MIGRATION OF SANDHILL CRANES,

UPPER TANANA RIVER VALLEY, ALASKA

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LIST OF FIGURES

LIST OF TABLES

ABSTRACT

MIGRATION OF SANDHILL CRANES, UPPER TANANA RIVER VALLEY, ALASKA

Studies of migrating Sandhill Cranes were conducted in the upper Tanana River Valley region of eastern Alaska from fall 1976 to spring 1979 to determine the timing and characteristics of the passage as they might relate to the construction of the Northwest Alaskan Gas Pipeline.

More than 150,000 to 200,000 cranes migrate through the region, primarily from the last week of August to the first week of October and from the last week of April to the middle of May. During the peak of migration, as many as 10,000 to 50,000 cranes per day may pass through the region. Ground utilization is confined primarily to overnight roosting and feeding and to periods of bad weather; open areas are selected for roost sites, with a preference shown for the alluvial islands of wide, braided riverbeds. Timing and routes of migration are affected by weather conditions, especially strong winds and poor visibility. Cranes are primarily daylight, fair-weather migrants, but sometimes migrate at night and during inclement weather. Most migration occurs between 1000 and 3000 ft AGL.

Cranes are relatively tolerant of potential environmental disturbances, with 500 ft a frequent minimum threshold distance at which most cranes will tolerate a wide range of human activities. They react at greater distances under more stressful stimuli.

If damage to roosting sites is prevented and if the timing of potentially disturbing construction activities can be adjusted to avoid direct conflict with migrating cranes (i.e., near occupied roosts or feeding sites or near flying flocks), Sandhill Cranes will not pose serious problems to pipeline construction.

TABLE OF CONTENTS

MIGRATION OF SANDHILL CRANES, UPPER TANANA RIVER VALLEY, ALASKA

Brina Kessel

INTRODUCTION

Two-thirds of the world's population of the Lesser Sandhill Crane (Grus canadensis canadensis) passes through the upper Tanana River Valley, eastern Alaska, during a 2- to 3-week period each spring and fall (see below). At Delta Junction (64°02' N, 145°44' W), their migratory pathway is briefly constricted to a width of 20-25 miles; and near George Lake (63°47'N, 144°31'W) in spring to possibly only 10 miles.

Other than the fact that it existed, little was known about this spectacular passage until Northwest Alaskan Pipeline Co. began to support studies of this movement in fall 1976. Studies were continued in fall 1977, spring and fall 1978, and spring 1979, to determine the timing and characteristics of the passage as they might relate to the construction of the Northwest Alaskan Gas Pipeline, a pipeline that is to parallel the Alaska Highway through the upper Tanana Valley from Delta Junction to the Alaska-Canada border. More specifically, the objectives were

1. to determine the numbers, timing, flight routes, and altitude of crane migration through the upper Tanana-Chisana river valleys; and, if possible, determine predictability in these factors relative to weather conditions;
2. to determine the amount and kind of ground utilization by cranes in the region during migration, and delineate specific ground sites used by feeding and roosting cranes;
3. to document, as opportunity presented itself, the effects of potential disturbance factors (aircraft, vehicles, noises, people, etc.) on crane behavior; and
4. to prepare recommendations that might mitigate any detrimental effects to cranes of pipeline construction and construction-related activities.

Study Area

The main study area extended from the Delta River (approx. 145°50' W) to the Alaska-Canada border (144°00' W), a distance of approximately 150 miles; and from Mt. Fairplay (63°40' N, 142°13' W) and the Ladue River where it crosses the border (63°16' N) on the north to the Tanana-Chisana rivers on the south (see Figs. 2-4). This pie-shaped study area consisted of about 450 mi^2 and included the flats and lowlands of the upper valley of the Tanana River and, to the north, the upland hills of the Tanana-Yukon Highlands.

Methods

Methods were primarily observational, with one field crew (one to two observers) stationed within the relatively constricted portion of the migratory pathway at Delta Junction and the other, a mobile crew (one to three observers), stationed in the vicinity of Tok Junction-Tetlin Junction-Taylor Highway. The Delta Junction crew made use of one of three main observation sites and had the assignment of obtaining as complete a count as possible of the cranes passing through the region. The main observation sites, which commanded relatively extensive views of the migratory routes, were 1) a control tower at the U.S. Army Ft. Greely air strip, 2) a west-facing outlook above the Delta River at about Mile 262 Richardson Highway, and 3) a knob overlooking the fields of the OHM farm on Remington Road.

The Taylor Highway crew was more mobile, covering primarily the area from Tetlin Junction to Mt. Fairplay and from Tanacross to Northway Junction. This crew was charged with determining the migratory pathways through the region, and crew members, using several automobiles, made daily searches of the region for migrating cranes. Whenever possible, when flocks of cranes were found, counts were made to ascertain the relative intensity of use of different routes. In addition, this crew used small fixed-winged aircraft on occasion to search for migrating flocks, to follow such flocks, and to search for roosting sites.

We found aircraft particularly useful for delineating migratory routes when we could get airborne during heavy flight passages. Likewise, information on roosting sites was most effectively obtained from early morning flights following a heavy passage late on the preceding day. Unless we knew that a major passage was underway, hunting for migratory flocks by aircraft proved to be ineffective (and expensive).

More or less continuous field observations were conducted throughout the main periods of spring and fall migration, 1977-79 (see Tables 2 and 3 for inclusive dates). During these periods of migration, observers attempted to remain at observation posts and in the field throughout the daily period of crane activity. Thus, on some days observations began prior to 04:00 AST or ended after 19:00, or even 21:00 AST.

Recorded field data for each crane observation, in addition to date and locality, included number of birds, time of day, flight height and direction, wind direction and velocity, height and percent of cloud cover, and descriptions of any ground utilization or reaction (or absence thereof) to disturbance. Hourly weather reports for Delta and Northway were obtained from the U.S. National Weather Service. These reports included height and characteristics of lowest clouds, height of cloud ceiling, total opaque sky cover, horizontal visibility, type of obstruction to visibility (fog, snow, rain), wind speed and direction, and barometric pressure.

For purposes of analysis, the crane field data from the stationary observation posts at Delta and the weather data from Delta and Northway were divided into time periods: Period 1, 05:00-10:00 AST; Period 2, 10:01-15:00; Period 3, 15:01-21:00; and Period 4, 21:01-04:59. With the aid of a computer, all crane and weather data were combined and summarized for these four daily periods for every day of each spring and fall

migratory period. Results reported below on the effects of environmental factors on crane behavior and migration flight patterns were drawn from these data summaries, from the raw data sheets, and from original field observations.

DISTRIBUTION AND ABUNDANCE

The world's population of Sandhill Cranes is comprised of approximately 285,000 to 320,000 birds of possibly six subspecies (Braun 1975). The Lesser Sandhill Crane (G. c. canadensis), the subspecies of this report, is the most numerous, with an estimated population of about 250,000 to 280,000 birds (Braun 1975). This subspecies nests in arctic and subarctic regions, mostly north of 60° N. Lat., from northeastern Siberia to the west edge of Hudson Bay, including the Canadian Arctic islands, and winters primarily from western Texas and northern Mexico to southern California (Walkinshaw 1949, Krechmar et al. 1978).

During a brief, 2- to 3-week period in both spring and fall, 150,000 to 200,000 Lesser Sandhill Cranes pass through the upper Tanana River Valley in eastern Alaska (see below); thus about 60% of the world's Sandhill Cranes and over two-thirds of the Lesser Sandhill Crane population migrate through the region.

It is becoming clear that the cranes that migrate through this region are the ones that summer throughout interior Alaska west of the Tanana-Yukon Highlands, throughout coastal western Alaska from the Yukon-Kuskokwim Delta to Kotzebue Sound, and in northeastern Siberia in the lowlands about Kolyuchin Bay and in the valleys of the lower Anadyr River and its tributaries. They winter primarily in eastern New Mexico-western Texas and adjacent northern Mexico. During migration they apparently comprise a large portion of the birds that frequent staging areas on the Platte River in central Nebraska (especially in spring) and in the Kindersley-Kyle-Outlook district of southwestern Saskatchewan--but probably not the Last Mountain-Quill Lakes area farther east in Saskatchewan (see Boise [1977] for southwest Saskatchewan sighting of Alaska-marked crane; Aldrich [1974] indicating that 67% of cranes at Last Mountain Lake are G. c. rowani, and evidence suggested by Gollop [1976]). On migration they are also seen in numbers in the Peace River district of northern Alberta and along the Alaska Highway between Fort Nelson, B.C., and Watson Lake, Y.T. Between Watson Lake and the Yukon River and eastern Alaska, the cranes apparently fly the drainages of the Frances and upper Liard rivers into the Pelly River drainage, a wilderness region where they are observed by relatively few people.

This assumption regarding the distribution of the cranes that migrate through the upper Tanana River Valley is based in part on returns of marked birds from Alaska to Texas and in part on an increasing file of unpublished reports from observers who have seen large numbers of cranes moving through various regions along the northwestern arm of the migration route(s). During springs 1978 and 1979 and fall 1978, at least seven marked cranes were seen at Delta Junction or Fairbanks, cranes that had been marked the preceding winter or spring at Rich Lake in western Texas or along the North Platte River in central Nebraska

(fide Paul A. Vohs, Oklahoma Cooperative Wildlife Research Unit). Additionally, returns of marked birds of this population have been obtained from Mexico, New Mexico, Mississippi (unusual), southwestern Saskatchewan, Yukon River Delta, Koyuk at the southeast edge of the Seward Peninsula, Cape Seppings north of Kotzebue Sound, and Siberia (USFWS Bird-Banding Laboratory; Vohs, in litt.; Boise 1977 and pers. comm.).

Dates and Size of Movement, Upper Tanana River Valley

The first signs of fall crane migration in interior Alaska can be detected during the first week of August, when cranes begin to gather at various staging sites; movement becomes more evident after 10 August, increasing in intensity through August (Kessel, unpubl. data). The main passage occurs during September, and a few individuals are still trailing southward through the Interior as late as 15 October (ibid.).

Some crane movement has been reported through the Delta Junction area during the last week of August, but in most years the movement is insignificant until early September. With some annual variation, significant numbers do not occur in the region until about 5 September, and some years not until almost a week later. During fall of 1977 and 1978, large numbers passed through the area from 13 to 24 September (Table 1). While there is considerable variation in the daily count due to weather conditions (see below), on any single day during this 11-day period 10,000 to 50,000 cranes may move through the region. Maximum daily counts occurred on 19 September 1977 (51,000 cranes) and 21 September 1978 (47,000 cranes).

In spring, occasional sightings of cranes as early as 15 April have been reported in interior Alaska, but their usual first arrival date at Fairbanks is 22 April (Kessel, unpubl. data). With some variability due to weather, significant numbers do not occur in the Delta Junction area until the last day or two of April. During 1978 and 1979, large numbers passed through Delta Junction from 1 to 12 May (Table 2), with maximum daily counts occurring on 7 May 1978 (35,000 cranes) and 12 May 1979 (52,000 cranes).

Total crane counts made during fall migration at Delta Junction were 186,000 in 1977 and 198,000 in 1978 (Table 1). In spring, 172,000 cranes were counted in 1978 and 148,000 in 1979 (Table 2). These numbers are minimums, since they were only of birds actually seen. Some birds passed through the region before and after the count periods, a small but unknown number migrated after dark or in fog, and a few flocks slipped unobserved past the field crews. It is doubtful, however, that as many as 10% of the migrants were missed.

Flocks of migrating cranes are not easy to count (see Fig. 1), and the level of counting error and differences in such errors among the many observers that participated in the project are unknown. Hence, it is not known whether or not the variation in total numbers counted between years or between seasons is significant. The lower numbers in spring compared to fall would be expected, in view of the addition of young birds after the breeding season and losses due to mortality during migration and winter (The Office of Migratory Bird Management, U.S. Fish

Table 1. Dates and numbers of fall migrating cranes counted at Delta Junction, Alaska

Day	Number		
	1977	1978	1979
20-31 August		†	
1 September		250*	
2 September		150*	
4 September		70*	
5 September		-	2,000*
6 September		600*	5,000*
7 September	††	1,000*	
8 September	76	981*	
9 September	76	7,791	
10 September	534	206	
11 September	471	1,024	
12 September	1,830	1,400	
13 September	10,778	48	
14 September	10,058	9,722	
15 September	1,763	30,490	
16 September	4,648	14,790	
17 September	21,627	20,660	
18 September	21,188	21,692	
19 September	50,860	8,837	
20 September	14,350	1,305	
21 September	2,911	46,745	
22 September	2,375	12,726	
23 September	16,266	12,220	
24 September	25,305	3,747	
25 September	141	620	
26 September	296	1,000	
27 September	354	15 (at OHM)	
28 September	?	15 (same as 27 Sept.)	
TOTAL COUNT (Rounded Off)	186,000	198,000	

† Local residents report some migrating flocks moving
†† Local residents report no movement yet
* Partial counts

Table 2. Dates and numbers of spring migrating cranes counted at Delta Junction, Alaska

Day	Number	
	1978	1979
25 April	4	-
26 April	5	0
27 April	0	12
28 April	13	113
29 April	3,092	10
30 April	6,300	35**
1 May	26,489	9,512**
2 May	25,856	4,401**
3 May	3,908	5,435**
4 May	2,627	5,840
5 May	1.845	29,198
6 May	13,400	7,717
7 May	35,225	332
8 May	8,007	89
9 May	21,105	5,314
10 May	7,740	11,022
11 May	7,835	5,183
12 May	7,353	52,256
13 May	1,080*	6,426
14 May	50-100/day*	3,779
15 May		888
16 May		78
17 May	-	92
18 May	-	59
19 May	-	137
20 May	-	0
TOTAL COUNT (Rounded-Off)	172,000	148,000

* Partial counts

** Total counts derived from Taylor Highway observations, since most cranes slipped past Delta Junction observers.

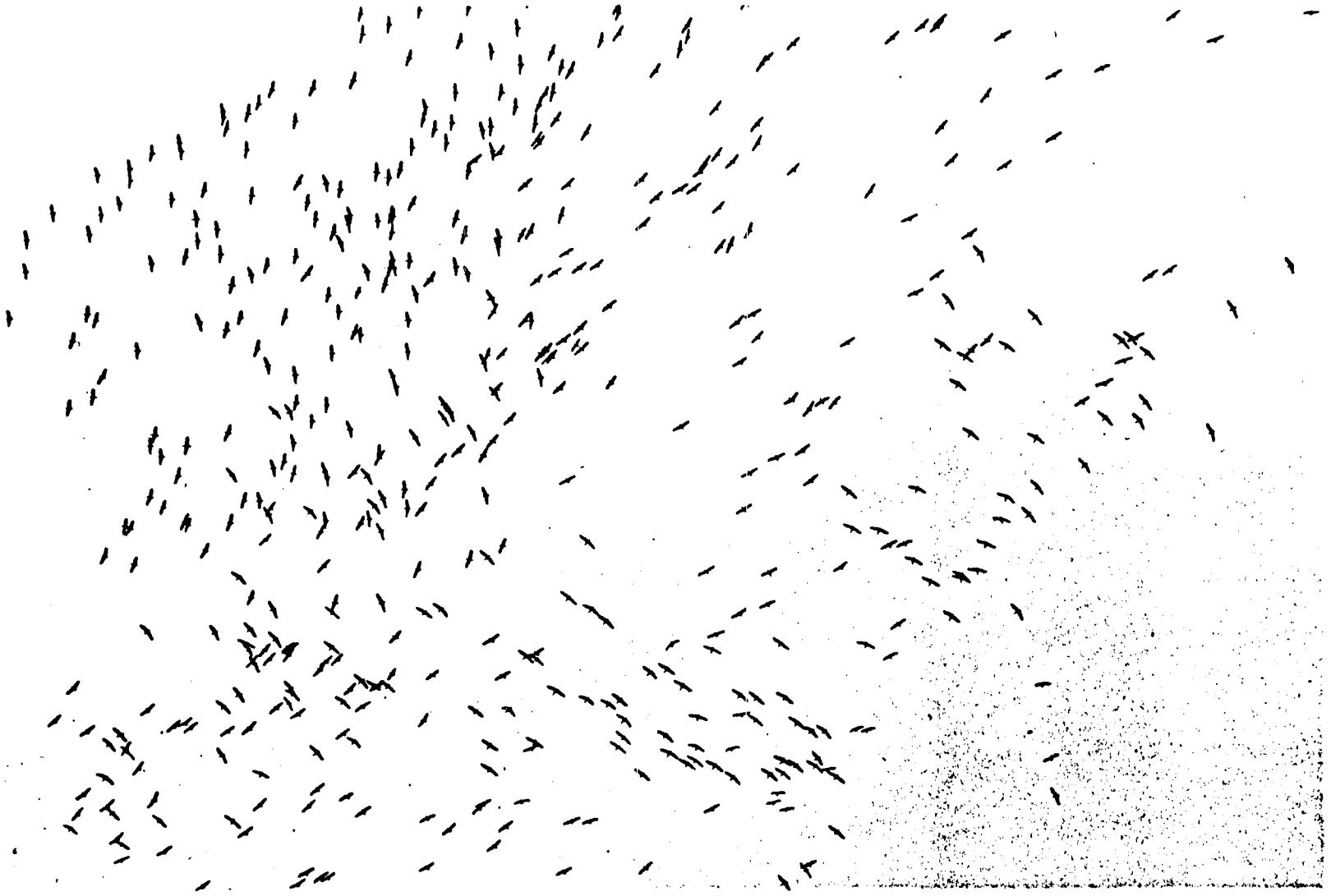

Figure 1. Migrating Sandhill Cranes, Delta Junction, Alaska, 7 May 1978

and Wildlife Service, Laurel, Maryland, estimates that 12,000-14,000 cranes are killed by hunters each year in the Central Flyway [unpubl. Admin. Repts., 1976-1978]).

Migratory Routes, Upper Tanana River Valley

In fall, most of the cranes from western Alaska move eastward along the north face of the Alaska Range, actually crossing over the northernmost "elbow" of the range. The main route passes over the Parks Highway between Rex and Healy (Kessel, unpubl. data). From there, the cranes move almost directly eastward, crossing the Delta River between Donnelly Dome and mid-way between Big Delta and Delta Junction. The usual route in 1977 and 1978 then took them eastward across the Delta Junction area, across the Tanana River, and into the southern edge of the Tanana-Yukon Highlands (see Fig. 2). After traversing these highlands and crossing the Taylor Highway, mostly between Miles 14 and 29, the cranes descended into Yukon Territory, Canada, to the vicinity of the White River at a point just south of the mouth of the Ladue River. After crossing the White River, the birds appeared to make a direct passage to the mouth of the Pelly River.

Several consistent variations were discernible in the above fall migration pattern, all caused by winds. First, if winds in the upper Tanana River Valley area (as recorded at the FAA Station at Northway, but not Delta) were from the NW (WNW to NNW), crane flocks, instead of entering the Tanana-Yukon Highlands, followed the course of the Tanana River ESE, taking shortcuts across major bends. At approximately 142°20' W, where the Tanana River turns S-SE, many cranes maintained an ESE course, crossing the south end of the Taylor Highway and passing over the hills north of the Tanana River; others continued up the Tanana River to different points some 30 miles from the Alaska-Canada border, where flocks cut eastward toward the White River (Fig. 2). The cutover occurred most frequently in the vicinity of Bitters Creek near Riverside, but sometimes not until the Gardiner Creek Drainage. Local reports indicate that sometimes this cutover may not occur until cranes reach Scottie Creek at the border. During the September movements of 1977 and 1978, about a third of the days had Tanana Valley migrations.

Second, if winds in the upper Tanana River Valley were from the SW, birds crossed the Taylor Highway farther north than otherwise. On 14 September 1978, for example, cranes even crossed at Mile 35 Taylor Highway, north of Mt. Fairplay.

The third fall variation resulted from strong (average 13-18 mph) generally SE winds at Delta, which occurred on a total of 7 days during 1977 and 1978 and which caused the migrating cranes to shift their route away from the Alaska Range (beginning at about Delta Creek) and therefore caused them to reach the Tanana-Yukon Highlands closer to the junction of the Delta and Tanana rivers (Fig. 2). During a preliminary survey in fall 1976, unusually strong winds in the Delta area caused some flocks to enter the Delta area as far north as over the Goodpaster River.

Reports received from local residents indicate a small fall movement of up to several thousand cranes farther north in the Tanana-Yukon Highlands, in the vicinity of Chicken and Boundary, Alaska. The relationship of these cranes to those of the upper Tanana Valley is unknown, but

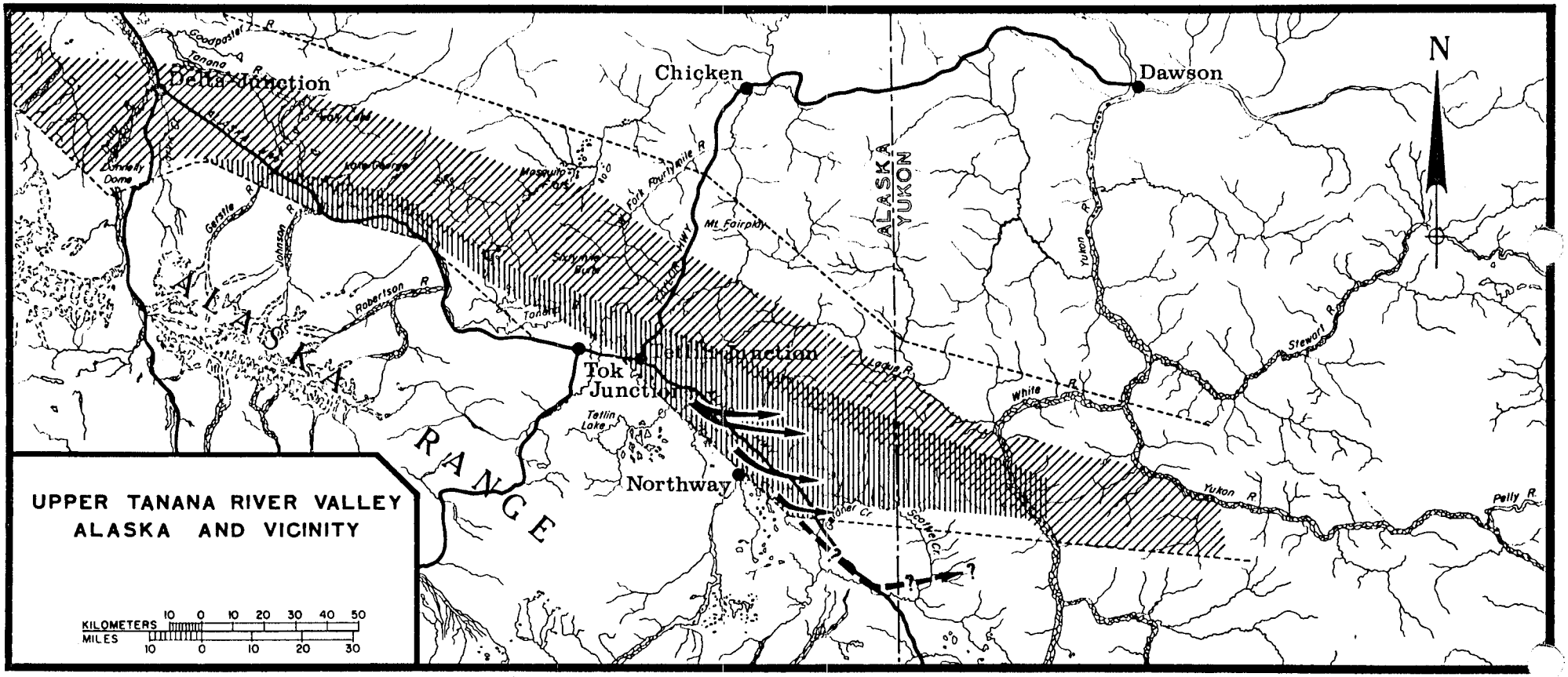

Figure 2. Fall migration pathway of Sandhill Cranes, upper Tanana River Valley, Alaska.

▨ Concentration of migrants. ▥ Concentration of migrants when winds from the northwest. ------- Outline of migration pathway.

these cranes apparently move directly eastward to the Yukon River in Yukon Territory.

In spring, the main migratory pathway through the upper Tanana River Valley was more constricted and farther south than in fall (Fig. 3). Generally, the pathway was similar to the southern, or Tanana Valley, route followed in fall under conditions of NW winds (cf Figs. 2 and 3); that is, cranes entered Alaska with a WNW heading, apparently from the mouth of the Pelly River, flew up the general drainage of the Ladue River, crossed the Taylor Highway, primarily between Miles 2.5 to 16, and then followed the Tanana River into the Delta Junction area.

Winds caused some route variations in spring, but their effects did not appear to be as frequent nor as great as in fall. ENE winds near the Alaska-Canada border, even if only 6-9 mph, caused the cranes to shift from their usual WNW direction to a more westerly direction, which brought them onto the Tanana River farther east than under other conditions, i.e., somewhere between Gardiner Creek and Riverside. This phenomemon was particularly evident during the afternoon of 3 May 1979; and, on the morning of 4 May, cranes were seen leaving roosts as far south as Tetlin Lake and crossing the Glenn Highway 15 miles south of Tok. In the Delta Junction area, as in fall, if strong winds (13-18 mph) came SE out of the mountains, migrating cranes tended to shift their route from the south side of the valley, where they were relatively close to the mountains, to a more central portion of the valley--although they did not go as far north as in fall. During the first few days of May 1979, however, unusually high winds of 16-22 mph from the SE apparently pushed the cranes far to the north, where at least 19,000 birds that had crossed the Taylor Highway slipped unseen past the observers at Delta Junction. On the only two days of strong SW winds at Delta in spring, birds also flew along the far north edge of the valley.

FLIGHT CONDITIONS, AND HEIGHT AND FLIGHT SPEED OF MIGRANTS

Flight Conditions

Sandhill Cranes fly under a wide range of weather conditions, but most migration occurs on days with good visibility and high, if any, cloud ceilings. Under some circumstances, however, some cranes will fly during inclement weather. About 400 cranes continued flying in a heavy rainstorm at Mile 1397 Alaska Highway at 14:00 Alaska Standard Time (AST) on 12 September 1977. On 19 September 1977, the day of the heaviest passage that season, it had rained all night at Delta Junction and continued to rain throughout the morning, with overcast at 1500 ft and scattered clouds at 500 ft and lower, yet a massive movement of cranes began about 08:30. Farther east on this same day, at about Mile 14 Taylor Highway, it was foggy and snowing all day, yet 4400 cranes crossed low (400 ft above ground level [AGL]) over the highway between 09:15 and 10:45, apparently birds that had spent the night on roosts in the valleys west of the highway; many more were heard flying above, out of sight, possibly above the clouds. Weather cleared farther south over the upper Tanana River during the morning, and 24,000 cranes were counted

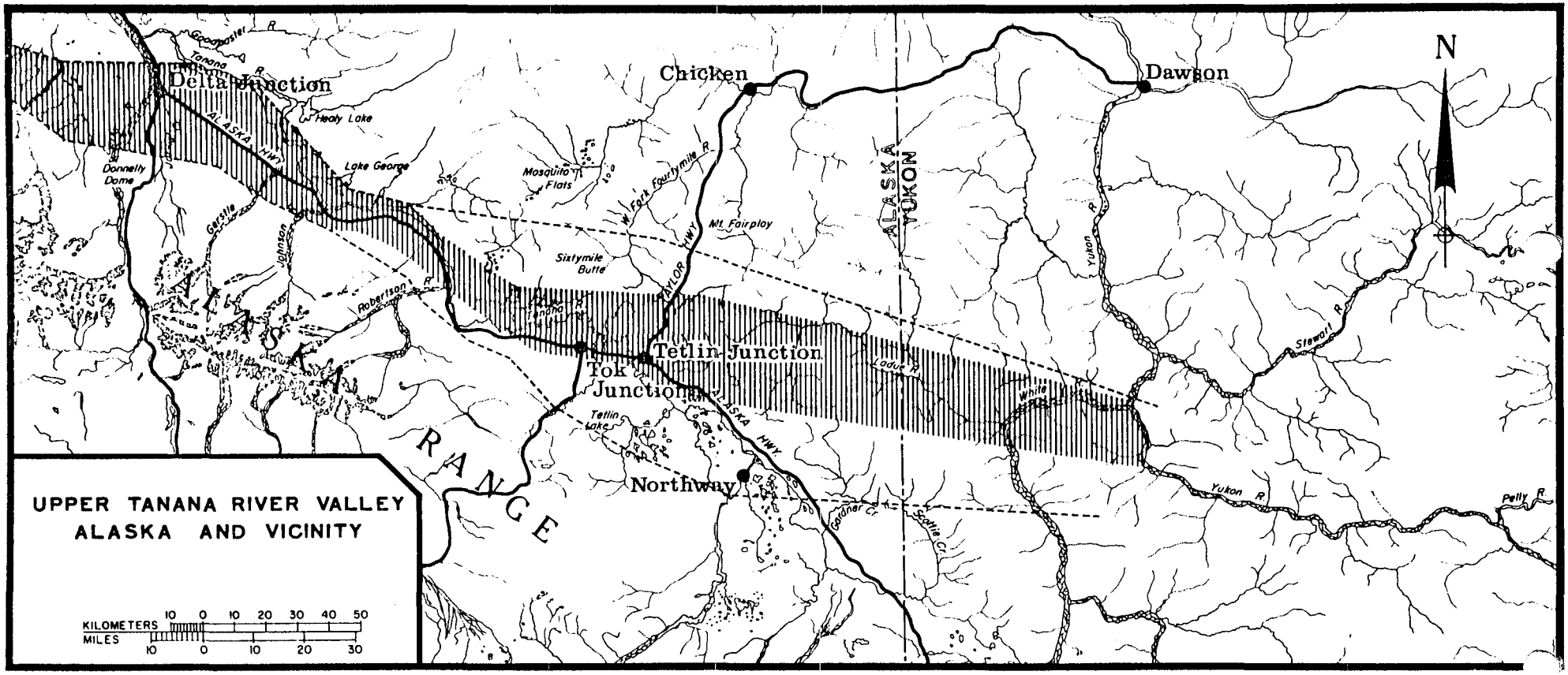

Figure 3. Spring migration pathway of Sandhill Cranes, upper Tanana River Valley, Alaska.

▥▥▥▥▥▥▥▥ Concentration of migrants. ------- Outline of migration pathway.

at Riverside between 09:00 and 19:00, apparently including the birds that had started moving through the Delta area at 08:30.

Again, on 22 September 1977, with snow falling all day and visibility less than .5 miles, at least 2000 cranes passed low north of Donnelly Dome in the Delta area, and 31 cranes flew up the valley past Mile 1392 Alaska Highway in fog and snow. And on 2 May 1978, a flock of 600 birds flew low in fog and rain past the scenic viewpoint at Mile 1344 Alaska Highway, between Cathedral Bluffs and the Robertson River; these birds were obviously following the immediate course of the Tanana River because of the poor visibility, instead of taking the usual cutoff across the bend and over the pass north of Cathedral Bluffs.

In all the above situations, when cranes flew during inclement weather, barometric pressure was rising in areas toward which the cranes were flying; apparently these birds somehow sensed the improved flying conditions ahead and pushed on with their migration.

Cranes do not usually fly in really bad weather, and occasionally bad weather forces flying birds to land (see Ground Utilization below). Poor visibility (primarily fog and snow), heavy rains (but not medium to light rain or drizzle), and strong headwinds (25-35 mph) are most likely to temporarily halt crane migration. Weather conditions along the cranes' migration routes in spring and fall cause flocks to bunch up, and this is the main reason for the variation in numbers of cranes that pass through a location on any given day during migration. The biggest migration days through Delta Junction in both spring and fall occurred after periods of few cranes (see Tables 1 and 2) and with improving weather conditions.

Quartering tail winds, even if light, seemed to have a consistent influence on the route of crane migration through the upper Tanana River Valley. Winds from WNW to NNW over the Tanana-Yukon Highlands in fall and ENE winds in spring caused flight lines to shift southward to the Tanana River Valley, and SW winds in fall pushed cranes farther north than usual (see Migratory Routes, above).

Flight Heights

Most flocks of migrating cranes flew between 1000 and 3000 ft AGL, with the mean flight height somewhat lower in fall than in spring, and lower in bad then good flying weather. In fall, most birds flew between 1000 and 2000 ft AGL, with many flocks flying as low as 500 ft; flight heights in fall seldom exceeded 3000 ft. In spring, heights as high as 3000 ft were common, and few flocks flew lower than 1000 ft--except in early morning and late afternoon near roosting and feeding areas. Until 11 May in spring, flight heights of 4000-6000 ft were recorded on some days, and on 3 days (4-6 May 1979) some flights along the Alaska Range south of Delta Junction were recorded at heights of 7000-8000 ft AGL.

Reasons for the generally higher flight heights in spring compared with fall and for the extremely high flights on some days in early May are unknown, but they may be associated with the unstable patterns of surface winds and updrafts caused by the sharp changes in night-day temperatures at this season and by the temperature differences over

snow-covered vs snow-free surfaces. At these higher altitudes cranes could be avoiding the turbulence caused by the cold, ground level air contacting the warm, upper layers.

Flight Speeds

The normal flight speed of migrating cranes was about 30-35 mph, based on several instances of timing with an automobile speedometer and on six instances of knowing how long it took flocks to cover the distance between Delta Junction and the Taylor Highway or Riverside. Ground speed varied with wind conditions, and flocks were monitored at 55-70 mph with strong tail winds. Flights were correspondingly slowed by head winds, with cranes showing great difficulty in flying against 20-30 mph head winds.

GROUND UTILIZATION

Ground utilization by migrating cranes in the upper Tanana River Valley is limited, being confined primarily to overnight roosting and feeding and to periods of inclement weather. The region is not a staging area, but a constricted passageway through which cranes must pass in spring and fall.

Roosting Sites

Roosting sites used by Sandhill Cranes in the upper Tanana River Valley were characterized by openness, a situation that presumably provides a degree of protection from potential predators. Four basic types of roosts were used: 1) alluvial islands of wide, braided, glacial riverbeds, 2) extensive wet meadows or those at pond, lake, or creek margins, 3) open, low shrub meadows or bogs, and 4) farm fields. Additionally, in spring, some flocks roosted on river aufeis and on the ice of ponds and lakes.

The alluvial islands, surrounded by river channels, seemed to be the preferred roosting habitat, and this habitat was used wherever its presence coincided with appropriate roosting times. In fact, there were indications that migrants stopped earlier in fall in the vicinity of the preferred Delta River roost than farther east where cranes overflew shrub bogs and wet meadows (see below). The farm field habitat was the least used for roosting and was used less in fall (hunters?) than in spring. Instead, most overnighting cranes fed on the fields in the evening and morning, but roosted on river bars within 6-8 miles. Occasionally, however, a few birds spent the night on the farm fields near Delta Junction; and, early on 10 May 1979, 400 overnighting cranes were seen in a large, newly-cleared field of the Delta Barley Project. They roosted on the exposed soil beside small snow-melt ponds, between the piled rows of cleared trees.

There were several major roost areas in the region and a number of lesser roost sites. The utilization of these sites from night to night during spring and fall migration varied with the size of the day's passage and with the general routing of this passage through the region (for variations see Tables 1 and 2 and Figs. 2 and 3).

The most important roost, i.e., used most consistently and by large numbers of cranes (> 5,000), was that provided by the braided bed of the Delta River from roughly west of Donnelly Dome (~63°45' N) to its junction with the Tanana River (~64°09' N). The braided riverbed of the White River, Y.T., appeared to provide an equally important roosting area, perhaps the next "preferred" site east of the Delta River.

Two other major sites were Mosquito Flats, at the headwaters of the Mosquito Fork of the Fortymile River, and the Tanana River flats from south of Tetlin Junction to Riverside and perhaps as far south as the Tetlin lakes area (see Fig. 4 and Appendix). Of only slightly less significance, especially in spring, were riverbar roosts on the Tanana River east of Clearwater Lake (approx. 145°20' W), on the Gerstle River both above and below the Alaska Highway bridge, on the upper Johnson River, and on the Tanana River near the mouth of the Johnson River.

A number of lesser roosting sites were identified along the Tanana River Valley and in the drainages of the Tanana-Yukon Highlands (Fig. 4 and Appendix).

Daily Times of Ground Use

Sandhill Cranes are primarily daylight migrants, with almost all of their activity occurring between the beginning of Civil Twilight* in the morning and the ending of Civil Twilight in the evening. Occasionally, however, migratory movement may continue after dark.

During the September migration period, apparently under constraints of daylight (see Table 3), cranes seldom began to leave their roosting sites before 05:00 AST--essentially at sunrise in early September but barely light enough for vision at the beginning of Civil Twilight in late September. Often, however, for no evident reason, flocks would not begin to vacate roosts until 06:00-06:30, or sometimes even 07:00 or 8:00 AST. Weather conditions may further delay roost departures. Flocks usually would remain at roosts until morning ground fog had dissipated, which sometimes was as late as 10:00. Departure was also delayed for several hours under conditions of strong winds. On 12 September 1978, when winds were from the east at 20-30 mph, cranes did not begin to leave the Delta River bars until 09:00, and they had so much difficulty flying against the winds, especially the 40 mph gusts, that they landed on the farm fields east of the roost. On 18 September 1978, with 14 mph ESE winds (headwinds), roosts on the Delta River did not begin to break up until 08:30, and a roost of 2000 birds from Jarvis Creek did not leave until 11:00.

Except when environmental conditions have delayed departure, birds usually leave the roost gradually. Birds may remain at the roost for an hour or more after awakening--stretching, preening, "dancing," and apparently feeding. Then the exodus itself may continue for an hour, with some birds leaving to continue their migration directly and some flying to nearby sites (river edges or nearby farms) to feed 15-75 minutes before beginning the day's flight.

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*Sun at 6° below the horizon at sea level, providing just enough light for human, and presumably crane vision.

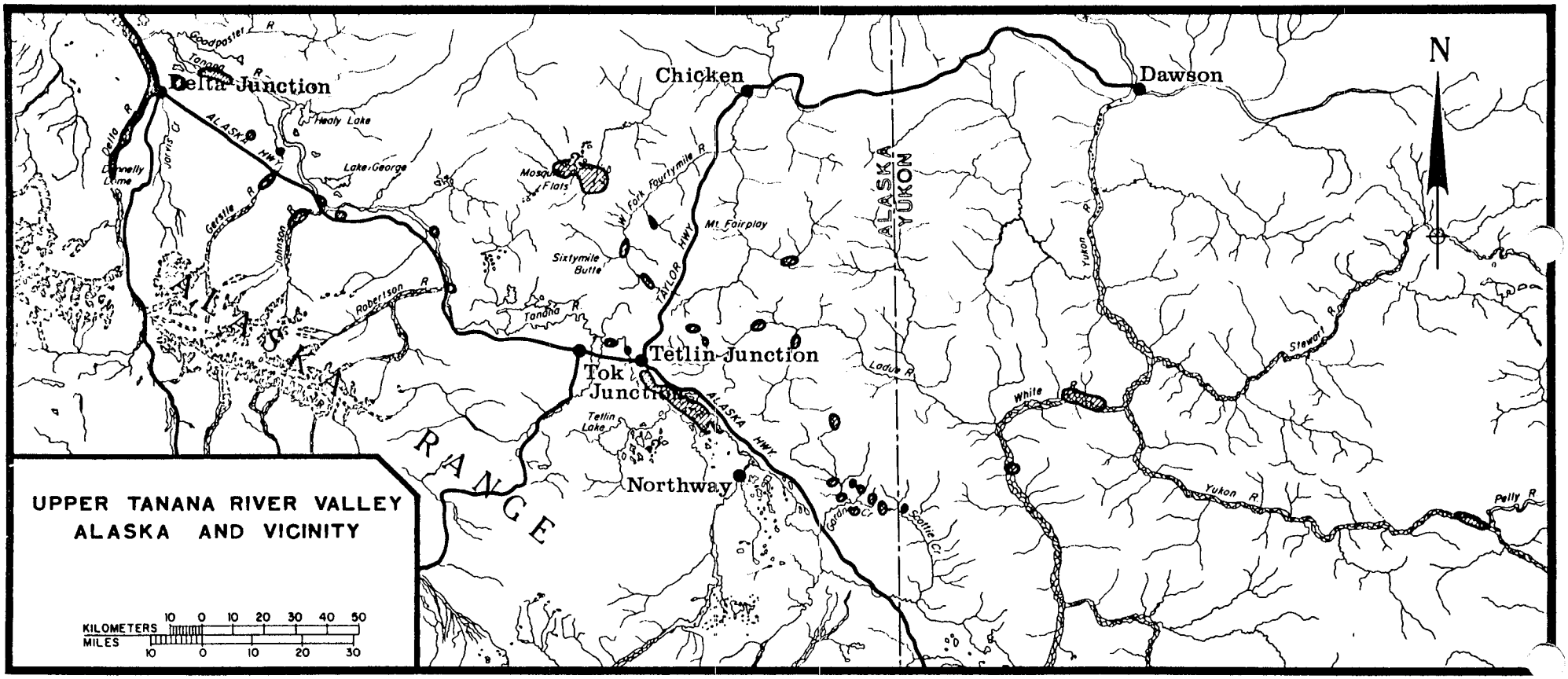

Figure 4. Sandhill Crane roosting sites observed 1976-79, upper Tanana River Valley and vicinity.

Aside from the daily light cycle, the time of evening roosting seems dependent in large part upon the proximity of a suitable roosting site after about 14:30 AST. Birds sometimes landed to feed on farm fields as early as 14:30, and several times birds were seen settling on roosts on the Delta River at 15:00-15:30 (once, on 25 September 1976, at 14:35 in strong winds). Most often, however, birds in the Delta area went to roost between 16:00 and sunset (about 18:00). Farther east, the birds often continued to fly 1.0 to 1.5 hrs later in the evening than at Delta. For example, on 17 September 1978, the last birds settled on the Delta River at 16:00, whereas a steady passage continued over Mile 27 Taylor Highway until 17:10, and the last flock set down on a branch of the West Fork of the Dennison River at 17:30. Similarly, on 18 September 1978, migration ceased at Delta at 15:00, with birds entering the Delta River roost 15:00-15:20, but flocks were still entering the Mosquito Flats roost at 16:05 and were still crossing the Taylor Highway at 17:05-17:15. On 18 September 1977, cranes stopped passing through Delta at 14:15 but continued over the Taylor Highway until 17:35. On 21 and 22 September 1978, migration at Delta stopped at 16:40 and 16:50, respectively, whereas flocks flew over the Tetlin Junction area at 18:35 and 18:45 on 21 September and crossed Mile 20 Taylor Highway at 18:00 and 18:07 on 22 September.

The difference in roosting times in fall between Delta Junction and the upper Tanana River-Taylor Highway area suggests the possibility that the Delta River is a preferred roosting area, with cranes stopping there even if they arrive as early as 14:30. The next "preferred" site, with the possible exception of Mosquito Flats and the Tanana River flats between Tetlin Junction and Riverside, appears to be the braided glacial bed of the White River in Yukon Territory. Perhaps birds that pass the Delta River too early for roosting "try" to reach either the Mosquito Flats or the White River before dark, putting down on secondary roost sites (various forks of the Fortymile River, Ladue River, Gardiner Creek Flats, sandbars of the Tanana River, etc.) if darkness overtakes them. This hypothesis is further substantiated by observations on 18 September 1977, when cranes stopped moving through Delta at 14:15, but large numbers of incoming cranes put down on the Delta River bars as late as 18:30.

During spring migration, daylengths are so long at the latitude of the upper Tanana River Valley (see Table 3) that daylight is not the constraining influence that it is in fall; and, hence, times of leaving and entering roosts are more variable.

Most frequently in spring, cranes did not leave their roosts before 05:30-06:00 AST. On 8 May 1978, however, 450 cranes gradually left a Delta River roost from 04:00 to 04:30 and appeared to head to local farm fields to feed*; and, on 11 and 12 May 1979, several small groups of cranes were heard passing over the Clearwater State Campground between 03:00 and 03:30--birds that seemed most likely to have come off the Tanana River bars just east of the campground (the last flights over the Taylor Highway the preceding evenings had been 17:15 and 19:05, respectively, with no evidence of night flights), and were probably headed for the

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*The last 500 birds left this roost at 07:10 and headed WNW down the Tanana River Valley on migration.

Table 3. Times of official sunrise, sunset, beginning of morning Civil Twilight, and ending of evening Civil Twilight in the upper Tanana River Valley, Alaska (mean latitude of 63°30' N). Exact local times vary slightly with altitude, which varies from 1000 to 3000+ ft in the region, and with the proximity and height of hills and mountains.

Day	Alaska Standard Time			
	Morning		Evening	
	Civil Twilight*	Sunrise	Sunset	Civil Twilight*
9 September	04:17	05:06	18:47	19:36
17 September	04:42	05:29	18:19	19:06
23 September	04:59	05:45	17:58	18:44
1 May	01:51	03:38	20:19	22:05
7 May	01:23	03:20	20:37	22:33
13 May	00:51	02:59	20:56	23:05

*Sun 6° below horizon at sea level

farm fields along Remington Road. The most frequent hour of the day for actual migration to get underway was between 06:10 and 07:30, either directly from roosts or after feeding in nearby fields and meadows. Occasionally, some birds would continue to arrive at feeding fields as late as 08:30 and not leave on migration until after 09:30 (groups left Delta Junction fields at 08:58 and 09:40 on 11 May 1979).

As in fall, some roosts did not break up until much later in the morning than usual. On 2 May 1978, 385 cranes left the river bars of the upper Gerstle River in small flocks between 08:40 and 09:05, and on 5 May 1978, about 1900 birds in several flocks appeared to be rising off a roost in the flats of the Tanana River south of Tetlin Junction at 10:00-10:10.

In the evening during spring migration, some migrating birds were seen dropping into the farm fields at Delta Junction to feed as early as 14:00 to 15:00, but more frequently they did not stop until between 18:00 and 19:00. Observations of actual roosting times in spring were few, but cranes were seen entering roosts between 17:00 and 21:15.

Occasionally, cranes continue to migrate after dark, a phenomenon recorded six times during the fall:

19 September 1977--Flocks of several hundred cranes flew just north of Riverside at 19:00 and 20:00 on a clear night.

22 September 1977--After dark, and during a snowstorm that had lasted all day, cranes were heard passing over Riverside as late as 20:00 and 21:00.

14 September 1978--Cranes were heard at Delta Junction as late as 21:00 and later and again between 04:30-05:50 the following morning--perhaps having flown all night.

15 September 1978--Cranes, on a clear, calm, near-full moon night after a major passage, were heard at Delta at 21:00 and later at 19 Mile Taylor Highway at 21:15.

16 September 1978--Migration continued at least until 19:20 near Tetlin Junction.

6 October 1978--About 25 cranes were heard flying over Mile 3 Stampede Trail (N of Healy on the Parks Highway) during the night.

With the long daylight hours during spring migration, flying into the "night" hours was more frequent than in fall. On the nights of 30 April and 1, 2 and 4 May 1979, small flocks passed over the Taylor Highway until 23:00; and on 6 May 1978 and 9 May 1979, cranes flew over the Clearwater campground at Delta Junction as late as 22:00 and 21:45, respectively. On 5 May 1979 and 8 May 1979, at 02:00 and 03:30, respectively, small flocks were heard passing over the camp at Mile 13.5 Taylor Highway.

Occasionally, inclement weather during the day caused migrating cranes to land to await better flying conditions. On 19 September 1978, a weather front carrying snow worked its way westward up the valley of the Ladue River between 07:45 and 09:45. By 10:15 it was raining and fog had formed. A few cranes struggled eastward across the Taylor Highway during the morning, but at 11:40 a flock of 1000 birds wheeled

as it came up over the Taylor Highway ridge and returned westward and settled in a valley bottom of a branch of the West Fork of the Fortymile River. On this same day at Delta Junction, even though it looked like a good flying morning, migrants coming in from the west began setting down on the Delta River in mid-morning--apparently sensing the bad weather approaching from the east, even though the rain did not reach Delta until noon.

On 20 September 1978, during an all day snow storm, four cranes were found sitting on the Taylor Highway itself at 09:10, and a flock of 20 birds landed on an alpine shoulder of Mt. Fairplay and apparently proceeded to feed on the root stocks of the lousewort, Pedicularis labradorica.

On 1 May 1978 an all-day passage of over 26,000 cranes through the Delta Junction area was temporarily halted by storm clouds and heavy rains. The cranes shifted their route as the storm moved in at 13:00 and the winds changed from 5-8 mph ESE to 15-20 mph NE; and, as the storm filled the valley, the birds dropped low and eventually landed on the farm fields along Remington Road. The weather began clearing at 18:00, and at 19:00 many of the grounded birds took off again on their westward migration.

Even in good flying weather, especially in spring, a few cranes may occasionally drop down during the day to feed on farm fields. On 7 May 1978, for example, there was a slow turnover of cranes using the Remington Road fields throughout the day, but there were fewer than 200 cranes on the ground at any one time, compared to a day-long passage of over 35,000 cranes.

REACTION TO HUMAN ACTIVITIES

A number of factors, in addition to inherent species characteristics, may affect the responses of birds to unusual or potentially threatening incidents. Responses may differ with varying characteristics of the stimulus, such as strength, frequency, regularity, suddenness, etc., or they may differ with the experience of the individual bird or group of birds affected. The time of day, the condition of the bird(s), and its predisposition will also affect responses, as may flock size.

Immediate, overt responses are readily observed, and these form the basis of the following discussion. It is extremely difficult to obtain information about possible delayed reactions, possible subtle effects such as on the nervous system, or on possible long-term accumulation of effects; but, based on current knowledge, this type of information does not seem necessary for adequate protection of Sandhill Crane populations in Alaska.

Inherently, while constantly alert to potential dangers in its surroundings, the Sandhill Crane does not frighten easily. It appears to be a reasonably adaptable bird, habituating to new stimuli that are not associated with unpleasant or harmful experiences. It is fairly tolerant, for instance, of routine human activities, such as the uniform

movement of aircraft and highway traffic, but less tolerant of stopping vehicles, of people on foot, or of the sound of gunfire. Characteristically, responses to disturbance are brief, with flocks quickly resuming whatever their activity as soon as the disrupting stimulus ceases.

During the course of this study, field observers monitored reactions of cranes to over 115 potentially disturbing events--75+ with aircraft, 25+ with highway vehicles, and 15+ with other stimuli. Observations were made primarily on a fortuitous basis, both by field crews alert to developing potential interactions as cranes roosted, fed, or flew near observation points and by observing reactions of cranes to highway vehicles and aircraft used in gathering information on roosting sites and migration flight paths.

Aircraft vs Flying Cranes

Flying cranes were most reactive to aircraft approaching them in a head-on direction at the same altitude. A PA-18 Supercub under this situation stressed flocks sufficiently at 1000 to 1500 ft to cause them to break up, reverse direction, etc. A Cessna 185 caused one flock to reverse direction while still at a distance of 1800-2500 ft. On the other hand, a flock showed no response to a single-engined plane that approached from a head-on direction, but was 200 ft higher and 600 ft to one side of the flock.

Cranes were most tolerant of aircraft either above, below, or behind them. Flocks tolerated a Supercub up to 300 ft from above and to within 100-150 ft from below without visible stress. A Cessna 185-type plane passed 250-300 ft below and at a 1300 ft horizontal distance from 150 circling cranes without disturbing them, and a large military plane passed 500 ft below and 2600 ft horizontally from 500 cranes without causing a visible response. A flock of 30 cranes, flying at 300 ft AGL, swerved as a small plane took off beneath them, but almost immediately resumed its original flight path.

With approaches from behind, a Supercub several times approached to within 150 ft before the birds began to deflect their flight line slightly to one side. On one heavy flight day, however, when flocks were reported as being "spookier" than usual, flocks began to deflect when a Supercub got to within 700-800 ft from behind.

On lateral approaches, 500 ft seemed to be a common threshold distance for crane responses. On numerous occasions, cranes showed no visible reaction to small planes at a horizontal distance of 500-700 ft At one time, 60 birds never broke formation when a Supercub approached as close as 200 ft, although they gradually turned away from the plane. On another occasion, however, a flock of 500 cranes shied from a Supercub at 300 ft as it was being overtaken. Several observers reported cranes reacting to small planes as far away as 1300 ft (1/4 mile), but the direction of approach relative to the flock was not recorded; in at least one instance, the plane was circling for a landing.

Cranes appeared to respond at greater distances to large, noisy fixed-wing aircraft and to helicopters, although observed incidents were

few and the type of helicopter made a considerable difference. A Grumman Goose at 1.5 miles was possibly the cause of about 500 cranes turning and circling for about a minute, until the sound of the plane receded. A flock of 20 cranes broke formation and changed direction when they got to within about 1 mile of two Cobra helicopters that were preparing for take-off. Another group circled 180° away from a helicopter (type not recorded) as it approached to within 1500-2500 ft. A flock at 1000 ft AGL showed no response to a helicopter 700 ft below and slightly to one side, but veered away when approached by a helicopter taking off. On the other hand, a flock at 150-200 ft AGL showed no response to a helicopter taking off over 1000 ft from its path; a swirling flock at 2000 ft AGL showed no visible reaction to a helicopter that passed 1000 ft beneath it at about 0.5 mile horizontal distance; and a flock did not react to a helicopter 1500 ft beneath it that was coming in for a landing.

A few observations suggested that large flocks (>400 birds) may be more sensitive to aircraft than small flocks (<25 birds).

Aircraft vs Roosting or Feeding Cranes

Cranes on the ground were fairly tolerant of aircraft passing over them, being perhaps a bit less sensitive when they were roosting on the gravel islands of river beds than when roosting on aufeis, in upland boggy areas, or in open fields. They may also be somewhat less sensitive after they have settled on a roost at the end of a flying day than in the morning when they are awakening to a new day.

A frequent threshold distance for discernible crane responses to overflying aircraft seemed to be about 500 ft AGL. On at least seven occasions, small planes passed over cranes at an estimated 500 ft AGL without causing overt reactions. In several other incidents at this height, the birds looked upward or showed some signs of nervousness, but did not flush. In two instances, cranes on sandbar island roosts in early morning tolerated even closer approach by a Cessna 172: a group of 400 birds showed no reaction when circled at 300-400 ft; and a group of over 2000 birds circled by the plane twice at 200-300 ft showed no reaction, but flushed for a short distance when the plane got down to 100 ft. Mostly, however, when aircraft approached ground flocks at elevations of less than 500 ft AGL, part or all of the birds flushed--although they almost invariably settled down again as soon as the disturbing aircraft had gotten 500-700 ft away from the flock.

In some instances, flocks or parts of flocks flushed as small planes overflew them at 500 ft or at greater heights. One flock of 575 birds rose temporarily from a riverbar when a Cessna 185, flying at 500 ft AGL, got within a distance of 1300 ft, and 100 cranes on a gravel bar flushed at 2600 ft from a Cessna 172 flying at 150 ft AGL. Three instances were recorded in which some or all birds flushed in the morning from upland bog roosts when small planes (Cessna 172, Cessna 185, PA-18 Supercub) approached to within 1300-1800 ft (1/4 - 1/3 miles), but all quickly settled again (at other times, bog roosts did not react to planes at 500 ft). In the only two encounters with cranes roosting on

ice or snow, one flock of 75 on the Gerstle River flushed briefly from aufeis when a Cessna 172 was 1000 ft away and a flock of 175 on a snow-covered sandbar of the Tanana River flew from a Helio-courier at a distance of 1800-2600 ft.

Again, cranes on the ground were more reactive to larger planes and to helicopters. Two groups of cranes on a riverbar roost showed stress, but did not flush, when a Grumman Goose flew over them at 800 ft AGL. Several hundred cranes (=25% of roost) were flushed off river sandbars by a noisy Piasecki H-21 helicopter flying at 500 ft AGL; a helicopter (size not recorded) flushed a flock of 50 cranes from beside a pond when 1300 ft away at 250-300 ft AGL; but a Bell Ranger-type (fairly quiet) helicopter did not appear to affect this latter flock as it passed at a horizontal distance of 2000 ft and at 800 ft AGL.

Ground Traffic vs Flying Cranes

Flying cranes were reasonably tolerant of ground activities beneath them, concordant with their relative tolerance for aircraft activity below them (see above). Although cranes of a flock at 1000 ft AGL were aware of a stopped vehicle on the Taylor Highway and observers standing alongside (they turned their heads and looked down, but did not deviate their flight pattern), 500 ft AGL is, again, something of a threshold distance for disturbance reactions. Three instances occurred in which flocks flying at 400 and 500 ft AGL changed flight paths either as an observer stepped out of a vehicle beneath them or when a truck passed under them. On the other hand, a flight of 815 cranes in six flocks, flying at 400 and 500 ft AGL in and out of a low ceiling of clouds and drizzle, showed no visible response to the traffic at the Tok intersection nor to people who came out of local buildings to view them; a flock of 125 cranes flew, in rain and sleet, directly over a stopped vehicle on the Taylor Highway at 500 ft just as the observers got out of the vehicle, and they showed no overt reaction; and a flock of 250 cranes at 200 ft AGL did not react when a car door opened beneath them and the driver got out and waved his arms.

Cranes crossing the narrow, unpaved Taylor Highway at heights of less than 400 ft AGL almost invariably shied or veered sharply if their route was intercepted by vehicles moving along the road below them. This type of response was observed in flocks of 50 to 200 birds flying at heights of 75-100 ft, 200 ft, and 250-300 feet. Such disturbed flocks crossed the road immediately after vehicles had passed or increased their height to 400-500 ft and then crossed the road. Twice, portions of these disturbed flocks swept across the highway directly over vehicles at 300 ft AGL, perhaps seeing them too late to react as they flew over the spruce forests bordering the road.

Highway Vehicles vs Cranes on Ground

Responses of cranes to moving vehicles varied with noisiness of the vehicle and the consistency of its movement as well as the distance and

visibility to the cranes. Also, accommodation to repeated, non-harmful stimuli was evident in cranes that remained at a locality for any length of time.

Generally, automobile and light truck highway traffic 600-1000 ft away seldom caused a response from feeding/resting cranes. A noisy farm combine-machine on a highway, however, caused cranes at about 1300 ft to show "alert" reactions; and a stopping vehicle caused four cranes at 1000 ft to walk away.

At distances of 500-600 ft and closer, reactions varied more, depending on the type of stimulus and the degree of habituation of the cranes. A flock of 55 feeding birds flushed as a car motor started 500-600 ft away; and 17 feeding birds stopped and watched a pickup pass at 500 ft on a farm road, and, when the pickup went past the other way 15 minutes later, the cranes stopped feeding and slowly stepped away. One group of 1000 cranes was undisturbed by a pickup passing at 400 ft along a farm road, whereas two other instances occurred where birds were flushed at this distance--one by a loud pickup and the other by a big jeep hauling a mechanical crane. One group of four birds tolerated a slow-moving vehicle that passed within 300 ft, but showed stress reactions of flapping wings and hopping.

Gunfire and Other Ground Disturbances

Invariably, cranes responded strongly to the sound of gun shots. Birds on open fields flushed at distances greater than 1500-2000 ft, although often we were unable to determine the exact location from which the shots were fired, and birds usually left the immediate area--instead of resettling as they do when most other disturbing stimuli cease. A flock of 450 cranes, flying at 500 ft, milled and spiralled upward to 1500 ft when hunters opened fire on them; they then continued their migration flight path at 1500 ft. Another group of 250 birds, flying at 1000 ft, veered sharply upward and slightly aside as a hunter shot at them and then continued on their way.

A group of 130 cranes roosting on sandbar islands of the Delta River reacted to the beginning of activities at a riverside gravel yard, 2000 ft away. When heavy equipment (large caterpillar tractors and big belly-dump trucks) was started at 04:30, the noise seemed very loud in the quiet of the early morning, and the cranes awoke and gradually and unhurriedly worked their way another 1000 ft farther across the braided river from the noise.

Horseback riders rode along a farm road within 200-250 ft of feeding cranes, causing stress displacement behavior (flapping wings, running from road, etc.), but no flight.

A group of 42 feeding birds flushed at about 1300 ft in mid-May, when a man, with no attempt at concealment, walked toward them across an open field.

Cranes tolerated a working farm tractor at 700-800 ft in early May, but they remained alert and gradually moved away from it as they fed.

Habituation

Several instances of accommodation to potentially disturbing events were noted during the study.

On farm fields at Delta Junction, a small flock of summer resident cranes in 1979 accustomed themselves to the farming activities. On 25 May, 40 birds were alert and cautious, but did not flush, when they found themselves 200 ft from a working farm tractor on one side and 200 ft from a slow-moving vehicle 180° to the other side. This same group of cranes also became adjusted to the local cows and horses, including frisky, galloping behavior, and got so that by late June a cautious man on foot could come within 150-200 ft of them.

A small group of cranes near Fairbanks in 1978 habituated to regular traffic along a paved road to the extent that they continued to feed only 100-150 ft from passing cars; they showed alert reactions, however, if vehicles changed speeds, and they moved away if vehicles stopped.

SUMMARY AND CONCLUSIONS

More than 150,000 to 200,000 Sandhill Cranes migrate through the upper Tanana River Valley, Alaska, during September and May each year. These cranes comprise about 60% of the world's Sandhill Crane population, and they truly represent an international population. They summer in interior and western Alaska and eastern Siberia, winter in western Texas-eastern New Mexico and northern Mexico, and migrate spring and fall via the North American Central Flyway.

Generally, crane migration occurs in the upper Tanana River Valley from the last week of August to the first week of October, and from the last week of April to the middle of May. Flights in the region are strongly influenced by weather, which may cause annual variations of as much as 5 to 7 days in the timing of migration and which affects daily flight and roosting times, flight heights and speeds, and the exact route followed. Severe weather may even temporarily halt migration, causing flocks to bunch up, so that migration often occurs in pulses, with some days during the main migration period having tremendous flights and others almost none. During the peak of migration (13-24 September and 1-12 May), as many as 10,000 to 50,000 cranes may be expected to migrate through the region on any given day.

Sandhill Cranes are primarily daylight migrants, although occasionally they fly after dark. Likewise, they are primarily fair-weather migrants, but a few sometimes fly through inclement weather to better weather ahead. Most migration occurs between 1000 and 3000 ft AGL, averaging somewhat lower in fall than spring and somewhat lower in bad flying weather than good. During early May, cranes may fly as high as 8000 ft AGL. Migration flight speed is 30-35 mph, with actual ground speeds being faster with tail winds and slower with head winds.

Ground utilization by migrating cranes in the upper Tanana River Valley is confined primarily to overnight roosting and feeding and to periods of bad weather. Birds may enter roosts any time after about 14:30 AST and leave any time from the beginning of daylight to 11:00.

Cranes select open areas for roosting, and seem to prefer the alluvial islands of wide, braided riverbeds. The Delta River and White River appear to be "preferred" roosting sites, and possibly, also, Mosquito Flats and the Tanana River lowlands between Tetlin Junction and Riverside. The amount of use a roosting site receives on any given night depends in large part on the number of cranes moving through the region on that particular day and whether or not flight lines that day bring them into the proximity of a given roost during mid- to late afternoon.

Cranes are relatively tolerant of potential environmental disturbances. While a number of factors affect the reaction responses of Sandhill Cranes, 500 ft seems to be a frequent minimum threshold distance at which most cranes will tolerate a wide range of human activities. Under some circumstances, especially with habituation, closer activities will be tolerated. Under more stressful stimuli (loud aircraft and noisy vehicles and equipment, head-on approaches of aircraft, gunshots, stopping vehicles, or people on foot), cranes react at greater distances. One-fourth mile (1300 ft) is a frequent reaction distance for these more stressful stimuli, although some reactions occur at horizontal distances of 0.5 mile (2600 ft) and a few perhaps farther (1+ mile with Cobra helicopters and Grumman Goose). It is noteworthy that the growing population of the Big Delta-Delta Junction area (currently about 4000 people) and the considerable aircraft activity generated by this population and nearby Ft. Greely (airfield active since World War II) does not seem to have adversely affected Alaska crane populations or even to have caused them to alter their flight path to avoid flying directly over these centers of human activity.

RECOMMENDATIONS

The following recommendations for the management of construction activities vis à vis migrating cranes are derived from the data presented above. Cranes using the Tetlin-Northway Wetlands, either for roosting or breeding, are covered under earlier recommendations submitted with the final report, "Wetland bird populations in the upper Tanana River Valley, Alaska," December 1977.

1. Prevent alteration of habitat at crane roosting sites. Avoid mining or other wise disturbing river gravel from known or potential riverbar roosts on the Delta, Tanana, Gerstle, Johnson, and Robertson rivers. (Little is known about riverbar roost site characteristics required by cranes, so protection of current sites is the only safe approach at this time.)
2. Be especially alert to possible disturbance interactions with Sandhill Cranes between 29 April and 15 May and between 5 and 26 Spetember. These are the periods of main migratory movement through this region.
3. Avoid disturbances at sites of ground utilization (roosting and feeding sites) while they are occupied by cranes. The following disturbance restrictions are recommended:

a. Maintain a minimum above ground level height of 1000 ft for small, fixed-winged aircraft.
b. Maintain a minimum above ground level height of 1500 ft for helicopters and other noisy aircraft.
c. Maintain a minimum horizontal buffer zone of 0.5 miles for moderate ground disturbances near roosts (e.g., starting and stopping of automobiles and light trucks, pedestrian traffic, etc.).
d. Maintain a minimum horizontal buffer zone of 0.75 miles for operation of big, noisy construction equipment.
e. Blasting even beyond 1 mile of an occupied crane roost should be avoided, as should blasting when migrating cranes are flying overhead or close by.

Such avoidance stipulations could be put into effect throughout the region throughout the main migratory periods or could be more finely tuned in the field by a monitoring program designed to determine the actual time of use of a particular roost, i.e., which nights and at what hours (see Recommendation No. 5).

4. Aircraft pilots must remain alert to the possibility of flocks of cranes, flying between 500 and 3500+ ft AGL (to 6000+ ft in early May), in the region during the migratory periods, both for their own safety and to avoid harassment of the cranes. Avoid approaching a flying flock head-on at the same altitude any closer than 0.5 miles. From any other direction, avoid approaches closer than 0.25 miles (approx. 1300 ft). Helicopters and other especially noisy aircraft should give flying cranes a wider berth of at least 0.5 miles in any direction.
5. If, under specific situations, these recommendations prove unduly restrictive, variances could be considered based on results of a field monitoring program. Since the number of migrants, specific routes used, and degree of roost utilization vary from day to day during migration, transitory disturbances could be allowed under careful supervision when cranes are not in the area of disturbance. Detailed monitoring, however, should not be necessary unless such variance requests are anticipated.

ACKNOWLEDGMENTS

Special thanks are due the more than 15 field assistants that participated in the gathering of the field data for this report. Stephen O. MacDonald, University of Alaska Museum, and Michael A. Spindler, currently U.S. Fish and Wildlife Service, deserve special mention because of their leadership in field activities and their significant contributions to data interpretation. Additional data were contributed by a number of local residents of the study area--including staff of the Alaska Department of Fish and Game and the Alaska Department of Natural Resources, Delta, and the U.S. Bureau of Land Management, Tanacross--and by Robert J. Ritchie, Alaska Biological Research, Fairbanks.

Appreciation is hereby expressed to the OHM Corporation for permission to use a site on their Remington Road farm at Delta Junction for an observation site and to the U.S. Army, Ft. Greely, for their cooperation in the use of a lookout tower on the military base. Fortymile Air, Tanacross, provided outstanding service to the field crews throughout the study. And the FAA staff at both the Delta and Northway facilities were most helpful in providing us with weather data and related information.

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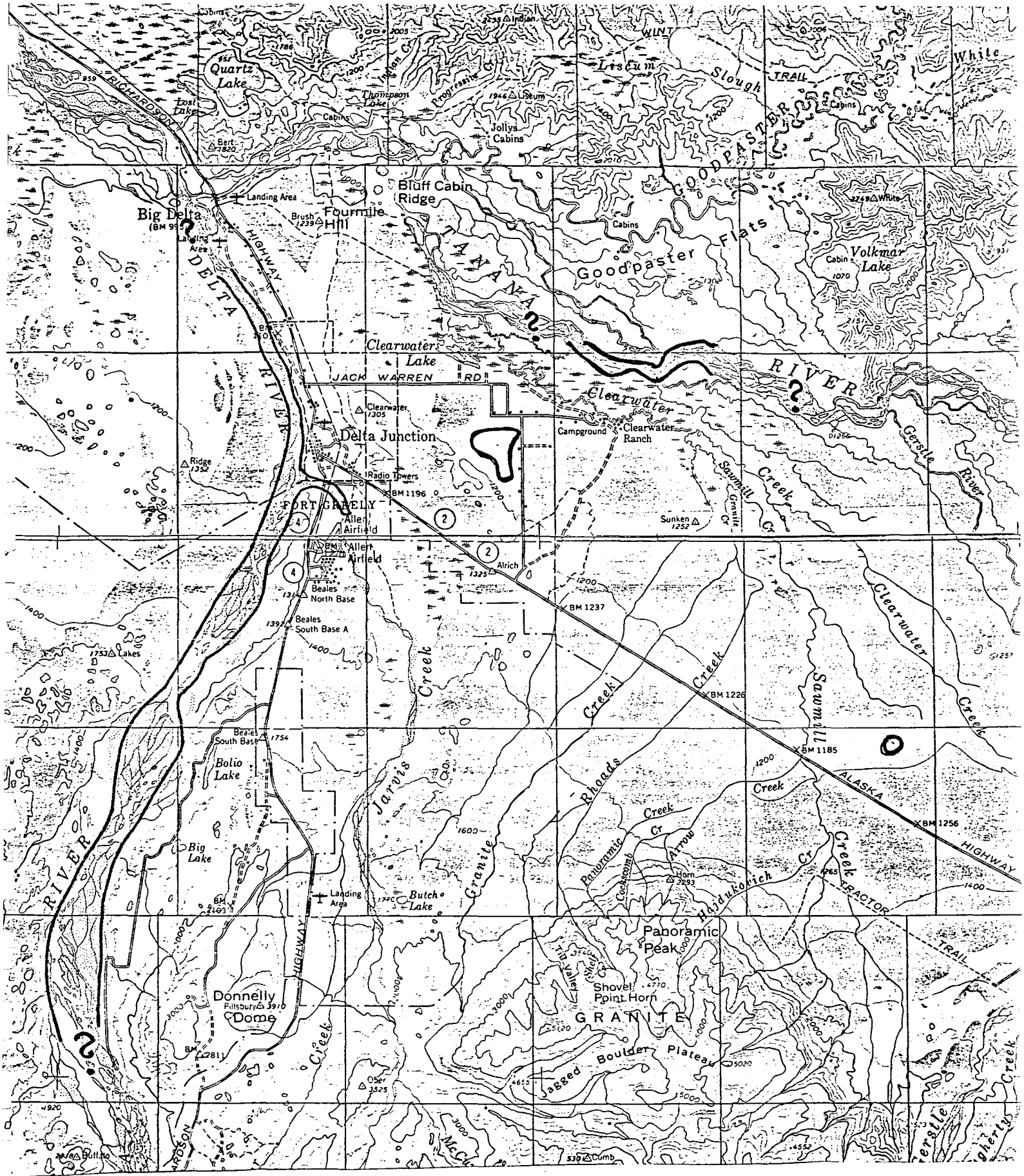
A P P E N D I X

Large scale maps of Sandhill Crane roosting sites observed 1976-1979, upper Tanana River Valley and vicinity. Scale 1:250,000 / 1 inch = 4 miles.



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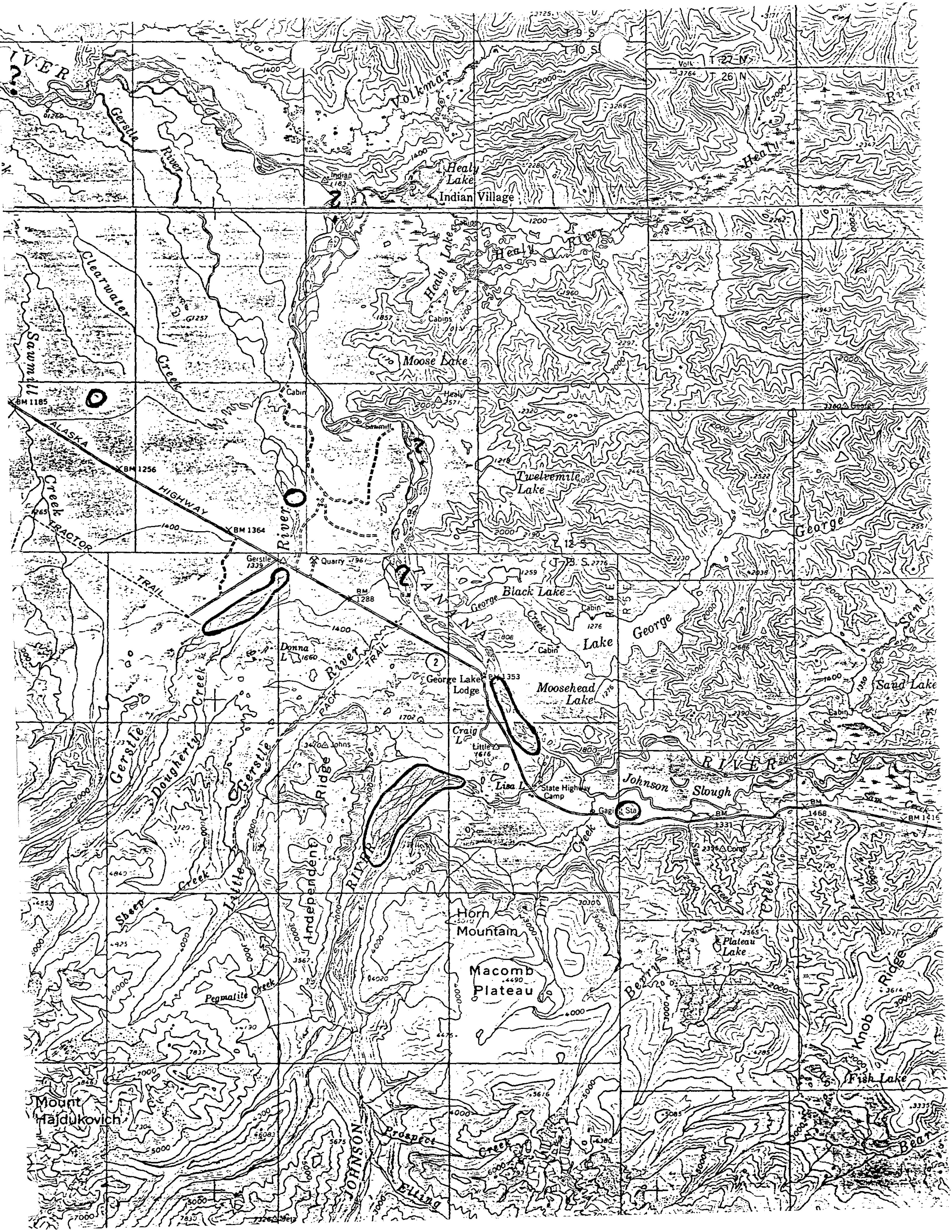
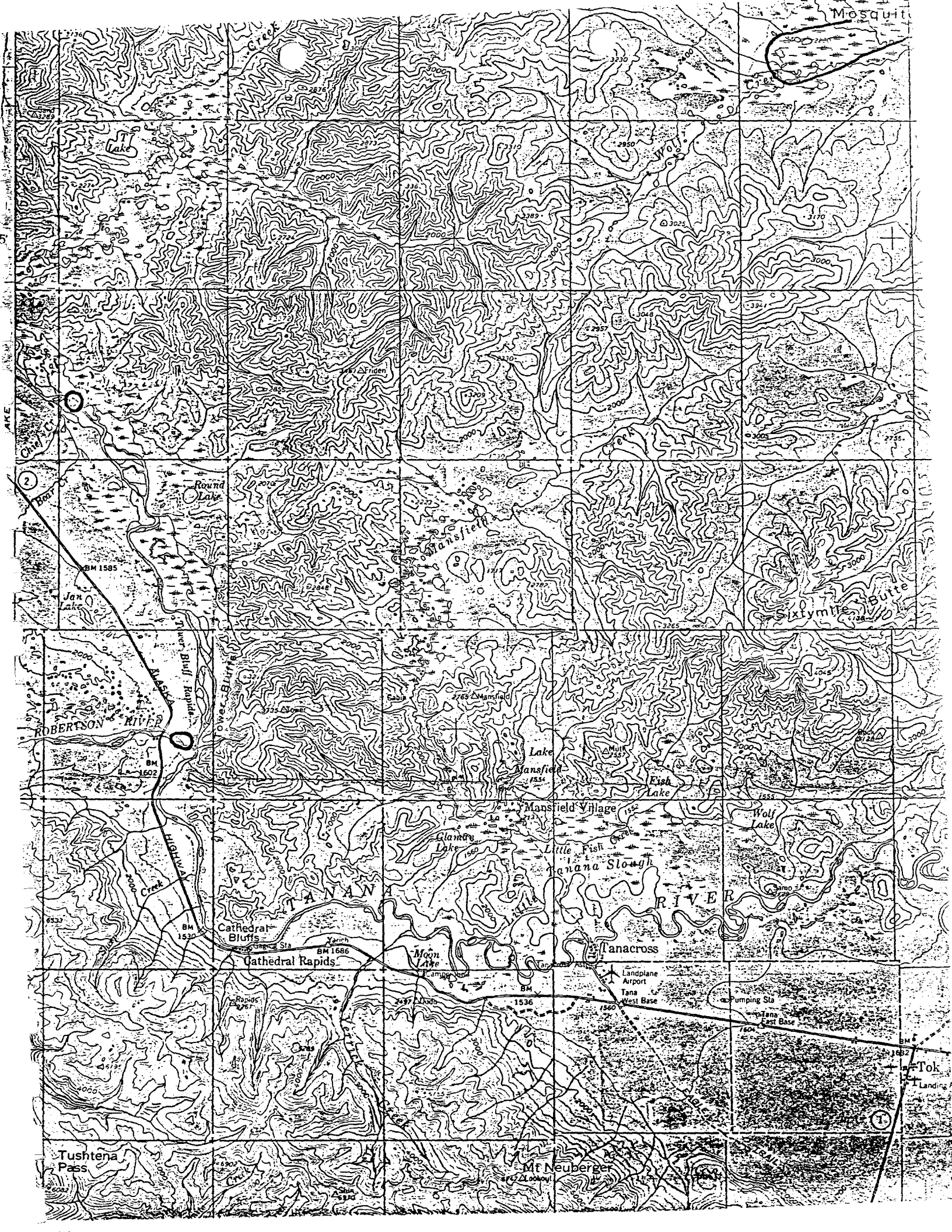
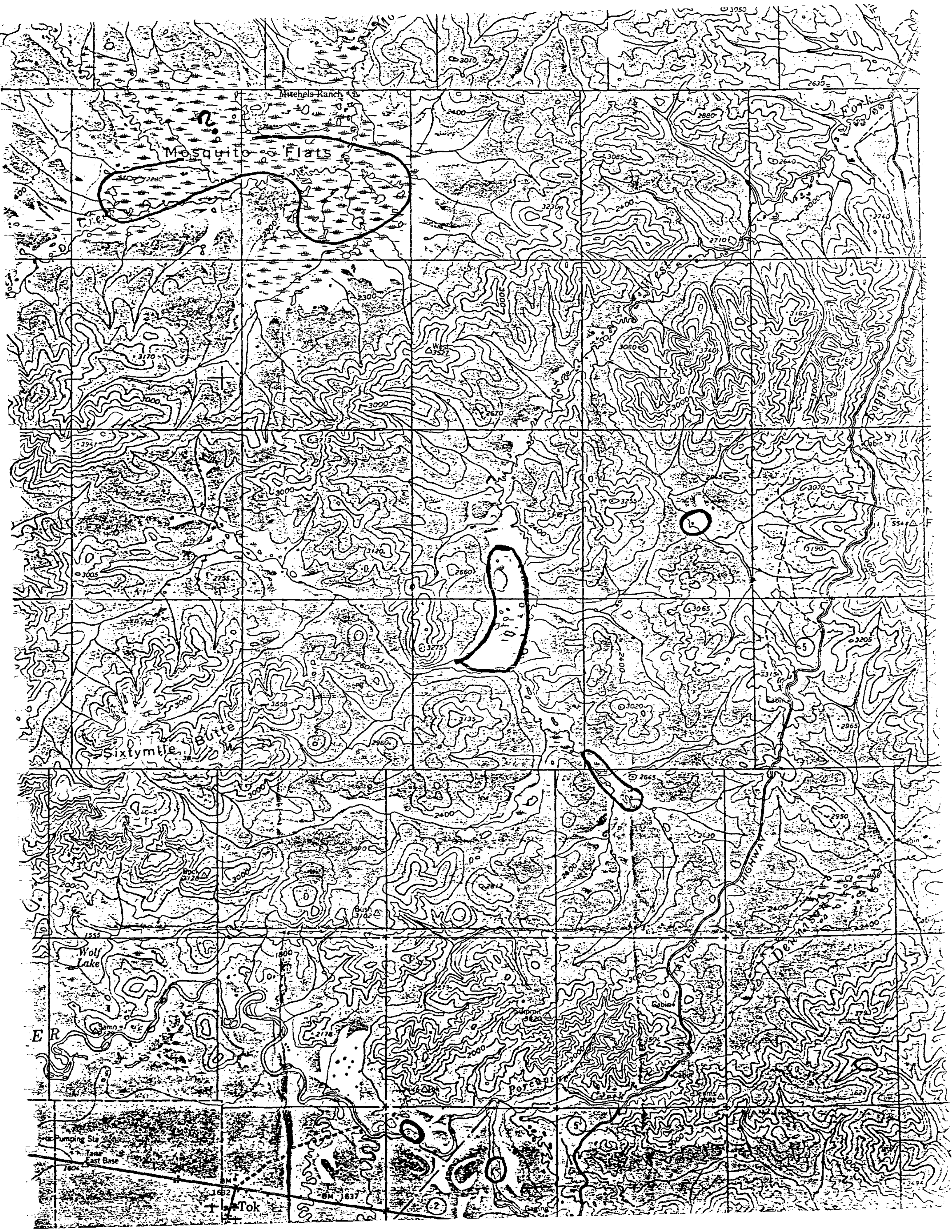
5 0 5 10 15 20 25 KILOMETERS

CONTOUR INTERVAL 200 FEET

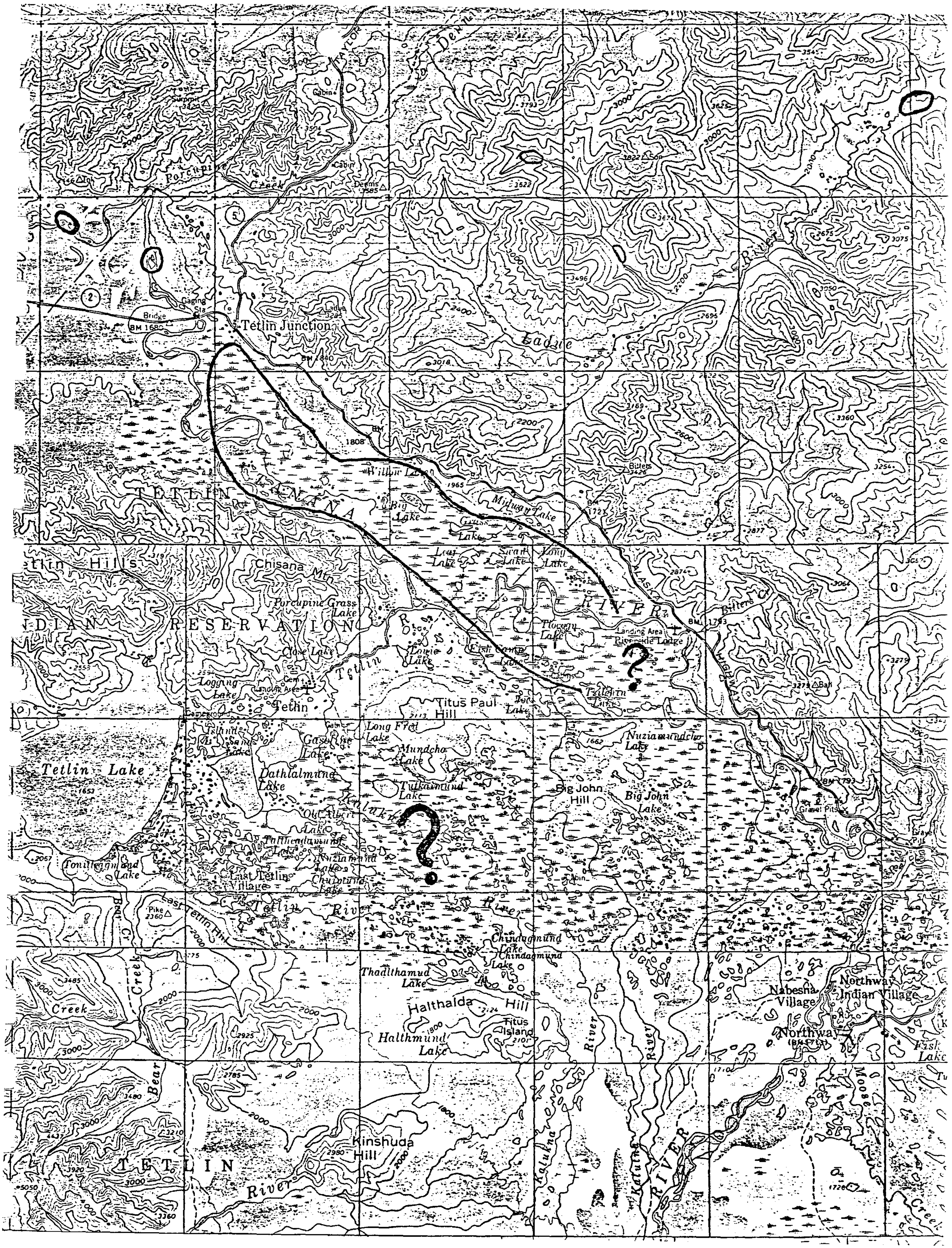
DATUM IS MEAN SEA LEVEL


Volkmar
Healy Lake
Indian Village
Healy Lake
Healy River
Clearwater Creek
Sawmill Creek
Gerstle River
Moose Lake
Twelvemile Lake
Healy
Sawmill
Cabin
Cabins
ALASKA HIGHWAY
TRACTOR TRAIL
BM 1185
BM 1256
BM 1364
BM 1288
BM 1353
Gerstle
Quarry
George Black Lake
George Creek
TANANA
Lake George
Moosehead Lake
Donna L
PACK TRAIL
River
George Lake Lodge
Craig L
Lisa L
State Highway Camp
Gaging Sta
Johnson Slough
RIVER
Sand Lake
George
Gerstle
Dougherty Creek
Little Gerstle
Independent Ridge
Johns
RIVER
Sheep Creek
Little
Horn Mountain
Macomb Plateau
Pegmatite Creek
Berry Creek
Plateau Lake
Knob Ridge
Fish Lake
Mount Hajdukovich
JOHNSON
Prospect Creek
Elting
Bear
T 9 S
T 10 S
T 27 N
T 26 N
T 12 S
T 13 S

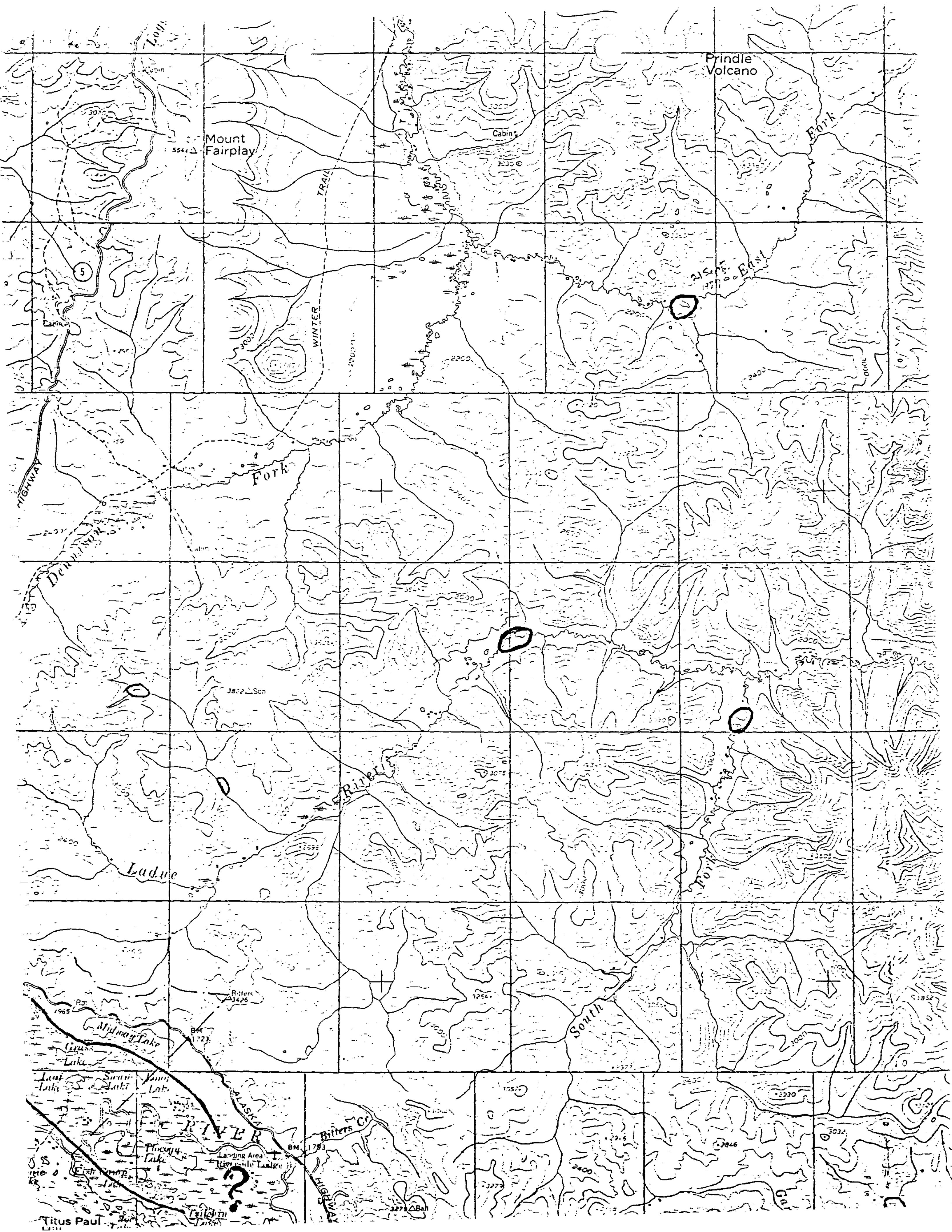

Mosquit
Creek
T Lake
Wolf
Chief Cr
Bear
Round Lake
Mansfield
BM 1585
Jan Lake
Sixtymile Butte
Tower Bluff Rapids
Lower Bluffs
ALASKA
ROBERTSON RIVER
BM 1602
Lake Mansfield
Fish Lake
Mansfield Village
Wolf Lake
Glandy Lake
Little Fish
Tanana Slough
TANANA
RIVER
HIGHWAY
2000 Creek
BM 1530
Cathedral Bluffs
Cathedral Rapids
BM 1686
Moon Lake
Tanacross
Landplane Airport
Tana West Base
Pumping Sta
Tana East Base
BM 1536
Tok
Landing
Tushtena Pass
Mt Neuberger
Lookout



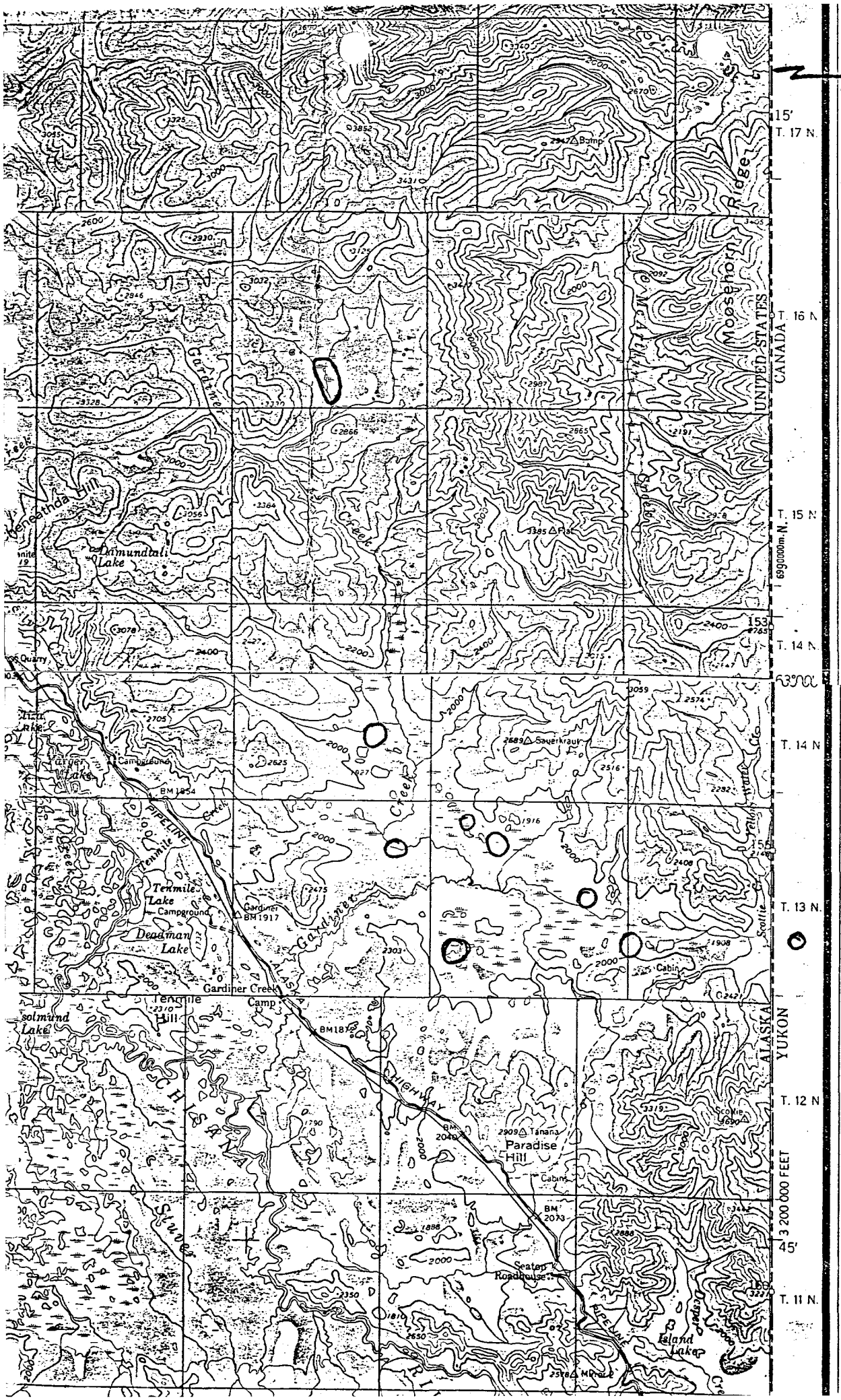
Mitchels Ranch
Mosquito Flats
West 3522
Sixtymile Butte
Rock 3126
Bush 3102
Wolf Lake
Porcupine
Cabin
HIGHWAY
Pumping Sta
Tanc East Base
Tok
BM 1632
BM 1637
Dennis 3585
Fork



Porcupine Creek
Cabin
Tetlin Junction
Bridge
Gaging Sta
BM 1680
Ladue
Ladue River
TETLIN
TANANA
RIVER
Willow Lake
Big Lake
Midway Lake
Grass Lake
Leaf Lake
Swan Lake
Long Lake
ALASKA HIGHWAY
Bitters
Tetlin Hills
Chisana Mtn
Porcupine Grass Lake
INDIAN RESERVATION
Close Lake
Logging Lake
Tetlin
Tetlin River
Lowie Lake
Fish Camp Lake
Tlocogn Lake
Landing Area
Riverside Lodge
Tetlin Lake
Titus Paul Hill
Long Fred Lake
Gasoline Lake
Mundcho Lake
Dathlalmund Lake
Tulkaimund Lake
Big John Hill
Big John Lake
Nuziamundcho Lake
Gravel Pits
Last Tetlin Village
Tomillegmund Lake
Last Tetlin Hill
Pike
Bear Creek
Creek
Chindagmund Lake
Thadlthamud Lake
Halthalda Hill
Halthmund Lake
Titus Island
Nabesna Village
Northway Indian Village
Northway
Fish Lake
Kinshuda Hill
Kalukna River
River
Moose Creek
TETLIN
?
?



Prindle
Volcano
Mount
Fairplay
Cabin
TRAIL
WINTER
East
Fork
HIGHWAY
Fork
Dennison
River
Ladue
Fork
South
Bitters
Midway Lake
Grass
Lake
ALASKA
RIVER
Bitters Cr
Landing Area
Riverside Lodge
HIGHWAY
Titus Paul


Roosts also on White River, Yukon Territory
15'
T. 17 N.
T. 16 N.
T. 15 N.
T. 14 N.
T. 14 N.
T. 13 N.
T. 12 N.
T. 11 N.
3 200 000 FEET
45'
UNITED STATES
CANADA
YUKON
ALASKA
Mooseshorn Ridge
Kenashtada Hill
Jamundali Lake
Gardiner Creek
Tenmile Lake
Campground
Deadman Lake
Gardiner Creek
Tenmile Hill
Solmund Lake
Paradise Hill
Seatep Roadhouse
Island Lake
PIPELINE
HIGHWAY
Campground
Cabin
Cabins
BM 1917
BM 1854
BM 2040
BM 2073
2589 Sauerkraut
2909 Tanana
3385 Flat
2947 Bump
2576 Mount