Steel Taconite Operation, St. Louis County, Minnesota, March 22, 1974.

[h] Application for Permit (submitted to the Minnesota Pollution Control Agency), Hibbing Taconite Project.

[i] Application for Permit (submitted to the Minnesota Pollution Control Agency), Expansion of Eveleth Taconite Project.

expansion of taconite mining presently under construction, being engineered, or planned will require approximately 112 sq miles (290 sq km) of additional land. The total for existing and short term expansion involves 153 sq miles (396 sq km) or 97,920 acres (39,627 hectares) of land.

From a land use perspective, to support the increased taconite mining and processing, changes will have to occur to accomodate homes, roads, public facilities, and associated industries. Thus, while the short term expansion of taconite mining and processing will require 112 sq miles (290 sq km), those activities indirectly tied to it will require additional land.

No long term projections of land use changes associated directly or indirectly with taconite mining and processing have been made. The present taconite mining operations have extracted 3% of the 45 billion long tons (46.5 billion mt) of taconite recoverable by open pit mining methods. If the mining and processing of non-magnetic taconite or the underground mining of magnetic taconite became economically feasible, the potential ore supply would be increased greatly.

The State of Minnesota presently is conducting a copper-nickel regional study, which is to describe the existing environmental setting in the Arrowhead Region and to project the impacts of mining and processing the copper-nickel ores on the physical and human environment. When this study is complete, the

State will determine whether to proceed with copper-nickel mining in the State. Several companies have leases to mineral rights on State land and have completed testing and studies. A few miles southeast of Ely, INCO has completed an exploratory shaft and has also taken an extensive bulk sample. AMAX is now in the process of completing its tests shaft near Babbitt.

Forestry. Forested land accounts for approximately 77% of land in the 8 county region. A majority of these 11,400,000 acres (4,613,416 hectares) are available for timber production. The demand for wood products will be the principal factor in determining the growth or reduction of this industry. An overall improvement in the national economy most likely will cause increased demand for forest products. About 66% of the allowable cut is being used, indicating that there could be significant expansion of timber production (233). It should be noted, however, that the surplus allowable cut is generally low value hardwood pulp species and at this time there is no surplus of conifer or high value hardwood saw timber in the State (234).

The forest products industry has conflicts with other land uses. It has been estimated that since 1962, nearly a million acres (0.4 million hectares) or 11% of the commercial forest land has been removed from production in 18 counties in northeasten Minnesota (235). Much of this land is in the BWCE and the new Voyageurs National Park. However, other land is being removed from forest production because of increased urbanization. During the period of low demand for forest products, the impact of land removed from timber production does not seem critical. If and when demand increases, this land may be viewed differently. Better management of forested lands may increase forest production. Wood production on commercial forest land could be increased from the current level of one-third cord per acre per year (3.0 cu m per hactare per year) to an average of three-fourths to one cord per acre per year (6.7 to 9.0 cu m per hactare per year (236).

In the past few years, the price of commercial forest land has increased above the economic value that the land can generate. The average price of county land in St. Louis County has risen from $27 per acre ($67 per hectare) in 1972 up to $61 per acre ($151 per hectare) in 1975. This amounts to an average increase at a compound rate of over 27% per year. If the county began assessing this land at full market value which is required by law, taxes would increase substantially and much of this land might be transformed from forest production to private recreation and other uses (237).

Voyageurs National Park. Voyageurs National Park was officially established in 1975 and ecompasses 210,000 acres (84,984 hectares) of forests and water area. The area will be managed as a natural area by the National Park Service and portions will be reviewed for inclusion in the National Wilderness System. The water bodies in the Park will be utilized for a variety of activities such as camping, hiking, swimming, boating, fishing, and cross-country skiing. Creation of the Park recognizes the uniqueness of the area as a national resource. Its development will increase national exposure and tourism. The area presently attracts 350,000 users per year. Upon completion of the various facilities, annual visitor days are expected to be 1 to 1.3 million.

While development of the Park will create changes in the use of the 200 sq miles (518 sq km), it also will cause changes in the surrounding area, particularly along access roads to the Park.

The principal changes will be associated with tourist accomodations and services such as restaurants, service stations, boat rentals, and grocery stores. Since most of the existing commerical establishments will be able to accomodate additional customers, the greatest demand will be for overnight lodging. At maturity, the park is anticipated to require 1,100 additional lodging units during peak daily usage. Approximately 65% of all tourists will have to be housed in private facilities. No estimates have been made as to the amount of land required to meet this demand for overnight facilities. There are no estimates for other required land uses and facilities.

Boundary Waters Canoe Area. The BWCA is comprised of 2 zones: The interior zone with 618,000 acres (250,096 hectares) and the portal zone with 412,000 acres(166,730 hectares). In the past few years, there has been considerable controversy over the use of the portal zone, which surrounds the interior zone and acts as a buffer. Some wish to see this area remain a wilderness area, while others wish to use its forest resources. The portal zone has been designated as an area available to timber harvest. While national legislation may reverse this usage, the portal zone now is managed under the Multiple Use Sustained Yield Act of 1960.

Due to the increased number of visitors ot the BWCA, a reservation system was established in 1976 and will again be in effect in 1977.

Agriculture. Agriculture has been an continues to be on the decline in the Arrowhead Region. Due to the increased worldwide demand for food products this trend may be reversed, but at this time there is little evidence to support such a contention. The land use in the Arrowhead Region devoted to agricultural purposes declined by 33% from 1959 to 1969. The number of farms dropped from 1,208 in 1959 to 519 in 1969, a reduction of 57%. During these 10 years, the average farm size increased from 140 acres (56.7 hectares) to 231 acres (93.5 hectares) (238).

Many dairy farms which were too small to be economically feasible units are now beef raising operations on a part-time basis. The region experienced a 29% drop in numbers of dairy cows between 1969 and 1973 and a concurrent 21.4% increase in beef cattle (239).

Three crops appearing to have potential for future development are potatoes, wild rice, and horticultural crops. In the past 15 years, the production of wild rice increased from 14 acres (5.7 hectares) to over 20,000 acres (8,094 hectares). There are numerous difficulties, such as disease and birds, in commercially raising wild rice. Potato production in the Arrowhead Region, although minimal at this time, could be expanded in suitable areas. Much of the Arrowhead Region is suited for raising horticultural crops (240).

A major problem which may affect agriculture in the Arrowhead Region is land availability and price. Land in the region now is being acquired for private recreation and speculative purposes. Between 1970 and 1974, land prices increased by more than 244% while land prices in the State as a whole increased 85.2%. Dairy lands increased in price by 109% between 1970 and 1974.

Land Use Plans

No comprehensive land use plan has been adopted for the Arrowhead Region. Attempts have been made to incorporate County Comprehensive Plans into a composite that would be acceptable to each of the 7 counties, but this effort proved fruitless. Similarly, Cass County has no land use plan.

A number of State and Federal agencies have adopted policies which form *de facto* development plans for the Region. Due to the extensive land holdings of the U.S. Forestry Service and the DNR, the plans and policies which direct the use of these lands substantially influence the region and the individual counties.

While supposedly both State and Federal forests are managed under the sustain yield-multiple use concept, no declared policy can be found concerning State forest management (241). The sustained yield policy states that the amount of forest harvested should be equal to the growth over a given period of time. The multiple use concept states that forest lands should also be available for other compatible uses such as hunting, snowmobiling, fishing, and camping.

The individual counties manage tax-forfeited lands in a similar manner, but usually on a less intense basis. While some of the tax-forfeited land may be designated for recreational purposes, the majority of these lands are available for timber harvest. Forest harvesting on these lands is allowed on a permit basis. A private individual may request a timber harvest permit on tax-forfeited land if the amount of land involved is of limited size. If the timber to be harvested is of high value, the county must hold an auction at which those interested bid on the timber. The DNR also has policies which tend to encourage recreation on tax-forfeited land.

While there are many State agencies involved in activities that influence land use, few statewide plans exist. The Minnesota Department of Transportation (MDOT) is now preparing a statewide plan. While none of the State or Federal policies may be in conflict, little or no formal coordination appears to exist among the various government levels or agencies to insure that individual policies are supportive instead of detrimental to one another.

Recreation

The Arrowhead Region (Region 3) and adjoining Regions 2 and 5 are rich in natural recreational resources as well as public facilities for recreational use. These facilities are available on a daily basis to residents of the area. Great numbers of tourists travel within the area to utilize the many parks, lakes, and forests of these regions.

Water Resources. The Arrowhead Region, Region 2, and Region 5 contain approximately 2 million acres (0.8 million hectares) of lakes, providing ample opportunity for fishing, boating, and other water-related recreation. Among these lakes are Leech, Winnibigoshish, Mille Lacs, Kabetogama, Pokegama, and Vermilion, among the largest lakes in the State of Minnesota (242). Several lakes are controlled by the U.S. Corps of Engineers as reservoir projects, but are often available for public recreation. Lake basin acreage for the Arrowhead Region and Regions 2 and 5 are presented in Table IV-130.

TABLE IV-130

COMPARISON OF LAKE AREA - MINNESOTA REGION 2, REGION 3 (ARROWHEAD), AND REGION 5 WITH STATE TOTAL LAKE AREA (242)

	Lake Basin Total Area		"Dry" Basin[a] Area		"Wet" Basin[b] Area		Region Total Land Area		Percent of Lake Basin Area of 10 acres (4.0 hectares) or More
	acre	hectare	acre	hectare	acre	hectare	acre	hectare	
Region 2	771,519	312,223	7,980	3,229	763,539	308,993	4,399,360	1,780,358	17.4
Region 3 (Arrowhead)	895,027	362,205	12,046	4,875	883,708	357,624	12,477,440	5,049,441	6.3
Region 5	406,893	164,664	15,473	6,262	391,420	158,402	3,968,640	1,605,937	10.3
State total	3,409,109	1,379,617	308,702	124,927	2,100,407	850,004	53,803,520	21,773,511	6.32

[a] Dry Basins are "affected by ditch" or have exposed beds.

[b] Wet Basin Acreage is total acreage minus dry acreage.

Rivers and streams are abundant in these regions. Nine outstanding rivers have been selected for protection as part of Minnesota's Wild and Scenic River System. Included are the Crow Wing and the Mississippi in the Arrowhead Region; the Big Fork , Cloquet, Kettle, Little Fork, St. Louis, and Snake Rivers in Region 5; and the Red Lake River in Region 2. It is intended that these river corridors be preserved in their existing state for their outstanding scenic, natural, recreational, historic, or scientific values.

National Parks and Forests. The Arrowhead Region and Region 5 contain the 2.1 million acre (0.85 million hectares) Superior National Forest. The 650,000 acre (263,045 hectares) Chippewa National Forest extends into all 3 regions. These are the only national forests in Minnesota and are very popular outdoor recreation attractions. Contained within the Superior National Forest is the 1.03 million acre (0.42 million hectares) BWCA, a National Recreation Area.

The only National Park in Minnesota is the Voyageurs National Park in the Northern part of the State, bordering Canada. It includes 210,000 acres (84,984 hectares).

State Parks and Recreation Lands. The Minnesota DNR controls nearly 2.7 million acres (million hectares) of land in the Arrowhead Region. This includes 36,700 acres (14,852 hectares) of park land in 15 parks, 1.9 million acres (768,903 hectares) of forests, nearly 37,000 acres (14,973 hectares) of game and fisheries management land, and 800,000 acres (323,748 hectares) of other land holdings. In addition, small amounts of land are held by other State agencies for recreational use, such as highway wayside rests managed by the MDOT.

The Minnesota DNR administers approximately 1.6 million acres (0.65 million hectares) of recreational land in Region 2. Over one-third of this land is State Forest land and another one-third is within wildlife management areas. Nearly 34,000 acres (13,759 hectares) are contained in the region's 4 State Parks and recreation areas.

The DNR holds about 261,000 acres (105,623 hectares) in Region 5. Of this land, 155,000 acres (62,726 hectares) are in 6 State forests, 2,526 acres (1,022 hectares) are in 2 State Parks, and 212 acres (85.8 hectares) are in the Schoolcraft State Recreation Area. The Schoolcraft State Recreation Area is on the border of the Arrowhead Region, about 7 miles (11.4 km) from the Clay Boswell Station. In addition, the State holds about 31,000 acres (12,545 hectares) of wildlife management land and numerous lake accesses, as well as 73,000 acres (29,542 hectares) of other land holdings.

Recreation resources in the Arrowhead Region, Region 2 and Region 5 are presented in Table IV-131. A listing of state parks, recreation areas, monuments, and waysides in the Arrowhead Region and Regions 2 and 5 are presented in Table IV-132. Table IV-133 presents an inventory of outdoor recreation facilities in the Arrowhead Region 3, Region 2, and Region 5.

Future Trends. Trends indicate that the demand for recreation facilities and activities will continue to increase in the future. The attraction of the region recreation facilities for recreation lies in the natural resources of the area - lakes, forests, and scenery. The Minnesota market for tourism seems to be gradually changing from dependence on natural resource recreation to the provision of man-made activities such as golf, tennis, and recreation halls (245).

Projections for participation in various outdoor activities have been made for the State of Minnesota. Table IV-134 shows the projected number of times each type of activity is expected to be participated in up to the year 1990. Playing outdoor games, bicycling, and driving for pleasure rate the highest and participation in at least the first 2 of these activities is expected to increase substantially by 1990. Swimming, pleasure walking, and fishing also are very popular, with swimming and pleasure walking expected to increase. Picnicking, snowmobiling, and camping have substantial popularity, as well, and camping is expected to increase by 100% from 1975 to 1990. Canoeing has a relatively low participation occasion rate, but is projected to increase in popularity by more than 50% from 1975 to 1990.

The State has made general plans for recreational facility improvements for the Arrowhead Region and Regions 2 and 5. The relative needs of these regions compared with the other regions in the State are shown in Table IV-135. This shows the Arrowhead to rank ninth in overall need and thus it probably will get a rather low priority from the State for facilities funding. Region 2 rates eleventh in the State for overall activities needs and Region 5 rates fifth.

Up-to-date plans have not yet been made for facilities in the individual counties in the region. The most recent known plans for Itasca County were made by the County in 1968 and are, therefore, outdated.

TABLE IV-131
RECREATION RESOURCES - MINNESOTA REGION 2, REGION 3 (ARROWHEAD), AND REGION 5 (243)

	Region 2	Region 3 (Arrowhead)	Region 5	Total
National Parks				
number	0	1	0	1
acre	-	219,000	-	219,000
hectare	-	88,626	-	88,626
National Forests[a]				
number	1	2	1	2
acre	63,000	2,400,000	287,000	2,750,000
hectare	25,495	971,245	116,235	116,145
National Recreation Areas				
number	0	1	0	1
acre	-	1,000,000	-	1,000,000
hectare	-	404,686	-	404,686
National Wildlife Refuges				
number	0	1	0	1
acre	-	20,296	-	20,296
hectare	-	8,213	-	8,213
U.S. Corps of Engineers Reservoir Lands				
number	0	3	4	7
acre	-	1,174	1,048	2,222
hectare	-	475	424	899
National Historic Sites				
number	2	12	15	29
National Historic Landmarks				
number	0	4	0	4
State Wild and Scenic Rivers				
number	3	7	2	9[c]
State Parks				
number	3	15	2	20
acre	30,800	36,696	2,526	70,022
hectare	12,464	14,850	1,022	28,337

TABLE IV-131 (continued)
RECREATION RESOURCES - MINNESOTA REGION 2, REGION 3 (ARROWHEAD), AND REGION 5 (243)

	Region 2	Region 3 (Arrowhead)	Region 5	Total
State Recreation Areas[d]				
number	1	2	1	4
acre	2,786	1,044	222	4,052
hectare	1,127	422	89.8	1,640
State Forests				
number	8	18	6	32
acre	76,653	1,903,022	155,154	2,134,829
hectare	31,020	770,126	62,788	863,935
State Lake Accesses				
number	131	198	343	772
State Waysides				
number	0	7	1	8
acre	-	1,251	82	1,333
hectare		506	33	539
State Wildlife Management Areas				
acre	417,847	36,913	30,907	485,667
hectare	169,097	14,938	12,508	196,542
TOTAL LAND AREA				
acre	4,399,360	12,477,440	3,968,640	20,845,440
hectare	1,780,358	5,049,441	1,606,052	8,435,850

[a] The Chippewa National Forest extends across Regions 2, 3, and 5 and contains 650,000 acres (263,046 hectares). The Superior National Forest is entirely within Region 3 and contains 2.1 million acres (849,840 hectares).

[b] Sites in the National Historic Register.

[c] Several rivers pass through more than one region.

[d] Schoolcraft State Recreation Area, contains 79 acres (31.97 hectares) in Region 3 and 214 acres (86.60 hectares) in Region 5.

TABLE IV-132
STATE PARKS, RECREATION AREAS, MONUMENTS, AND WAYSIDES
MINNESOTA REGION 2, REGION 3 (ARROWHEAD), AND REGION 5

	County	Year Established	Total Authorized Land Area		Total Land Acquired	
			acre	hectare	acre	hectare
State Parks						
Region 2						
Itasca	Becker Clearwater Hubbard	1891 1891 1891	30,365.00	12,288.28	29,290.60	11,853.48
Lake Bemidji	Beltrami	1923	445.48	180.27	405.48	164.09
Little Elbow Lake	Mahnomen	1963	3,127.00	1,265.45	1,104.35	446.91
Region 3 (Arrowhead)						
Baptism River	Lake	1945	705.85	285.64	705.85	285.64
Bear Head Lake	St. Louis	1961	4,371.00	1,768.8	4,111.00	1,663.66
Cascade River	Cook	1957	2,813.00	1,138.38	1,895.00	766.87
George Crosby - Manitou	Lake	1955	5,160.00	2,088.17	4,790.00	1,938.44
Gooseberry Falls	Lake	1937	1,662.00	672.58	741.83	300.20
Jay Cooke	Carlton	1915	11,196.00	4,530.86	8,920.00	3,609.79
Judge C. R. Magney	Cook	1957	4,514.00	1,826.75	4,195.00	1,697.65
McCarthy Beach	St. Louis	1945	2,562.00	1,036.80	1,743.91	705.73
Savanna Portage	St. Louis	1961	15,758.00	6,377.03	14,605.55	5,910.65
Scenic	Itasca	1921	1,334.79	540.17	1,334.79	540.17
Split Rock Lighthouse	Lake	1945	996.00	403.06	155.17	62.79
Temperance River	Cook	1957	133.00	53.82	133.00	53.82
Tower Soudan	St. Louis	1963	982.20	397.48	982.20	397.48
Region 5						
Charles A. Lindgergh	Morrison	1931	328.00	132.73	295.62	119.63
Crow Wing	Crow Wing	1959	2,198.00	889.49	1,418.22	573.93
	Cass	1959				
State Recreation Areas						
Region 2						
Zippel Bay	Lake of the Woods	1959	2,946.00	1,192.20	2,785.75	1,127.35
Region 3 (Arrowhead)						
Moose Lake	Carlton	1971	965.00	390.52	965.00	390.52
Region 5						
Schoolcraft	Cass	1959	295.00	119.38	212.33	85.92
State Waysides						
Region 3 (Arrowhead)						
Caribou Falls	Lake	1947	91.62	37.07	91.62	37.07
Cross River	Cook	1961	2,560.00	1,035.99	600.00	242.81
Devils Track Falls	Cook	1961	240.00	97.12	240.00	97.12
Flood Bay	Lake	1961	19.00	7.68	27.00	10.92
Franz Jevne	Koochiching	1967	117.83	47.68	117.83	47.68
Kodonce River	Cook	1947	127.80	51.71	127.80	51.71
Ray Berglund	Cook	1951	45.90	18.57	45.90	18.57
Region 5						
Inspiration Peak	Otter Tail	1931	82.00	33.18	82.00	33.18
State Monuments						
Region 2						
Count Beltrami	Beltrami	1945	1.00	.40	1.00	.40
Region 3 (Arrowhead)						
Moose Lake	Carlton	1929	.10	.04	.10	.04

TABLE IV-133

OUTDOOR RECREATION FACILITIES INVENTORY - REGION 2, REGION 3 (ARROWHEAD) AND REGION 5

	Tent Camping Areas	Tent Camping Sites	Vehicle Camping Areas	Vehicle Camping Sites	Total Camping Areas	Total Camping Sites	Picnicking Areas	Picnicking Tables	Trails: Horse mile	Horse km	Snow mile	Snow km	Hiking mile	Hiking km	Bike mile	Bike km	Multi-use mile	Multi-use km	Nature Trails number	Nature Trails mile	Nature Trails km	Golf Courses 9-hole	Golf Courses 18-hole
Region 2																							
Beltrami	5	34	40	631	45	665	48	328	18	28.9	92	148.0	64	102.9	6	9.6	51	82.0	11	8	13	2	1
Clearwater	3	131	7	712	10	843	7	413	-	-	96	154.5	27	43.4	-	-	-	-	1	3	4.8	2	-
Hubbard	11	84	32	736	43	820	47	219	86	138.4	186	299.3	108	173.8	18	28.9	133	214.0	5	30	48.3	2	-
Lake of the Woods	8	61	17	366	25	427	18	62	4	6.4	112	180.2	17	27.3	2	3.2	8	12.8	3	7	11	-	-
Mahnomen	3	15	6	104	9	119	13	29	-	-	3	4.8	-	-	-	-	-	-	-	-	-	1	-
Total	30	325	102	2,549	132	2,874	133	1,051	108	173.8	489	786.9	216	347.6	26	41.8	192	308.9	20	49	78.9	7	1
Region 3 (Arrowhead)																							
Aitkin	9	37	34	542	43	579	37	105	11	17.7	241	387.8	88	141.6	1	1.6	74	119.1	3	2	3.2	2	-
Carlton	-	-	7	408	7	408	15	405	-	-	76	122.3	26	41.8	-	-	24	38.6	1	1	1.6	2	-
Cook	8	52	31	724	39	776	20	34	5	8.0	58	93.3	45	72.4	1	1.6	10	16.0	5	6	9.6	2	-
Itasca	14	53	74	1,133	88	1,186	114	432	47	75.6	298	479.6	121	194.7	37	59.5	119	191.5	6	12	19.3	4	-
Koochiching	9	77	14	138	23	215	23	41	-	-	229	368.5	4	6.4	-	-	-	-	2	3	4.8	1	-
Lake	11	82	36	779	47	861	44	343	-	-	52	83.6	55	88.5	1	1.6	15	24.1	3	4	6.4	2	-
St. Louis	44	212	50	902	94	1,114	111	825	-	-	327	526.2	70	112.6	-	-	41	65.9	6	4	6.4	12	6
Total	95	513	246	4,626	341	5,139	364	2,185	63	101.4	1,632[a]	2,626.4	760[a]	1,223.1	40	64.4	770[a]	1,239.2	26	35	56.3	25	6
Region 5																							
Cass	25	308	98	1,670	123	1,978	123	394	39	62.7	123	197.9	238	283.0	50	80.4	94	151.2	9	9	14.5	6	-
Crow Wing	14	337	55	1,079	69	1,416	66	304	9	14.4	22	35.4	62	99.7	29	46.6	49	78.8	12	15	24.1	10	3
Morrison	1	2	8	167	9	169	7	64	-	-	-	-	1	1.6	-	-	-	-	2	3	4.8	3	-
Todd	2	9	11	127	13	136	16	72	5	8.0	30	48.2	8	12.8	7	11.2	7	11.2	-	-	-	2	-
Wadena	-	-	4	91	4	91	8	237	28	45.0	28	45.0	28	45.0	-	-	28	45.0	1	3	4.8	1	-
Total	42	656	176	3,134	218	3,790	220	1,071	81	130.3	203	326.7	337	542.3	86	138.4	178	286.4	24	30	48	22	3

TABLE IV-133 (Continued)
OUTDOOR RECREATION FACILITIES INVENTORY - REGION 2, REGION 3 (ARROWHEAD), AND REGION 5

	Tennis Courts	Playgrounds			Athletic Fields			Ball Fields	Ice Skating Rinks	Swimming Beaches			Swimming Pools			Boat Accesses		Marinas		Ski Areas
											Water			Water			Parking			
	number	number	acre	hectare	number	acre	hectare			number	sq ft	sq m	number	sq ft	sq m	number	Spaces	number	capacity[b]	number
Region 2																				
Beltrami	10	71	37	15.0	19	129	52.2	17	10	81	2,154,260	200,137	7	3,984	370	93	1,840	86	832	1
Clearwater	3	2	11	4.5	4	21	8.5	5	2	4	100,800	9,365	1	800	74	34	357	4	76	–
Hubbard	8	85	38	15.4	22	116	46.9	21	5	89	1,558,315	144,772	4	4,052	376	87	1,018	76	699	1
Lake of the Woods	1	16	3	1.2	4	17	6.9	3	2	12	167,850	15,594	1	800	74	18	579	31	574	–
Mahnomen	1	5	3	1.2	3	28	11.3	7	3	7	87,200	8,101	–	–	–	16	282	8	117	–
Total	23	179	93	37.6	52	311	125.9	53	22	193	4,068,425	377,969	13	9,636	895	248	4,076	205	2,298	2
Region 3 (Arrowhead)																				
Aitkin	6	35	29	11.7	14	74	30.0	19	3	52	575,050	53,424	3	2,050	190	88	1,983	51	442	1
Carlton	9	10	14	5.7	17	91	36.8	21	10	10	201,000	18,673	–	–	–	15	2,306	4	44	2
Cook	2	17	11	4.5	6	111	44.9	6	2	21	243,050	22,580	3	1,537	143	59	1,136	22	211	1
Itasca	32	92	28	11.3	37	157	63.5	38	21	134	2,443,695	227,027	3	2,497	232	186	2,256	121	965	2
Koochiching	4	16	10	4.0	15	54	21.9	17	5	14	178,800	16,611	–	–	–	30	261	15	156	–
Lake	2	25	9	3.6	5	25	10.1	6	1	35	428,405	39,800	–	–	–	61	1,266	34	379	1
St. Louis	46	123	78	31.6	86	321	129.9	104	74	106	1,942,925	180,503	4	1,520	141	203	3,472	100	1,595	5
Total	101	318	179	72.4	180	833	337.1	211	116	372	6,012,925	558,619	13	7,604	706	642	12,680	347	3,792	12
Region 5																				
Cass	16	176	104	42.1	43	210	85.0	45	4	240	3,505,400	325,662	10	6,474	601	209	4,270	223	2,641	1
Crow Wing	25	129	42	17.0	42	215	87.0	44	2	180	3,546,852	329,513	6	6,826	634	125	2,503	144	1,351	1
Morrison	5	10	12	4.9	10	71	28.7	13	7	13	137,320	12,757	–	–	–	17	488	11	85	–
Todd	–	16	9	3.6	6	17	6.9	6	2	22	340,950	31,675	1	800	74	34	895	25	245	1
Wadena	12	8	5	2.0	9	60	24.3	16	5	3	61,000	5,667	1	–	–	14	664	3	14	–
Total	58	339	173	70.0	110	573	231.9	124	20	458	7,591,522	705,275	18	14,100	1,310	399	8,820	406	4,336	3

TABLE IV-134
MINNESOTA OUTDOOR RECREATION ACTIVITY PROJECTIONS

Category	Annual Activity Occasions[a] (millions) 1975	1980	1990	Percent Change 1975-1980	1975-1990
Playing outdoor games	177.7	204.4	264.7	15	49
Bicycling	153.0	181.0	226.0	18	47
Driving for pleasure	130.0	155.0	na[b]	19	na
Swimming	65.9	74.6	95.0	13	44
Pleasure walking	34.5	45.5	na	32	na
Fishing	27.9	29.8	34.8	7	25
Picnicking	19.5	21.5	26.1	10	34
Snowmobiling	16.1	na	na	na	na
Camping	14.5	18.8	29.0	30	100
Water skiing	9.2	11.2	na	22	na
Horseback riding	8.7	na	na	na	na
Canoeing	2.8	3.2	4.3	14	53
Backpacking	1.2	1.5	na	25	na
Skiing					
Downhill	0.9	na	na	na	na
Cross-country	na	na	na	na	na
Hunting					
Big game	1.0	na	na	na	na
Small game	2.5	na	na	na	na
Waterfowl	1.2	na	na	na	na

[a] Total number of times individuals have participated in each activity in the year.

[b] na means not available.

TABLE IV-135
REGIONAL DISTRIBUTION OF DEVELOPED RECREATION FACILITIES DEFICIENCIES (243)

Region No.	Region Rank	Total Needed Area %	Trails Area %	Athletic Fields and Playgrounds %	Public Access %	Camping Area %	Swimming Area %	Picnic Area %	Golfing Area %
1	8	4.0	5.4	0.2	1.2	3.5	2.1	0.7	c
2	11	0.9	c	c	10.5	c	c	c	c
3	9	3.5	1.2	6.6	14.1	8.6	c	5.6	c
4	4	7.7	7.5	c	24.9	8.0	c	1.7	c
5	5	7.5	8.6	c	13.4	8.0	c	4.1	c
6	7	6.2	7.5	c	9.7	5.5	c	2.1	c
7	2	14.2	12.8	1.7	9.5	18.9	30.1	15.8	84.6
8	10	2.9	3.1	1.2	2.9	4.3	1.1	1.5	c
9	6	6.6	7.7	0.9	6.3	6.9	9.8	1.3	c
10	3	10.1	10.8	10.4	1.2	7.8	34.0	7.6	c
11	1	36.4	35.5	79.0	6.3	28.6	23.0	59.9	15.4
Total[a]		100.0	100.1	100.0	100.0	100.1	100.1	99.9	100.0
Needed area									
acre		41,046	27,104[b]	3,993	3,470	3,328	1,219	996	936
hectare		16,611	10,969	1,616	1,404	1,347	493	404	379

[a] Data do not always add up to 100.0, due to rounding.

[b] Trail requirements of 27,104 acres (10,968.6 hectares) do not reflect the potential for using the same trail segment for multi-use activity; hence duplication is involved in the acreage requirement.

[c] means no identified deficiency.

The following is a list of the priorities for the Arrowhead Region, Region 2 and Region 5 as presented in the 1974 Minnesota State Comprehensive Outdoor Recreation Plan.

- o Provide at least minimal public access on all lakes suitable for water activities, wildlife, or fish management.
- o Preserve shore areas needed for public recreation by monitoring the implementation of the State shorelands zoning act and accelerating acquisition of high quality shorelands.
- o Transferring of lands needed by Voyageurs National Park, and planning for the Park's peripheral area (Arrowhead Region).
- o Prepare feasibility study of State recreation area in the vicinity of northeast Brainerd, West Cuyuna Range (Region 5).
- o Provide non-motorized trails where need can be demonstrated.
- o Expand snowmobile trials mileage where need is demonstrated and encourage greater county participation in meeting trail deficiencies (Arrowhead Region and Region 5).
- o Provide additional campsites where need is demonstrated, emphasize private developments to meet developed site deficiencies (Arrowhead Region and Region 5).
- o Provide a sufficient number of picnic areas to meet deficiencies (Arrowhead Region and Region 5).
- o Community recreation facilities should be increased to reduce the areas very substantial deficiencies (Regions 2 and 5).
- o Expand fish management programs.
- o Protect and interpret the region's outstanding historic and natural resources.
- o Study alternatives for protection of the North Shore (Arrowhead Region).
- o Promote the State's public land use programs.
- o Key wetland areas to be acquired and mature forests 'recycled' in order to provide improved waterfowl and deer habitat, respectively (Region 5).
- o Expand nature interpretation programs (Region 2).

Plans for Recreation Land Additions

Arrowhead Region. Recreation land expansion for the Arrowhead Region is expected to total 4,648 acres (1,881 hectares) or about a 10% increase over existing area (Table IV-132. Expansion of Scenic and Schoolcraft State Parks in Itasca County is receiving low priority.

No acquisition of land or scenic easements on any of the Wild and Scenic Rivers is planned in the Arrowhead Region (246).

The Taconite Trail, part of which is intended for snowmobiling, is planned to be expanded from its present length of 95 miles (152.9 km) to a total of 185 miles (297.7 km) by acquisition of 1,080 acres (437 hectares) more in the 1975-77 biennium. In addition, the Northland National Trail, a multi-use non-vehicular trail which would extend from Vermont to North Dakota, is planned to cross the region.

Region 2. Land acquisition for expansion of State Parks or recreation areas in Region 2 has received low priority between 1975 and 1977. No acquisition is planned for expansion of the Wild and Scenic Rivers or for the Heartland Trail, a multi-use State trail, which extends from Park Rapids in Hubbard County to Cass Lake.

Region 5. Low priority is given to expansion of the 3 State parks in Region 5. This is also true of the Wild and Scenic Rivers in the region. No land purchase is planned for the Heartland Trail at this time. The Northland National Trail is planned to cross Region 5 at some future time. Acquisition Priorities for Regions 2, 3, and 5 are presented in Table IV-136.

Local

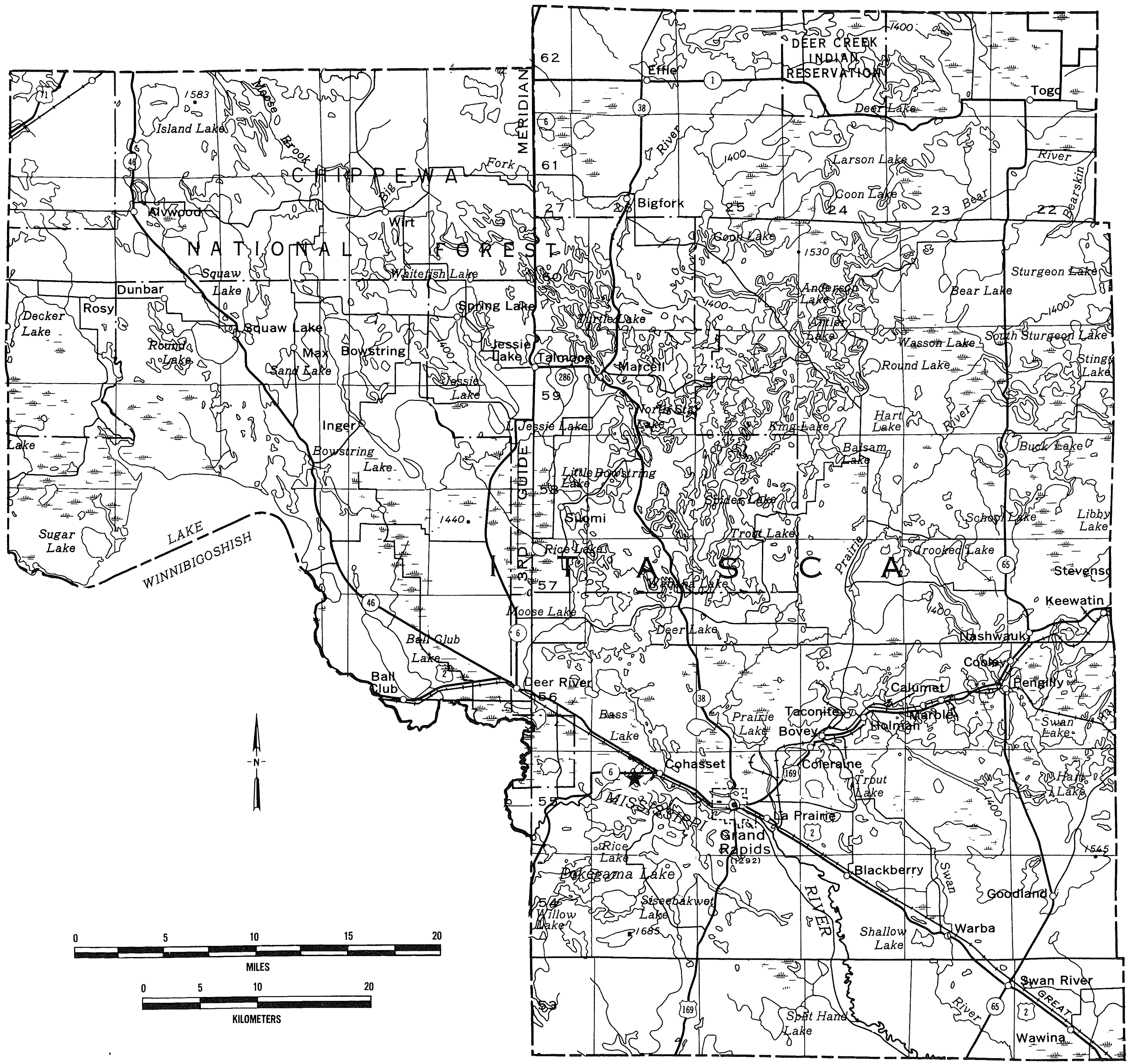
The local land use and recreational area is Itasca County, which is one of the 7 counties of the Arrowhead Region and is located at the Region's western edge. A group of 22 townships and 12 cities within Itasca County, where approximately 98% of MP&L's permanent labor force reside, also will be included in the local area. (Figure IV-101)

Land Use

Most land in Itasca County is classified as forest. Water is the second largest classification. A summary of land uses in Itasca County is presented in Table IV-137.

Forestry. The most outstanding natural features of Itasca County are the forests. Over 15,000,000 acres (6,070,285 hectares), of the county's total area, is contained in forest. An additional 518,000 acres (209,627 hectares) is commercial forest land in private ownership. Thus, a total of about 79% of Itasca county is forest (247).

Of this forested land, 93% is utilized for commercial forest production. Public forest areas include the Chippewa National Forest and the Big Fork, George Washington, Golden Anniversary, Black Duck, and Bowstring State Forests. In addition, there are 3 County Memorial Forests and one natural wildlife area in Itasca County. Figure IV-102 illustrates forested areas in Itasca County.



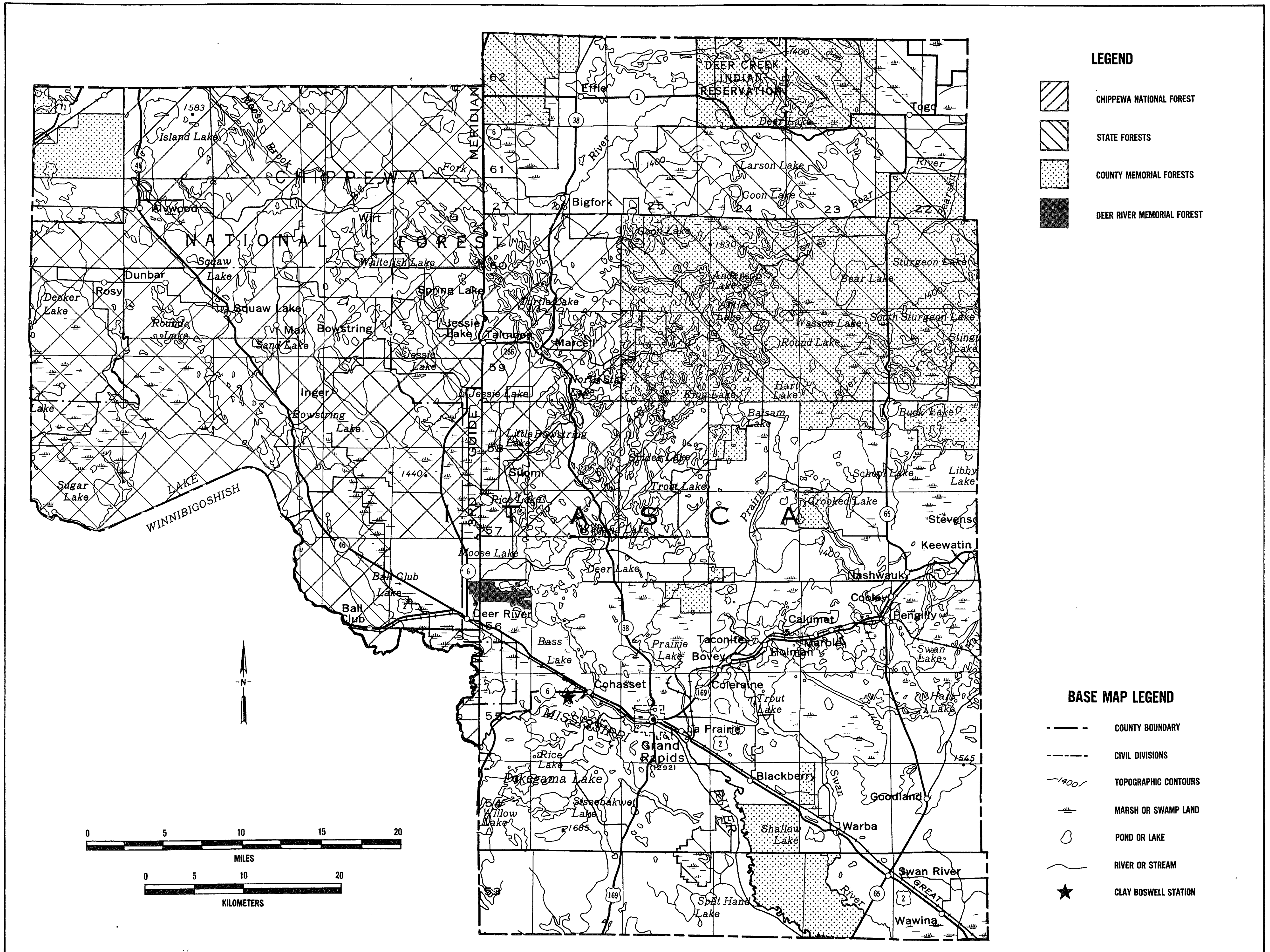
LEGEND

BASE MAP LEGEND

- COUNTY BOUNDARY
- CIVIL DIVISIONS
- 1400 TOPOGRAPHIC CONTOURS
- MARSH OR SWAMP LAND
- POND OR LAKE
- RIVER OR STREAM
- ★ CLAY BOSWELL STATION

LAND USE - ITASCA COUNTY

FIGURE IV-101



FORESTS - ITASCA COUNTY

SOURCE: OUTDOOR RECREATION RESOURCES, ITASCA COUNTY, AQUR, JYRING, WHITEMAN AND MOSER, INC., NOVEMBER 1968

FIGURE IV-102

TABLE IV-136
ACQUISITION PRIORITIES 1975-1977 - MINNESOTA STATE PARKS
REGION 2, REGION 3 (ARROWHEAD), AND REGION 5 (246)

State Park	Existing Area		Expansion	
	acre	hectare	acre	hectare
Region 2				
Camp Beltrami State Monument	1	.40	-	-
Itasca	29,291	11,853	-	-
Lake Bemidji	405	164	-	-
Little Elbow Lake	1,104	447	-	-
Zippel Bay Recreation Area	2,946	1,192	-	-
Total	33,747	13,657	-	-
Region 3 (Arrowhead)				
Baptism River	706	286	-	-
Bear Head Lake	4,111	1,664	-	-
Caribou Falls (Wayside)	92	37	-	-
Cascade River	1,895	767	-	-
Cross River (Wayside)	600	243	-	-
Devils Track Falls (Wayside)	240	97	-	-
Flood Bay (Wayside)	19	7	-	-
Franz Jevne (Wayside)	118	48	-	-
George Crosby-Manitou	4,790	1,938	188	76
Gooseberry Falls	742	300	97	39
Jay Cooke	8,920	3,609	175	71
Judge C. R. Magney	4,195	1,697	-	-
Kodonce River (Wayside)	128	52	-	-
McCarthy Beach	1,744	706	277	12
Moose Lake Recreation Area	965	390	-	-
Moose Lake Monument	0.1	.04	-	-
Ray Bergland (Wayside)	46	18	-	-
Savanna Portage	14,606	5,911	290	117
Scenic	1,335	540	-	-
Split Rock Lighthouse	155	63	85	34
Temperance River	133	54	-	-
Tettagouche	-	-	3,536	1,431
Tower Soudan	982	397	-	-
Total	46,522	18,827	4,648	1,881
Region 5				
Charles A. Lindbergh	296	120	-	-
Crow Wing	1,418	574	-	-
Schoolcraft	212	86	-	-
Total	1,926	779	0	0

TABLE IV-137
LAND USE IN ITASCA COUNTY (225)

	Itasca County						22 Townships Percentage of County
	22 Townships			County			
	acre	hectare	percent	acre	hectare	percent	
Forested	329,480	133,336	71.4	1,518,120	614,361	79.4	21.7
Cultivated	15,800	6,394	3.4	24,920	10,085	2.3	63.4
Pasture and open	40,080	16,220	8.7	102,920	41,650	5.4	38.9
Water	32,520	13,160	7.0	172,440	69,784	9.0	18.9
Marsh	5,920	2,396	1.3	26,040	10,538	1.4	22.7
Urban residential	12,440	5,034	2.7	24,400	9,874	1.3	51.0
Urban, non-residential or mixed residential	6,720	2,719	1.5	10,440	4,225	0.5	64.4
Extractive[a]	18,320	7,414	4.0	32,880	13,306	1.7	55.7
Transportation	160	65	-	240	97	-	66.6
Total	461,440	186,738	100.0	1,912,400	773,921	101.0	24.1

[a] The MLMIS data reported 18,360 acres (7,430.03 hectares) of extractive land use in the County. More recent DNR research has estimated 32,880 acres (13,306.06 hectares) in this use with almost all such use concentrated along the Iron Range.

Cultivated, Pasture, or Open Land. Cultivated land accounts for approximately 24,920 acres (10,085 hectares) of 1.3% of the total land area in Itasca County. No single agricultural crop dominates in the county; however, the most acreage was devoted to oats in 1974. Agricultural land within Itasca County declined from 175,000 acres (71,184 hectares) in 1959 to 120,100 acres (48,603 hectares) in 1969, for a reduction of approximately 32%.

Pasture or open land accounted for 102,920 acres (41,650 hectares) of land or 5.4% in Itasca County in 1974. Hay production within Itasca County used 40,400 acres (16,349 hectares) of this land within Itasca County (34).

Water, Marsh, and Swamps. Water bodies account for 172,000 acres (69,606 hectares) of Itasca County. According to the Water Resources Committee (35), there were 945 lakes of 10 acres (4.0 hectares) or larger within Itasca County. These lakes are one of the major reasons for the location of significant recreational facilities in the County, such as resorts and public recreation areas. Marsh or swamps accounted for 1.4% of Itasca County land use. Table IV-138 presents lake acreage for Itasca County, the Arrowhead Region, and the State.

Urban Residential/Urban and Non-Residential or Mixed Residential. Urban Residential land in Itasca County accounts for 24,000 acres (9,874 hectares) or 1.3% of total land area. The Urban and Non-Residential or Mixed Residential classification accounts for 10,400 acres (4,225 hectares) or 0.5% of Itasca County land use.

The two urban land types are concentrated in Itasca County along the Mesabi Iron Range, extending from Grand Rapids to Keewatin. The 12 cities in this area

TABLE IV-138
COMPARISON OF LAKE AREA - ITASCA COUNTY AND REGION 3 (ARROWHEAD) WITH STATE TOTAL LAKE AREA (243)

	Lake Basin Total Area		"Dry" Basin[a] Area		"Wet" Basin[b] Area		Total Land Area		Percent of Lake Basin Area of 10 acres (4.0 hectares) or More
	acre	hectare	acre	hectare	acre	hectare	acre	hectare	
Itasca County	183,768	74,368	1,434	580	184,424	74,634	1,856,000	751,096	9.9
Region 3 (Arrowhead)	895,027	362,204	12,046	4,875	883,708	357,624	12,477,440	5,049,441	6.3
State Total	3,409,109	1,379,617	308,702	124,927	2,100,407	850,004	53,803,520	21,773,512	6.32

[a] Dry Basins are "affected by ditch" or have exposed beds.

[b] Wet Basin Acreage is total acreage minus dry acreage.

(Table IV-139) which include Coleraine, Bovey, Taconite, Marble, Calumet, and Nashwauk, represent the principal urban development in the County. These cities have developed mainly in response to iron ore mining along the Mesabi Iron Range. Grand Rapids has the largest population in Itasca County and provides a range of services to the County population and the other communities on the eastern end of the Mesabi Iron Range.

The Clay Boswell Station is located within Bass Brook Township. The area to the east of the Clay Boswell Station is suburban in character and was formerly included in the village of Cohasset. Cohasset was dissolved as a village in November, 1975, to become part of Bass Brook Township. The land which surrounds the Clay Boswell Station on the north, east, west, and south is rural and used primarily for farm and rural non-farm residences.

TABLE IV-139
INCORPORATED CITIES - ITASCA COUNTY (235)

	1970 Population
Bovey	858
Calumet	460
Coleraine	1,219
Cooley	33
Deer River	815
Grand Rapids	7,247
Keewatin	1,382
La Prairie	413
Marble	770
Nashwauk	1,341
Taconite	352
Warba	248

Extractive. Approximately 1.7% of Itasca County is devoted to the various activities associated with the extractive land use category. For the specific land uses of the iron mining industry, tailing or waste basins account for 9,880 acres (3,998 hectares); surface, lean ores, and taconite stockpiles occupy 9,720 acres (3,934 hectares); open pits and underground mines occupy 6,320 acres (2,558 hectares); mine plants and facilities account for 4,200 acres (1,700 hectares); and water reservoirs occupy 2,760 acres (1,117 hectares).

Transportation. U.S. 169 is a 2-lane highway in Itasca County until it reaches Pengilly, where it becomes a 4-lane divided highway which extends to Virginia.

U.S. 2 is principally a 2-lane roadway in Itasca County. The Section from Grand Rapids to Cohasset is a 4-lane undivided roadway. The section from Cohasset to Deer River is being upgraded to 4 lanes. It is estimated that road construction will be completed by the end of 1978. Both of these roads are under the jurisdiction of the State of Minnesota.

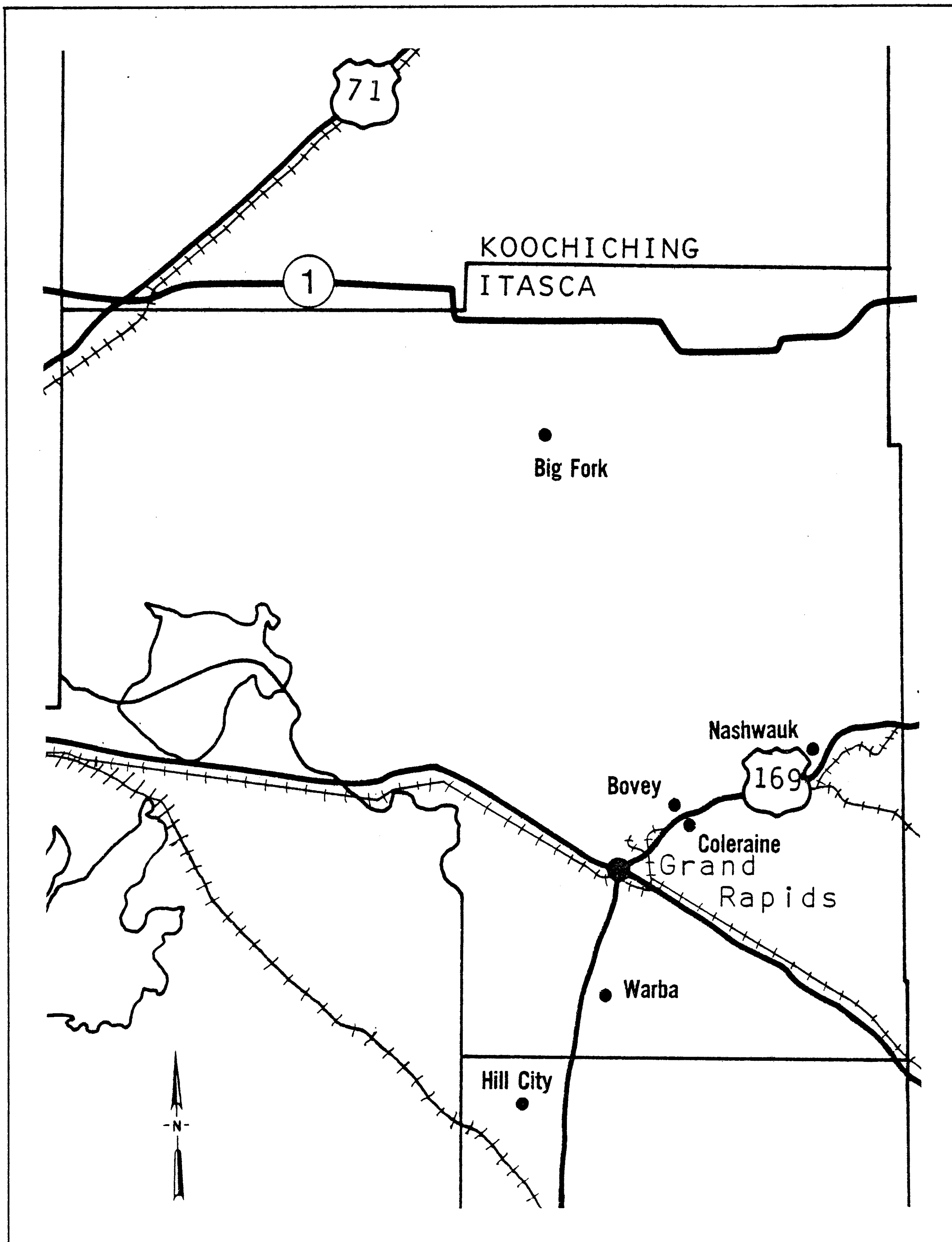
Arterial roadways in the area provide access on a subregional scale. Minnesota Trunk Highway (T.H.) 6 is a State route which begins at Big Falls (north of the community of Cohasset) and terminates in the Mille Lacs Lake area. This highway, which is a 2-lane roadway, passes through the Clay Boswell Steam Electric Station and is an important site access route. Other State highways which are available for access to the area include T.H. 46, T.H. 38, T.H. 200, and T.H. 84.

There are certain Itasca County roadways in the area which could be used for access. These include County State-Aid Highway (CSAH) 62, SCAH 11, County Road 258, County Road 249, County Road 51, County Road 234, and County Road 227. These highways and roads are shown on Figure IV-103.

Itasca County is served by the Burlington Northern Railroad system which connects Grand Rapids to Duluth and southern Minnesota and also Bemidji and the western United States. The line which connects Duluth with the western United States is located at the northern boundary of the Clay Boswell Station. A spur line serves the Station.

Land Ownership

Within Itasca County, 935,000 acres (378,381 hectares) of land or 54% are in public ownership. The Federal and State governments each own and manage approximately 320,000 acres (134,356 hectares). The County manages 290,000 acres (117,359 hectares) of tax-forfeited land. The great majority of Federal land is contained in Chippewa National Forest. Approximately 98% of all State land in the County is in forest lands. The County has designated 239,657 acres (96,986 hectares) of the 290,000 acres (117,359 hectares) of tax-forfeited land as County Memorial Forests. While the remaining land is managed in a similar manner to the Memorial Forests, this land can be sold by the County if such sales are approved by the State.



ROADWAYS AND RAILROADS ITASCA COUNTY	FIGURE IV-103

Land Use Plans

Itasca County has not adopted a comprehensive land use plan. A study was conducted in the late 1960's which produced a variety of documents, some of which were adopted while others were not. Based on that study, countywide zoning was adopted which included shoreline management provisions. In addition, the County has adopted subdivision control ordinances and sanitary codes.

While individual townships have not developed land use plans as such, they have adopted township zoning which reflects the preferred location of activity.

In the absence of a comprehensive plan, the zoning designation for the County and townships can help to indicate projected uses. Table IV-140 records the land area and percentage of Itasca County in various zoning classifications.

The majority of land in Itasca County is zoned as open space which allows no residential use, and includes minimally tilled land, pasture, forest, and public open space recreation uses. Approximately 17% of land within Itasca County is zoned for seasonal or year-round residential use. The major portion of this land is zoned for 40,000 to 80,000 sq ft (3,716 to 7,432 sq m) lots. Heavy industrial areas which include mining account for 4% of the land within the County. Municipal areas (parcels within incorporated jurisdictions) make up 2% of the land within the County.

TABLE IV-140
ZONING CLASSIFICATION - 22 TOWNSHIP AREA - ITASCA COUNTY (225)

Classification	Itasca County Area			22 Township Area		
	acre	hectare	percent	acre	hectare	percent
Open space	1,240,400	501,972	65.9	216,800	87,736	47.0
Water	62,120	25,139	3.3	9,120	3,690	2.0
Public	157,360	63,681	8.4	12,000	4,856	2.6
Municipal area	31,560	12,772	1.7	27,360	11,072	5.9
Industrial						
Light	1,520	615	-	800	324	0.2
Heavy	72,320	29,267	3.8	63,120	25,543	13.7
Commercial-Recreation	5,600	2,266	0.3	1,040	421	0.2
Seasonal residential	6,240	2,525	0.3	440	178	-
Recreation						
20,000-40,000 sq ft (1,858 - 3,716 sq m)	7,200	2,914	0.4	5,320	2,153	1.1
40,000-80,000 sq ft (3,716 - 7,432 sq m)	266,560	107,873	14.2	106,840	43,236	23.1
80,000 sq ft-5 acres) (7,432 sq m-2.0 hectares)	31,200	12,626	1.7	18,600	7,527	4.0
Total	1,882,120	761,667	100.0	461,440	186,738	99.8

Local Community Plans. A majority of the communities within the 22 township area do not have comprehensive plans. The exception is the City of Grand Rapids. Most of the communities have, or are in the process of adopting, zoning ordinances to help control the location of land uses. Due to the size of these communities, with the exception of Grand Rapids, the principal land use is residential and service commercial. These communities are not large enough to attract and sustain major commercial activity. Many communities have land zoned for mining within their boundaries. This zoning is a function of the area's geology.

Development Constraints and Opportunities

The physical characteristics of the land, present use, and ownership influence the availability of land for purposes such as agriculture, residential, construction, or vacation homes. The land's physical features are influential in determining how land may be used to respond to future development trends.

Three individual indicators were used to determine those areas within the 22 townships available for urban development such as residential use (225). These criteria were 1) potential for ground water contamination; 2) soil wetness; and 3) septic tank limitations. If any one of these criteria was rated as severe, then the urban development acceptability was rated as having severe problems. All criteria had to be rated as having slight problems to result in a slight problem classification. All other areas were designated as having moderate problems.

The total area of the 22 townships is 461,440 acres (186,738 hectares). Approximately 13% of this area was not rated due to its present uses which are 1) mining, 2) urban development (either developed or presumably developable) and, 3) water bodies.

Based on the analysis of the 3 criteria, it was found that 83,400 acres (33,751 hectares) or 18% of the area had only slight problems for urban development as indicated in Table IV-141. These areas have no hazard of leaching, well to excessibly well drained soils, and only slight limitations on septic tank use. Over one-half of the area in the 22 townships was found to have severe problems for urban development. This area encompasses 257,160 acres (104,069 hectares). These areas would have a potential for leaching, poor to very poorly drained soils, and severe septic tank limitations. The remaining 13% of the land in the 22 townships was found to have moderate problems for urban development.

Within the area not rated, the urban area may have land for development. It is within this area that the communities of the 22 townships are included. Specific data are not available on the land area of each community. If water and extractive land use areas are subtracted from the 61,320 acres (24,815 hectares) of land not rated for constraints, the remaining 10,480 acres (4,241 hectares) would be in urban areas. While this does not include all the land in the community limits, it does include areas which now are developed.

TABLE IV-141
URBAN DEVELOPMENT ACCEPTABILITY - 22 TOWNSHIP AREA - ITASCA COUNTY (250)

	Land Area		
	acre	hectare	Percentage
Slight problems	83,400	33,751	18.1
Moderate problems	59,560	24,103	12.9
Severe problems	257,160	104,069	55.7
Not rated			
Mines, urban areas, and water	61,320	24,815	13.3
Total	461,440	186,738	100.0

Due to the development density in these areas, public water and sewer services are desirable, if not mandatory. An estimated 150 to 180 vacant lots with sewer and water are available for development in the 12 cities in the 22 townships. There are approximately 30 available lots in mobile home parks. In total, there are between 150 and 210 vacant lots in these communities (251).

Utilities

Land use often is controlled by the availability of public utilities. While there are many homes being built with private water supply and sewage disposal, this is becoming the exception in residential development. Table IV-142 indicates the availability of water and sewer service in the fourteen communities within the 22 township area. Those communities without sewer and water service normally follow the Itasca County guidelines for septic systems. Other than in the City of Grand Rapids, there are few vacant lots which have public sewer and water in adjacent streets. The communities normally require hookup to existing public sewer and water if it is available. However, some communities have areas where homes have been built without extension of water and sewer lines. Most of the communities that have public utilities will increase the service area within their city limits if economically feasible. Public water and sewer facilities are provided in 10 of the 14 communities. Most of the housing units have public utilities available since the larger communities (population 1,000 or more) provide these utilities. Two of the four communities not providing public water and sewer, Pengilly and Cohasset, are not incorporated cities.

Recreation

Itasca County has many natural resources and substantial public land holdings, providing opportunities for recreation.

Forests. A total of about 79% of Itasca County is forest and open to the public for various forms of recreation, such as hunting and snowmobiling.

Administration of the public forest lands often overlaps but the County is responsible for the largest portion of public forests or 290,000 areas (117,358

TABLE IV-142
WATER AND SEWER AVAILABILITY - 22 TOWNSHIP AREA COMMUNITIES - ITASCA COUNTY (251)

City	1970 Pop.	Public Water	Public Sewer	Any Areas Lacking Public Sewer and Water	Vacant Lots With Utilities
Bovey	858	yes	yes	no	10±
Calumet	460	yes	yes	yes	few
Cohasset[a]	436	no	no	yes	none
Coleraine	1,219	yes	yes	no	few
Deer River	815	yes	yes	no	few
Grand Rapids	7,247	yes	yes	no	100±
Keewatin	1,382	yes	yes	no	10±
La Prairie	413	no	no	yes	none
Marble	770	yes	yes	yes	few
Nashwauk	1,341	yes	yes	no	few
Pengilly[a]	na[b]	no	no	yes	none
Taconite	352	yes	yes	yes	10±
Warba	248	yes	yes	no	35±[c]
Zemple	71	no	no	yes	none

[a] Not an incorporated city.

[b] na means not available.

[c] Hookup to sewer required.

hectares), of which 239,657 acres (96,985 hectares) is managed as County Memorial Forests. The Chippewa National Forest, also extends into Itasca County and is under Federal management. The Minnesota DNR manages 317,000 acres (128,285 hectares) of forests, 233,000 acres (94,292 hectares) of which are in 5 State Forests within Itasca County (Figure IV-102).

Lakes and Rivers. There are over 1,000 lakes in Itasca County, comprising nearly 10% of the total County area. These lakes vary greatly in character and physical feature, and offer a variety of opportunities for recreational and scenic experience. Two of the largest lakes in the region, and the State, are at least partly within the County. These are Winnibigoshis and Pokegama Lake (Figure IV-104).

A system of "aqua highways", or rivers suitable for canoeing, boating, and other water-oriented activities exists within the County as shown in Figure IV-104. These include the Mississippi, Big Fork, Bowstring, Paririe, Rice, and Swan Rivers, and Gale Brook. This system connects many towns, lakes, and historical areas.

State Parks and Recreation Areas. There are 2 State Parks in, or partially in, Itasca County as shown in Figure IV-104. Scenic State Park, covering 1,375 acres (556 hectares), is located about 40 miles (64 km) north of Grand Rapids. It has very primitive landscape, but highly developed facilities.

Schoolcraft State Park, consisting of 295 acres (119 hectares), is located 12 miles (19 km) west of Grand Rapids along the Mississippi, partially in Itasca County, and partially in Cass County. Developed improvements are on the Cass County side of the Mississippi with the Itasca County portion of the park used mainly as a buffer.

There are no State recreation areas, waysides, or monuments in Itasca County. However, the Taconite Trail is being developed between Grand Rapids and Ely.

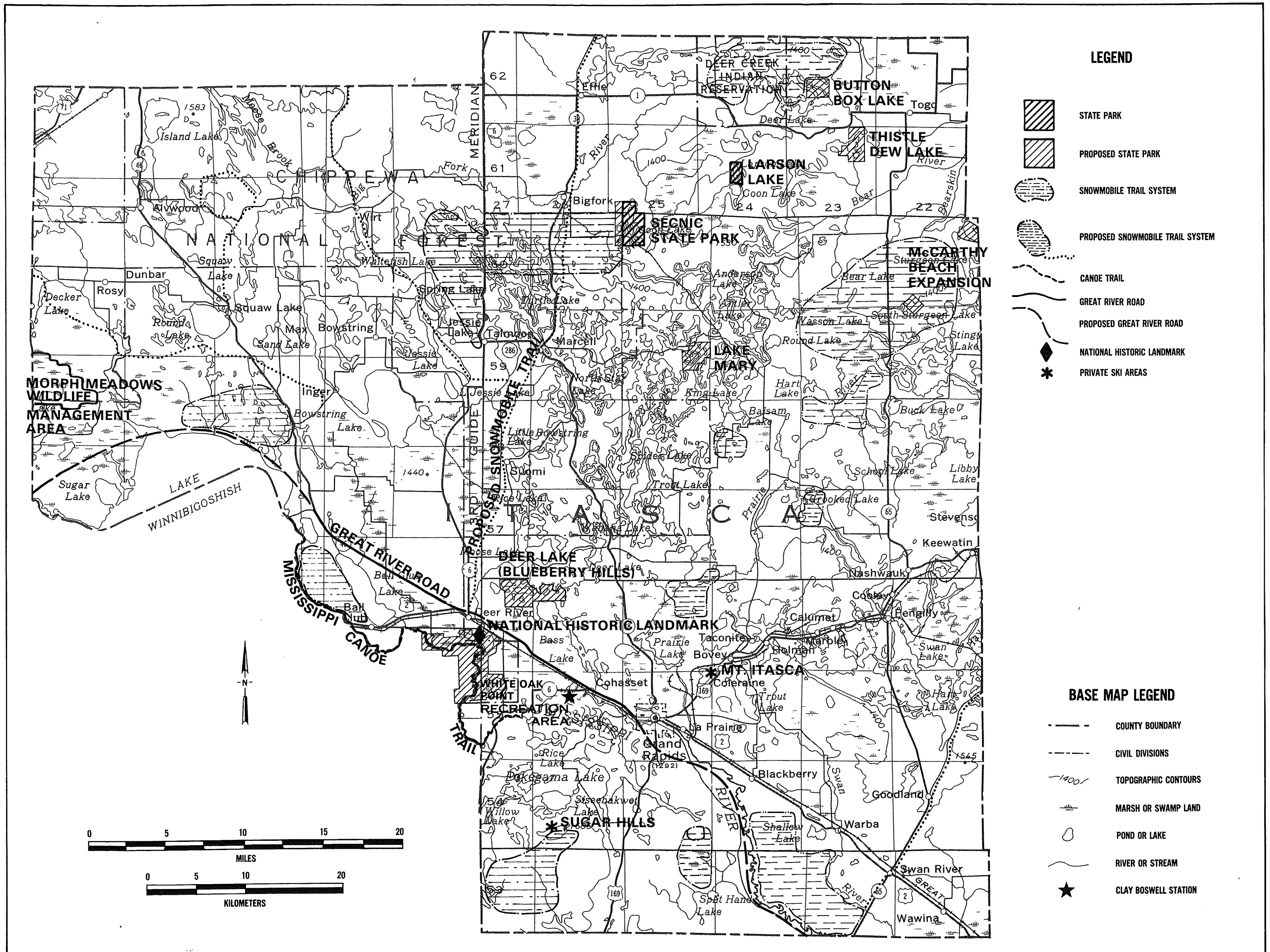
Other Recreation Areas. There are no Itasca County parks, but there are at least 75 public lake accesses, may of which provide boat launching areas, picnic areas, and campgrounds. There are a variety of recreational facilities provided in the County forests.

In addition, there are 7 "Outstanding Natural Areas", including a wildlife management area owned by the State and a natural area owned by the U.S. Forest Service. These are the Morph Meadows Wildlife Management Area with 6,320 acres (2,558 hectares), Sunken Lake Natural Area with 640 acres (259 hectares), Swan River Natural Area with 520 acres (210 hectares), Charles Godfrey Natural Area with 340 acres (138 hectares), Fishhook Lake Natural Area with 120 acres (49 hectares), Deer Lake Natural Area with 200 acres (81 hectares), and Big Fork Natural Area with 360 acres (146 hectares).

Inventory of Recreation Facilities in Itasca County. The most recent available data regarding recreation facilities in Itasca County is presented in Table IV-133. Itasca County rates highest in the region for total number of campsites, especially for vehicular camping. It also ranks comparatively high in numbers of picnic sites and all types of trails. Itasca County also has the most swimming areas in both beaches and pools. In boating and marina capacity, the County is second in the region. In most other categories of recreational facilities, Itasca County ranks second to St. Louis County, where Duluth is located.

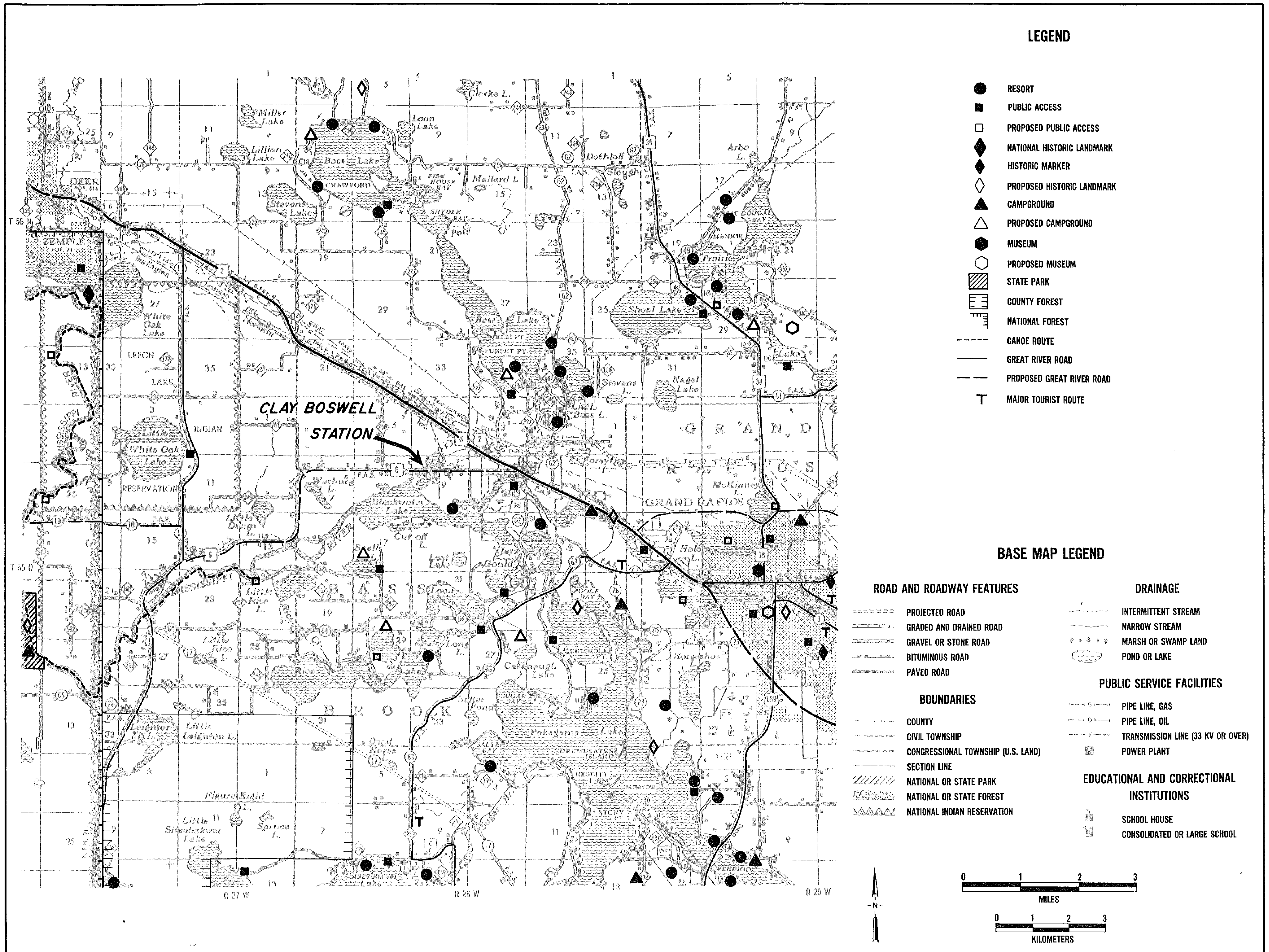
Numerous opportunities for recreation exist within 6 miles (9.6 km) of the Clay Boswell Station (Figure IV-105). The Mississippi River abuts the site, flowing through Blackwater Lake, which connects with Pokegama Lake to the south. Area residents use Blackwater Lake for a number of activities such as canoeing, trapping, wild riceing, fishing, and hunting. A string of lakes also extends north to Deer Lake. Southwest of the Station is 6,400 acres (2,590 hectares) of County Forest.

The nearest major recreational area is Schoolcraft Lake State Park, about 7 miles (11 km) west of the Clay Boswell Station. Two museums also are in the area; one in Grand Rapids and one a few miles (km) north.



PARKS AND OUTDOOR RECREATION AREAS
ITASCA COUNTY

FIGURE IV-104



RECREATION AREAS WITHIN 6 MILES (9.7 KM) OF CLAY BOSWELL STEAM ELECTRIC STATION

FIGURE IV-105

Facilities for recreation provide about 20 public lake accesses within 6 miles (9.6 km) of the Clay Boswell Station. There are also 20 to 30 resorts. Several areas are provided for recreation in the immediate Grand Rapids and Mississippi Rivers vicinity, such as the Izaak Walton Park, Sylvan Park with 0.6 acres (0.24 hectares), Blandin Gardens, Riverside Park with 26 acres (10.5 hectares), and the Prairie River Wayside.

Plans for Recreation Land Additions. Goals set forth in the 1968 Itasca County recreation plan show expansion of Scenic State Park by 50% and over 14,000 acres (5,666 hectares) of land being added in 6 proposed new State parks (Table IV-143). Other recreation areas exist within the State forests. These tend to be small, but probably only include the areas actually developed for recreation. It is proposed to expand the existing 90 acres (36 hectares) to nearly 250 acres (101 hectares). Other special and high density recreation areas were proposed to be expanded from a total of 140 acres (57 hectares) to 385 acres (156 hectares).

In Itasca County, no land at this time is managed by the State for wildlife propagation. The 1974 Minnesota State Comprehensive Outdoor Recreation Plan includes no acquisition for the 1975-77 biennium, but 1,771 acres (717 hectares) are desired in the short range plan and 5,500 acres (2,226 hectares) more are planned by 1985.

Site-Specific

The site-specific designation refers to an area within one-half mile of the Clay Boswell Station boundary.

Land Use

The total acreage within the site-specific area is 7,763 acres (3,141.6 hectares). When completed, Clay Boswell Units 1, 2, 3, and 4 will require 3,600 acres (1,457 hectares) of land, which is 46% of the total area within one-half mile of the Clay Boswell Station. The present land use is recorded in Table IV-144. The predominant use is woodlands (36.3%), while farmsteads, cultivated, and pasture land account for 930 acres (376 hectares) or 33% of the area. The area to be acquired by MP&L for proposed Unit 4 contains 38 dwellings of which 12 are farm dwellings.

Land Ownership. The Clay Boswell Station is bordered on the south by the Mississippi River, and on the north by the Burlington Northern Railroad right-of-way, and lies directly west of the community of Cohasset in Bass Brook Township. The following is a legal description of MP&L's Clay Boswell Lands (252).

> SW¼ - SW¼ Section 3-55-26 lying South of the Burlington Northern Railway R/W, all of Sections 4 and 5-55-26 lying South of the Burlington Northern Railway R/W, all of Section 6-55-26, all of Section 7-55-26 lying North of

TABLE IV-143
PLANNED RECREATION AREA EXPANSION - ITASCA COUNTY (251)

Recreational Unit or Area	Existing Area 1968 acre	Existing Area 1968 hectare[a]	Potential Addition acre	Potential Addition hectare[a]	Potential Total acre	Potential Total hectare[a]
National Forest	331,321	134,081	-	-	331,321	134,081
State Parks						
Scenic	2,422	980	1,240	502	3,662	1,482
Schoolcraft (Itasca County portion)	79	32	-	-	79	32
McCarthy Beach	0	0	780	316	780	316
Thistledew	0	0	5,880	2,380	5,880	2,380
Turtle Lake	0	0	400	162	400	162
Lake Mary	0	0	1,520	615	1,520	615
Deer Lake (Blueberry Hills)	0	0	3,500	1,416	3,500	1,416
Days High Landing-White Oak Point	-	-	2,500	1,012	2,500	1,012
Total	2,501	1,012	15,820	6,403	18,321	7,415
State Forest Recreation Areas						
Moose Lake	6	2.4	-	-	6	2.4
Cottonwood Lake	10	4.1	30	12.1	40	16.2
Little Long Lake	0.5	0.2	9.5	3.8	10	4.1
Burnt Shanty Lake	5	2.0	15	6.1	20	8.1
Long Lake	5	2.0	15	6.1	20	8.1
Larson Lake (to be part of Thistledew State Park)	8	3.2	-	-	-	-
Mirror Lake	0.5	0.2	9.5	3.9	10	4.1
Lost Lake	na[b]	na	na	na	na	na
Owen Lake	na	na	na	na	na	na
Bear Lake	15	6.1	5	2.0	20	8.1
Beatrice Lake (to be part of McCarthy Beach)	10	4.1	-	-	-	-
Big Fork River (County)	0	0	40	16.2	40	16.2
Sherry Lake (County)	0.2	0.1	39.8	16.1	40	16.2
Wendigo Community (County)	0.5	0.2	39.5	16.0	40	16.2
Total	60.7	24.6	203.3	82.3	246[c]	99.6[c]
High Density Special Recreation Areas						
American Legion Memorial Park	25	10.1	125	50.6	150	60.7
Blandin Beach	3	1.2	6	2.4	9	3.6
Pokegama Dam Recreation Area	10	4.1	2	0.8	12	4.9
Ball Club Recreation Area	20	8.1	-	-	20	8.1
Big Fork Beach	1	0.4	2	0.8	3	1.2
Gunn Memorial Park (private, open to public)	60	24.3	-	-	60	24.3
Trout Lake Beach	3	1.2	2	0.8	5	2.0
Lions Recreation Area	5	2.0	3	1.2	8	3.2
Twin Lakes Recreation Area	10	4.1	2	0.8	12	4.9
Goodland Recreation Area	3	1.2	3	1.2	6	2.4
Wendigo Beach	0.5	0.2	-	-	0.5	0.2
Mississippi Great River Road Recreation Area	-	-	100	40.5	100	40.5
Total	140.5	56.9	245	99.2	385.5	156.0

[a] Columns will not always total due to rounding of numbers.

[b] na means not available.

[c] The totals for existing area and potential additions will not equal the potential total due to acreage in Larson Lake and Beatrice Lake being added to the State Park system.

TABLE IV-144
EXISTING LAND USE IN EXPANSION AREA - CLAY BOSWELL STEAM ELECTRIC STATION

Land Use	Area acre	Area hectare	Percent
Suburban residential	50	20	1.8
Farmsteads	30	12	1.1
Cultivated	580	235	20.6
Pasture	320	129	11.4
Woodlands	1,020	413	36.3
Ash ponds	0	0	-
Bogs	380	154	13.5
Public highways	110	45	3.9
Lakes	50	20	1.8
Open, miscellaneous	273	110	9.7
TOTAL	2,813	1,138	100.1

the Mississippi River, all of Sections 8 and 9-55-26 lying North of Blackwater Lake, the West half of NW¼ Section 10-55-26 and the West half of the SW¼ Section 10-55-26 lying North of the Mississippi River and Blackwater Lake, and all of Section 18-55-26 lying North of the Mississippi River and Blackwater Lake.

The existing Clay Boswell Station area and land required for the expansion of the Clay Boswell Station is shown in Figure IV-106 in addition to existing land use in the area. Table IV-145 describes lands acquired by MP&L, and Table IV-146 describes land yet to be acquired for the proposed action.

Transportation

The only known roadway proposal involves a relocation of T.H. 6. The proposal involves constructing T.H. 6 on a new alignment from U.S. 2 south to the vicinity of County Road 249. Existing T.H. 6, which proceeds east to the community of Cohasset could then be turned back to the County. Figure IV-107 illustrates this proposal.

Existing traffic volume data is shown on Figure IV-108 for the area roadways. The State has analyzed the effect of relocating T.H. 6 in regard to traffic volumes. Figure IV-107 presents the projected volumes for 1977 on relocated T.H. 6 and 1979 projected volumes at the T.H. 6/U.S. 2 intersection.

There are no traffic signals in the vicinity of the Proposed Action.

TABLE IV-145
PROPERTY ACQUIRED FOR CLAY BOSWELL STEAM ELECTRIC STATION

Description	Acquisition Date	Land Use
Unit 4 and Unit 3 Buffer Zone		
A tract of land situated in the NE¼-NE¼ Section 8-55-26 approximately 2 acres (.81 hectare)	12/31/75	Residential
A tract of land situated in Government Lot 1 Section 9-55-26 approximately .034 acre (.014 hectare)	12/31/75	Residential
A tract of land situated in Government Lot 1 Section 9-55-26 approximately .34 acre (.14 hectare)	12/31/75	Residential
A tract of land situated in the NW¼-NE¼ Section 8-55-26 approximately 3.5 acres (1.4 hectares)	12/31/75	Farm-Residential
Government Lots 5, 6, and 7, Section 7-55-26 Government Lots 1, 2, 3, 6, 7, 8, 9, and NE¼-NW¼ Section 18-55-26	12/2/76	Farm-Residential
Lots 10, 11, 12, Block 1 Skelly's First Addition to Cohasset	12/31/75	Residential
Lots 2, 3, 4, Block 2 Skelly's First Addition to Cohasset	12/31/75	Residential
Lot 4 or the NW¼-NW¼; Lot 5 of the SW¼-NW¼; and Lot 6 or the NW¼-SW¼, Section 6-55-26	12/31/75	Farm-Residential
South Half of the NE¼ the SE¼-NW¼ North Half of the SE¼, Section 6-55-26	12/31/75	Farm
NE¼-SW¼, Section 6-55-26	12/31/75	Farm
SW¼ of Section 5-55-26 except a tract containing approximately 5 acres (2.0 hectare)	12/31/75	Farm-Residential
North Half of the NW¼-SW¼ Section 10-55-26	12/31/75	Residential
The West 80 ft (24.4 m) of the East 620.5 ft (189.1 m) of the North 264 ft (80.5 m) of the SW¼-NW¼ of Section 10-55-26	9/23/76	Residential
That part of Government Lots 1 and 2 Section 5-55-26 lying and being South of the right-of-way of the Great Northern Railroad Co.	3/14/77	Residential
That part of Government Lot 1 Section 9-55-26 which lies North of State Highway 6 excepting a tract of land containing 2.4 acres (.97 hectare) and excepting the North 677.1 ft (206.4 m) thereof	2/8/77	Residential

TABLE IV-145 (continued)
PROPERTY ACQUIRED FOR CLAY BOSWELL STEAM ELECTRIC STATION

Description	Acquisition Date	Land Use
Unit 4 and Unit 3 Buffer Zone (continued)		
A tract of land situated in Government Lot 5 Section 10-55-26 approximately 0.4 acre (.16 hectare)	9/23/76	Residential
That part of the SW¼-SW¼ Section 3-55-26 lying South of the Railroad right-of-way	12/31/75	Raw Land
A tract of land situated in Government Lot 5 Section 10-55-26 approximately 1.0 acre (.40 hectare)	12/31/75	Residential
Lots 5, 6, 7, Block 2 Skelly's First Addition to Cohasset	12/31/75	Residential
The West 200 ft (61 m) of the East 540.5 ft (164.7 m) of the Unplatted part of the SW¼-NW¼ Section 10-55-26 lying North of Skelly's First Addition to Cohasset	12/31/75	Residential
Lots 6 and 7, Block 1 Skelly's First Addition to Cohasset	9/23/76	Residential
Lots 5, 8, and 9, Block 1; Lot 1 of Block 2; Lots 4 and 5 of Block 3, Skelly's First Addition to Cohasset, the East 340.5 ft (103.8 m) of the North 258.5 ft (78.8 m) of the SW¼-NW¼, Section 10-55-26 the North 258.5 ft (78.8 m) less the East 790.5 ft (240.9 m) of the SW¼-NW¼, Section 10-55-26	9/23/76	Residential
The East Half of the NE¼-NW¼ Section 7-55-26	12/31/75	Residential
Government Lots 3 and 4 Section 5-55-26	12/31/75	Farm-Residential
A tract of land situated in SE¼-SW¼ Section 5-55-26 approximately 5 acres (2.0 hectares)	12/31/75	Residential
The NW¼-NW¼, Section 10-55-26 except a tract approximately 1 acre (.4 hectare)	1/7/76	Residential
Lots 1, 2, 3, and 4, Block 1 Skelly's First Addition to Cohasset	1/7/76	Residential
NW¼-SE¼ and Government Lots 4 and 8 Section 7-55-26	1/7/76	Farm
SW¼-NE¼, Section 7-55-26	1/8/76	Farm-Residential

TABLE IV-145 (Continued)
PROPERTY ACQUIRED FOR CLAY BOSWELL STEAM ELECTRIC STATION

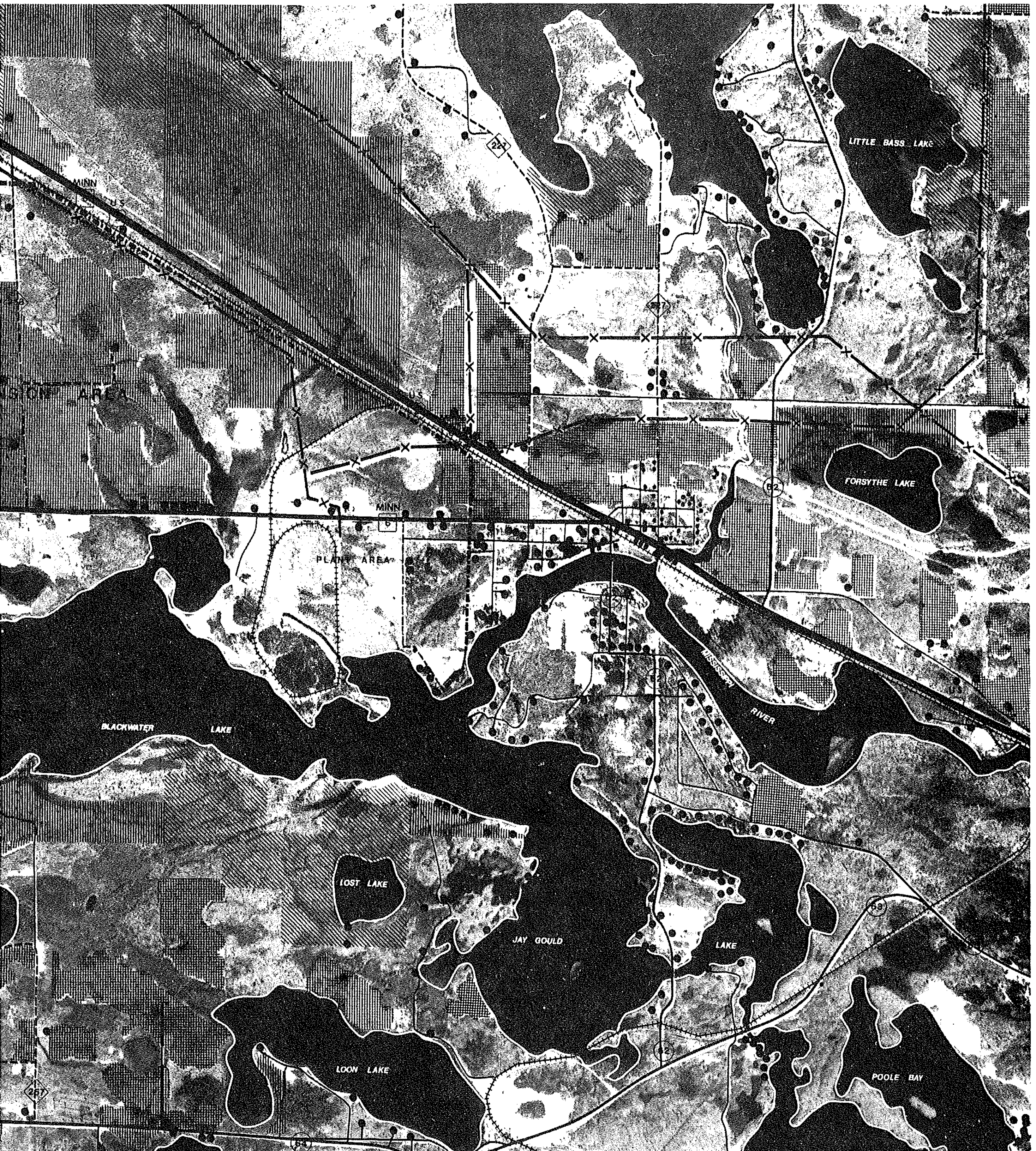
Description	Acquisition Date	Land Use
Unit 4 and Unit 3 Buffer Zone (continued)		
South Half of the NE¼, Section 5-55-26 North Half of the SE¼, Section 5-55-26 SE¼-SE¼, Section 5-55-26 All of the NE¼-NE¼, Section 5-55-26 except a tract of land containing approximately 2.0 acres (.81 hectare)	1/30/76	Farm-Residential
The SW¼-SW¼, Section 4-55-26 and the North 677.1 ft (206.4 m) of Government Lot 1 of Section 9-55-26 which lies North of State Highway 6. The SW¼-SE¼ Section 5-55-26 and all the NW¼-NE¼ Section 8-55-26 except a tract of land containing approximately 3.5 acres (1.4 hectares)	1/30/76	Farm-Residential
South Half of the NW¼-SW¼, Section 10-55-26	4/28/76	Raw Land
South Half of the NW¼, Section 5-55-26	5/14/76	Farm-Residential
West Half of the NE¼-NW¼, Section 7-55-26	5/10/76	Farm-Residential
The North 200 ft (61.0 m) of the South 730 ft (222.5 m) of the East 150 ft (45.7 m) of the West 183 ft (55.8 m) of the SW¼-NW¼, Section 10-55-26	8/4/76	Commercial-Residential
Government Lot 7, Section 6-55-26	8/2/76	Farm-Residential
Lots 1, 2, and 3, Block 3 Skelly's First Addition to Cohasset	4/7/76	Residential
The SE¼-SW¼, Section 6 NW¼-NW¼ or Lot 1, Section 7-55-26	5/25/76	Farm-Residential
The East Half of the NE¼-NE¼, Section 9-55-26 The East 232.5 ft (70.8 m) of the West 465 ft (141.7 m) of the NE¼-NE¼ Section 9-55-26 a tract of land in the NW¼-NW¼, Section 10-55-26 containing approximately 1.0 acre (.40 hectare)	5/24/76	Raw Land
The West 120 ft (36.6 m) of the Easterly 740.5 ft (225.7 m) of the Northerly 258.5 ft (78.8 m) of the SW¼-NW¼ and the Westerly 50 ft (15.2 m) of the Easterly 790.5 ft (240.9 m) of the Northerly 258.5 ft (78.8 m) of the SW¼-NW¼, Section 10-55-26	6/22/76	Residential
A tract of land situated in Government Lot 5 Section 10-55-26 known as Lot 4 and 5 approximately 1.0 acre (.40 hectare)	6/21/76	Residential
SW¼-NW¼, Section 4-55-26	10/29/74	Raw Land
The West 232.5 ft (70.8 m) of the NE¼-NE¼, Section 9-55-26	3/16/72	Residential
The West Half of the NE¼-NE¼, Section 9-55-26 less the West 465 ft (141.7 m) thereof	3/23/73	Residential

TABLE IV-145 (Continued)
PROPERTY ACQUIRED FOR CLAY BOSWELL STEAM ELECTRIC STATION

Description	Acquisition Date	Land Use
Unit #3		
The East Half of the SW¼-NE¼, Section 9-55-26	12/12/68	Farm-Residential
That part of the East 432 ft (131.6 m) of Government Lot 1, Section 9-55-26 which lies south of State Highway 6 and a strip of land containing about .5 acre (.2 hectare) in the Northwest corner of Lot 2, Section 9-55-26	12/12/68	Residential-Commercial
Government Lots 4 and 6, Section 8-55-26	12/6/68	Raw Land
The NE¼-NW¼, Section 9-55-26 except railway right-of-way and except a tract of land containing approximately 4.1 acres (1.6 hectares)	12/20/68	Raw Land
SE¼-NE¼, Section 9-55-26 and Government Lot 7 Section 9-55-26	12/20/68	Farm-Residential
SW¼-NE¼, Section 8-55-26	2/21/69	Farm-Residential
The East 730 ft (222.5 m) of the West 883 ft (269.1 m) of that part of Government Lot 1, Section 9-55-26 lying South of the centerline of State Highway 6	2/24/69	Residential-Commercial
That part of Government Lot 1, Section 9-55-26 lying South of State Highway 6, less the West 883 ft (269.1 m) thereof, and less the East 432 ft (131.6 m) thereof containing approximately .02 acre (.01 hectare)	3/13/69	Raw Land
The SE¼-NW¼ and the SW¼-NW¼, Section 8-55-26	3/13/69	Farm-Residential
The SE¼-NE¼ and the NE¼-SE¼, Section 7-55-26 the NW¼-SW¼, Section 8-55-26	3/13/69	Farm-Residential
The East 70 ft (21.3 m) of the West 153 ft (46.6 m) of Government Lot 1, Section 9-55-26 lying South of State Highway 6	3/19/69	Residential
Government Lot 9, Section 7-55-26	8/25/71	Raw Land
Government Lots 2 and 3, Section 8-55-26	10/16/69	Farm-Residential
NW¼-NE¼, Section 9-55-26 SW¼-SE¼, Section 4-55-26	4/7/70	Residential
Government Lot 1, Section 8-55-26	5/5/70	Raw Land
The West 83 ft (25.3 m) of Government Lot 1 Section 9-55-26, lying South of State Highway 6	5/5/70	Recreation
A tract of land situated in the NE¼-NW¼ Section 9-55-26 approximately 4.1 acres (1.6 hectares)	9/26/74	Commercial-Residential

TABLE IV-145 (continued)
PROPERTY ACQUIRED FOR CLAY BOSWELL STEAM ELECTRIC STATION

Description	Acquisition Date	Land Use
Units 1 and 2		
Government Lot 6, Section 9-55-26	12/12/55	
Government Lot 5, Section 9-55-26	12/12/55	
NW¼-SE¼, Section 9-55-26	12/12/55	
Government Lot 8, Section 9-55-26	12/10/55	
Government Lot 2, Section 16-55-26	12/10/55	
West Half of SW¼-NE¼, Section 9-55-26	12/12/55	
Government Lots 2, 3, and 4, Section 9-55-26	3/6/56	



CLAY BOSWELL AREA

LAND USE

- U.S. HIGHWAY
- STATE HIGHWAY
- C.S.A. HIGHWAY
- COUNTY ROAD
- RAILROAD
- TRANSMISSION LINE
- RESIDENTIAL
- TRAILER PARK
- COMMERCIAL
- CROPLAND
- MP&L EXPANSION AREA
- STATE PUBLIC LAND
- COUNTY PUBLIC LAND

0 500' 1000' 2000' 4000'

EXISTING SITE AND PROPOSED EXPANSION AREA - CLAY BOSWELL STEAM ELECTRIC STATION

SOURCE: MP&L, "ENVIRONMENTAL REPORT", EXHIBIT III-H-6

FIGURE IV-106

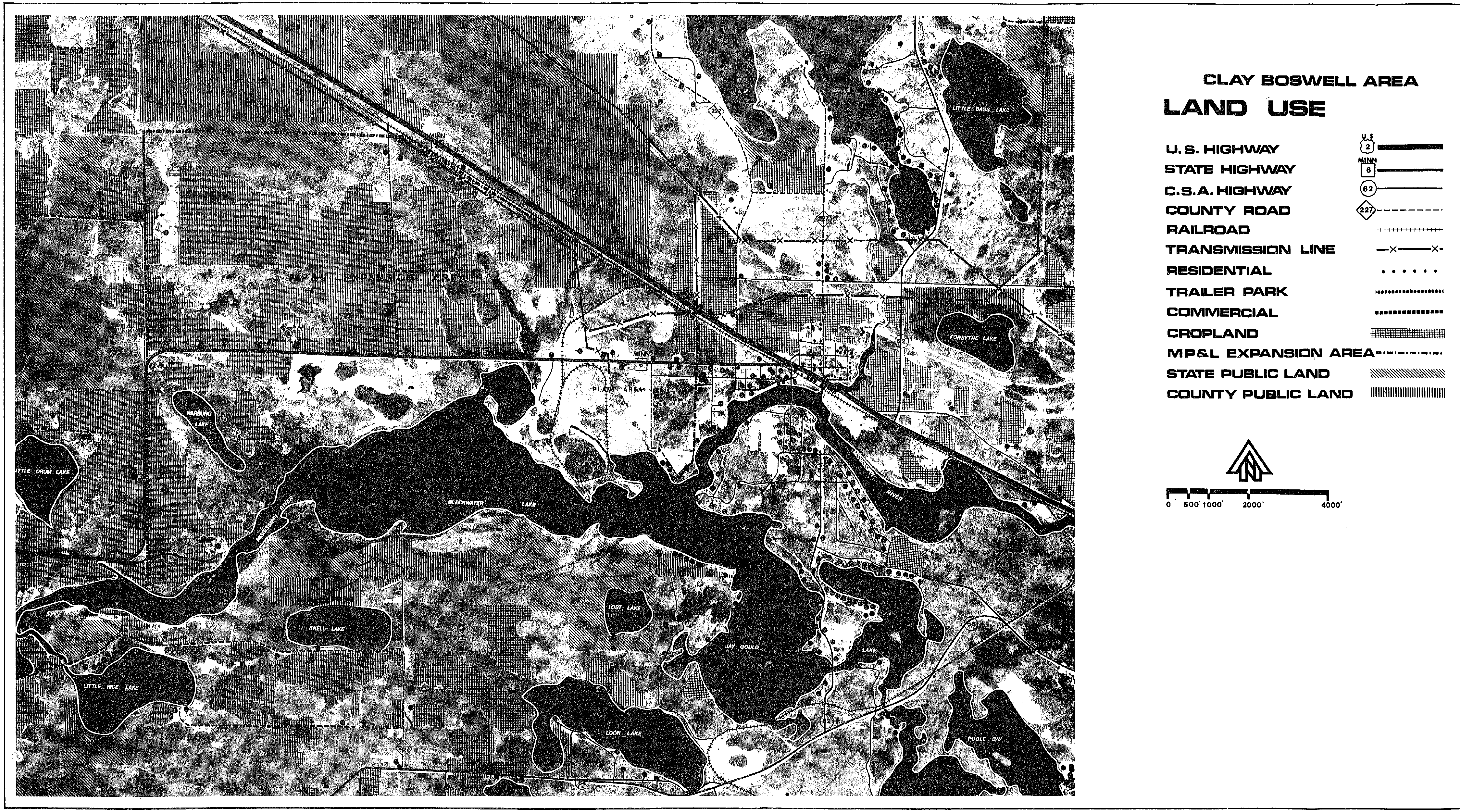
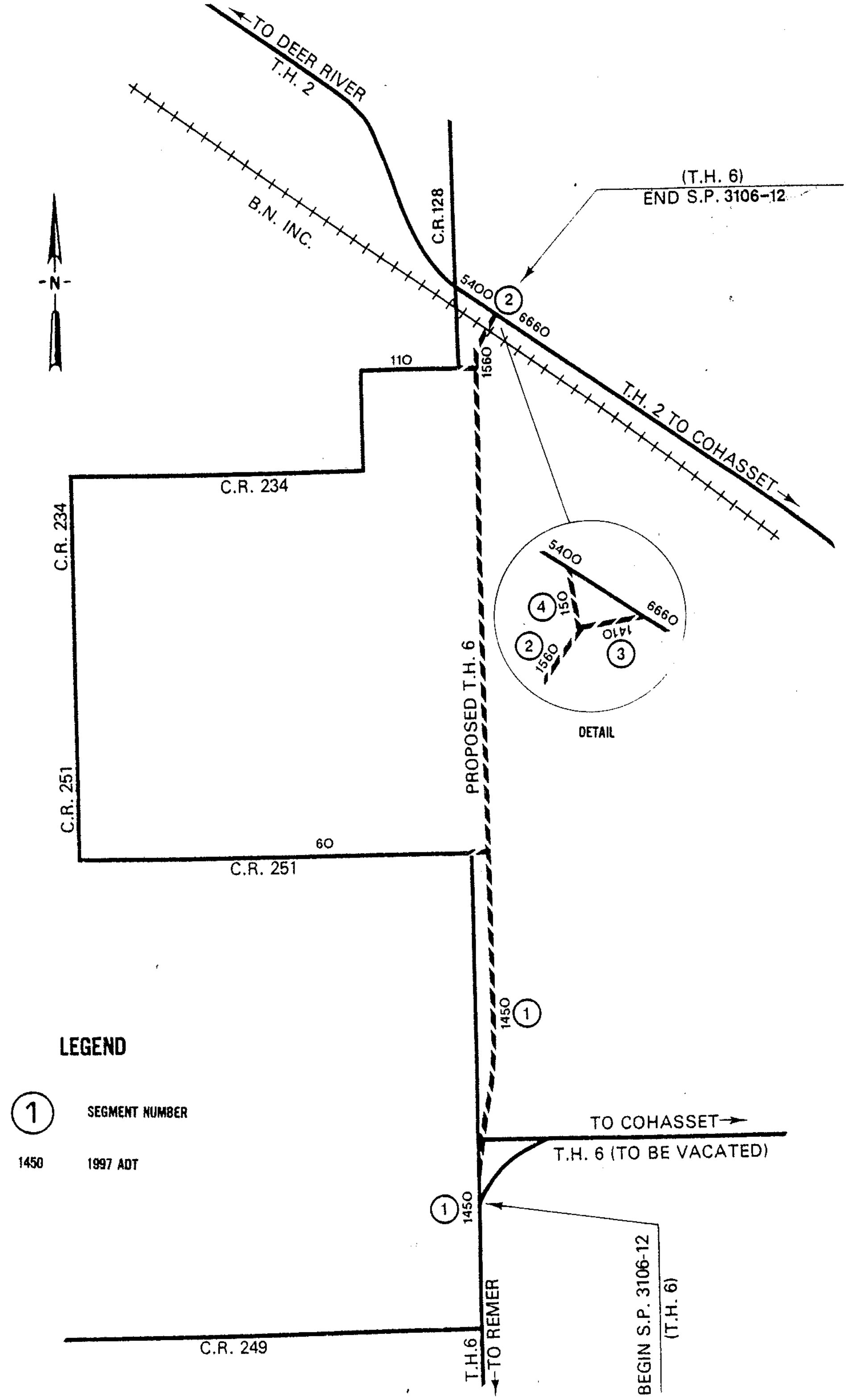

CLAY BOSWELL AREA
LAND USE
U.S. HIGHWAY
STATE HIGHWAY
C.S.A. HIGHWAY
COUNTY ROAD
RAILROAD
TRANSMISSION LINE
RESIDENTIAL
TRAILER PARK
COMMERCIAL
CROPLAND
MP&L EXPANSION AREA
STATE PUBLIC LAND
COUNTY PUBLIC LAND
0 500' 1000' 2000' 4000'
LITTLE BASS LAKE
FORSYTHE LAKE
MP&L EXPANSION AREA
PLANT AREA
WARBURG LAKE
BLACKWATER LAKE
MISSISSIPPI RIVER
RIVER
SNELL LAKE
LOST LAKE
JAY GOULD LAKE
LITTLE RICE LAKE
LOON LAKE
POOLE BAY

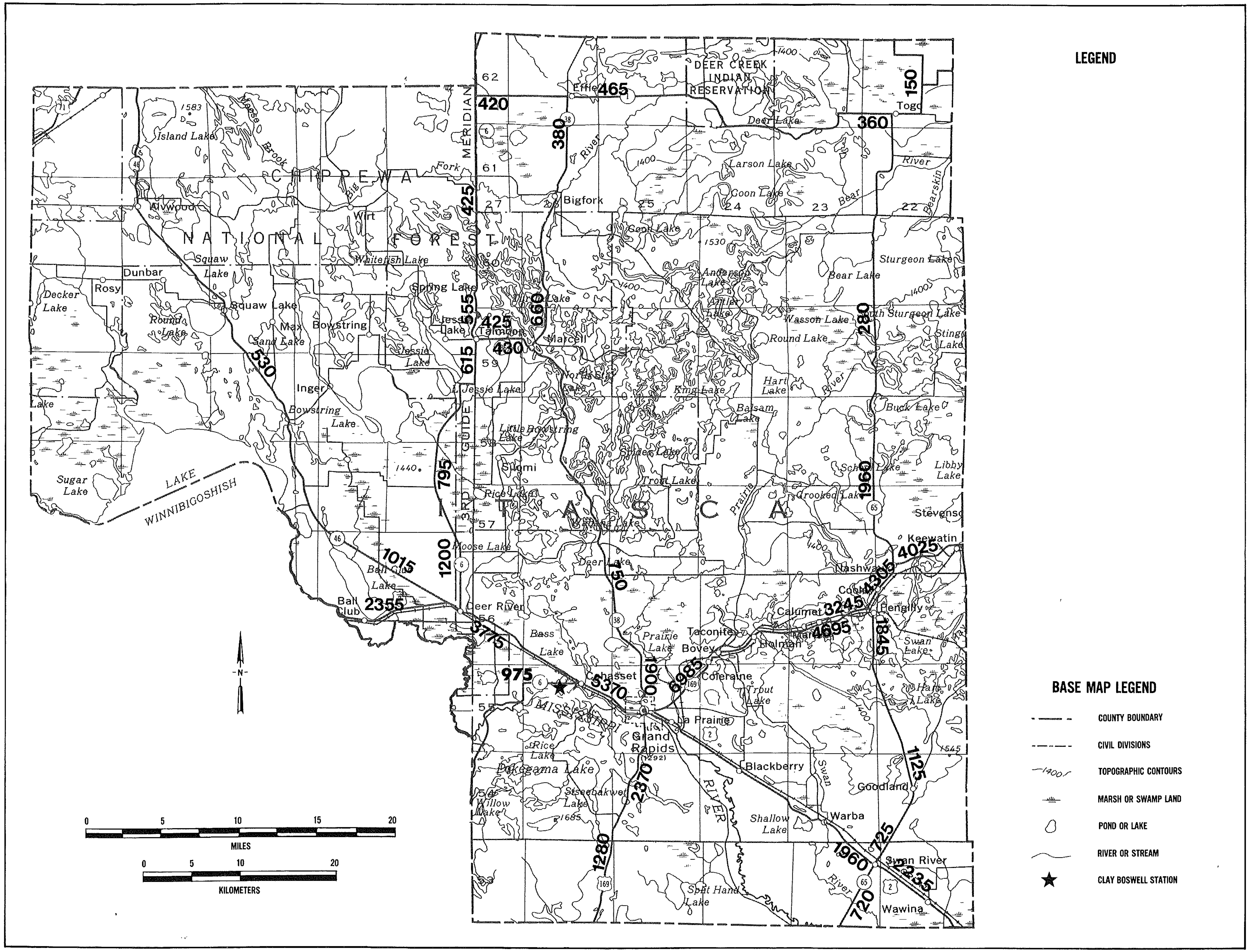
TABLE IV-146
PROPERTY TO BE ACQUIRED FOR UNIT 4 - CLAY BOSWELL STEAM ELECTRIC STATION

Description	Land Use
<u>Condemnation</u>	
Tract of land situated in Government Lot 5, Section 10-55-26 1.4 acres (0.56 hectare) more or less	Residential
Tract of land situated in Government Lot 5, Section 10-55-26 0.5 acre (0.2 hectare) more or less	Residential
Auditor's Tract Eight (8) of Government Lot 5, Section 10-55-26 0.5 acre (0.2 hectare) more or less	Residential
Auditor's Tract Nine (9) of Government Lot 5, Section 10-55-26 0.5 acre (0.2 hectare) more or less	Residential
Government Lots Two (2) and Three (3) of Section 7-55-26	Residential
S½-SE¼ Section 6; N½-NE¼, Section 7; N½-NW¼ Section 8; all in Township 55 North, Range 26 West	Farm-Residential
Auditor's Tract Ten (10) of Government Lot 5, Section 10-55-26 0.5 acre (0.2 hectare) more or less	Residential
That part of the SW¼-NW¼, Section 10-55-26 lying South of the Plat, except the North 500 ft (152.4 m) of the South 530 ft (161.5 m) of the West 153 ft (46.6 m) and except the North 200 ft (60.9 m) of the South 730 ft (222.5 m) of the East 150 ft (45.7 m) of the West 183 ft (55.7 m)	Raw Land
<u>Purchase in Process</u>	
Auditor's Tract Two (2) of Government Lot 5, Section 10-55-26 1.0 acre (0.4 hectare) more or less	Residential
North 500 ft (152.4 m) of the South 530 ft (161.5 m) of the West 153 ft (46.6 m) of the SW¼-NW¼ Section 10-55-26	Residential
<u>Contract for Deed</u>	
Tract of land situated in Government Lot 5, Section 10-55-26 28 acres (11.3 hectares) more or less. We have full Use and Occupancy of the Premises.	Resort
<u>Public Lands</u>	
Government Lots, 1, 2, 3, Section 6-55-26	Raw Land
NW¼-SW¼, SE¼-SW¼ and that area lying South of the Burlington Northern Railway Right-of-Way in the following five (5) parcels: SE¼-NW¼, NE¼-SW¼, NW¼-SE¼, NE¼-SE¼, and SE¼-SE¼, all being in section 4-55-26	Raw Land



PROPOSED RELOCATION OF MINNESOTA
TRUNK HIGHWAY 6 AND PROJECTED TRAFFIC VOLUMES

FIGURE IV-107



ROADWAYS AND EXISTING TRAFFIC VOLUMES - VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION

FIGURE IV-108

HISTORY AND ARCHAEOLOGY

Since the Clay Boswell Steam Electric Station is on the shore of the Mississippi River near the headwaters region, there is an abundance of information available in explorers' journals and surveyors' maps from the 18th and 19th centuries. The search for the source of the Mississippi River attracted adventurers from all over the western world. As a trade route, fur traders transported furs to Lake Superior and downstream to major river ports. Zebulon Pike passed by the site of the Clay Boswell Station in 1805 and 1806 while searching for the source of the Mississippi. He was followed by Lewis Cass in 1820 and Henry Rowe Schoolcraft in 1832 (254).

The area near the present Clay Boswell Steam Electric Station was once the site of Indian villages. Recent maps of the Bass Brook Township area compiled by William Trygg from the original surveyors' notes show a Pokegama Indian Village south of the Mississippi River and downstream between the present Bass Brook Township and Grand Rapids in 1867 (255) (Figure IV-109). Trygg's map also shows a portage crossing the southeast corner of the site for the proposed solid waste disposal pond for the Clay Boswell Unit 4. This Indian trail started from Pokegama Falls and ran north of Blackwater Lake and Oak Point to White Oak Point (255).

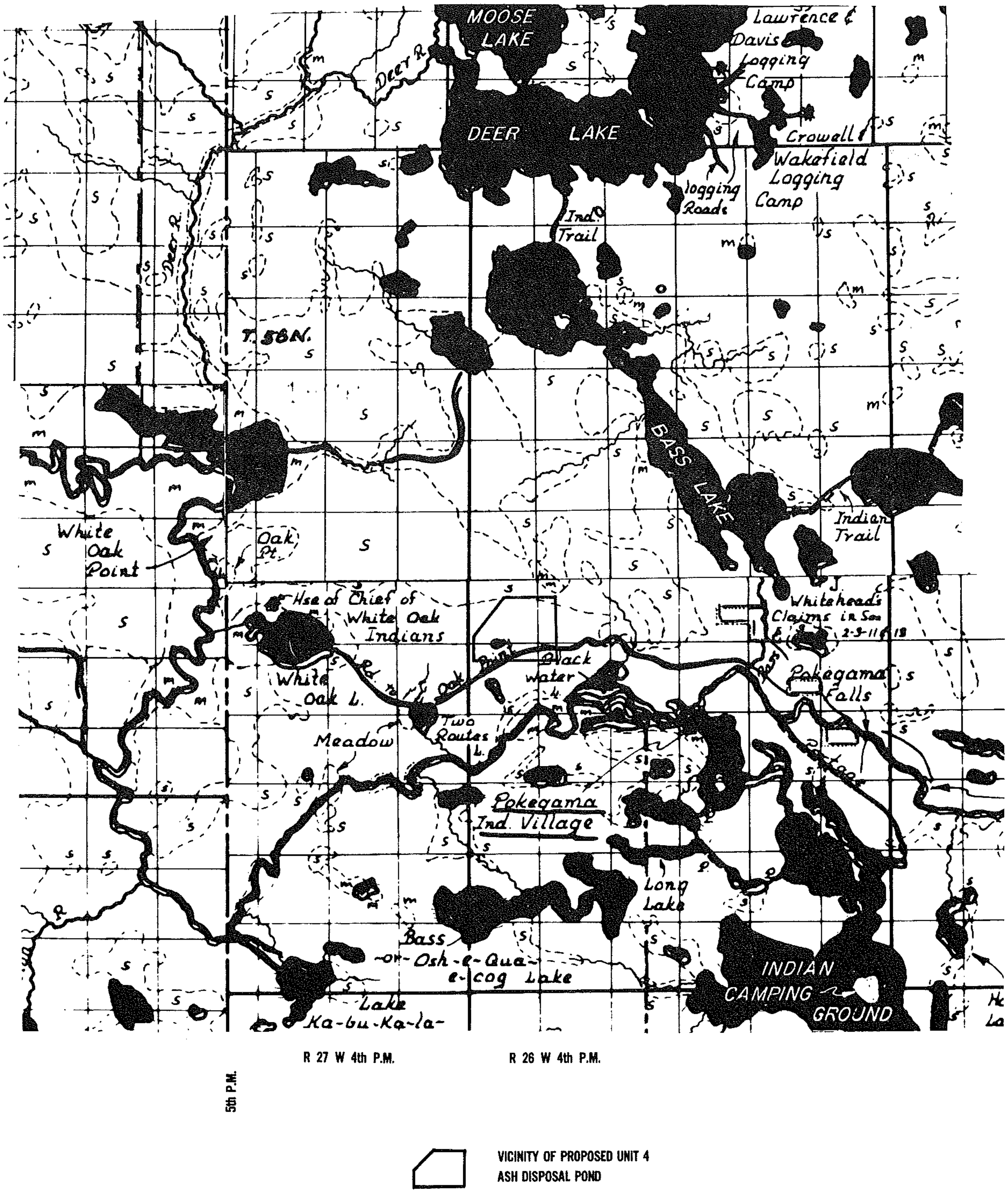
The State Surveys, from which Trygg drew the raw data for his maps, indicate that an Indian trail ran from the northernmost point of the Mississippi River in Section 10 west through Section 10, the northern part of Section 8, and the northern part of Section 7. In sections 8 and 9, the trail is some distance north of Warburg Lake. This trail is identified in the original survey notes as "The Road to White Oak Point" (256) (Figure IV-110).

In the southeast corner of Bass Brook Township, on Pokegama Lake, an old Indian village is indicated on the survey maps. It is identified more precisely as a sugar camp. Also indicated on the boundary line between Sections 10 and 15 is another Indian village near the junction of Pokegama Lake with the Mississippi River (256).

The Work Projects Administration (WPA) Papers at the Minnesota Historical Society yielded no information on sites or buildings in the area. They do contain descriptions, general in nature, of prehistoric sites in the Bass Brook Township vicinity and the location of an early cemetery within the township. The information on Indian settlements is primarily on White Oak Point. The cemetery is identified as Wildwood Cemetery. Its plat was certified in 1916 by the Register of Deeds for Itasca County as being in the northwest corner of the SE 1/4 of the NW 1/4 of Section 10 of Bass Brook Township (257). Archaeological records at the University of Minnesota and the Minnesota Historical Society show the existence of an Indian village site in the SE 1/4 of the NW 1/4 of Section 23. This site was investigated by University of Minnesota archaeologists in 1961 and yielded some stone and pottery items (258).

White Oak Point

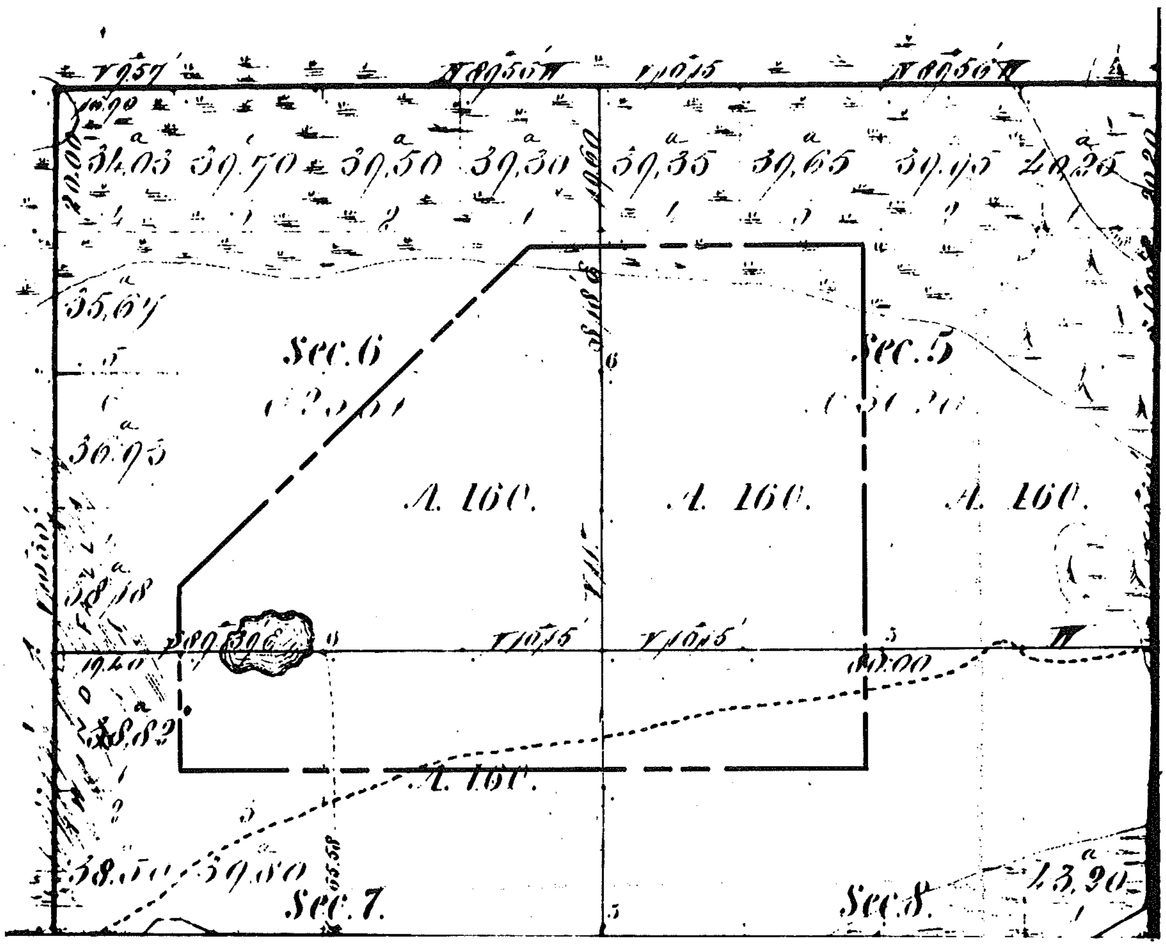
The most significant historical resource in the vicinity of the Clay Boswell Station is at White Oak Point - several miles up river from the proposed



ORIGINAL SURVEY MAP - VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION

SOURCE: ADAPTED FROM, TRYGG, J.W., "COMPOSITE MAP OF UNITED STATES LAND SURVEYORS ORIGINAL PLATS AND FIELD NOTES", 1966, SHEETS 18 AND 19, Ely, Minnesota

FIGURE IV 109



TOWNSHIP 55 N AND RANGE 26 W

LEGEND

INDIAN TRAIL TO WHITE OAK POINT

VICINITY OF PROPOSED UNIT 4
ASH PROPOSAL POND

MINNESOTA SURVEY MAP - NORTHERN HALF OF BASSBROOK TOWNSHIP SHOWING INDIAN PORTAGE TRAIL SOURCE: MINNESOTA SECRETARY OF STATE	FIGURE IV-110

construction area. This prehistoric site is of importance because of its antiquity and the information it has yielded on early man in Minnesota.

Excavations on the site conducted by Professor Lloyd A. Wilford, State archaeologist, in the 1940's and 1950's revealed burials and habitations ranging in age from the early to the late Woodland Indian period (1000 B.C. to 1700 A.D.) (259). White Oak Point is listed on the National Register of Historic Places and the Minnesota State Registry of Historic Sites (260). Professor Elden Johnson, the present State archaeologist, considers White Oak Point to be one of the State's most important landmarks because of its long use as a prehistoric habitation site (260).

There is extensive historical literature on White Oak Point. Joseph N. Nicollet, the eminent astronomer, mapmaker, and explorer, described this point on the Mississippi in his Journal on Wednesday, September 14, 1836 (261):

> From where we camped for the night, we could see looking near north, the tip of a tree that concealed a large lake (White Oak Lake). This lake, similar in size and in its swampy aspect to Muddy Lake that we saw yesterday, is crossed by Deer River. From the same camp, to the northeast, we perceived the Great Point of Oaks.

Nicollet left the area some time later, intrigued by "two or three hillocks" he would like to have excavated:

> On the Great Point of Oaks there were two or three hillocks I wanted very much to go and examine. I was anxious to determine whether or not they were man-made, true to the custom of people passed away, whites or natives, who have left monuments to tell of their passage on earth. But we were hurrying and lacked the proper utensils to make such diggings (262).

That Nicollet's surmise was correct was corroborated decades later. The Hill and Lewis Survey which was established to survey the State for prehistoric burial mounds includes the following entry for White Oak Point (263).

> WHITE OAK POINT. The river is exceedingly crooked, and winds through broad savannas overgrown with meadow and reed grasses, and intersected by sloughs in every direction. Oak Point is the only place where canoes can land for the distance of many miles, and is distinguished in Chippewa tradition as having marked for a long time the northwestern limit of the Chippewa possessions. We learned from one of our voyageurs that when the grass is burnt off the "point," the forms of a great number of ancient lodges can be seen, which were so constructed that the floors were sunk below the surface of the ground. We saw two circles, each about 30 feet in diameter, raised a few inches above the general level, and the area inside was apparently excavated to a slight depth. Near them, and at the most projecting point of land, is a mound about 40 feet in diameter at the base, and 5 feet high. It is a circle (i.e. a round tumulus) and on the side next the land is a narrow raised pathway leading to the top. Just where the pathway terminates are the remains or the stump of a large oak. The top of the mound commands a view of several miles across the savanna, up and down the river. The voyaguer alluded to say that the smaller circles are arranged

in one great circle, the mound forming the center of the ring next the river; and that the remains of earthen pots have frequently been found here.

General historical information on the area around the Clay Boswell Station was gathered mainly from the most recent and best history of Itasca County, James E. Rottsalk's Pines, Mines and Lakes: The Story of Itasca County, Minnesota (264). Rottsalk maintains that 3 traders built fur posts at White Oak Point in 1791. He claims that Zebulon Pike spent a night with a trader named Grant in the latter's house on Pokegama Lake in 1806. He states that the American Fur Company had a post at the north end of Winnibigoshish in 1823-24. The only mission in the county, according to Rottsalk, was William T. Boutwell's established in 1837 on Pokegama Lake. Rottsalk says that the first schoolhouse primarily for Indian children in Itasca County was opened by Roman Catholic missionaries, Father Joseph Buh, Father Francis Pierz, and Father Ignatius Tomazin, at White Oak Point on "the shore of White Oak Lake" in 1869 (264).

White settlement of the Cohasset area began in 1892 after the railraod was built. A woman named Jessie Lawrence lived in a log cabin on the north side of the Mississippi River and established a school in her home primarily for children of white settlers (265).

Numerous accounts record the extensive lumbering operations in the vicinity of the Clay Boswell Station. Iron mining operations were not unknown in the area. It was reported that the Tod-Stambrough Company of Cleveland took options on the SE 1/2 of the SW 1/4 of Section 13 of Bass Brook Township in 1921 with the intention of starting iron mining operaions there. No other reference to this mine was found (266).

AESTHETICS

To evaluate and quantify the aesthetic impacts of a structure such as the Clay Boswell Steam Electric Station is difficult due to the subjective nature of such a process. Two aesthetic aspects of the facility are examined in the following section: one mainly concerns the architectural and landscape design elements, while the other concerns the visual relationship of the facility to the immediate environment.

Much of the area near the Clay Boswell Station is dominated by lakes and forest. The many resorts and lake homes in the area exhibit its recreational orientation. Grand Rapids, the nearest urban area to the Clay Boswell Station, also provides many recreational services. It is visually an urban area with the presence of typical urban land uses. This urban character extends from Grand Rapids to the Cohasset area. The presence of a major industrial structure, such as the Clay Boswell Station must be viewed in the context of both a rural, recreational area and an urban concentration. In addition it must be remembered that the most prominent visual element of the present Clay Boswell Station is the 700 ft (213.4 m) stack.

The Clay Boswell Station is composed of several enclosed buildings, the tallest of which is 208 ft (63.4 m). Also on the site are several auxiliary structures, fly ash reclamation areas, solid waste disposal ponds, an electrical switch yard, a railroad yard, and 4 tall smoke stacks, the largest of which is 700 ft (213.4 m). The complex is illuminated brightly during night hours.

From existing Minnesota Trunk Highway (H.T.) 6, mainly the Unit 3 building is visible as well as the stacks, the switch yards, and Unit 3 cooling tower (Figures IV-111 and IV-112). The building is grey with orange graphic designs. The ash ponds west of the Clay Boswell Station are not visible from the road due to screening by a berm approximately 10 ft (3.05 m) in height (Figure IV-113). Figure IV-114 shows the ash pond and generating facilities from the top of the berm. Figure IV-115 shows the field northeast of the intersection of existing Minnesota T.H. 6 and County Road 258, the future site of the proposed Unit 4 ash and SO sludge pond. Figure IV-116 presents all the viewing points discussed in this section. Similarly Figures IV-117 and IV-118 show the fields northwest of that same intersection also planned for the proposed new ash and SO sludge pond. At present no natural screening exists between the field and these roads. However, the fields are screened from U.S. Highway 2, by wooded lands (Figure IV-119).

The Clay Boswell Station is visible from few places in Grand Rapids, and its visual impact must be considered minimal because of the strong visual impacts of other heavy industry located in the immediate area.

On transportation routes, tree cover allows only intermittent views of the Station, though it is visible at points up to 6 or 7 miles (9.6 or 11.3 km) away. For the most part, views of the station are possible only at those points where there are expanses of water between the roads and the trees (Figures IV-120 and IV-121).

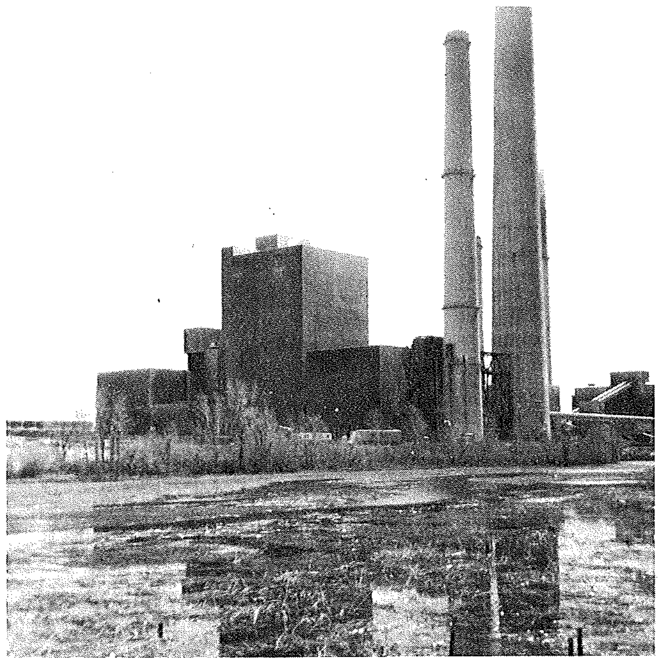
U.S. Highway 2 is the major route through the area and part of the Great River Road system now being developed paralleling the Mississippi River through the State. From this road, coming from the southeast, the Clay Boswell Station first becomes visible from approximately 5 miles (8 km) away at Grand Rapids' western city limits (Figure IV-122). It remains visible through the community of Cohasset (Figure IV-123) as far as a point roughly perpendicular to the Station (Figure IV-124) beyond which point it disappears behind the trees and only reappears intermittently to a distance approximately 5 miles (8 km) from the Station.

The greatest visual impacts of the Clay Boswell Station in the area are on some of the lake homes and resorts. The stacks and plumes can be seen from certain points up to about 6 miles (9.6 km) away (Figure IV-125) although it appears very small at the distance. Trees and hills screen this view from many places primarily during the summer. The Station is most visible from homes and resorts that have lakes between the Station and the viewing points (Figures IV-126 and IV-127).

The Clay Boswell Station is most visible from public lands on County Road C along the south shore of Blackwater Lake directly south of the plant (Figure IV-128). Figure IV-129 shows the same view at night. The station is visible from several points along the east shore of Jay Gould Lake (Figure IV-130), and from more distant and scattered points such as northern Bass Lake (Figure IV-131), Little White Oak Lake, and Lake Pokegama (Figure IV-132). It is also visible from the Sugar Hills Ski Resort which is 9 miles (14.5 km) from the Station.

In addition to the visual impacts caused by the physical structure of the Clay Boswell Station itself, 2 other visual impacts are obvious. First, smoke and vapor produced by the generating facilities are highly visible. The amount of steam, and the number of stacks being operated depends on operating procedures. The direction and height of the plume depends on wind and other atmospheric conditions. Because of the prevailing winds in the area the plumes tend to drift to the southeast most frequently. These plumes can extend for a distance of several miles from the stacks. If the air is calm and the sky clear and blue, the white plume will be more visible than the tallest stack, rising a total of up to 1,500 ft (457 m) above the ground, thus being visible from a much greater distance.

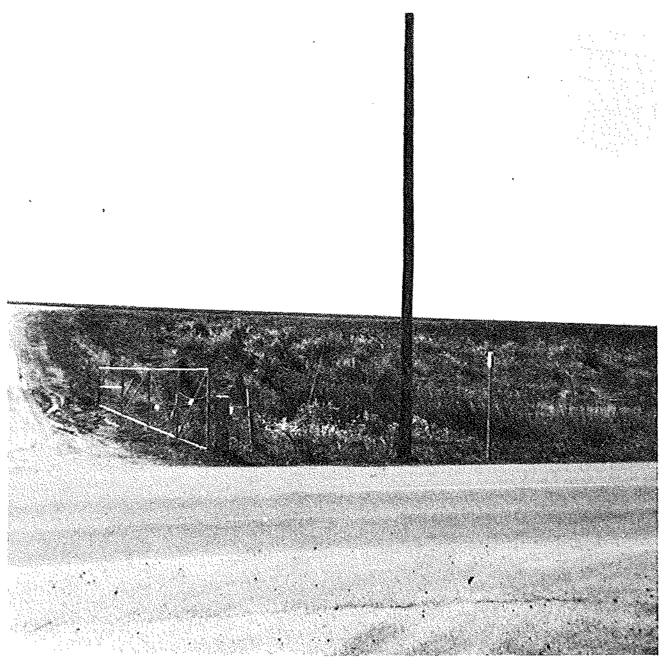
Second, another more local condition resulting from the stack emissions is the fly ash which settles on everything within a radius of approximately one half mile (0.8 km) of the Station. This fly ash gives vegetation and man-made structures in the area a white cast and it also coats the generating facilities and detracts greatly from any painting and graphics on their surfaces.



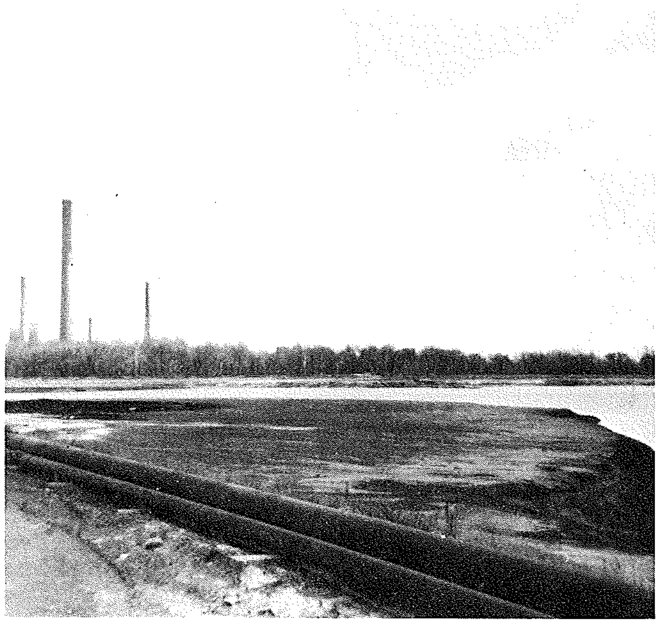
PROPOSED UNIT 4 FROM MINNESOTA T.H. 6 - LOOKING SOUTHEAST
CLAY BOSWELL STEAM ELECTRIC STATION
VIEW POINT 1 ON FIGURE IV-116

FIGURE IV-111

SWITCHYARD AND UNIT 3 COOLING TOWER FROM MINNESOTA T.H. 6 CLAY BOSWELL STEAM ELECTRIC STATION VIEW POINT 2 ON FIGURE IV-116	FIGURE IV-112

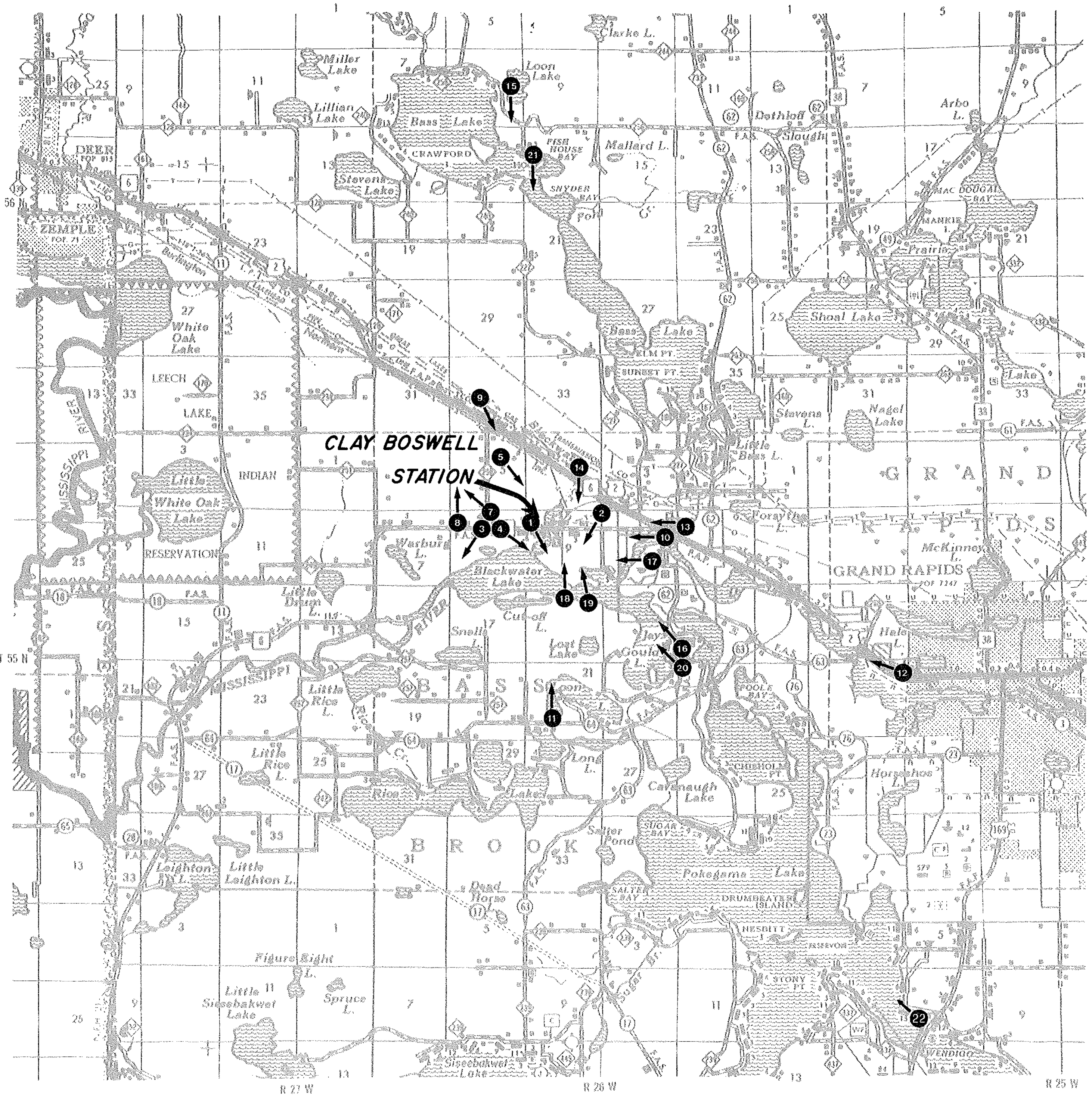


BERM NORTH OF EXISTING ASH POND ALONG MINNESOTA T.H. 6 - LOOKING SOUTH CLAY BOSWELL STEAM ELECTRIC STATION VIEW POINT 3 ON FIGURE IV-116	FIGURE IV-113



EXISTING FLY ASH DISPOSAL POND WEST OF GENERATING FACILITIES LOOKING SOUTHEAST FROM TOP OF BERM CLAY BOSWELL STEAM ELECTRIC STATION VIEW POINT 4 ON FIGURE IV-116	FIGURE IV-114

FUTURE FLY ASH AND SO_2 SLUDGE DISPOSAL POND SITE NORTHEAST OF INTERSECTION OF MINNESOTA T.H. 6 AND COUNTY ROAD 258 FROM COUNTY ROAD 258 - LOOKING SOUTHEAST CLAY BOSWELL STEAM ELECTRIC STATION VIEW POINT 5 ON FIGURE IV-116	FIGURE IV-115



LEGEND

CAMERA POSITION AND DIRECTION

BASE MAP LEGEND

ROAD AND ROADWAY FEATURES

- PROJECTED ROAD
- GRADED AND DRAINED ROAD
- GRAVEL OR STONE ROAD
- BITUMINOUS ROAD
- PAVED ROAD

BOUNDARIES

- COUNTY
- CIVIL TOWNSHIP
- CONGRESSIONAL TOWNSHIP (U.S. LAND)
- SECTION LINE
- NATIONAL OR STATE PARK
- NATIONAL OR STATE FOREST
- NATIONAL INDIAN RESERVATION

DRAINAGE

- INTERMITTENT STREAM
- NARROW STREAM
- MARSH OR SWAMP LAND
- POND OR LAKE

PUBLIC SERVICE FACILITIES

- PIPE LINE, GAS
- PIPE LINE, OIL
- TRANSMISSION LINE (33 KV OR OVER)
- POWER PLANT

EDUCATIONAL AND CORRECTIONAL INSTITUTIONS

- SCHOOL HOUSE
- CONSOLIDATED OR LARGE SCHOOL

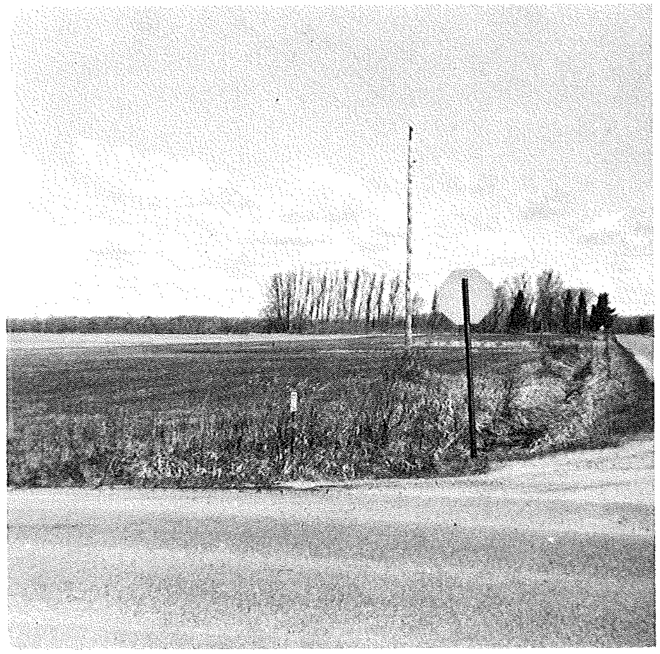
N

0 1 2 3 MILES

0 1 2 3 KILOMETERS

MAP SHOWING VIEWING POINTS VICINITY OF CLAY BOSWELL STEAM ELECTRIC STATION

FIGURE IV-116

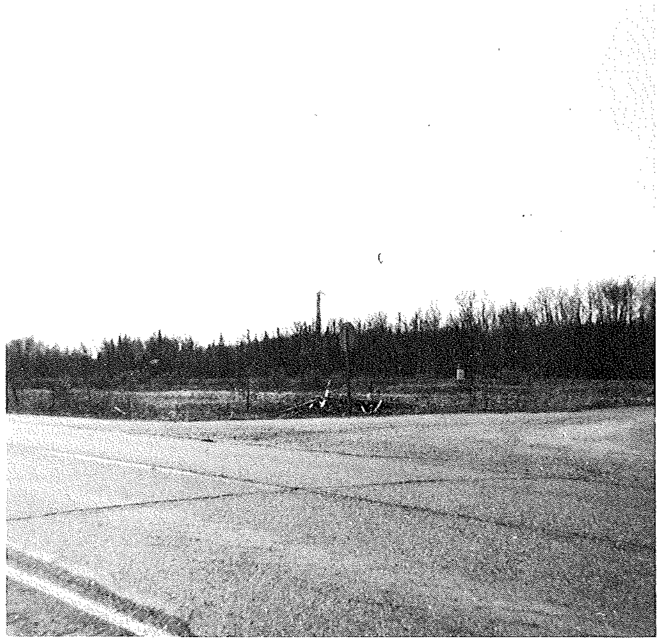


FUTURE FLY ASH AND SO_2 DISPOSAL POND SITE NORTHWEST OF INTERSECTION OF MINNESOTA T.H. 6 AND COUNTY ROAD 258 LOOKING NORTH
CLAY BOSWELL STEAM ELECTRIC STATION
VIEW POINT 7 ON FIGURE IV-116

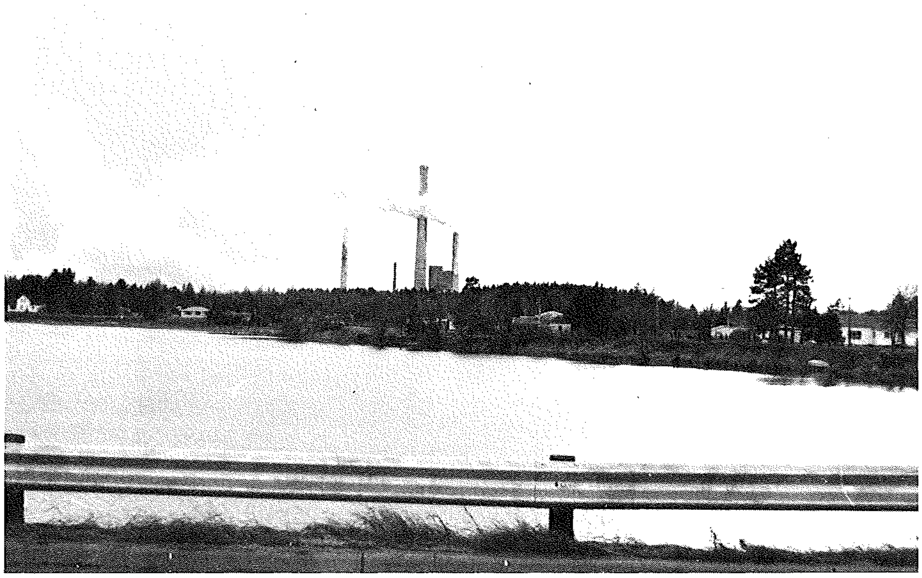
FIGURE IV-117

SITE OF FUTURE ASH AND SO_2 SLUDGE DISPOSAL POND NORTHWEST OF INTERSECTION OF MINNESOTA T.H. 6 AND COUNTY ROAD 258 FROM MINNESOTA T.H. 6 - LOOKING NORTH
CLAY BOSWELL STEAM ELECTRIC STATION
VIEW POINT 8 ON FIGURE IV-116

FIGURE IV-118



U.S. HIGHWAY 2 AT COUNTY ROAD 258 – LOOKING SOUTHWEST CLAY BOSWELL STEAM ELECTRIC STATION VIEW POINT 9 ON FIGURE IV-116	FIGURE IV-119



COUNTY ROAD 256 AND MISSISSIPPI RIVER CROSSING LOOKING WEST 1¼ MILE (2.0 KM) CLAY BOSWELL STEAM ELECTRIC STATION VIEW POINT 10 ON FIGURE IV-116	FIGURE IV-120

COUNTY ROAD 64 SOUTHWEST OF COUNTY ROAD 63
LOOKING NORTH 3 MILES (4.8 KM)
CLAY BOSWELL STEAM ELECTRIC STATION
VIEW POINT 11 ON FIGURE IV-116

FIGURE IV-121

U.S. HIGHWAY 2 AT WESTERN GRAND RAPIDS CITY LIMIT
LOOKING WEST 5 MILES (8.1 KM)
CLAY BOSWELL STEAM ELECTRIC STATION
VIEW POINT 12 ON FIGURE IV-116

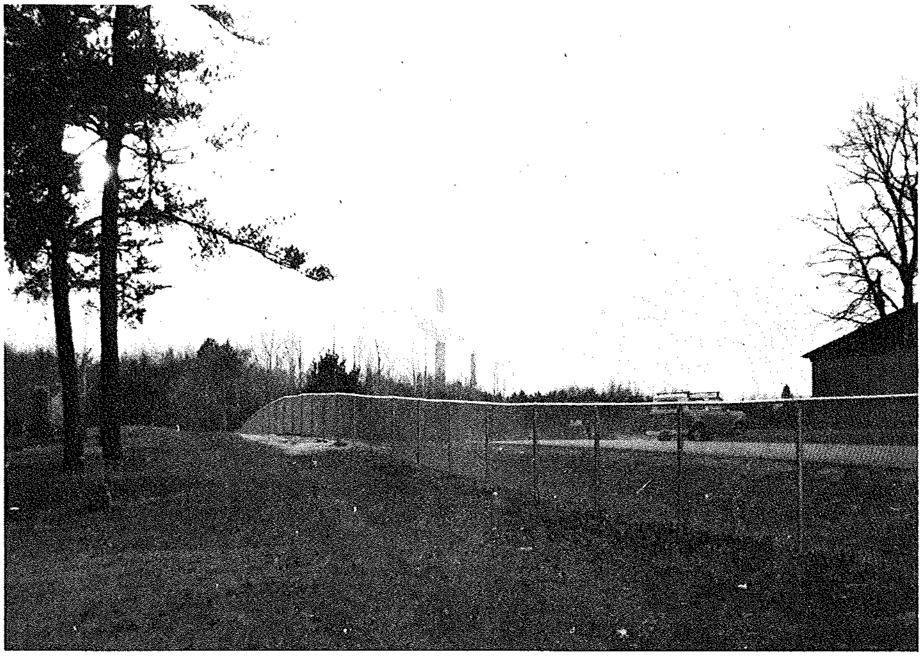
FIGURE IV-122

U.S. HIGHWAY 2 AT BASS BROOK CROSSING, COHASSET LOOKING WEST 1.5 MILES (2.4 KM) CLAY BOSWELL STEAM ELECTRIC STATION VIEW POINT 13 ON FIGURE IV-116	FIGURE IV-123

U.S. HIGHWAY 2 AT APPROXIMATELY BLACKWATER CREEK CROSSING LOOKING SOUTH 1 MILE (1.6 KM) CLAY BOSWELL STEAM ELECTRIC STATION VIEW POINT 14 ON FIGURE IV-116	FIGURE IV-124

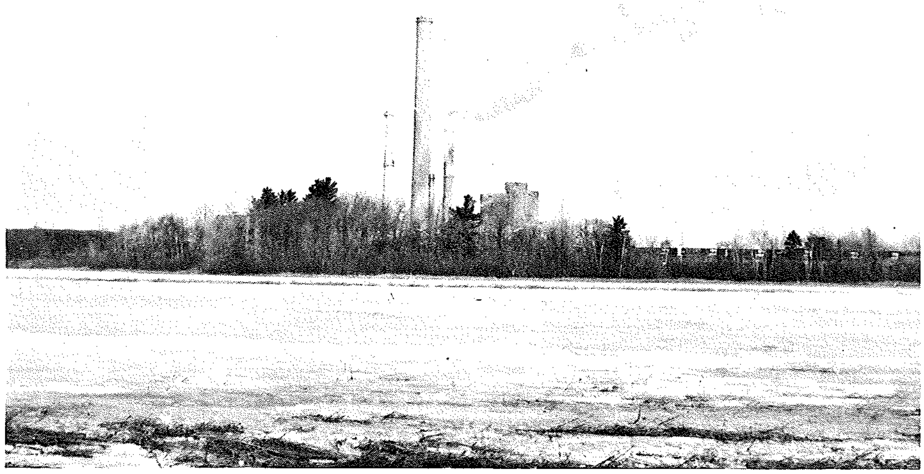
COUNTY ROAD 256 - NORTH SIDE OF BASS LAKE LOOKING SOUTH 6 MILES (9.7 KM) CLAY BOSWELL STEAM ELECTRIC STATION VIEW POINT 15 ON FIGURE IV-116	FIGURE IV-125

COUNTY ROAD 62 - SOUTH OF TOWNSHIP ROAD H LOOKING WEST 2 MILES (3.2 KM) CLAY BOSWELL STEAM ELECTRIC STATION VIEW POINT 16 ON FIGURE IV-116	FIGURE IV-126



WILDWOOD CEMETERY - COUNTY ROAD 62 AT COUNTY ROAD J
LOOKING WEST 1 MILE (1.6 KM)
CLAY BOSWELL STEAM ELECTRIC STATION
VIEW POINT 17 ON FIGURE IV-116

FIGURE IV-127



SOUTH OF BLACKWATER LAKE
LOOKING NORTH 1 MILE (1.6 KM)
CLAY BOSWELL STEAM ELECTRIC STATION
VIEW POINT 18 ON FIGURE IV-116

FIGURE IV-128

SOUTH OF BLACKWATER LAKE
LOOKING NORTH 1 MILE (1.6 KM) - NIGHT VIEW
CLAY BOSWELL STEAM ELECTRIC STATION
VIEW POINT 19 ON FIGURE IV-116

FIGURE IV-129

JAY GOULD LAKE AT COUNTY ROAD 62 OVER CHANNEL TO LITTLE
JAY GOULD LAKE LOOKING NORTHWEST 2 MILES (3.2 KM)
CLAY BOSWELL STEAM ELECTRIC STATION
VIEW POINT 20 ON FIGURE IV-116

FIGURE IV-130

COUNTY ROAD 256 - NORTH SIDE OF BASS LAKE
LOOKING SOUTH 6 MILES (9.7 KM)
CLAY BOSWELL STEAM ELECTRIC STATION
VIEW POINT 21 ON FIGURE IV-116

FIGURE IV-131

WENDIGO AREA - LAKE POKEGAMA - HIGHWAY 169
LOOKING NORTHWEST 8 MILES (12.9 KM)
CLAY BOSWELL STEAM ELECTRIC STATION
VIEW POINT 22 ON FIGURE IV-116

FIGURE IV-132

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