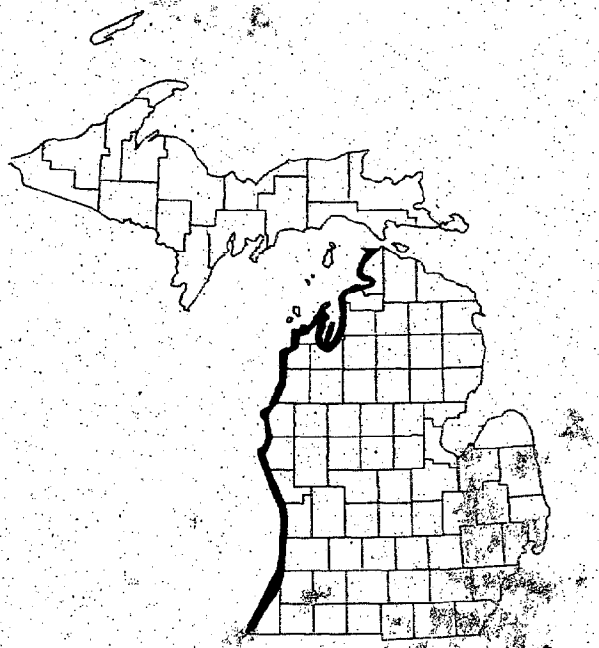
A SURVEY OF THE LAKE MICHIGAN COASTAL ZONE FOR GREAT LAKES ENDEMIC PLANT SPECIES



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Abstract

In 1992, a survey of 15 drowned river mouth sites along the Lake Michigan coastal zone was conducted to determine the presence of Great Lakes endemic plant species and other rare taxa. The primary objectives of the survey were to: 1) survey priority river mouth and lake channel sites to determine the presence of endemic and other previously unknown rare plant occurrences, as well as to inventory any known occurrences within these sites to obtain current status data, and 2) to conduct a systematic review of maps and aerial photos of the entire Lake Michigan shoreline in Lower Michigan to delineate potential new rare plant sites that merit eventual review. The survey resulted in total of four new rare plant occurrences and seven new natural community occurrences. Status information and other significant data were compiled for 22 rare plant and natural community occurrences relocated during the inventory. Information was also gathered concerning artificial disturbance and important exotic plant species that were observed during site inventories. Site summaries are presented for each of the 15 sites inventoried. A systematic review of topographic maps and aerial photo imagery revealed numerous sites that merit field inventory, ranging from Berrien County to Emmet and Charlevoix counties. It was recommended that: 1) data on new and updated occurrences be promptly conveyed to appropriate management agencies, 2) surveys of the potential rare plant sites be conducted over the next few years, 3) a management strategy be prepared to address the control of exotic plants along the coastal zone, and 4) efforts should be made to determine the sources of helium balloons and streamers such that this refuse that accumulates along the shoreline can be eliminated.

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Introduction

The Great Lakes coastal zone, which comprises more than 3000 miles of shoreline throughout Michigan's peninsulas, forms a unique and fragile ecosystem, supporting a number of critically important natural communities and species. Fresh water sand dunes, interdunal wetlands, coastal marshes and estuaries, bedrock beaches, and other communities provide essential habitat for numerous plant and animal species, many of which are rare and dependent on the integrity and natural functioning of the shoreline system. Among the most fragile and vulnerable rare plants species of the entire Great Lakes region are its shoreline endemics. Once more abundant within their historic and currently restricted range, populations of these rarities have sustained local extirpations, serious fragmentation, and general diminishment largely through the direct and indirect effects of development activities within the coastal zone.

Despite a number of systematic shoreline inventories and related surveys by Michigan Natural Features Inventory (MNFI) and others (Albert et al. 1989, 1988, 1987; Comer 1993, 1991; Voice et al. 1982, Penskar & Ludwig 1981), it has been shown that there are significant gaps in the statewide natural features database, particularly for rare plants. The recent discovery of a large population of the endemic Pitcher's thistle (Cirsium pitcheri) near the mouth of the Manistee River exemplifies the existence of such gaps. This federal and state threatened species was not found until the preliminary development stages of a large condominium and marina complex along the river mouth and Lake Michigan shore. Because the development was considered vital to the City of Manistee, considerable controvery arose as work was unexpectedly delayed to assess the status and viability of the Pitcher's thistle population within the development zone.

The above situation illustrates the fundamental conflict between shoreline development and the necessity of maintaining unfragmented, viable habitat for globally rare, endemic species. As the pace of development within the coastal zone continues, particularly with regard to the construction of Great Lakes marinas and associated facilities, there is a critical need for more comprehensive knowledge of occurrences of Michigan's shoreline endemics as well as regionally rare (i.e. state listed) species. Although controversies with regard to appropriate land-use and the scope of development projects will not be avoided, the compilation of a more comprehensive shoreline database will enable problems to be identified early in the planning process, providing better opportunities for conflict resolution. The discovery of the Manistee River mouth Pitcher's thistle population thus provided the principal impetus for the current study.

The 1992 rare plant inventory of the coastal zone was initiated with two basic objectives; 1) to survey 15 priority river mouth and lake channel sites along the Lake Michigan basin to determine the presence of endemic and other previously unknown rare plant occurrences, as well as to inventory any known rare plant and natural community occurrences within these sites to obtain more specific status data, and 2) to conduct a systematic review of aerial photo imagery and U.S Geological Survey (USGS) topographic quadrangles of the Lake Michigan shoreline in Lower Michigan to delineate potential new rare plant sites that merit eventual survey.

Methods

The Study Area

Figure 1 identifies the 15 priority river mouth and lake channel sites inventoried during 1992 surveys. The sites, all located along the Lake Michigan shoreline, ranged from the Lake Charlevoix-Round Lake channel in Charlevoix County to the Galien River mouth in Berrien County. The remainder of the Lake Michigan shoreline in Lower Michigan comprises the areas that were reviewed through topographic maps and aerial photo imagery.

Field Survey Preparation

Prior to field surveys, USGS topographic quadrangles covering the 15 river mouth sites and the associated Great Lakes shoreline areas were obtained. The corresponding MNFI quads with mapped element occurrence records (EOR's) were reviewed. Locations of all rare plant and natural community records shown on MNFI maps were then copied onto the quads to be carried into the field. Aerial photos were briefly examined for a few of the river mouth-lake channel sites, after which it was determined that utilizing these photos in the field would only assist minimally. No aerial photos were subsequently compiled for use during field surveys.

Field Surveys

Field surveys of the 15 priority river mouth sites and adjacent shoreline areas were conducted from July 29 to October 27, 1992, by MNFI botanist M. R. Penskar. It was intended, based on optimal plant phenologies, to begin inventories no earlier than July, based on the blooming/emergence periods for Cirsium pitcheri (Pitcher's thistle), Solidago houghtonii, (Houghton's goldenrod, federal and state threatened), Mimulus glabratus var, michiganensis (Michigan monkey-flower, federal and state endangered), Tanacetum huronense (Lake Huron tansy, state threatened), Orobanche fasciculata (fascicled

Figure 1. Location of the 15 principal Lake Michigan inventory sites.

broom-rape, state threatened), and other potential species.

Field inventories were conducted by systematically surveying and traversing as much potential rare habitat as possible in the immediate proximity (and north and south of) river mouth sites. The areas surveyed were marked on the topographic quads. If rare plant populations were known for a site, a careful attempt was made to relocate these populations and obtain data on their status and extent. Where practical, rare plant populations were censused by maintaining tallies as habitats were meander-searched. For Pitcher's thistle populations, separate tallies were recorded for adult (flowering) versus juvenile (non-flowering) plants. Habitats were surveyed as thoroughly as possibly by traversing back and forth to optimize the coverage of sites and the encountering of significant microhabitats, such as interdunal wetlands and ecotones. As sites were surveyed, complete lists of vascular plants were compiled, including notable, invasive exotic species. In addition to a species list for each site, notes were taken on the general quality of the natural communities, including information on significant natural and artifical disturbance features. In most instances, photos were taken from representative perspectives within each site; photos were also taken to illustrate important exotic species and examples of ORV and other artificial disturbances.

When rare plant populations were identified, standard MNFI field forms were completed. Population sizes were tallied where possible or estimated, and the location and extent of occurrences were marked on the field topographic maps. Where appropriate, voucher specimens for verification and submission to the University of Michigan Herbarium were collected via an endangered-threatened species permit issued by the MDNR Wildlife Division.

When accessible and relatively easy to survey, substantial areas north

and south of river mouth/channel sites were surveyed. In perched dune areas, periodic traverses were performed across representative slopes and blowouts. Most coastal dune areas were bordered by an abrupt transition to forested habitats (e.g. Mesic Northern Forest, Mesic Southern Forest); little time, however, was spent in forested areas even when a rare plant occurrence was known (e.g. ginseng) such that the shoreline coverage for endemic species would be maximized.

Data Analysis, Transcription, and Updating

Following field surveys, inventory data (MNFI field forms, field notes, photos, and quad map notations) were compiled, reviewed, and summarized. Field forms were finished with additional data from field notes and maps. New plant records were evaluated, given an element occurrence rank[1], and then transcribed. Field notes were used to update and expand the data for known occurrences that were encountered, for both plant and natural community records. Analysis of field data resulted in several new natural community occurrences for Open Dunes and Interdunal Wetland. Field data and photos of potential new natural community occurrences were reviewed with MNFI staff ecologists D. A. Albert and P. J. Comer. MNFI forms for these community occurrences were subsequently completed such that these records could later be transcribed. Following data analysis, all field forms and updated and transcribed records were submitted for mapping and entry into the MNFI heritage database, from where the data will eventually be exported to the statewide MIRIS and CIWPIS databases.

[1]"Element occurrence rank", noted basically as A, B, C, or D, is a heritage evaluation of the quality of the occurrence; an A-ranked occurrence is considered an exemplary, viable population, whereas D-ranked occurrences are those that are generally small, occur in degraded sites, and have poor viability.

Aerial Photo/Topographic Quadrangle Review for Potential Rare Plant Sites

The entire Lake Michigan coastline of the Lower Peninsula was systematically examined via USGS topographic quadrangles and 1:24,000 scale color infrared aerial photos to determine the presence of potential new rare plant sites. All major islands in northern Lake Michigan were also evaluated in this overview. Areas were selected initially through examination of MNFI topographic quads with mapped element occurrences, such that only previously unexplored gaps would be evaluated. After this initial delineation of sites, aerial photos were reviewed to determine if significant habitat remained, and from this, a pool of selected potential sites was identified for future field inventories. New aerial photos of the Lower Peninsula shoreline taken in 1992 were available and subsequently used for this analysis.

Results

Rare Plants and Natural Communities

A total of 11 new element occurrences were identified during the inventory (Table 1). Maps of the specific areas examined, indicating the extent of field coverage, are provided in Appendix A. Four of the occurrences were significant rare plant populations, three of which are federally listed endemics, consisting of a new population of Solidago houghtonii (Houghton's goldenrod, federal and state threatened), two new populations of Cirsium pitcheri (Pitcher's thistle, federal and state threatened), and a new population of Lycopodium appressum (appressed clubmoss, state threatened), the latter an Atlantic Coastal Plain disjunct species. Seven of the element occurrences were new records for natural communities, consisting of six occurrences of Open Dunes and one occurrence of Interdunal Wetland. All new natural community occurrences documented during the inventory were identified within designated Critical Dune Areas (MDNR 1989).

Twenty-two element occurrences previously identified in the MNFI statewide database were relocated. Of these, 16 occurrences were rare plant populations, consisting of nine occurrences of Pitcher's thistle, three occurrences of Bromus pumpellianus (Pumpell's brome grass, state threatened), two occurrences of Tanacetum huronense (Lake Huron tansy, state threatened), and two occurrences of Utricularia subulata (zigzag bladderwort, state threatened).

Exotic plant species of the Great Lakes Coastal Zone

A number of exotic plant species were identified during the survey, several of which were observed to be widespread on the Lake Michigan coastline. These species were identified during the compilation of thorough species lists for each site inventoried. A compilation of the most

Table 1. Element occurrences identified during the 1992 MNFI Lake Michigan coastal zone survey.

SITE NAME	KNOWN ELEMENT OCCURRENCES RELOCATED AND UPDATED[1]	NEW ELEMENT OCCURRENCES DOCUMENTED
1. Lake Charlevoix	Bromus pumpellianus (#.017)[2] Bromus pumpellianus (#.003) Bromus pumpellianus (#.004) Cirsium pitcheri (#.006) Cirsium pitcheri (#.075) Cirsium pitcheri (#.077) Tanacetum huronense (#.002) Tanacetum huronense (#.007)	Solidago houghtonii (Fisherman's Island State Park) Open Dunes (Fisherman's Island State Park) Interdunal Wetland (Fisherman's Island State Park) Open Dunes (McSauba Park)
2. Betsie Lake	Cirsium pitcheri (#.034)	Open Dunes (Frankfort) Open Dunes (Elberta)
3. Arcadia Lake	Cirsium pitcheri (#.039)	Open Dunes (South Arcadia)
4. Portage Lake	-	Cirsium pitcheri (Portage Point)
5. Manistee River mouth	Cirsium pitcheri (#.013)	
6. Pere Marquette Lake	-	-
7. Pentwater Lake	Cirsium pitcheri (#.030)	-
8. White Lake	-	Open Dunes (Sadony Bayou)
9. Muskegon Lake	Utricularia subulata (#.002) Open Dunes (#.008) Interdunal Wetland (#.002)	Cirsium pitcheri (Muskegon State Park) Lycopodium appressum (Muskegon State Park)

[1]Because of the large coastline areas surveyed along Lake Michigan, multiple occurrences of some elements are identified in the table. Distinct occurrences are those that are sufficiently distant from one another such that they can be considered two different populations (for plants and animals) or community sites.

[2]Element occurrence number assigned by MNFI.

Table 1 (cont'd). Element occurrences identified during the 1992 MNFI Lake Michigan coastal zone survey.

SITE NAME	KNOWN ELEMENT OCCURRENCES RELOCATED AND UPDATED	NEW ELEMENT OCCURRENCES DOCUMENTED
10. Spring Lake	Cirsium pitcheri (#.008) Open Dunes (#.014) Interdunal Wetland (#.008)	-
11. Lake Macatawa	-	-
12. Kalamazoo Lake	Cirsium pitcheri (#.004) Utricularia subulata (#.003) Open Dunes (.#020) Interdunal Wetland (#.007)	-
13. Black River	-	-
14. St. Joseph River	-	-
15. Galien River mouth	-	-

significant and invasive species encountered is provided in Table 2.

Potential Rare Plant Sites

During the examination of topographic maps and selected aerial photos, several Lake Michigan coastal sites were delineated that merit future field inventories for rare plant species. These sites are provided in Appendix B. More than 40 topographic maps, covering the entire shoreline of the Lower Peninsula and the shorelines of all the major islands of northern Lake Michigan, were reviewed. Of the maps initially reviewed, 20 contained one or more potential sites for examination via aerial photo imagery.

Table 2. Significant exotic plant species identified during the survey of 15 Lake Michigan coastal zone sites.

	Lake Charlevoix	Betsie Lake	Arcadia Lake	Portage Lake	Manistee River	Pere Marquette Lake	Pentwater Lake	White Lake	Muskegon Lake	Spring Lake	Lake Macatawa	Kalamazoo Lake	Black River	St. Joseph River	Galien River
Agropyron repens (Quack grass)	●			●			●								
Centaurea maculosa (Spotted knapweed)	●	●	●	●	●	●	●	●	●	●	●		●	●	
Elaeagnus umbellata (Autumn olive)						●	●				●				
Gypsophila paniculata (Baby's-breath)		●													
Hypericum perforatum (St. John's-wort)	●										●			●	
Lonicera tatarica (Tatarian honeysuckle)			●					●							
Melilotus alba (White sweet clover)		●			●	●			●			●		●	
Morus alba (White mulberry)									●		●				
Pinus nigra (Black pine)												●			
Pinus rigida (Pitch pine)										●					
Pinus sylvestris (Scotch pine)								●		●					
Poa compressa (Canada bluegrass)	●	●	●	●		●		●	●	●	●				
Populus alba (White poplar)							●								
Populus nigra* var. *italica (Lombardy poplar)		●	●	●	●	●	●	●				●	●	●	
Robinia pseudoacacia (Black locust)				●		●	●	●	●				●	●	●
Saponaria officinalis (Soapwort)	●	●	●	●	●		●	●	●	●	●		●	●	●
Silene vulgaris (Bladder campion)	●	●	●			●									

Site Summaries

The following provides a short discussion of each river mouth site inventoried. With the exception of two sites, both sides of each channel or river mouth area were surveyed. At Portage Lake in Manistee County, access through private land could not be obtained for inventorying the dunes on the south side of the channel. At the Galien River mouth, access could not be obtained to pass through a gated fence surrounding a tract of condominiums, although in this case there was virtually no dune habitat remaining, thus there was a poor likelihood that Pitcher's thistle or any other rare plant occurred there. Appendix A contains maps for each site inventoried and includes the specific shoreline areas covered and the locations of new occurrences of special plants and natural communities. Representative photos taken via 35 mm slides for most sites are provided in Appendix C. The majority of the exotic species noted below are included in Table 2.

1. **Lake Charlevoix (Charlevoix Co.)** Little sand dune habitat was found to remain immediately next to the channel that connects Lake Charlevoix to Lake Michigan via Round Lake. Despite the paucity of habitat, two special plant occurrences, both previously known, were found to persist along a remnant foredune area at the Charlevoix City beach, about 100-200 m south of the channel. A small population of Cirsium pitcheri, consisting of 20 plants, most of which were sterile rosettes, was observed on the low foredune between the forested, developed area and the beach. The thistle occurred on the foredune with scattered plants of the state threatened Bromus pumpellianus (Pumpell's brome grass) and typical foredune species such as Ammophila breviligulata (dune or marram grass), Prumus pumila (sand cherry), Asclepias

syriaca (milkweed), Toxicodendron radicans (poison ivy), and Juniperus horizontalis (creeping juniper). There was some evidence of artificial disturbance in these rare plant colonies due to foot-traffic by beach users.

Due in part to accessibility, a considerable portion of the adjacent shoreline was walked and inventoried. North of the Lake Charlevoix channel, the shoreline was surveyed all the way to North Point. At McSauba Park, known occurrences of Pitcher's thistle, Pumpell's brome grass, and Tanacetum huronense (Lake Huron tansy) were observed; the dunes were recorded as a new occurrence of Open Dunes. The Open Dunes had not been previously recognized by MNFI within this Critical Dune Area (MDNR 1989). South of the channel, the entire shoreline was surveyed through Bell's Bay and down to the small peninsula jutting out near Fisherman's Island. Known occurrences of Pitcher's thistle, Pumpell's brome grass, and Lake Huron tansy were found in Fisherman's Island State Park. Additional colonies of Pumpell's brome grass and tansy were documented along Bell's Bay, significantly extending the local ranges of the known occurrences.

Three important new element occurrences were identified in Fisherman's Island State Park. An occurrence of Open Dunes and an occurrence Interdunal Wetland were recorded within the park's Critical Dune Area (MDNR 1989). Within primarily the Interdunal Wetland, a large population of Houghton's goldenrod (Solidago houghtonii) was discovered, comprising the southernmost population in the Lake Michigan basin. The nearest known population of Houghton's goldenrod to the north occurs in Sturgeon Bay, Emmet County, and thus the Fisherman's Island State Park population consists of a southern range extension of approximately 40 miles (64 km). The discovery of this Houghton's goldenrod population was the most significant rare plant identified during the coastal zone survey.

In all of the shoreline areas surveyed around Lake Charlevoix, a standard array of exotic species was observed, such as Saponaria officinalis (soapwort), Centaurea maculosa (spotted knapweed), Silene vulgaris (bladder campion), and Agropyron repens (quack grass). These species were relatively common, particularly in disturbed areas such as along foot-paths, but none appeared to be sufficiently invasive to pose a serious problem at this point in time.

2. **Betsie Lake (Benzie Co.)** Fairly extensive areas of shoreline north and south of the Betsie Lake channel were surveyed. North of the channel at the Frankfort City beach, virtually no undisturbed dune habitat remains. Ammophila was noted as being planted in two plots to stabilize an interior portion of the public beach. A known Pitcher's thistle colony, last observed in 1981 within the beach area, was sought but not found. A small intact dune field was surveyed around the Harbor Lights Motel and Condominium complex immediately adjacent to the channel; dune vegetation was present but no thistle was discovered. Subsequent to this survey, information and photos were received from a Leelanau County resident (R. Jones, pers. comm.) who documented the existence of a small colony growing among Ammophila and Calamovilfa longifolia (dune grass) near the condominium complex. No count of plants was received, but photos indicate that both adult and juvenile plants were present. Approximately two miles of shoreline north of the channel were surveyed, including a steep perched dune complex within a Critical Dune Area (MDNR 1989). The perched dune was recognized as a new Open Dunes occurrence.

South of the Betsie Lake channel, Pitcher's thistle was found to be locally frequent, extending south as far as the shoreline was surveyed, about 1 mile. Nearly 200 plants were tallied until it was determined that a count could not be adequately done; it was estimated that from 400-500 plants were

present. Plants occurred throughout a relatively broad dune field, across the face of the perched dune bluff, and in the bowl of a perched blowout. The dunes, which occur in a Critical Dune Area (MDNR 1989), were recorded as a new community occurrence for Open Dunes. A road actively used by beach visitors parallels the beach behind the foredune; this represents a serious degradation of the dunes, as does an even wider path apparently created by ORV use that follows and then extends the road.

Exotic species observed around the channel included Saponaria officinalis (soapwort), Centaurea maculosa (spotted knapweed), Poa compressa (Canada bluegrass), Gypsophila paniculata (baby's-breath), Populus nigra var. italica (Lombardy poplar), Melilotus alba (white sweet clover), and Silene vulgaris (bladder campion). Spotted knapweed was relatively frequent in disturbed areas. South of the channel, Lombardy poplar was observed to be aggressively spreading in the dunes through cloning via rhizomes.

3. Arcadia Lake (Benzie Co.) North of the Arcadia Lake channel relatively little dune habitat was present. Virtually no vegetation occurred on the heavily used public beach. The beach was backed by a small, intact foredune and a second, slightly higher backdune. The dunes were noted as being fairly disturbed and quite weedy, with such exotic species as Lonicera tatarica (tatarian honeysuckle), Centaurea maculosa (spotted knapweed), and Saponaria officinalis (soapwort).

South of the Arcadia Lake channel a wider portion of dune field occurs, which changes abruptly about 0.25 mi south to a high, steep, perched dune bluff fronted by an extremely narrow beach strand. A known Pitcher's thistle population was relocated and tallied. More than 260 plants were counted; 500 plants were estimated for the site. A known population of Orobanche fasciculata (fasciculed broom-rape) was carefully sought in the precise area

where it was identified previously by M. R. Penskar during a 1985 CZM survey. Despite careful searching no plants were found. Significant artificial disturbances within the habitat may have adversely affected this population. An actively used ORV path through the area where the previous colony occurred (see photos B-11 to B-13) has seriously degraded a portion of the dune field, allowing a number of exotic species to invade. Spotted knapweed, soapwort, Silene vulgaris (bladder campion), and Poa compressa (Canada bluegrass) were recorded, with knapweed being noted as a significant invasive plant. Populus nigra var. italica (Lombardy poplar) was also observed to be particularly aggressive, spreading through widespread rhizomes (photo B-14). The shoreline was surveyed up to nearly 2 miles south of the channel. Pitcher's thistle was noted as occurring primarily across the base of the dune bluff. Photos B-16 to B-18 depict the dunefield and perched dune areas.

4. Portage Lake (Manistee Co.) North of the Portage Lake channel, a small tract of open dunes occurring in a Critical Dune Area (MDNR 1989) was explored. The dunes were of moderately good quality, although bordered by numerous tracts of private homes on the forested bluff. A small but significant new occurrence of Pitcher's thistle was discovered, occurring primarily in the dunefield between the well-developed foredune and forested backdune area. Thirty-seven plants were tallied, and it was estimated that approximately 50-100 plants were likely present, associated with Ammophila breviligulata (marram grass), Artemisia campestris (wormwood), Calamovilfa longifolia (dune grass), Solidago spathulata (dune goldenrod), and Euphorbia polygonifolia (seaside spurge). Significant alien species included Centaurea maculosa (spotted knapweed), Populus nigra var. italica (Lombardy poplar), Poa compressa (Canada bluegrass), Agropyron repens (quack grass), Saponaria officinalis (soapwort), and Robinia pseudoacacia (black locust). As in other

sites, both Lombardy poplar and black locust appear to be actively invading the dunes through vegetative reproduction.

South of the channel, a small but apparently intact area of dunes appeared to offer a continuation of habitat suitable for more Pitcher's thistle colonies. This site, however, could only be viewed from north of the channel, as permission could not be obtained to access the south channel area through private property.

5. Manistee River mouth (Manistee Co.) Immediately north of the Manistee River mouth, virtually no dune vegetation remains at the heavily used public beach facility. Beyond the parking lot a stretch of remaining dunes begins, consisting basically of a small dune ridge that extends well back of the wide beach strand, paralleling the entry road. Small colonies of Pitcher's thistle occur on the dunes in close proximity to the condominiums being constructed. This population was unknown until the initiation of the condomimium-marina project, and was well-documented during a biological assessment, although the population count was not conducted at an ideal period (early spring). The small colonies were identified by flagging and stakes.

Further north, a few marked plants occurred on the landward side of "Dead Lake", a large shallow beach pool separated from Lake Michigan by a thin beach and dune strand. Beyond Dead Lake the best stretch of dunes occur, supporting a moderate number of Pitcher's thistle plants. The dunes comprise a relatively narrow zone restricted to the immediate shoreline area, backed by a flat, highly disturbed dunefield. Significant ORV roads were observed in portions of the dunes, and a paved road and electical services have been constructed for the development of the site; a prominent sign displays the development plans for numerous small home or condominium tracts.

Many exotic species were observed throughout the dunes north of the river

mouth, including Saponaria officinalis (soapwort), Cycloloma atriplicfolium (winged pigweed), Centaurea maculosa (spotted knapweed), Melilotus spp. (sweet clover), Mirabilis nyctaginea (wild four-o'clock), and Populus nigra var. italica (Lombardy poplar).

South of the Manistee River mouth little dune habitat was found. A small, fenced, signed area, site of a Pitcher's thistle transplant attempt, was surveyed to determine the status of the plants. One flowering plant and 18 mostly large juvenile plants were observed; these were partially shaded by an overhanging plant willow tree (Salix spp., possibly S. alba). While leaving the river mouth area, a degraded dune area east of Cherry street and south of 1st street was spotted. A brief, unsuccessful survey was conducted to determine the possible presence of Pitcher's thistle.

6. Pere Marquette Lake (Mason Co.) On the north side of the Pere Marquette channel, little dune habitat was found at the public beach. The small island of remaining dune was briefly surveyed for Pitcher's thistle, which was not found. South of the channel, an extensive area of perched dunes was surveyed (photos B-18 to B-20). Immediately south of the channel lies a densely developed tract of cottages in fairly degraded dunes, which were not closely surveyed. The entire stretch, however, from the township park at Buttersville to the Consumer's Power storage reservoir was walked, a distance of more than three miles. This stretch of perched dunes is extensive, and it was expected that Pitcher's thistle would be found. Careful searching of bluff face, the bowl of one blowout, and a dunefield below the reservoir failed to reveal any plants. The open dunes were somewhat more disturbed and weedy than comparable sites. In several areas along the base of the steep dune bluff, which was fronted by a very narrow beach strand, landowners had placed broken concrete, stones, and other types of rip-rap to stabilize the

slope. In these portions of the dunes it was also quite weedy, with many exotic and commonly cultivated plants not observed elsewhere during the shoreline survey. It appears that these plants were largely introduced as landowners picked up cast-off materials to use as rip-rap. Within the dunefield near the reservoir facility, it was also rather weedy, and there was clear evidence of ORV damage.

Significant and unusual exotic species included Centaurea maculosa (spotted knapweed), Poa compressa (Canada bluegrass), Melilotus alba (white sweet clover), Polygonum cuspidatum (Japanese knotweed), Syringa vulgaris (common lilac), corkscrew willow (Salix sp.), Robinia pseudoacacia (black locust), Populus nigra var. italica (Lombardy poplar), Elaeagnus umbellata (autumn olive), and Silene vulgaris (bladder campion).

7. Pentwater Lake (Oceana Co.) Approximately 1.5 miles on both sides of the Pentwater Lake channel were explored. North of the channel, the dunes are partially included within Mears State Park. Immediately north of the channel the site is heavily used for recreation. North of the parking lot a relatively narrow strip of beach and dunes extends for two miles or more, most of the area beyond the park developed via small tracts of cottages and homes. Within Mears Park there are trails and benches in the dunes (see photos B-22 to B-23). The shoreline is included within a Critical Dunes Area (MDNR 1989). Although slightly disturbed, the dunes comprise potential habitat for Pitcher's thistle, which was carefully sought through several traverses within the dune but not found. Particularly troublesome exotic plants observed were Populus alba (white poplar) and Robinia pseudoacacia (black locust).

South of the channel the dunes are similar but less disturbed (photo B-24), although there are numerous small tracts with residences behind the dunes. This stretch of shoreline also occurs within a Critical Dune Area

(MDNR 1989). Pitcher's thistle was observed beginning about 0.5 miles south of the channel, extending the range of the known occurrence to the south. Only 12 juvenile plants were tallied over much apparently suitable habitat. Most of the same exotic plants found north of the channel were observed here, including Populus alba (white poplar), an extremely aggressive clonal species. Elaeagnus umbellata (autumn olive) was suspiciously frequent, indicating that it may have been introduced for dune stabilization. A planting of Ammophila breviligulata (marram grass) for dune stabilization was observed from the beach. Along the beach, washed up plants of Potamogeton (pondweed) were encrusted with numerous zebra mussels (photo B-25).

8. **White Lake (Muskegon Co.)** North of the White Lake channel a relatively small stretch of dunes of reasonably good quality was explored. The dunes, which occur in a Critical Dune Area (MDNR 1989), are bordered landward by the "Sadony Bayou", a sluggish stream drainage formed at the mouth of Pierson drain. Some localized artificial disturbance by recreationists, primarily fisherman, was observed immediately adjacent to the channel. Behind a well-developed foredune, the dunes are characterized by a prominent depression (photo B-27), at the base of which is the stream channel. The dunes were well-vegetated with typical species such as Ammophila (marram grass), Populus deltoides (eastern cottonwood), Vitis riparia (riverbank grape), Elymus canadensis (Canadian wild rye), Salix myricoides (dune willow), Pinus banksiana (jack pine), Cornus stolonifera (red osier dogwood), and several other taxa. The habitat appeared to be of good potential for Pitcher's thistle, but several traverses throughout the dunes were unsuccessful in identifying a population. Consultation with MNFI associate ecologist P. Comer resulted in the recognition of this site as a new Open Dunes occurrence. Common exotic species observed included Saponaria officinalis (soapwort),

Robinia psuedoacacia (black locust), Centaurea maculosa (spotted knapweed), and Populus nigra var. nigra (Lombardy poplar). Other notable exotics were Lonicera tatarica (tatarian honeysuckle), Pinus nigra (black pine), Pinus sylvestris (Scotch pine), and Acer platanoides (Norway maple).

South of the White Lake channel at the lighthouse, a smaller stretch of dunes was surveyed; these also occur within a Critical Dune Area (MDNR 1989). The foredune was noted as being well-developed and vegetated with Ammophila (marram grass), Calamovilfa longifolia (dune grass), Elymus canadensis (Canadian wild rye), Salix cordata and S. myricoides (dune willows), and Vitis riparia (riverbank grape). The backdune forested bluff area is densely developed with numerous homes on small tracts. One foredune area was thickly vegetated with Ammophila, which was possibly planted for dune stabilization. Pitcher's thistle was sought but not found; the habitat may not be particularly suitable for this species, owing to the heavy vegetation cover and lack of exposed sand surfaces required by this species. Exotic species south of the channel included several clones of Robinia pseudoacacia (black locust) and a few species of lesser note, such as Verbascum thapsus (mullein), Poa compressa (Canada bluegrass), and Rumex acetosella (sheep sorrel).

9. Muskegon Lake (Muskegon Co.) North of the Muskegon Lake channel, the dune complex in Muskegon State Park comprises a significant, well-known landscape within a Critical Dune Area (MDNR 1989). A long traverse and several meander-searches were conducted through representative portions of the dunes, concentrating on several interdunal wetlands and non-forested habitat. Most forested portions of the dunes consisted of Pinus banksiana (jack pine) dominated areas. Data were gathered to update known records of Open Dunes and Interdunal Wetland tracked by MNFI. A known occurrence of Utricularia subulata (zigzag bladderwort, state threatened), an Atlantic Coastal Plain

disjunct species not observed since its discovery in 1987, was carefully sought and found. This species was found in new interdunal wetlands, extending its local range, and significant additional data on this plant and its habitat was obtained. Zigzag bladderwort, although extremely obscure (photos B-28 and B-31), was locally frequent within good quality Interdunal Wetlands, occurring in moist, calcareous sand in areas dominated by Cladium mariscoides (twig-rush), Scirpus americanus (threesquare), Eleocharis elliptica (spike-rush), Eleocharis pauciflora (few-flowered spike-rush), and Juncus spp. (rushes). Photo B-32 depicts an Interdunal Wetland site that contains a colony of Zigzag bladderwort.

Within the park, two significant new rare plant occurrences were documented. A large Interdunal Wetland, several acres in extent within the south-central portion of the park, was carefully surveyed, resulting in the discovery of Lycopodium appressum (appressed clubmoss, state threatened), another Atlantic Coastal Plain disjunct species. This species occurred in a more thickly vegetated wetland dominated by Calamagrostis canadensis (blue-joint grass), Spiraea tomentosa (steeplebush), Pinus banksiana (jack pine), Rhynchospora capillacea (beak-rush), Eupatorium perfoliatum (joe-pye-weed). Other notable associates included bog species such as Lycopodium inundatum (bog clubmoss), Drosera rotundifolia (round-leaved sundew), and Sphagnum subsecundum (sphagnum moss). Zigzag bladderwort was also found in this wetland near the periphery of small pools. After several interdunal wetlands were explored, open dune areas were carefully meander-searched for Pitcher's thistle, previously unknown for the site. Extensive searching revealed a relatively small colony on one dune slope and blowout, consisting of 23 juvenile plants and one flowering individual. The open dunes were estimated to support a population of at least 100 plants, based on available habitat.

South of the Muskegon Lake channel little dune habitat remains. On the lake the site is a public beach with little vegetation. A small area of open dunes, however, remains within a former sandpit (presumably a sand mining area) and this area was briefly explored to determine if Pitcher's thistle plants were present (photo B-33). The area was found to support several typical dune species, but was fairly disturbed and degraded by ORV paths and several exotic species such as Saponaria officinalis (soapwort), Robinia pseudoacacia (black locust), Morus alba (white mulberry), and other species.

10. Spring Lake (Ottawa Co.) North of the Grand River mouth, past the west end of Spring Lake, the shoreline lies within a Critical Dune Area (MDNR 1989). The Lake Michigan shore is developed for several miles with numerous small private tracts of cottages and homes, extending to the southern border of P. J. Hoffmaster State Park. The dunes, however, are well-developed in this area, and landward the largely forested dune complexes are not densely developed. The most significant tract of open dunes and wetland lies within the Kitchel Dunes Preserve, which is owned and managed by the City of Grand Haven. The preserve, which supports known occurrences of Open Dunes, Interdunal Wetland, and Pitcher's thistle, was surveyed throughout all representative habitats.

Data were gathered to update occurrence records for Open Dunes and Interdunal Wetland. The open dunes were also explored for Pitcher' thistle, which was observed as occasional. Previous data indicate that only a small population occurs within the preserve. This may be due to the fact that much of the tract is forested with Pinus banksiana (jack pine) and open dune habitat is somewhat limited, restricting sand movement and other processes necessary for Pitcher's thistle. Interdunal wetlands within and bordering the periphery of Kitchel Dunes were closely examined for Utricularia subulata

(zigzag bladderwort). These wetlands appeared to be of good potential habitat for this species but several painstaking searches failed to identify any plants.

Several of the common exotic species observed elsewhere were found in Kitchel Dunes, particularly around the more disturbed periphery, including such species as Centaurea maculosa (spotted knapweed), Saponaria officinalis (soapwort), and Poa compressa (Canada bluegrass). Pinus sylvestris (Scotch pine) was present in the preserve, and more notably, a large plantation of Pinus rigida (pitch pine)--identified during a previous CZM survey in 1985--was revisited to document its extent (photos C-1 to C-2).

South of the Grand River mouth the shoreline lies within a Critical Dune Area (MDNR 1989). The lakeshore immediately south of the river mouth is a public beach with no dune vegetation remaining. Further south the shoreline is completely developed. Within the forested dunes, which were not explored, there are substantially more homes than in similar habitat north of the river mouth.

11. **Lake Macatawa (Ottawa Co.)** Portions of the shoreline both north and south of the Lake Macatawa channel lie within Critical Dune Areas (MDNR 1989). There were no known element occurrences prior to the survey, and no element occurrences were identified during field surveys. North of the channel, little good quality dune habitat remains in Holland State Park (photo C-5). What habitat exists was briefly explored and found to be fairly degraded and highly disturbed. Numerous exotics were present. One private track visible from the park boundary had a planting of Ammophila breviligulata (marram grass) with a sign noting the area as a dune grass restoration project. North of the park the shore is highly developed and lined with elaborate condominium complexes (photo C-3) beyond the park's last foredune. Pitcher's thistle was

sought but not found.

South of the channel the shoreline is even more densely developed than than to the north. The dunes lie within a Critical Dune Area (MDNR 1989), including much of the forested dunes. The shoreline for about one mile south of the channel is largely unvegetated beach. Examination of the topographic map and photo following the dune survey indicated that possible Pitcher's thistle habitat occurs about 1.5 miles south where there is little development; these areas should be incorporated into a subsequent follow-up survey.

12. Kalamazoo Lake (Allegan Co.) The shoreline near the Kalamazoo River mouth comprises a significant Critical Dune Area (MDNR 1989) and includes several known elements in addition to a dedicated State Natural Area. North of the river mouth, the shoreline was accessed via Saugatuck Dunes State Park and surveyed down to the river mouth. The forested portion of the dunes consist of mesic forest, giving way to a moderate bluff above the beach. The dedicated Saugatuck Dunes Natural Area (photo C-6), an approximately 300-acre area centered around Pelican Peak, was explored throughout the open dunes and forested dune habitats. Data were gathered on known occurrences of Open Dunes and Interdunal Wetland; most of the latter habitat was surveyed near the channel. The natural area is considerably altered by a large planting of Pinus nigra (black pine), deliberately introduced to stabilize the dunes. The effect of this has been to degrade the dunes by diminishing the natural sand movement processes necessary for many sand dune plants, such as Pitcher's thistle. After extensive searching, a colony of Pitcher's thistle (part of a known occurrence) was finally found in a backdune area behind the black pine plantings. The colony, consisting of 22 sterile plants, did not look vigorous, and was restricted to a small area where there was active sand

movement.

Between the natural area and the channel, several Interdunal Wetlands (such as the one depicted in photo C-7) were carefully searched for possible new colonies of Utricularia subulata (zigzag bladderwort), an occurrence of which was known only for wetlands south of the channel. No plants were found, despite the availability of apparently suitable habitat. It is still possible, however, that plants of this species occur in wetlands north of the channel. Photo C-8 depicts a common piece of refuse washed ashore on beaches throughout Lake Michigan, the remains of a helim-filled party balloon and ribbon. Although the origin of these balloons is unknown, this item was observed on beaches throughout the Lake Michigan coastal zone, becoming more common in southern Lake Michigan. It is likely that the balloons and ribbons are a serious threat to wildlife that may become entangled in them.

South of the channel, the dune complex was surveyed from Oval Beach up to the channel. The Open Dunes within the city beach and park were found to be of good quality, although Populus nigra var. italica was noted as being particularly invasive in places and clearly presents a potential serious problem. Pitcher's thistle was found to be scattered to locally frequent in the backdune field near Oval Beach, with both adult and juvenile plants present. Several Interdunal Wetlands were carefully explored between Oval Beach and the channel. In the wetlands closer to the channel, a known occurrence of zigzag bladderwort last seen in 1987 was relocated, and in these wetlands this species was abundant. As observed in Muskegon State Park, the bladderwort was found in Cladium mariscoides (twig-rush) dominated areas of the interdunal wetlands. Additional data were gathered to update the occurrence record. A known occurrence of Rhexia virginica (meadow-beauty, state special concern), an Atlantic Coastal Plain disjunct species, was not

relocated.

13. Black River (Van Buren Co.) North of the Black River mouth channel, no dune habitat remains other than a wide, bare expanse of sand beach (photos C-17 to C-18). No element occurrences were known prior to the survey not discovered during the inventory. The shoreline has been completely developed with elaborate homes and condominiums. Several miles to the north there appears to be a relatively steep shoreline dune bluff and possible rare plant habitat that should be considered in future surveys. South of the river mouth, a very limited amount of habitat remains between the low, developed bluff and the wide sand beach (photo C-14 to C-15). A brief survey revealed very little, other than a thickly vegetated foredune which may have been planted with Ammophila breviligulata (marram grass) for dune stabilization. Several standard exotic species were present, including Populus nigra var. italica (Lombardy poplar), Robinia pseudoacacia (black locust), Saponaria officinalis (soapwort), and Cycloloma atriplicifolium (winged-pigweed). Here, as in several other sites surveyed, were numerous stranded balloons and ribbons.

14. St. Joseph River (Berrien Co.) Little dune habitat remains on either site of the river mouth. The best of the remaining dunes occurs within Tiscornia Park, a city beach and park on the north side of the river mouth. The dunes consist of a large foredune dominated by Ammophila breviligulata (marram grass), Calamovilfa longifolia (dune grass), Monarda punctata (horse-mint), Artemisia campestris (wormwood), Prunus pumila (sand cherry), Salix myricoides (dune willow), and several other typical sand dune species. Several exotics were present, particularly in the weedy backdune area, including Centaurea maculosa (spotted knapweed), Saponaria officinalis (soapwort), Hypericum perforatum (St. John's-wort), Euonymus europaea

(European euonymus), Melilotus alba (white sweet clover), Populus nigra var. italica (Lombardy poplar), and Yucca filamentosa (yucca). Remnant plants of Pitcher's thistle were sought but not found.

South of the river mouth channel there was a wide flat expanse of sand beach (Silver beach City Park), but the remaining area has been developed. A significant area was in the early stages of construction of a building complex (apparently a condominium site) and most dune areas that had been present were obliterated. The bit of remaining dune and dune vegetation occurred adjacent to the channel (photo C-12), consisting of an Ammophila-dominated foredune with Populus deltoides (eastern cottonwood), Panicum virgatum (switch-grass), and the exotic Robinia pseudoacacia.

15. Galien River (Berrien Co.) North of the river mouth channel lies a public park with a small remaining dune of moderate height (photo C-11). The dune is dominated primarily by Ammophila breviligulata (marram grass) and Calamovilfa longifolia (dune grass), with Prunus pumila (sand cherry) and eastern cottonwood. A boardwalk and stairs have been constructed along the dune for an outlook. Despite the limited habitat, the area was completely searched for Pitcher's thistle, and no plants were found. South of the channel, the shoreline has been completely developed, with the exception of a very small area of dune next to the channel (photo C-10). Access to the south side, through a gated condominium complex, was not gained; however, the likelihood of rare species such as Pitcher's thistle occurring in this site are minimal, and little was lost by not being able to survey here. Common exotics noted near the Galien River mouth were Robinia pseudoacacia (black locust) and Saponaria officinalis (soapwort).

Discussion and Recommendations

Rare Species and Natural Communities

Overall, the inventory of 15 river mouth and lake channel sites can be considered very productive, resulting in significant new rare plant occurrences and a vastly improved database for several previously known records. The identification of several new natural community occurrences was not anticipated prior to the survey and thus provided an unexpected benefit. Several of the new element occurrences were identified because fairly extensive areas of the Lake Michigan coastline were explored when river mouth and channel sites were accessed. Approximately 23 miles of lineal shoreline were covered over the entire survey. This, however, is a conservative estimate of the coverage actually achieved, since most sites were also repeatedly traversed through meander searches.

The identification of a large population of Solidago houghtonii (Houghton's goldenrod) in Fisherman's Island State Park was the most significant discovery during the survey. Prior to this discovery, populations were known no further south than Summer Island (Delta County) and Sturgeon Bay (Emmet County) in the Lake Michigan basin. The occurrence of this species south of Charlevoix thus represents an important range extension. The two newly documented Cirsium pitcheri (Pitcher's thistle) populations, found at Portage Point and in Muskegon State Park, respectively, were relatively small. Both, however, were discovered in close proximity to their respective lake channels, and any planned development and recreational activities near these channel sites will benefit from knowledge of these rare plant populations. The Portage Point colony is particularly important because it lies primarily on private land. The fourth new rare plant occurrence found during the survey, the discovery of the state threatened Lycopodium appressum (appressed

clubmoss) within Muskegon State Park, is similarly a significant record.

An important component of the survey was to relocate known occurrences of rare plant populations such that MNFI records could be improved with updated status information. Nearly all known (i.e. MNFI-tracked) occurrences within or near the 15 sites were found and appropriate status data were gathered, consisting of population tallies or estimates, lists of associate species, lists of and notes on invasive exotics, and notes on important natural and artificial disturbance factors, particularly human disturbances such as ORV incursions. As noted in Table 1, 16 known rare plant occurrences were relocated. For many occurrences, prior record data were minimal[2], and the survey thus resulted in vastly improved records for these populations. For several occurrences, exploration of more extensive areas of the shoreline also resulted in significant local range extensions within sites (e.g. the identification of colonies in additional sections in townships).

Although the shoreline survey was not initially conducted with the intention of accumulating natural community information, sufficient data were gathered such that community occurrences of Open Dunes and Interdunal Wetland could be recognized. It is notable that all seven new community occurrences were previously unidentified sites within designated Critical Dune Areas. In addition to the documentation of new natural community occurrences, six known occurrences of Open Dunes and Interdunal Wetland were within the study sites (see Table 1), and data gathered during rare plant surveys were used to update these community occurrence records.

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[2]Occurrence records are often comprised of the minimal data derived from herbarium labels or early, very cursory surveys, and thus many records may provide little information on associated species, disturbance, and the extent and condition of populations.

Exotic Species and Human Disturbance

Several invasive or potentially invasive exotic plant species were noted during the survey of coastal sites. The establishment of exotics has occurred primarily as a result of artificial disturbance, such as excessive foot-traffic and ORV use, or not uncommonly through deliberate introductions to stablize sand dunes and also serve as ornamental species. The net effect has been to degrade natural sand dune habitat and partially disable the abiotic processes--mostly sand movement--necessary to maintain the dunes and their associated biodiversity. Because many of these exotics appeared to pose a substantial threat to rare plant populations, appropriate notes were compiled on important alien species observed during the inventory.

A number of the recorded exotic species are widespread throughout the state, especially on roadsides and elsewhere, such as Centaurea maculosa (spotted knapweed), Poa compressa (Canada bluegrass), Silene vulgaris (bladder campion), and Saponaria officinalis (soapwort). Soapwort and bladder campion, for example, were found in many of the sites surveyed (Table 2), but like Canada bluegrass, Agropyron repens (quack grass), and some other species, did not seem to be a problem in most of the sites surveyed.

The most invasive species noted during the inventory were spotted knapweed, Populus nigra var. italica (Lombardy poplar), Populus alba (white poplar), Robinia pseudoacacia (black locust), Elaeagnus umbellata (autumn olive), and to some extent Melilotus alba (white sweet clover). Spotted knapweed thrives well in sand dune habitats, particularly where artificial disturbance occurs, which enhances the ability of this species to invade dunes from adjacent roadsides and other areas. As this plant becomes established it will likely be extremely difficult to eradicate as it displaces native vegetation. Black locust and especially Lombardy poplar were similarly

observed to be well-established in many dune habitats, and because of their ability to form clones (see photo B-14) these species will persist. Autumn olive, which was likely introduced as both a wildlife planting and sand dune stabilizer, was observed within relatively few sites, but found to be rapidly spreading. Based on prior knowledge of this species' biology elsewhere, this shrub will continue to aggressively invade the dunes without control efforts.

White poplar, although only observed in one site, was noted because of its extremely invasive characteristic. Once planted, it readily forms clones and is difficult to control. The shoreline sand dunes are highly vulnerable to this species, which appears to be well-adapted to the dune environment. This species has been observed to be particularly invasive elsewhere along the Lake Michigan shore, such as near Cross Village and other sites not within the 1992 study area.

Artificial (human) disturbance remains a significant threat along most shoreline areas. Other than creating conditions suitable for the invasion of exotic plant species, much of this disturbance is a direct threat to the integrity and functioning of sand dune systems. Shorelines continue to be heavily used for recreation, and where not controlled this threatens many rare plant populations. Perhaps the most persistent and pernicious problem is the ubiquitous use of ORV's on beaches and dunes, leading to the unnatural destabilization of back dunes and other areas, as depicted in some of the photos in Appendix C.

Lastly, as noted previously, the remains of helium ballons and ribbon streamers were found repeatedly along the shoreline (see photo in Appendix C). Some residents encountered believed these to be released from as far away as Wisconsin, although the balloons were not identifiable as to origin. Clearly, the abundance of this refuse represents an important potential problem for

wildlife, such as gulls and other Great Lakes birds that may become entangled in it. At the very least, the balloons and streamers befoul the beaches and dunes to the extent that they degrade them aesthetically, and are very annoying to shoreline residents and recreationists.

Potential Rare Plant Sites

Systematic examination of the Lake Michigan shoreline via topographic maps and aerial photos revealed a number of shoreline areas that merit field inspection for rare plants (see Appendix B). These areas ranged from sites delineated in Berrien County to selected shorelines in the Beaver Island group, included Garden and Hog islands. Most of the sites identified along the southern portion of the Lake Michigan shoreline were of potential primarily for additional Pitcher's thistle populations. To the north, particularly in Charlevoix and Emmet counties (especially Beaver, Hog, and Garden islands and Waugoshance Island respectively), several areas provide potential habitat for several other possible species, including Houghton's goldenrod, Dwarf lake iris, Michigan monkey-flower, Lake Huron tansy, Pinguicula vulgaris (butterwort), and possibly other species. Survey of the identified sites will unquestionably result in significant new rare plant localities.

Recommendations

1. Information on new and updated occurrences should be promptly conveyed to appropriate management agencies, such that these occurrences can be considered in future planning activities.

2. Surveys of the potential rare plant sites delineated through map and aerial photo review should be conducted within the next few years, and systematic survey of all remaining Michigan shoreline areas in both peninsulas should be initiated.

3. A management strategy to control the invasion and spread of exotic plant species along Great Lakes shorelines should be prepared, including provisions for public education and the dissemination of information about the natural ecology of the shoreline ecosystem.

4. An attempt should be made to determine the source or sources (i.e. release points) of helium party balloons and their ribbon streamers, such that this frequent refuse along the Lake Michigan shoreline can be eliminated, which will enhance the aesthetic aspects of the coastal zone and also assist in the protection of wildlife.

Acknowledgements

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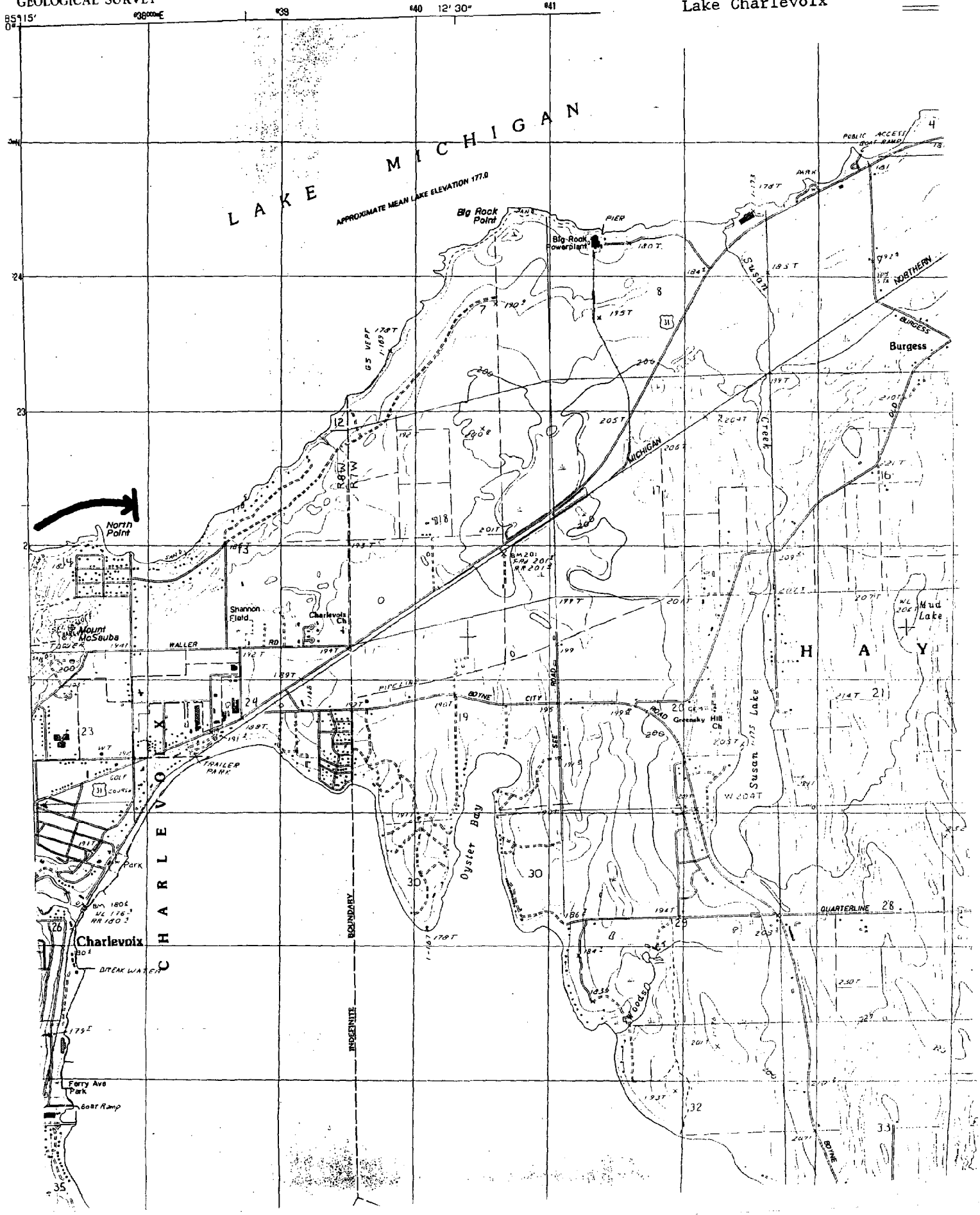
APPENDICES

Appendix A

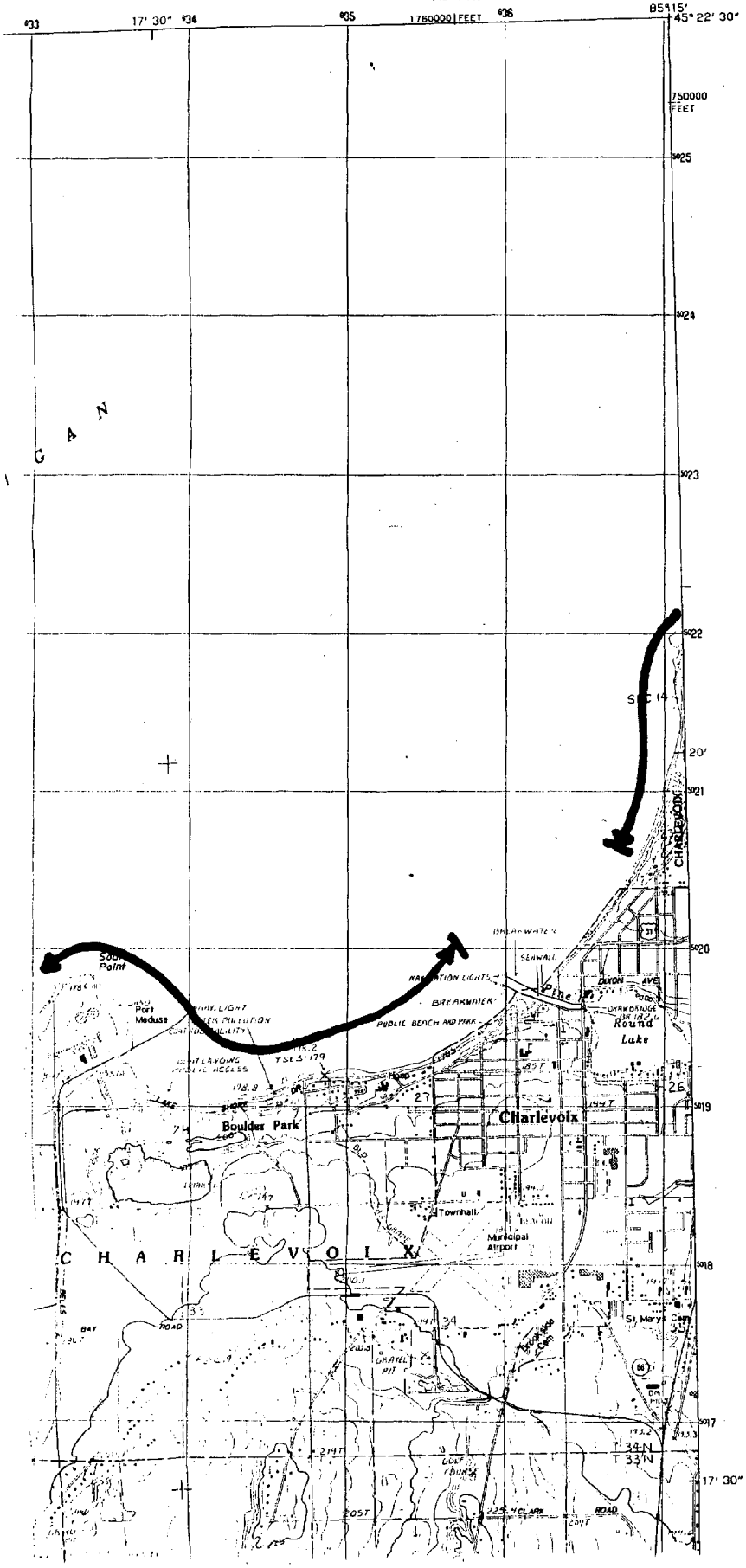
Maps of survey sites and specific shoreline areas inventoried

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Lake Charlevoix



Lake Charlevoix



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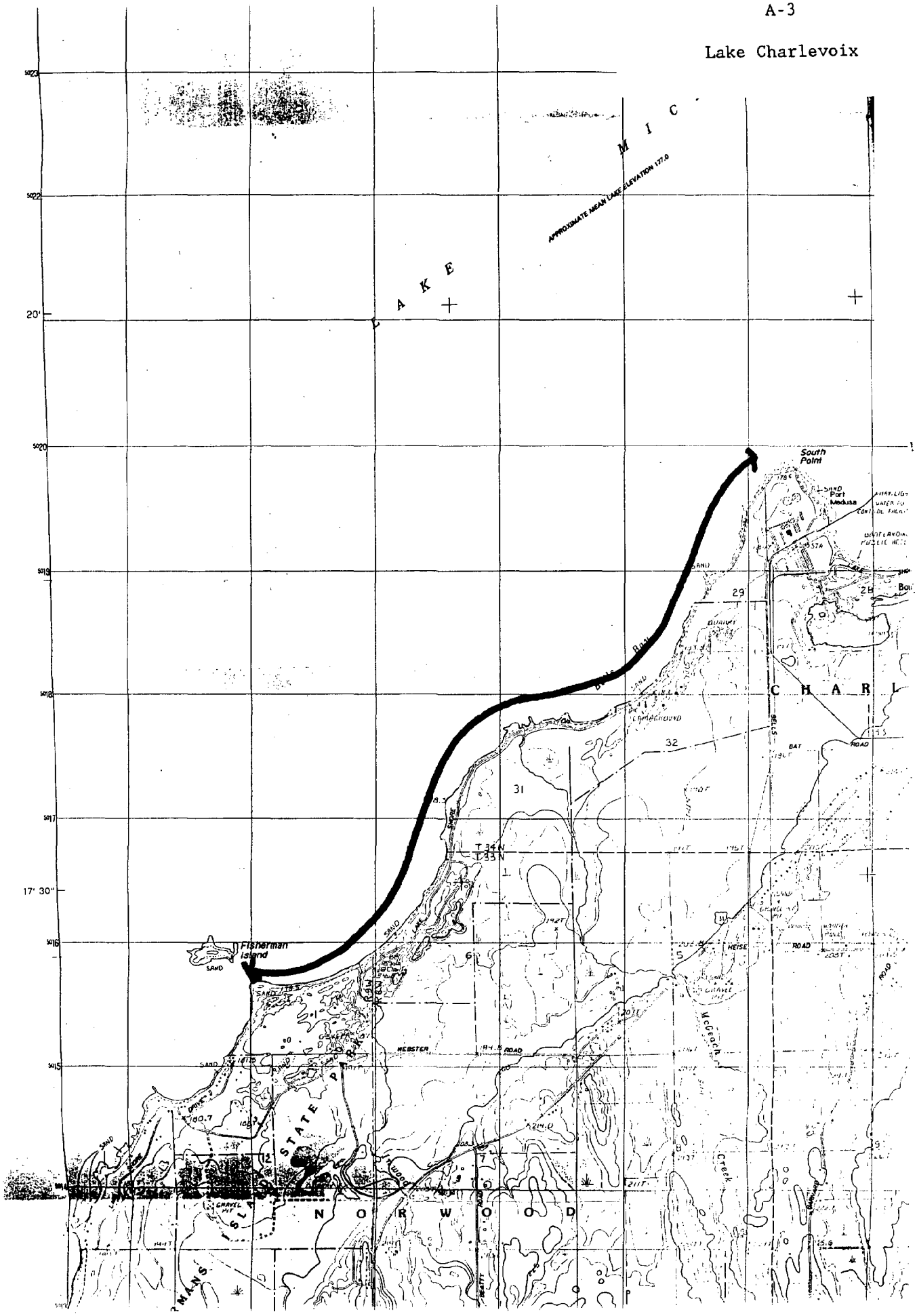
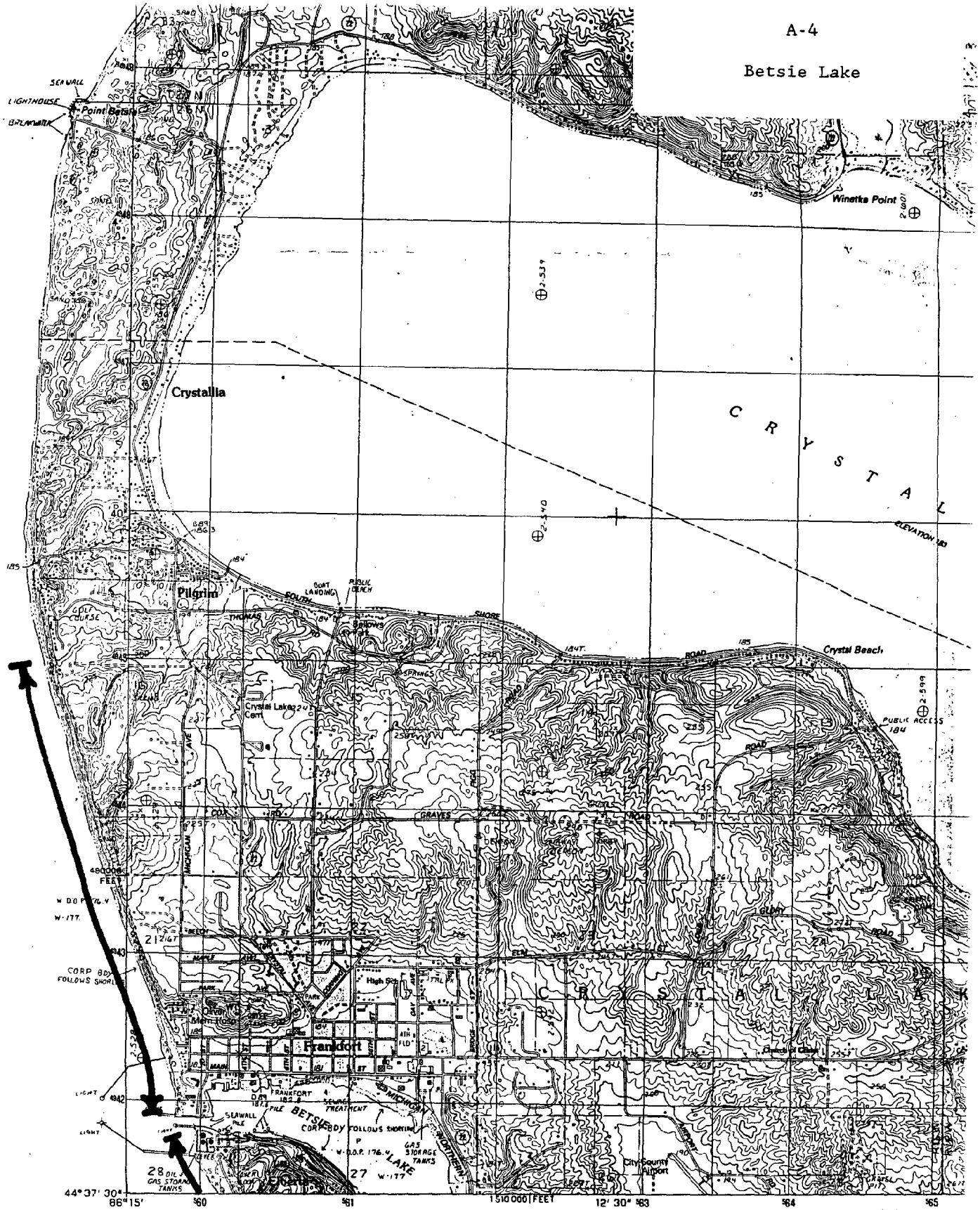


A-4

Betsie Lake



PRODUCED BY THE UNITED STATES GEOLOGICAL SURVEY
CONTROL BY ..... USGS AND NOS/NOAA
COMPILED FROM AERIAL PHOTOGRAPHS TAKEN 1977
FIELD CHECKED ..... 1979. MAP EDITED 1983
PROJECTION ..... UNIVERSAL TRANSVERSE MERCATOR
GRID: 1000-METER UNIVERSAL TRANSVERSE MERCATOR ..... ZONE 16
10,000-FOOT STATE GRID TICKS ..... MICHIGAN, CENTRAL ZONE
UTM GRID DECLINATION ..... 0°34' EAST
1983 MAGNETIC NORTH DECLINATION ..... 3°00' WEST
VERTICAL DATUM ..... NATIONAL GEODETIC VERTICAL DATUM OF 1929
HORIZONTAL DATUM ..... 1927 NORTH AMERICAN DATUM

To place on the predicted North American Datum of 1983 move the projection lines as shown by dashed corner ticks (3 meters north and 3 meters east)

There may be private inholdings within the boundaries of any Federal and State reservations shown on this map

NORTH

SCALE 1:25 000

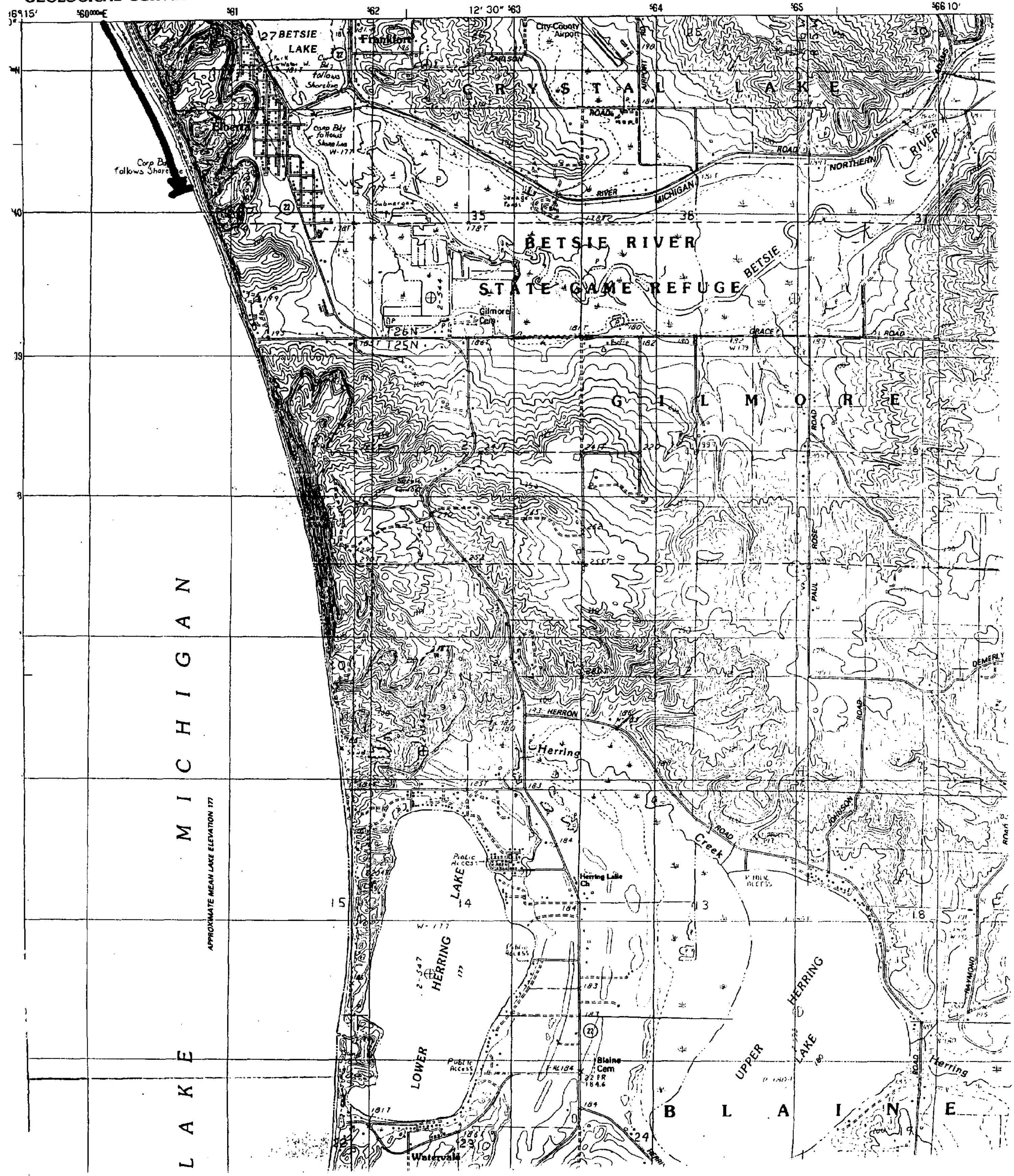
1 .5 0 KILOMETERS 1
1000 0 METERS 1000
1 .5 0 MILES
1000 0 1000 2000 3000 4000 5000 6000 70
FEET

CONTOUR INTERVAL 5 METERS
SUPPLEMENTARY CONTOUR INTERVAL 2.5 METI
SUPPLEMENTARY CONTOUR INTERVAL 1.5 METERS ALONG
CONTROL ELEVATIONS SHOWN TO THE NEAREST 0.1 M
OTHER ELEVATIONS SHOWN TO THE NEAREST 0.5 MF

To convert meters to feet multiply by 3.2808
To convert feet to meters multiply by .3048

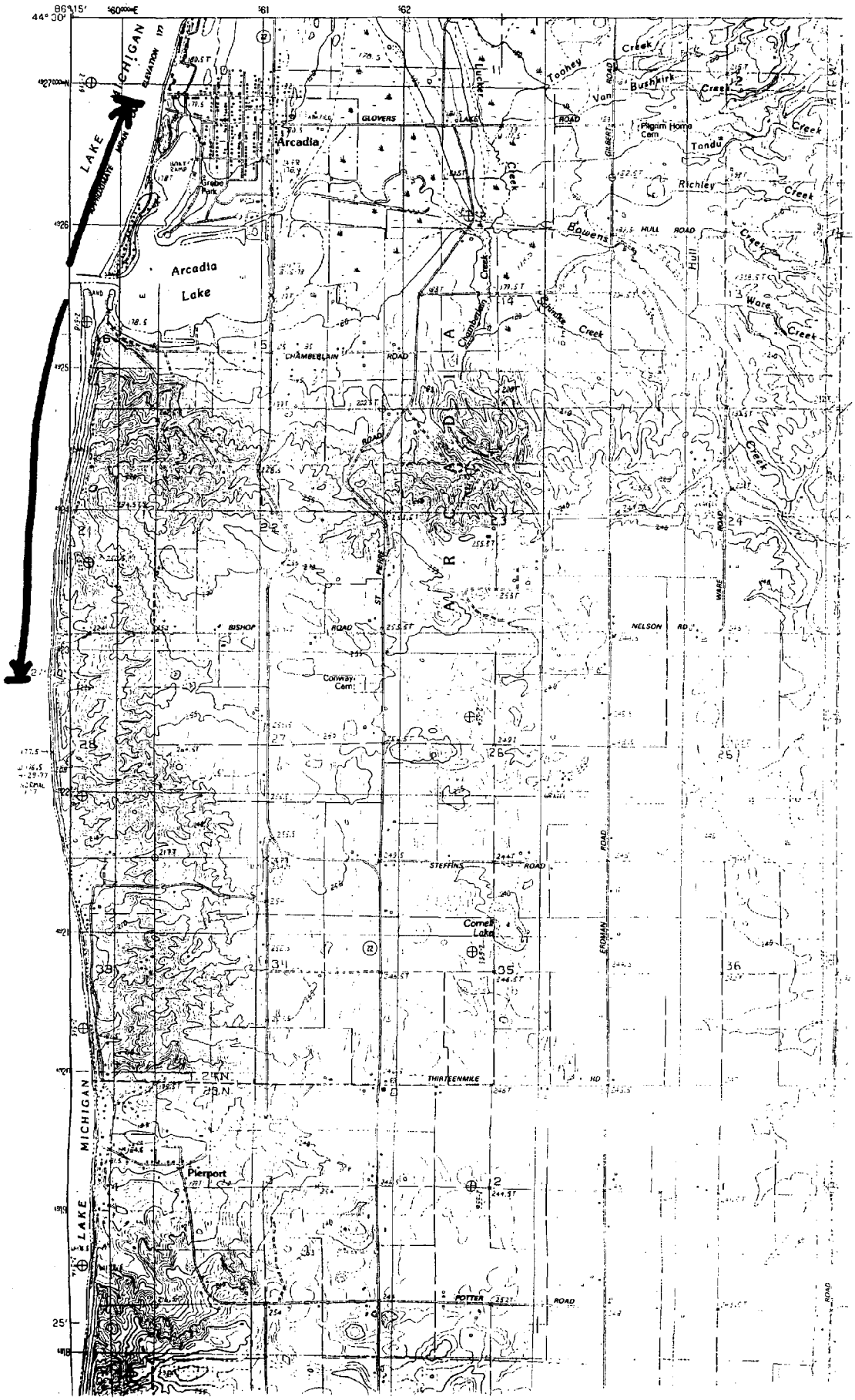
PROVISIONAL MAP
Produced from original manuscript drawings. Infor-
mation shown as of date of

UNITED STATES
ɔARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

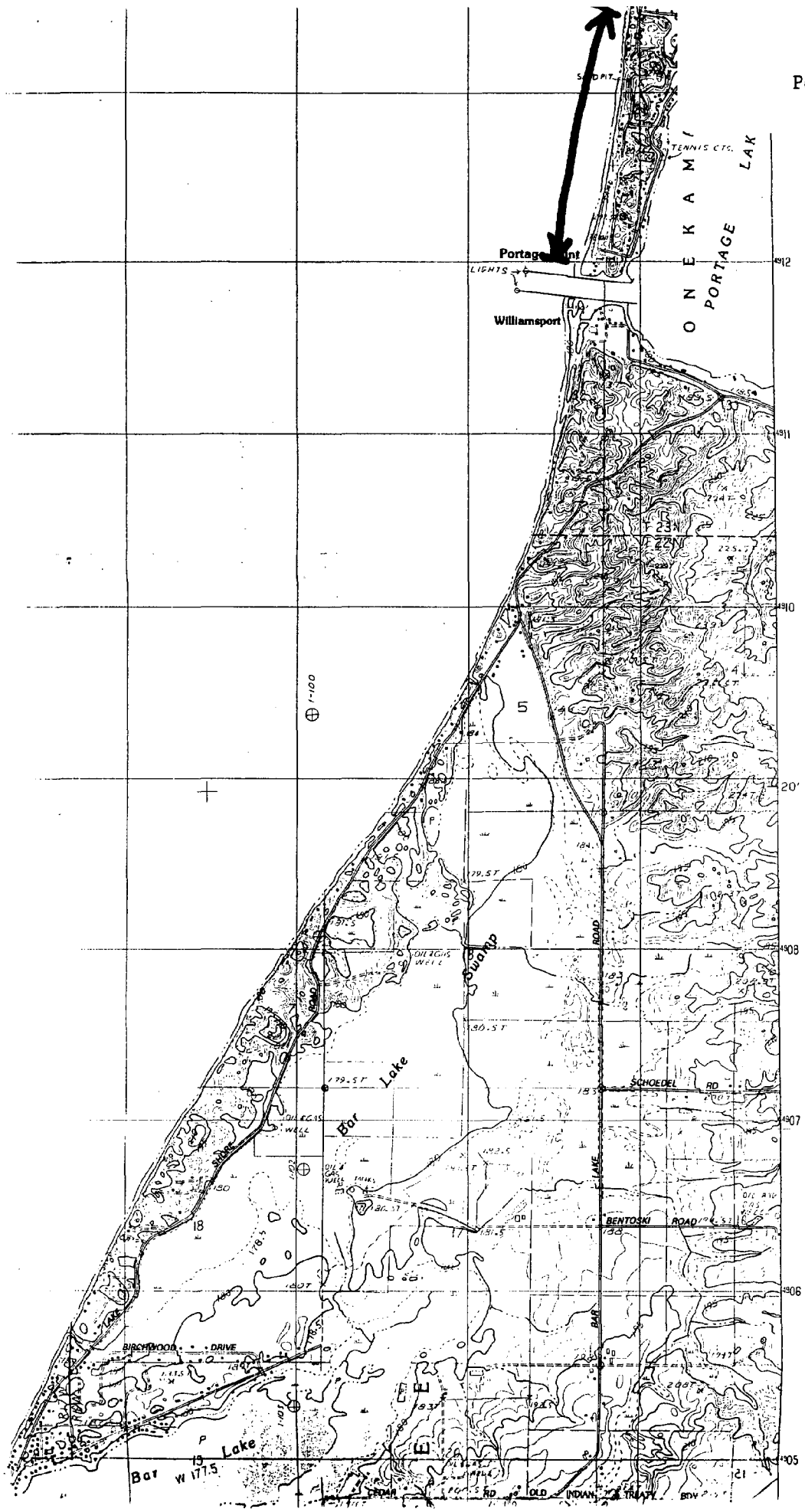


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Arcadia Lake

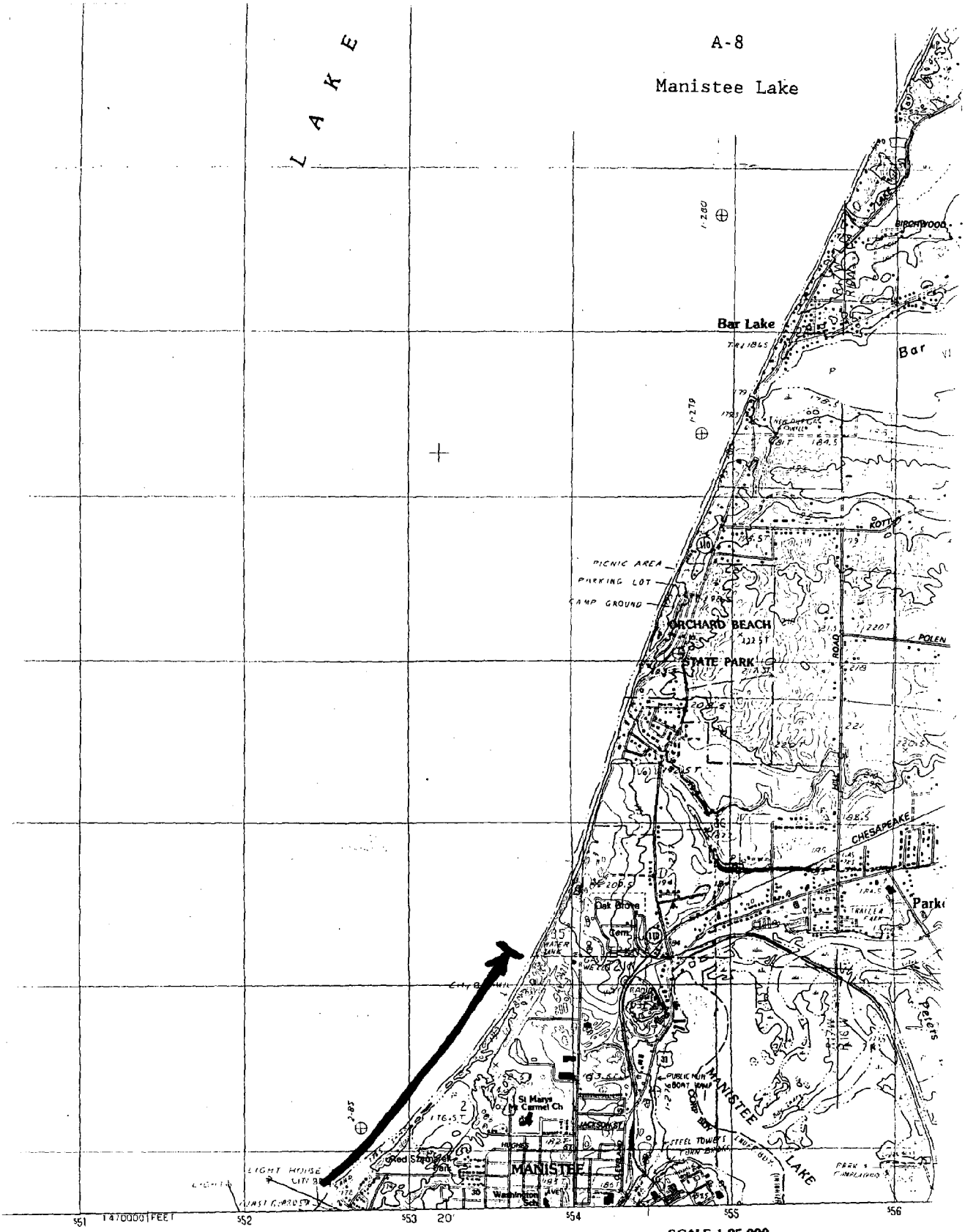


Portage Lake



A-8

Manistee Lake



SCALE 1:25 000

KILOMETERS 1 0 1
METERS 1000 0 1000
MILES 1 0 1
FEET 1000 0 1000 2000 3000 4000 5000 6000 7000 8000

CONTOUR INTERVAL 3 METERS
SUPPLEMENTARY CONTOUR INTERVAL 1.5 METERS
CONTROL ELEVATIONS SHOWN TO THE NEAREST 0.1 METER
OTHER ELEVATIONS SHOWN TO THE NEAREST 0.5 METER

To convert meters to feet multiply by 3.2808
To convert feet to meters multiply by .3048

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, RESTON, VIRGINIA 22092
AND THE GEOLOGICAL SURVEY DIVISION

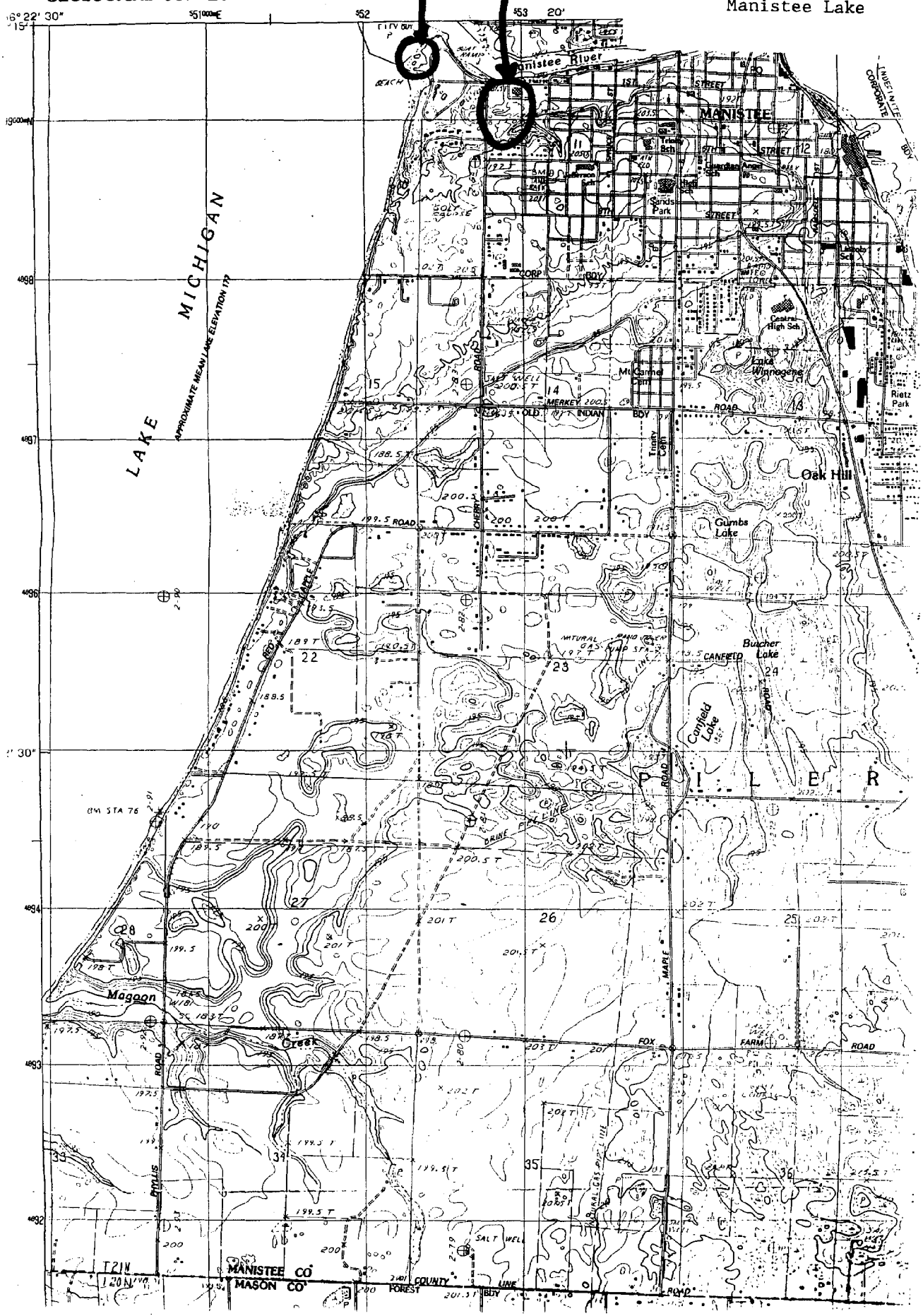
UNITED STATES GEOLOGICAL SURVEY
..... USGS AND NOS/NOAA
TOGRAPHS TAKEN 1977
1979. MAP EDITED 1983
..... LAMBERT CONFORMAL CONIC
L TRANSVERSE MERCATOR ..... ZONE 16
RID TICKS ..... MICHIGAN, CENTRAL ZONE
..... 0°29' EAST
LINATION ..... 2°30' WEST
NATIONAL GEODETIC VERTICAL DATUM OF 1929
..... 1927 NORTH AMERICAN DATUM
dicted North American Datum of 1983
lines as shown by dashed corner ticks
ters east)
inholdings within the boundaries of any
vations shown on this map
in which selected buildings are shown

NORTH

PROVISIONAL MAP
Produced from original manuscript drawings. Information shown as of date of field check.

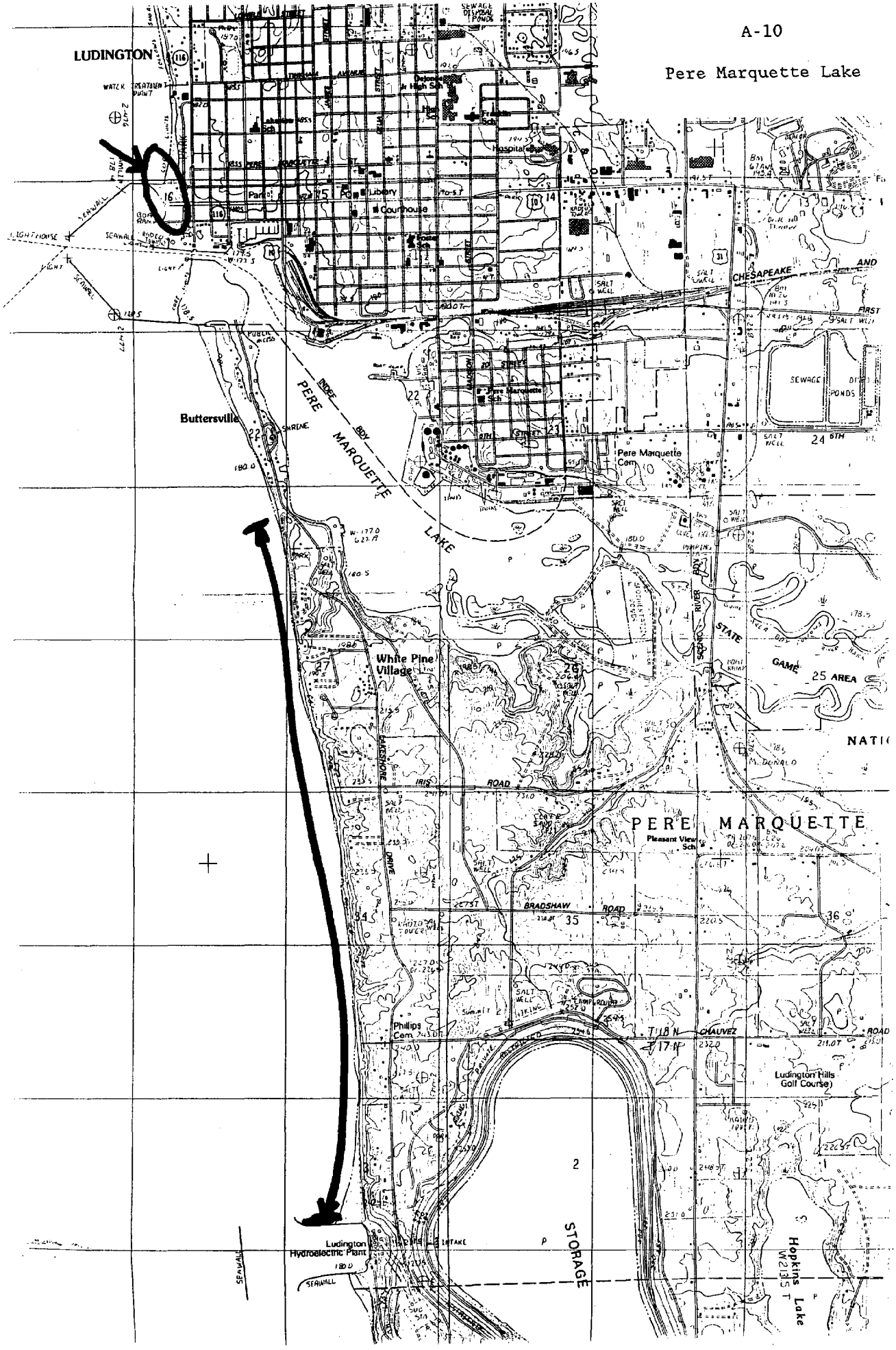
3

Manistee Lake



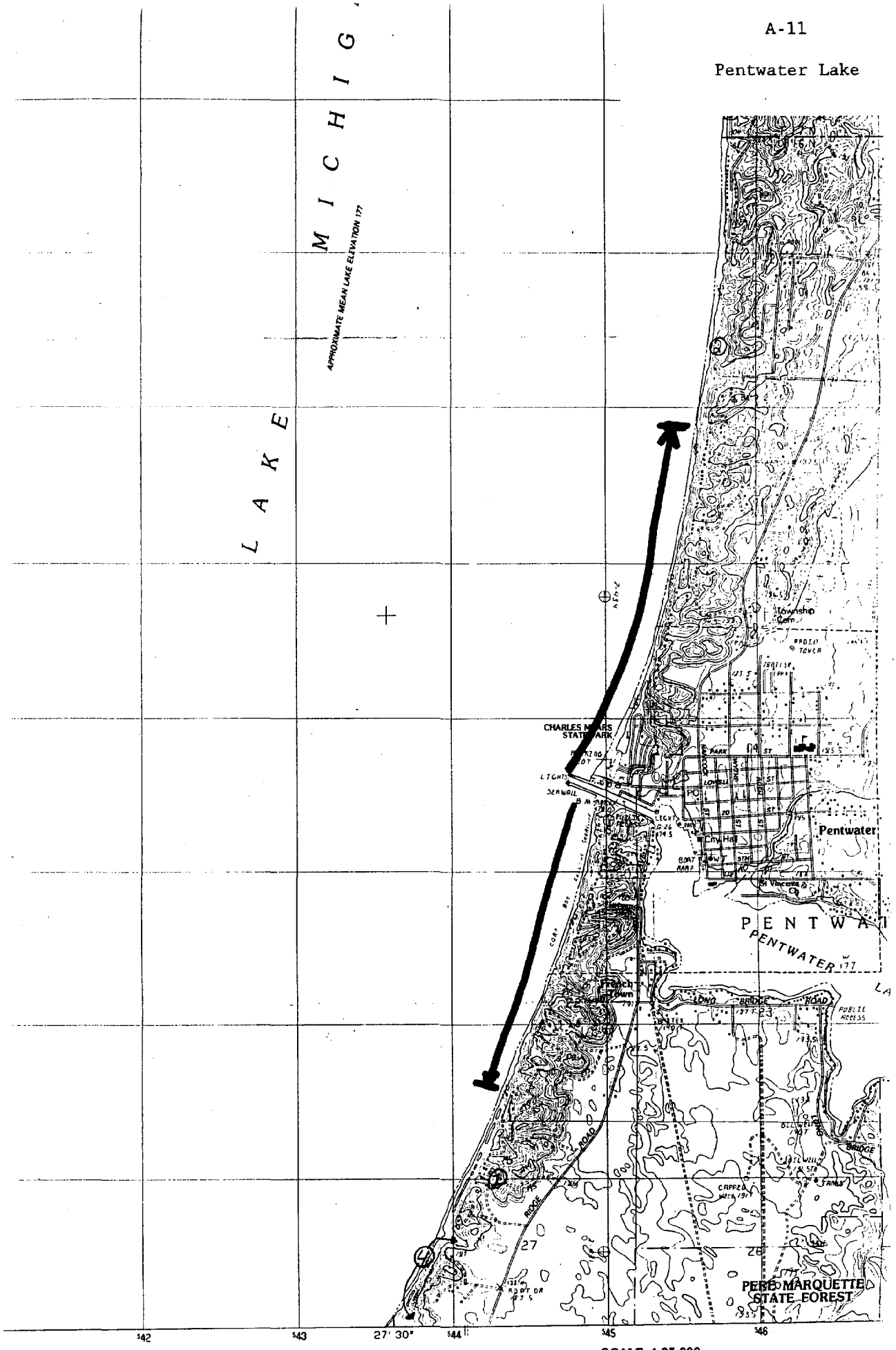
A-10

Pere Marquette Lake



A-11

Pentwater Lake

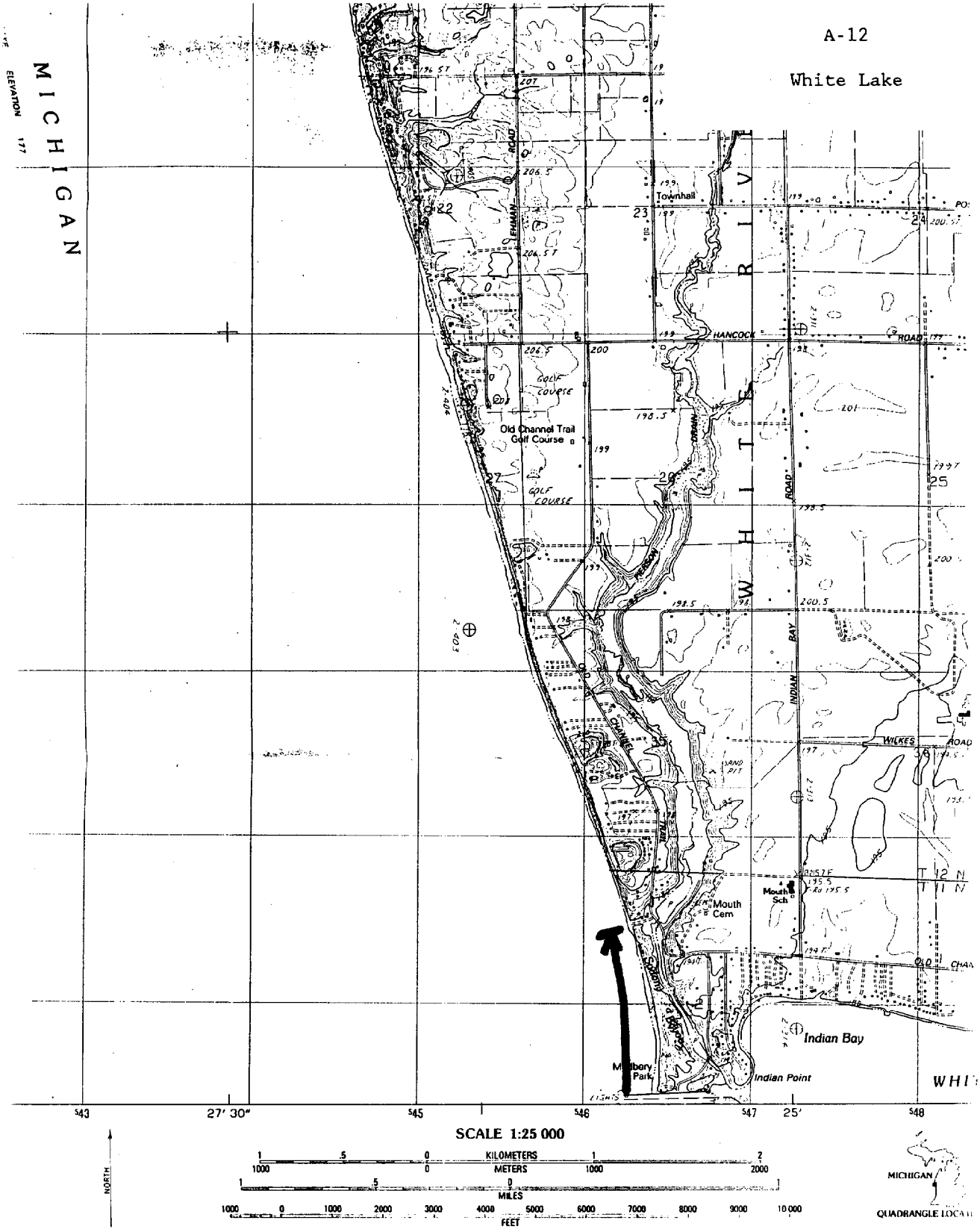


STATES GEOLOGICAL SURVEY

SCALE 1:25 000

A-12

White Lake



SCALE 1:25 000

KILOMETERS 1 .5 0 1 2
METERS 1000 0 1000 2000
MILES 1 .5 0
FEET 1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10 000

NORTH

MICHIGAN

QUADRANGLE LOCATION

PROVISIONAL MAP
Produced from original manuscript drawings. Information shown as of date of field check.

CONTOUR INTERVAL 3 METERS
SUPPLEMENTARY CONTOUR INTERVAL 1.5 METERS
CONTROL ELEVATIONS SHOWN TO THE NEAREST 0.1 METER
OTHER ELEVATIONS SHOWN TO THE NEAREST 0.5 METER
To convert meters to feet multiply by 3.2808
To convert feet to meters multiply by .3048

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, RESTON, VIRGINIA 22092
AND THE GEOLOGICAL SURVEY DIVISION
MICHIGAN DEPARTMENT OF NATURAL RESOURCES, LANSING, MICHIGAN 48909

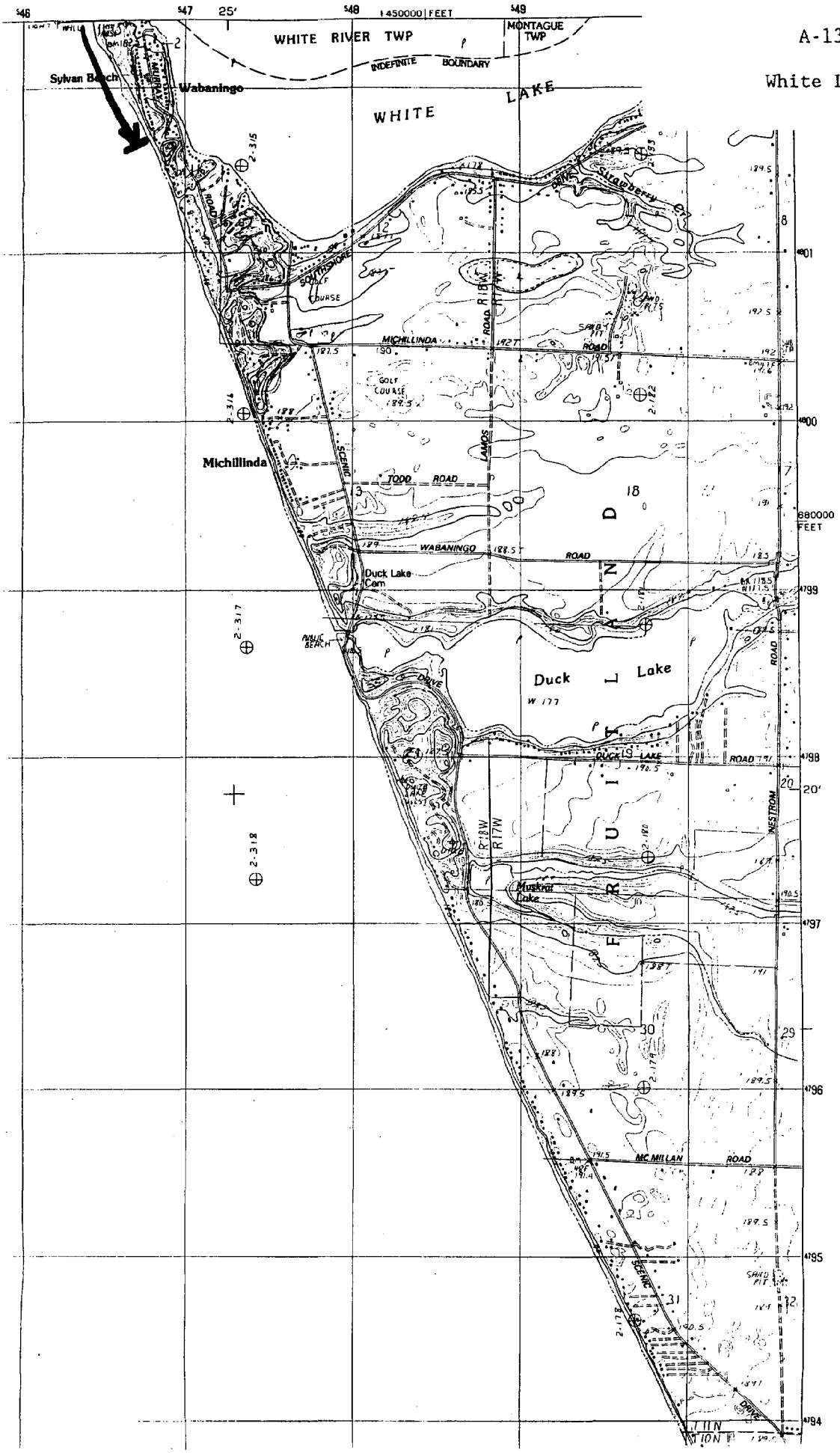
1	2	3	1 Bigsbie 2 Town C 3 Shelby
4		5	4 5 Montag
6	7	8	6 7 Michilli 8 Dalton

ADJOINING 7.5' QUADRANGL

CONTOURS AND ELEV
IN METERS

A-13

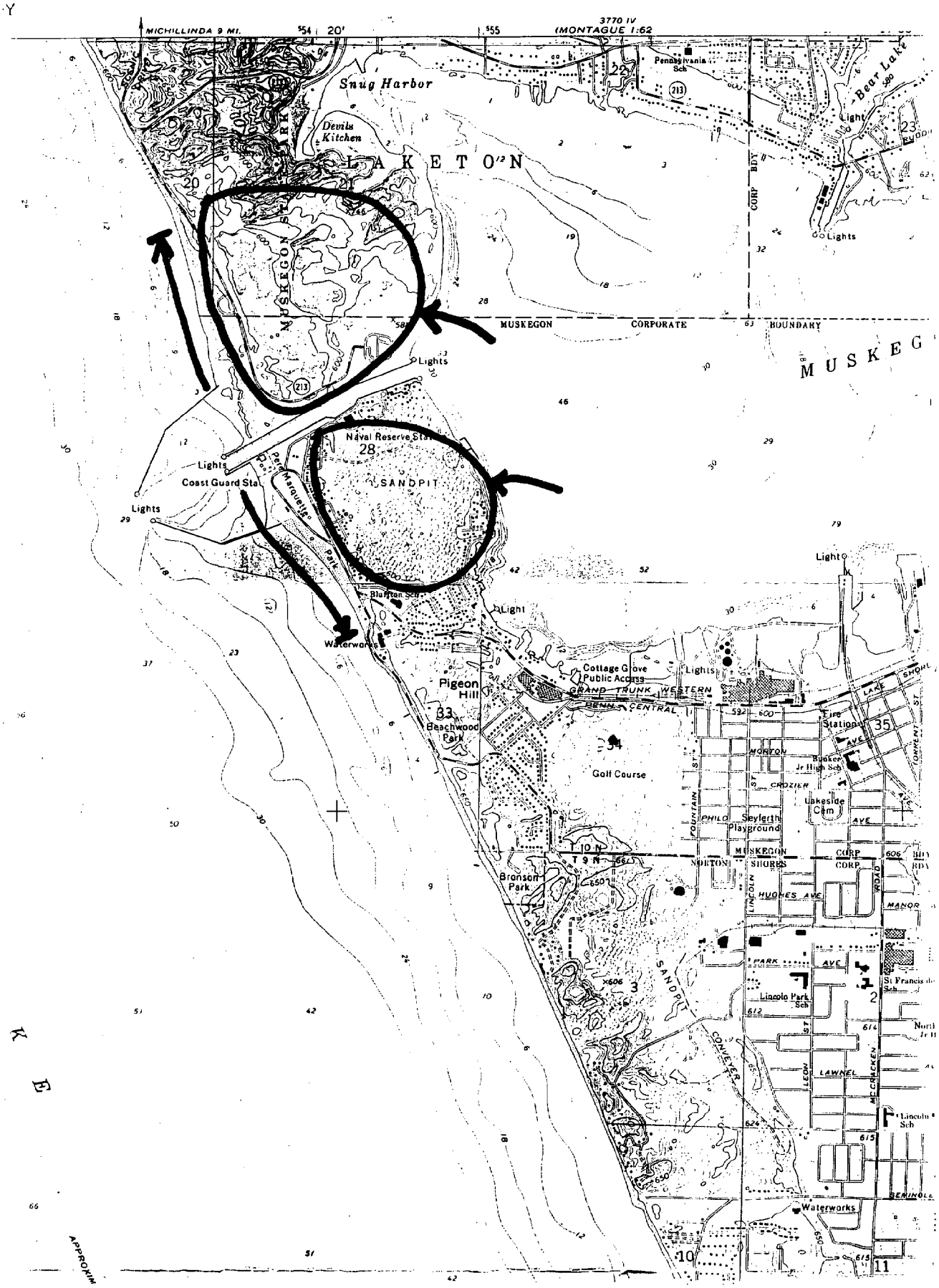
White Lake



TERIOR
Y

STATE OF MI(

Muskegon Lake

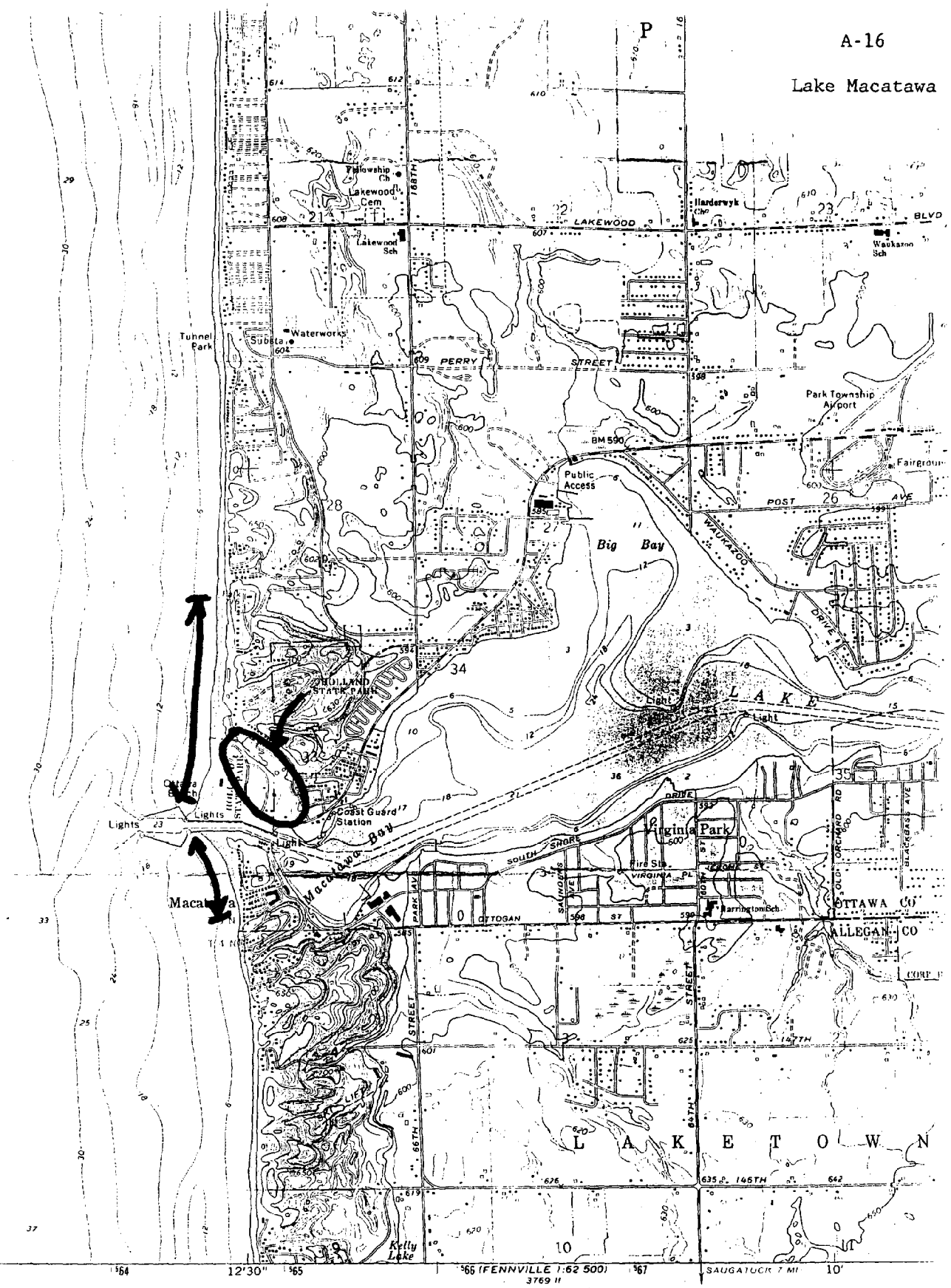


Spring Lake


HICKORY
SPRING
TAFT
CHESAPEAKE
GRAND HAVEN AND
168TH AVENUE
180TH AVE
Lake Hills Sch
FERRYSBURG CORP BDY
Smith Bayou
NORTH SHORE RD
City Hall
Ferrysburg
North Beach Park
The Sag
Sandpit
GRAND RIVER
Boat Ramp
Harbor Island
Powerplant
Robinson Park
Dornbos Island
Sewage Disposal
Sew Disp
South Channel
Hatton Park
JACKSON
Elliott Sch
Museum
Armory
FULTON
Courthouse
WASHINGTON
HOWARD ST
Central Sch
Kelly Park
Coast Guard Sta
Lights
Lighthouse
MULLIGANS HOLLOW PARK
GRAND HAVEN STATE PARK
APPROXIMATE MEAN LAKE LEVEL
DUNCAN PARK
LAKE FOREST CEMETERY
White Sch
GRAND AVE
OHIO AVE
WISCONSIN ST
HILLCREST
PENNOYER AVE
Perry Sch
Christian Jr High Sch
WAVERLY AVE
GRAND HAVEN
TAYLOR
FERRY ST
GRIFFIN ST
BEECHTREE ST
Eastern Park
Bolt Park
Jr High Sch
Griffin Sch
CORP BDY
LAKE MICHIGAN

A-16

Lake Macatawa



(FENNVILLE 1:62 500)
3769 II

SCALE 1:24 000

1 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETRE

CONTOUR INTERVAL 10 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS LOW WATER 576.8 FEET

MN GN
1° 18 MILS 0°33' 10 MILS

UTM GRID AND 1972 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

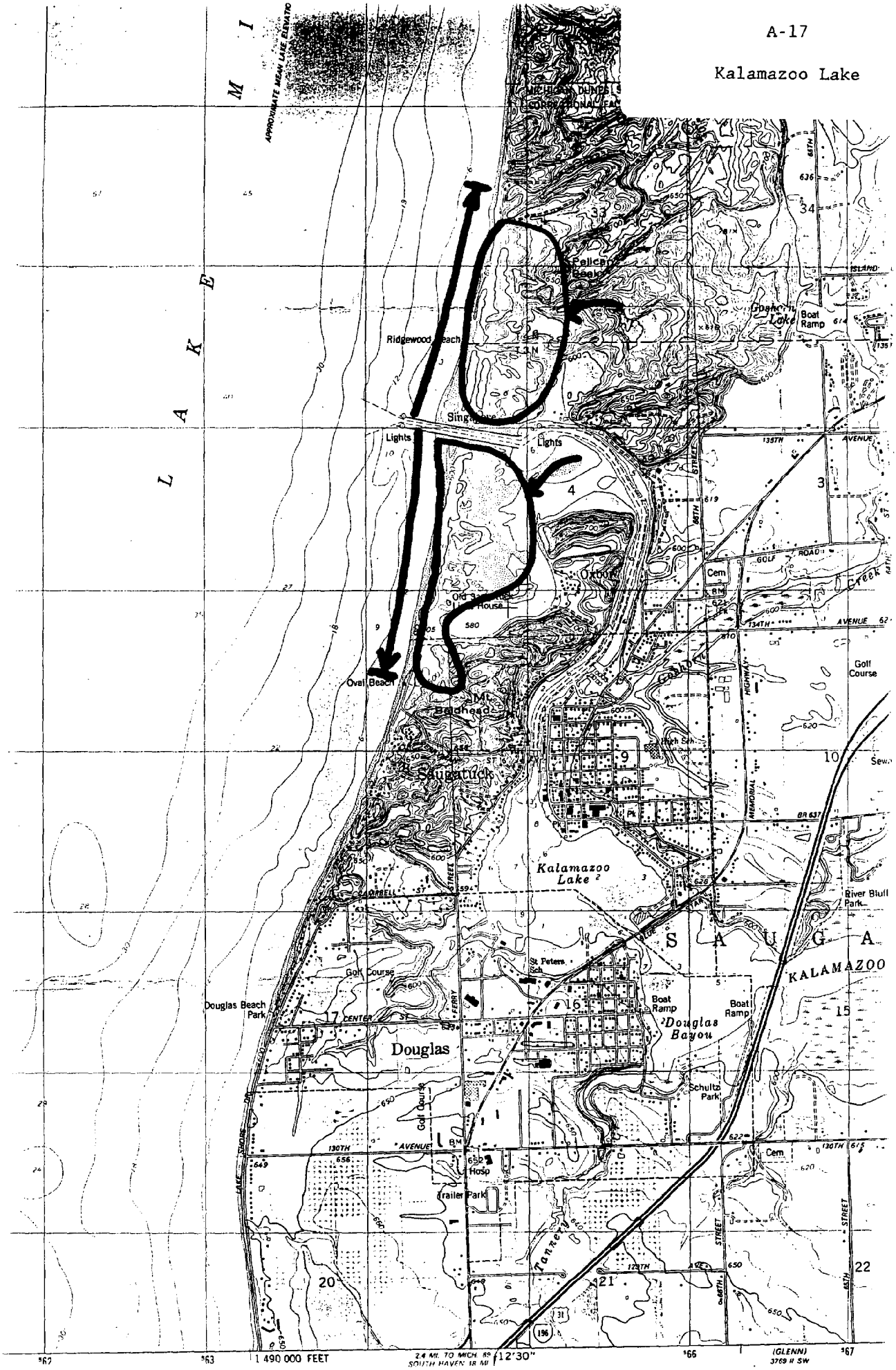
Charts 76 (1973)
tional purposes

MICHIG

QUADRAN

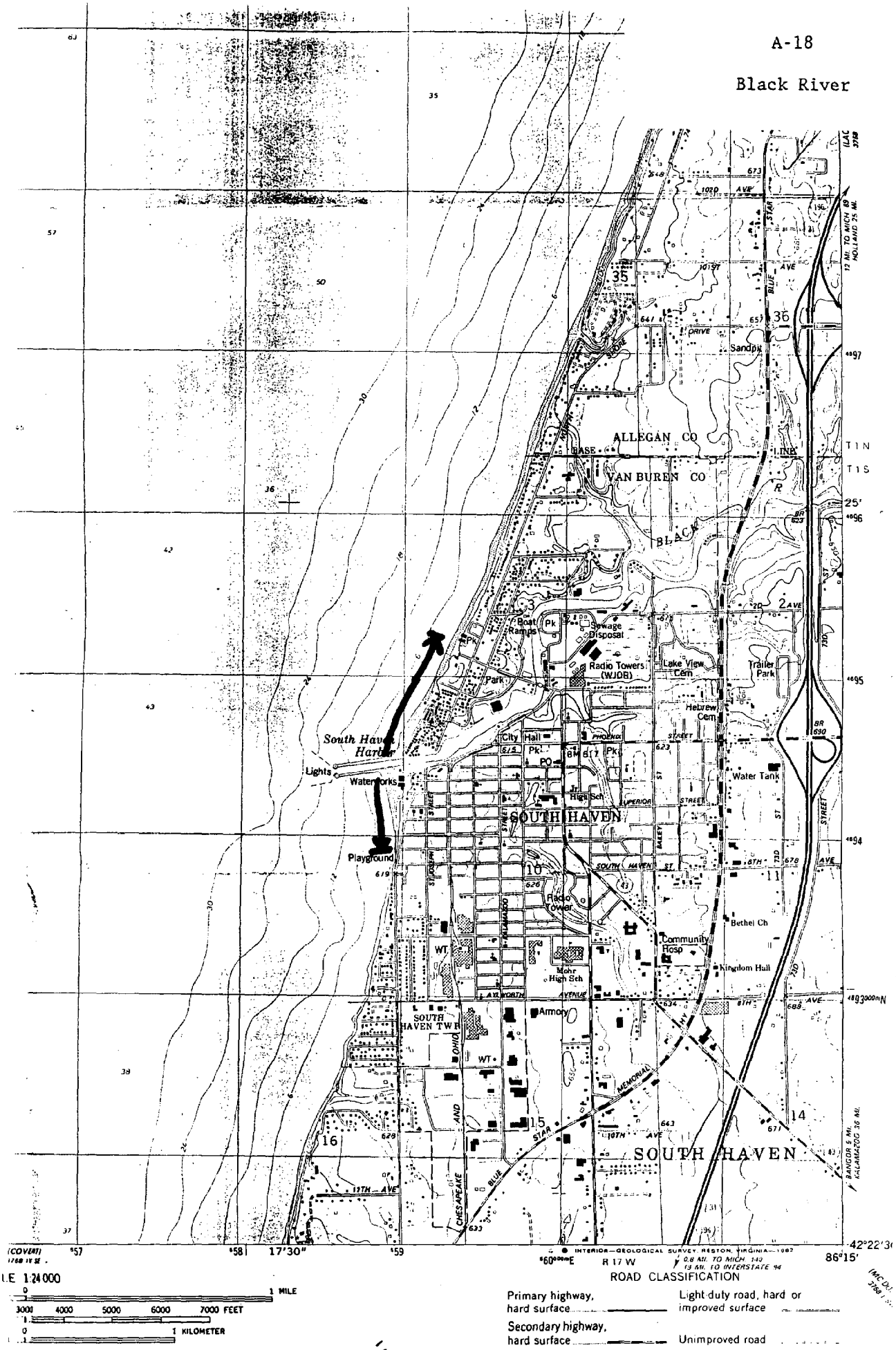
THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS

Kalamazoo Lake



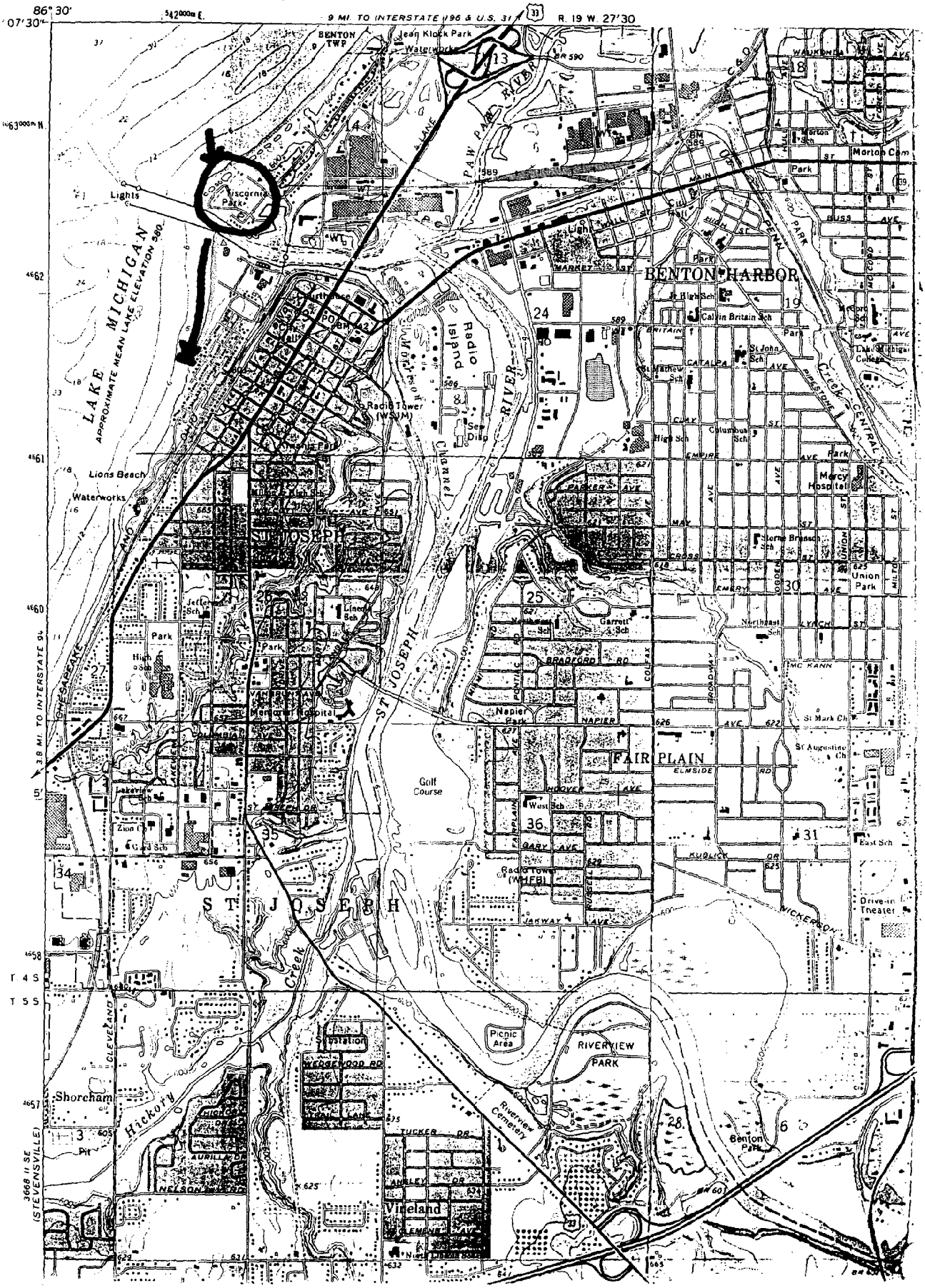
A-18

Black River



UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

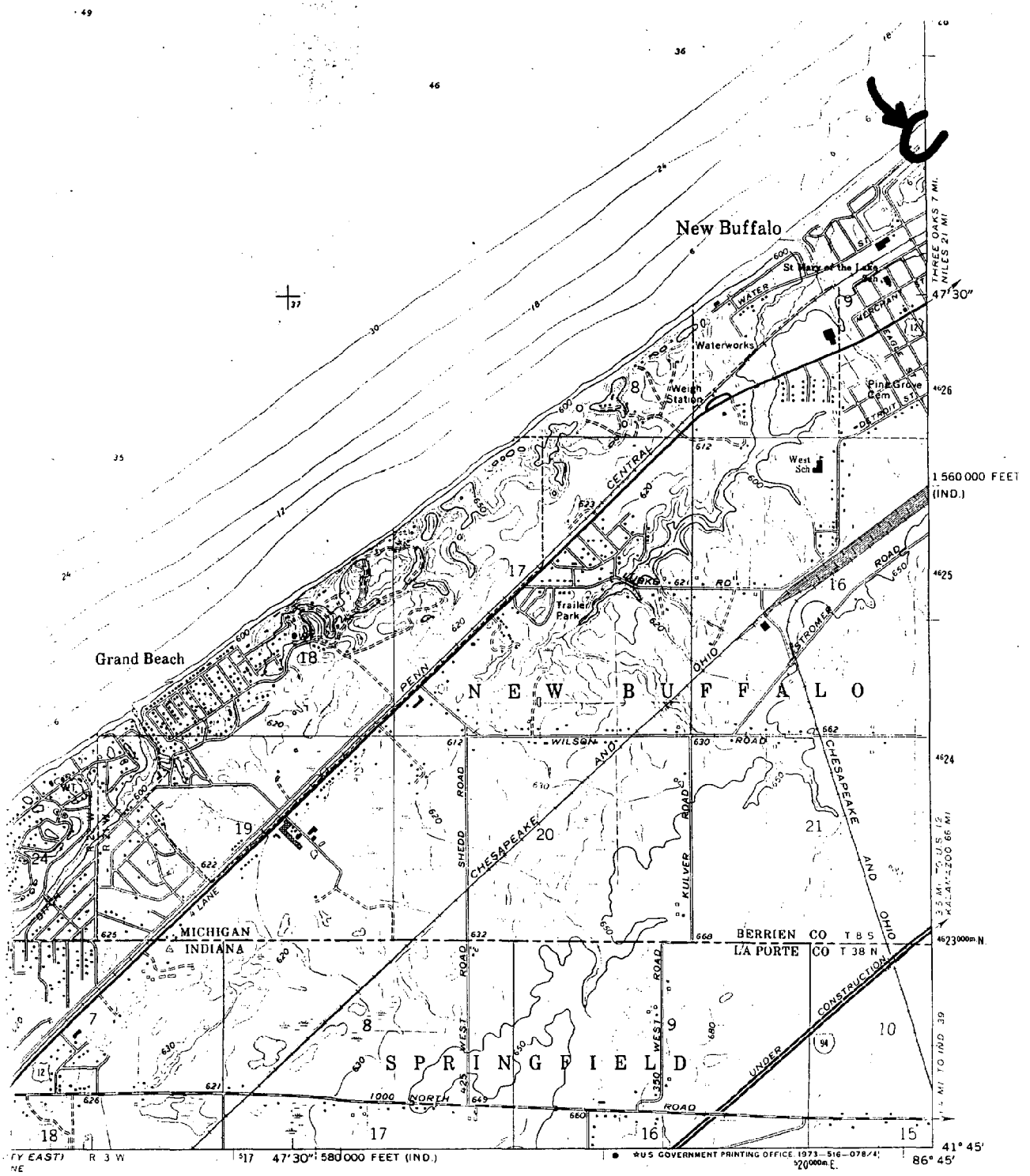
St. Joseph River



A-20

Galien River

Galien River



ROAD CLASSIFICATION

Primary highway, hard surface — Light-duty road, hard or improved surface

Secondary highway, hard surface — Unimproved road

Interstate Route · U. S. Route · State Route

10 FEET
A LEVEL
ATUM IS LOW WATER 576.8 FEET

MAP ACCURACY STANDARDS
VEY, WASHINGTON, D. C. 20242
URCES, INDIANAPOLIS, INDIANA 46204
SYMBOLS IS AVAILABLE ON REQUEST

MICHIGAN NATURAL FEATURES INVENTORY PROGRAM

NEW BUFFALO WEST, MICH.—IND.
N4145—W8645/7.5
1970
AMS 3667 IV SE—SERIES V862

USGS GOVERNMENT PRINTING OFFICE 1973—516—078/41

414

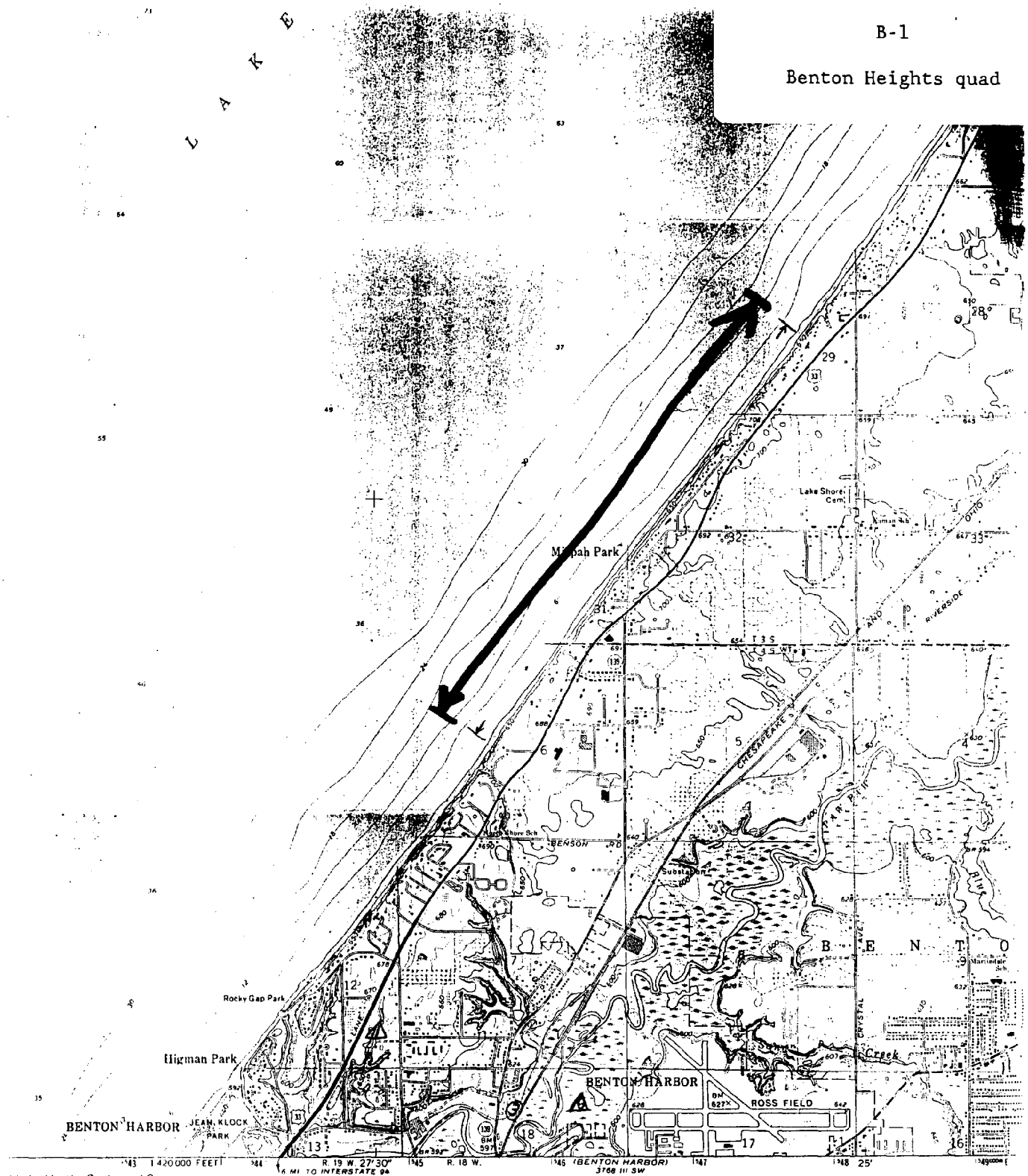
Appendix B

Potential new rare plant sites

identified through map and photo review

B-1

Benton Heights quad



...ublished by the Geological Survey
...te of Michigan agencies
...GS
...netric methods from aerial
... Field checked 1970
... compiled from U. S. Lake Survey
...rmation is not intended

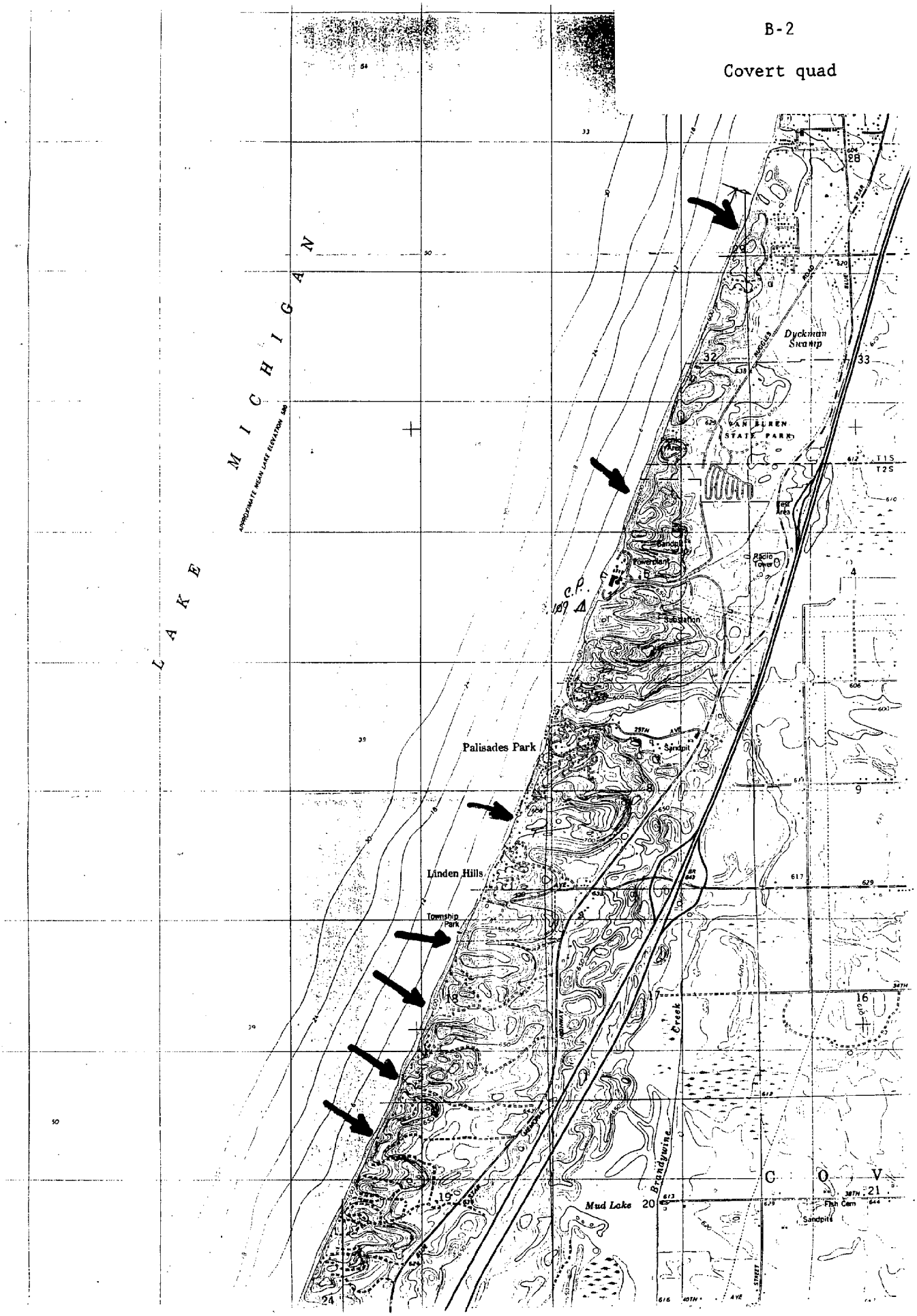
...7 North American datum
...Michigan coordinate system, south zone
...verse Mercator grid ticks.

...Much only landmark buildings are shown
...te selected fence and field lines where
...hotographs. This information is unchecked

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, WASHINGTON, D. C. 20242
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

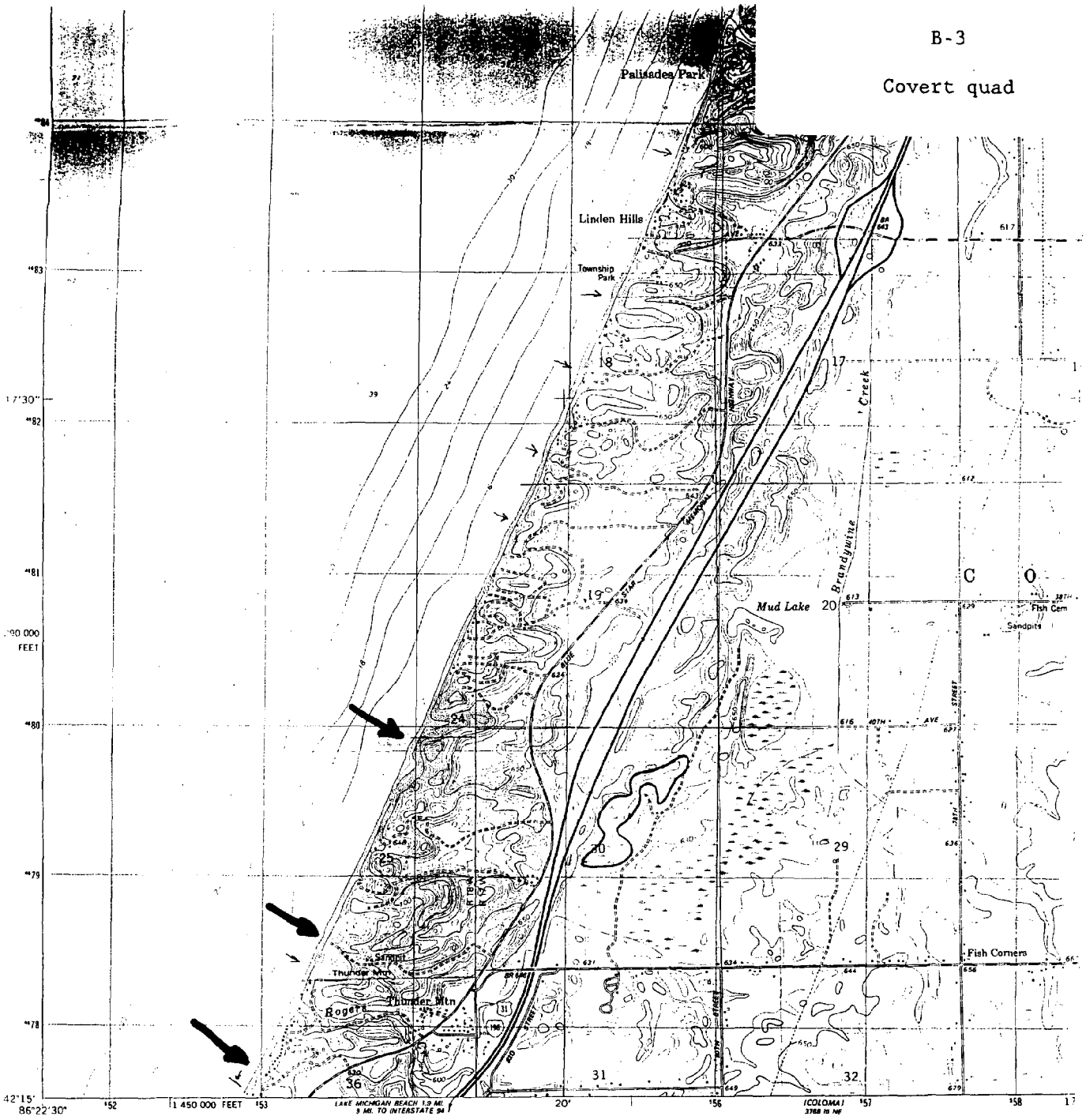
B-2

Covert quad



B-3

Covert quad



Mapped, edited, and published by the Geological Survey

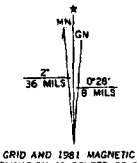
Control by USGS and NOS/NOAA

Topography by photogrammetric methods from aerial photographs taken 1976. Field checked 1977. Map edited 1981

Selected hydrographic data compiled from NOS chart 14905 (1975). This information is not intended for navigational purposes

Projection and 10,000-foot grid ticks: Michigan coordinate system, south zone (Lambert conformal conic)
1000-meter Universal Transverse Mercator grid, zone 16
1927 North American Datum
To place on the predicted North American Datum 1983 move the projection lines 1 meter north and 3 meters east as shown by dashed corner ticks

There may be private inholdings within the boundaries of the National or State reservations shown on this map



UTM GRID AND 1981 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS LOW WATER 576.8 FEET

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, RESTON, VIRGINIA 22092
AND BY THE GEOLOGICAL SURVEY DIVISION
MICHIGAN DEPARTMENT OF NATURAL RESOURCES, LANSING, MICHIGAN 48909
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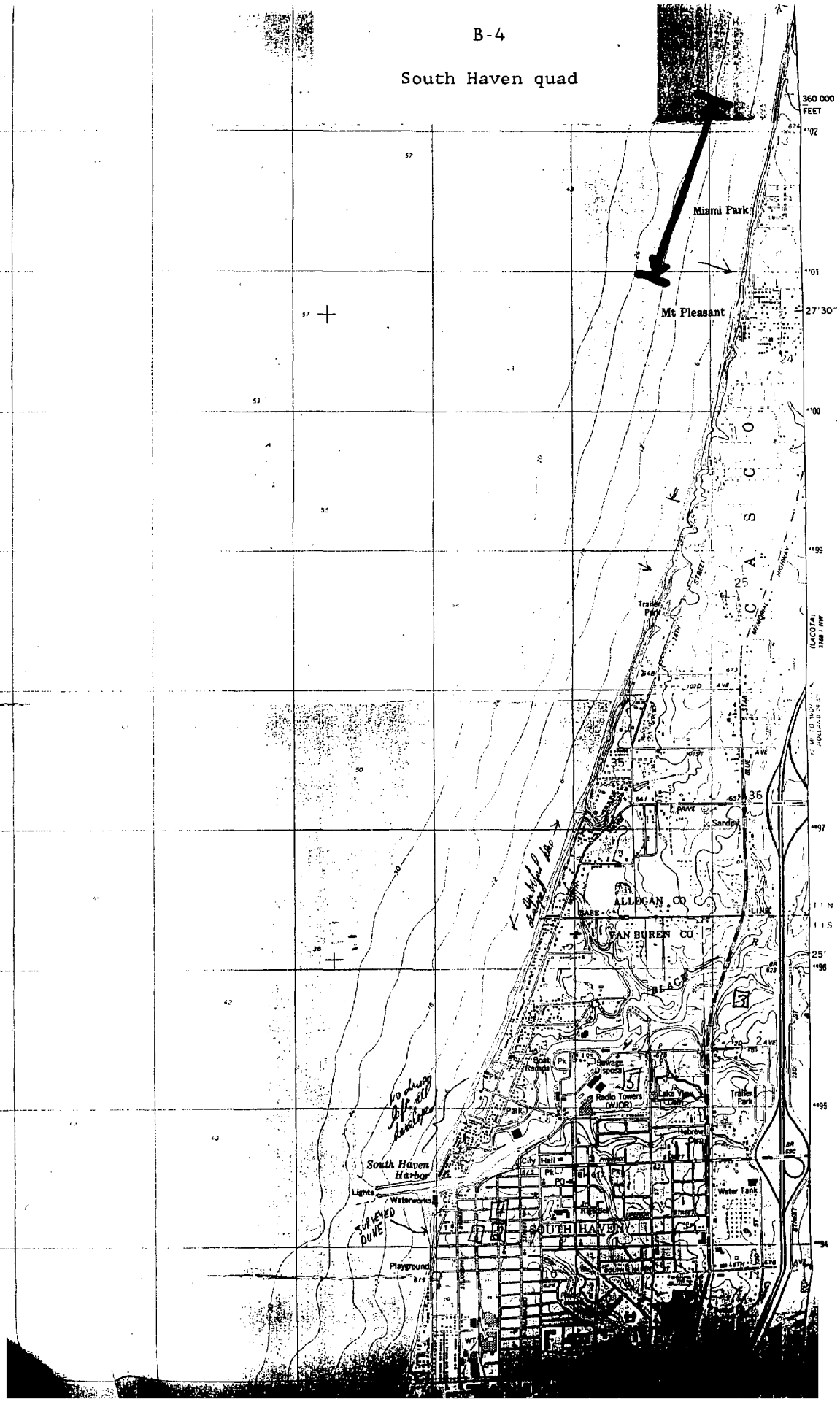
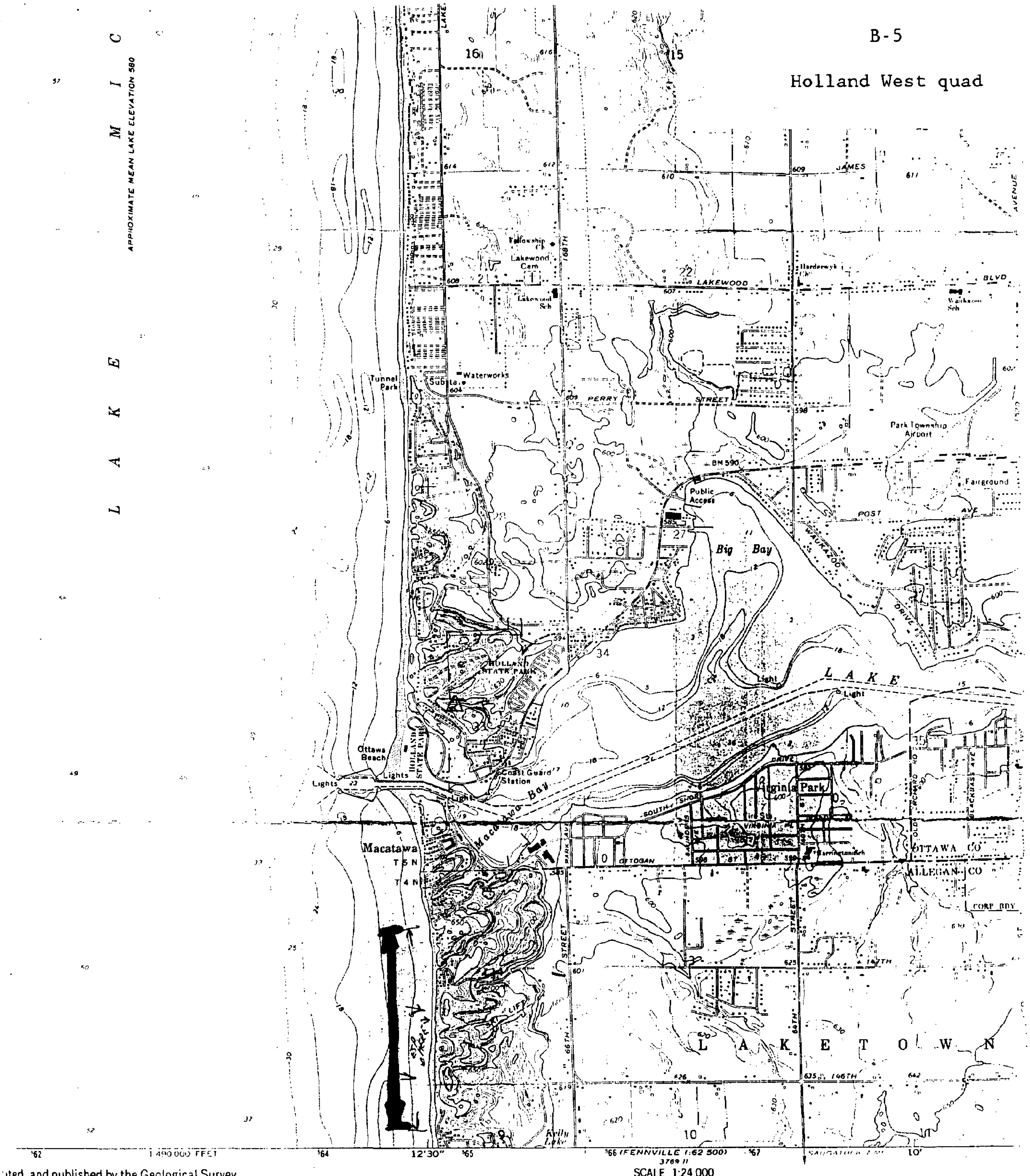
B-4

South Haven quad



B-5

Holland West quad



...ited, and published by the Geological Survey
...ion with State of Michigan agencies

...GS and NOS/NOAA

... photogrammetric methods from aerial
...taken 1969. Field checked 1972

...ographic data compiled from U.S. Lake Survey Charts 76 (1973)
...72). This information is not intended for navigational purposes

...d 10,000-foot grid ticks: Michigan coordinate
... zone (Lambert conformal conic)
Universal Transverse Mercator grid ticks,
...wn in blue. 1927 North American datum

...areas in which only landmark buildings are shown

...hed lines indicate selected fence and field lines where
...aerial photographs. This information is unchecked

MN GN
1° 18 MILS
0°33' 10 MILS

UTM GRID AND 1972 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 KILOMETRE

CONTOUR INTERVAL 10 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS LOW WATER 576.8 FEET

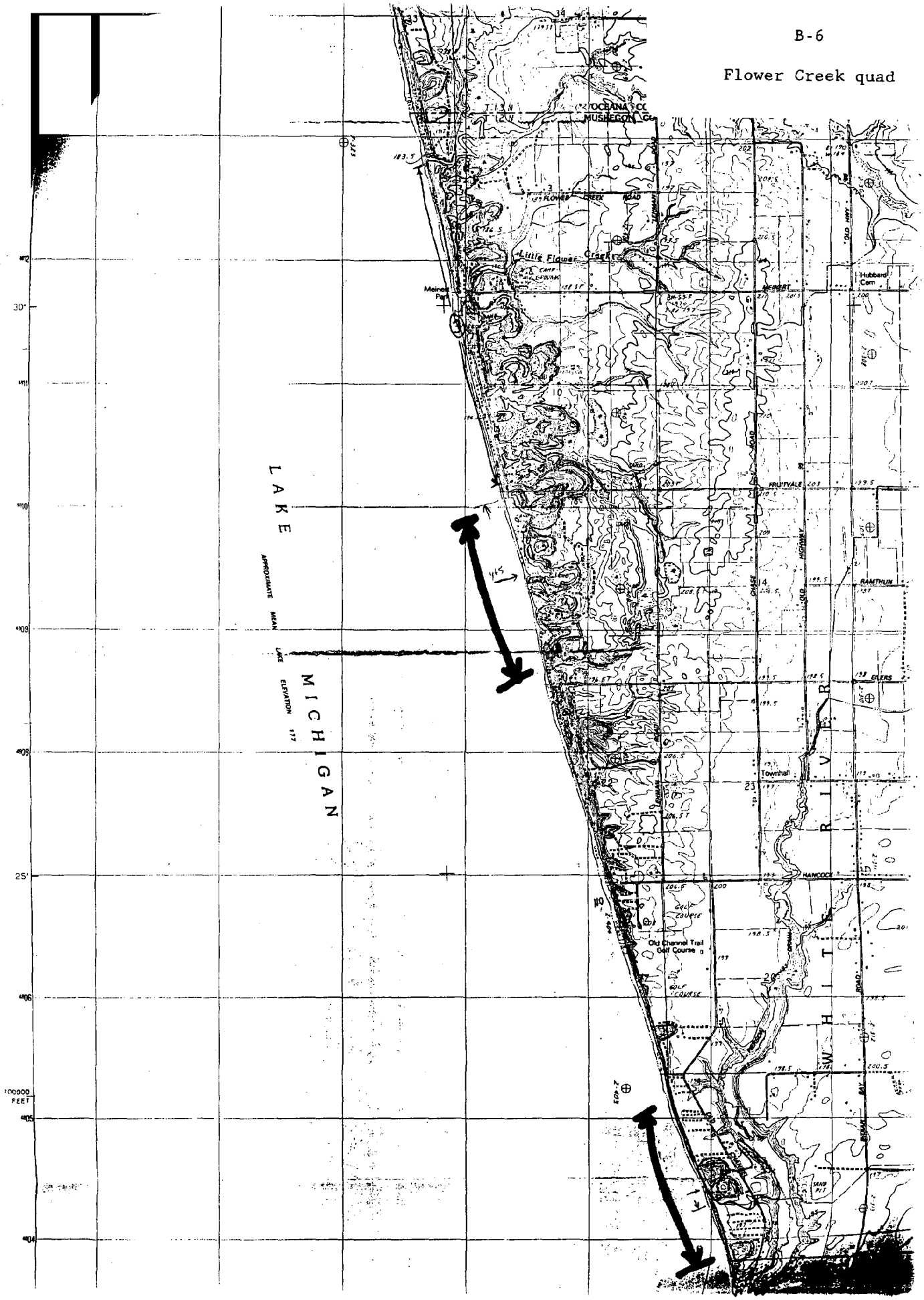
MICHIGAN

QUADRANGLE L...

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

B-6

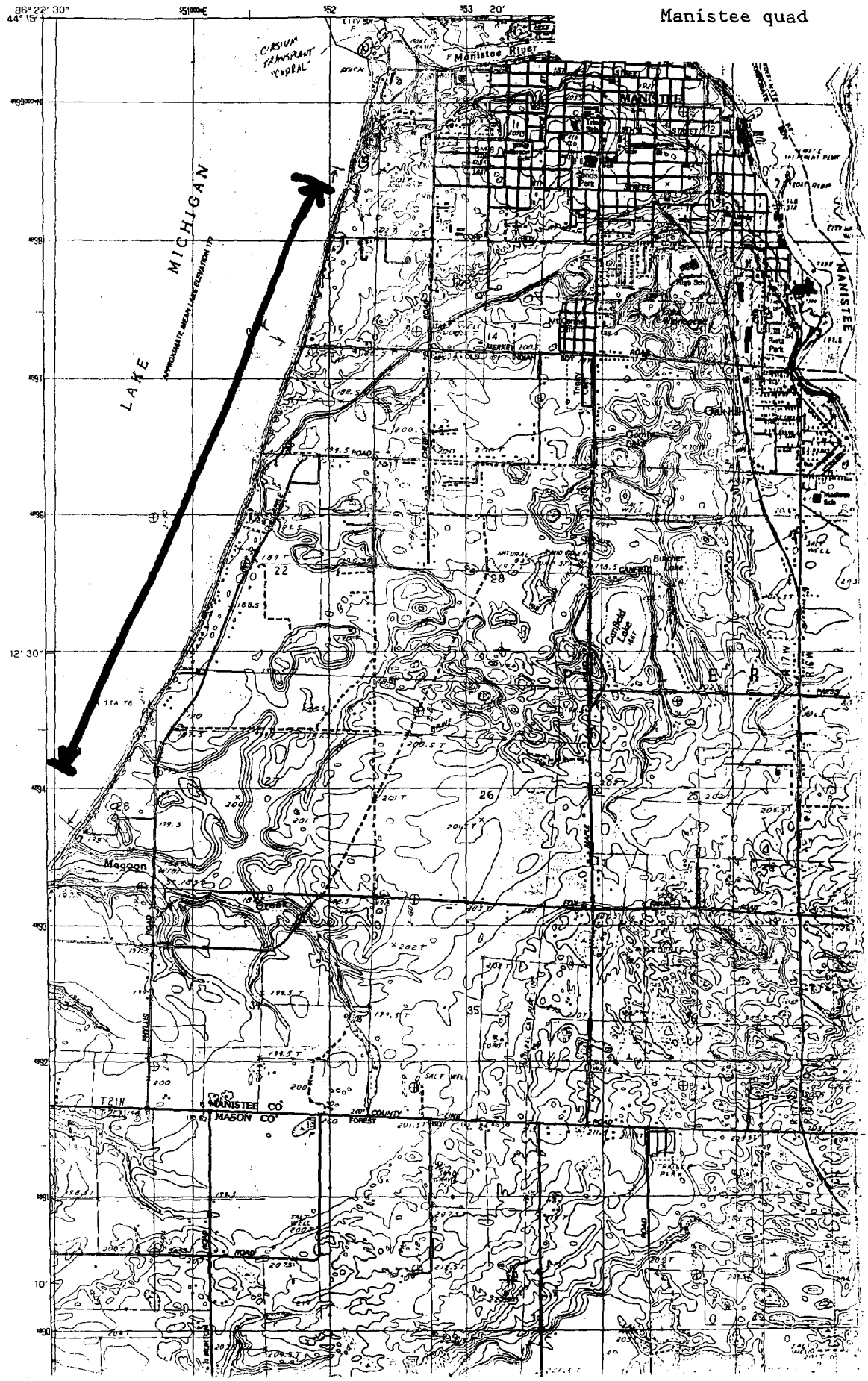
Flower Creek quad



UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

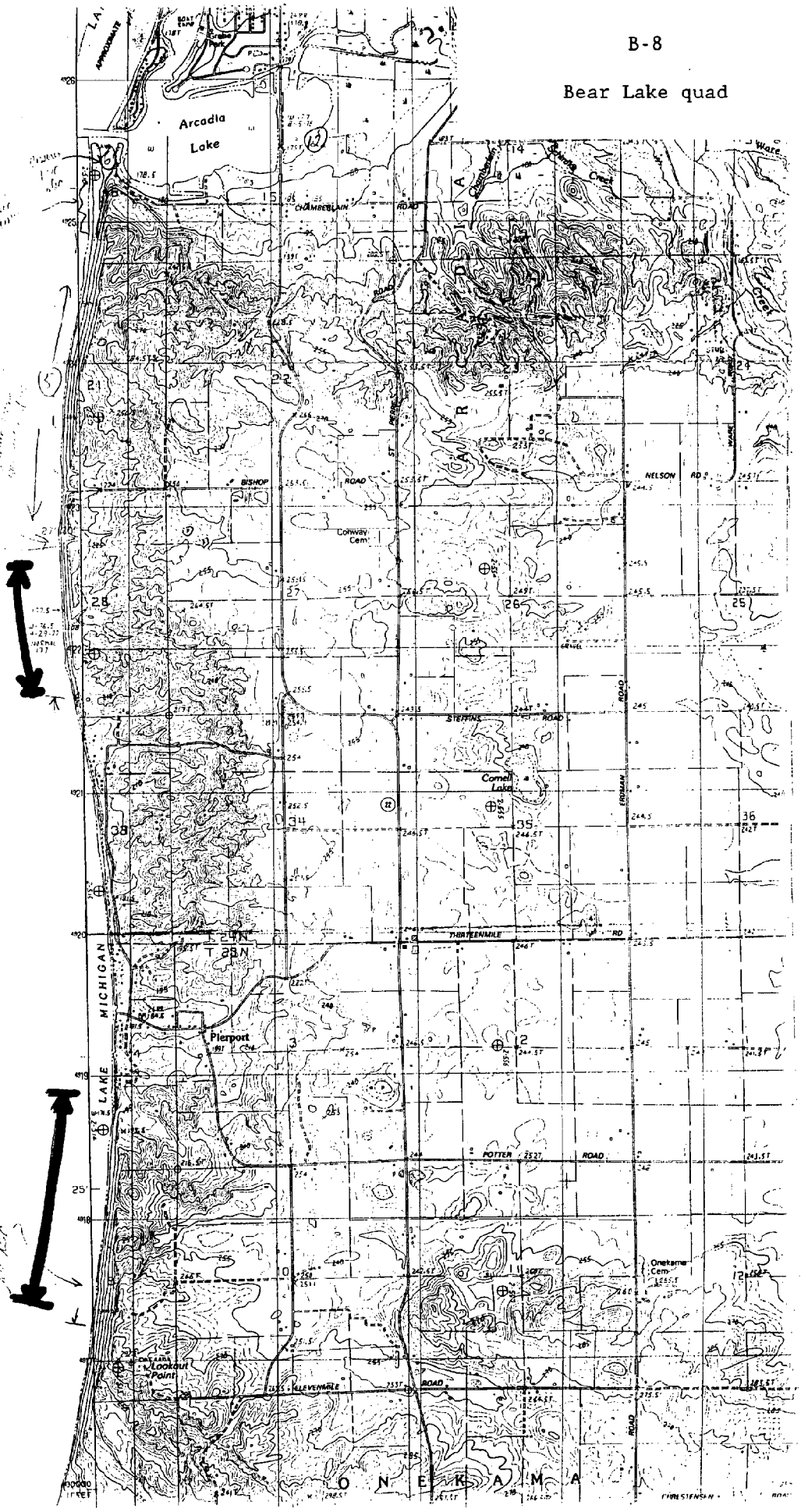
Manistee quad

pictured
1991



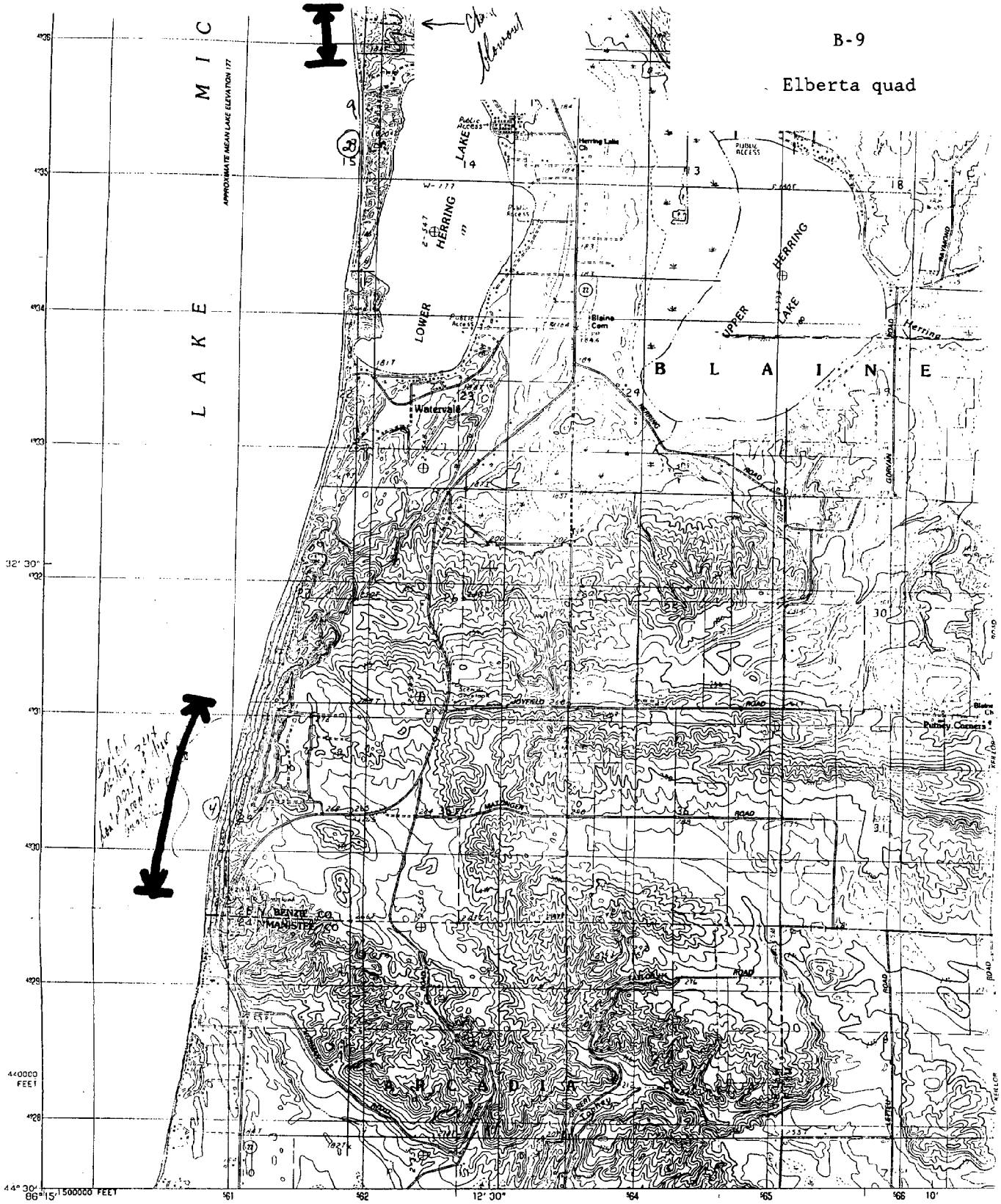
B-8

Bear Lake quad



B-9

Elberta quad



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CONTROL BY ..... USGS AND NOS/NOAA
COMPILED FROM AERIAL PHOTOGRAPHS TAKEN 1977
FIELD CHECKED ..... 1979. MAP EDITED 1983
PROJECTION ..... UNIVERSAL TRANSVERSE MERCATOR
GRID: 1000-METER UNIVERSAL TRANSVERSE MERCATOR ..... ZONE 16
10,000-FOOT STATE GRID TICKS ..... MICHIGAN, CENTRAL ZONE
UTM GRID DECLINATION ..... 0°34' EAST
1983 MAGNETIC NORTH DECLINATION ..... 2°00' WEST
VERTICAL DATUM ..... NATIONAL GEODETIC VERTICAL DATUM OF 1929
HORIZONTAL DATUM ..... 1927 NORTH AMERICAN DATUM

To place on the predicted North American Datum of 1983 move the projection lines as shown by dashed corner ticks (3 meters north and 3 meters east)

There may be private inholdings within the boundaries of any Federal and State reservations shown on this map

PROVISIONAL MAP
Produced from original manuscript drawings. Information shown as of date of field check.

SCALE 1:25 000

KILOMETERS 0 1 2
METERS 1000 0 1000 2000
MILES 0 1
FEET 1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10 000

CONTOUR INTERVAL 5 METERS
SUPPLEMENTARY CONTOUR INTERVAL 2.5 METERS
CONTROL ELEVATIONS SHOWN TO THE NEAREST 0.1 METER
OTHER ELEVATIONS SHOWN TO THE NEAREST METER
To convert meters to feet multiply by 3.2808
To convert feet to meters multiply by .3048

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
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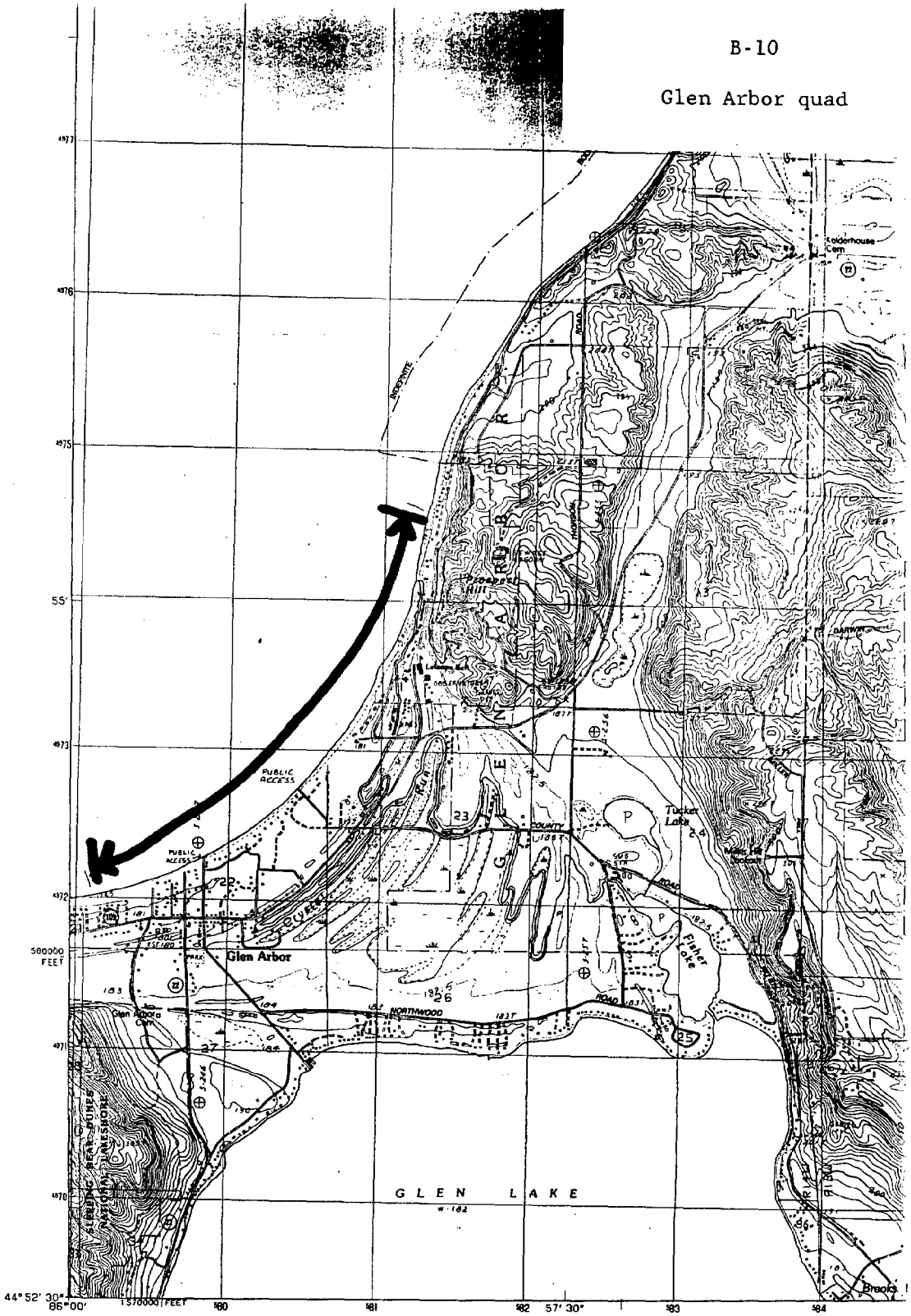
AND THE GEOLOGICAL SURVEY DIVISION
MICHIGAN DEPARTMENT OF NATURAL RESOURCES, LANSING, MICHIGAN 48909

ADJOIN CONT

B-10

Glen Arbor quad



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CONTROL BY ..... USGS AND NOS/NOAA
COMPILED FROM AERIAL PHOTOGRAPHS TAKEN 1977
FIELD CHECKED ..... 1979. MAP EDITED 1983
PROJECTION ..... UNIVERSAL TRANSVERSE MERCATOR
GRID: 1000-METER UNIVERSAL TRANSVERSE MERCATOR ..... ZONE 16
10,000-FOOT STATE GRID TICKS ..... MICHIGAN, CENTRAL ZONE
UTM GRID DECLINATION ..... 0°45' EAST
1983 MAGNETIC NORTH DECLINATION ..... 3°30' WEST
VERTICAL DATUM ..... NATIONAL GEODETIC VERTICAL DATUM OF 1929
HORIZONTAL DATUM ..... 1927 NORTH AMERICAN DATUM

To place on the predicted North American Datum of 1983 move the projection lines as shown by dashed corner ticks (3 meters north and 2 meters east)

There may be private inholdings within the boundaries of any Federal and State reservations shown on this map

PROVISIONAL MAP
Produced from original manuscript drawings. Information shown as of date of field check.

SCALE 1:25 000

1 .5 0 KILOMETERS 1
1000 0 METERS 1000
1 .5 0 MILES
1000 0 1000 2000 3000 4000 5000 6000 FEET

CONTOUR INTERVAL 5 METERS
SUPPLEMENTAL CONTOUR INTERVAL 2.5 M
AND 1.5 METERS ALONG SHORELINE
CONTROL ELEVATIONS SHOWN TO THE NEAREST 0.1 M
OTHER ELEVATIONS SHOWN TO THE NEAREST 0.5 MT

To convert meters to feet multiply by 3.2808
To convert feet to meters multiply by .3048

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY
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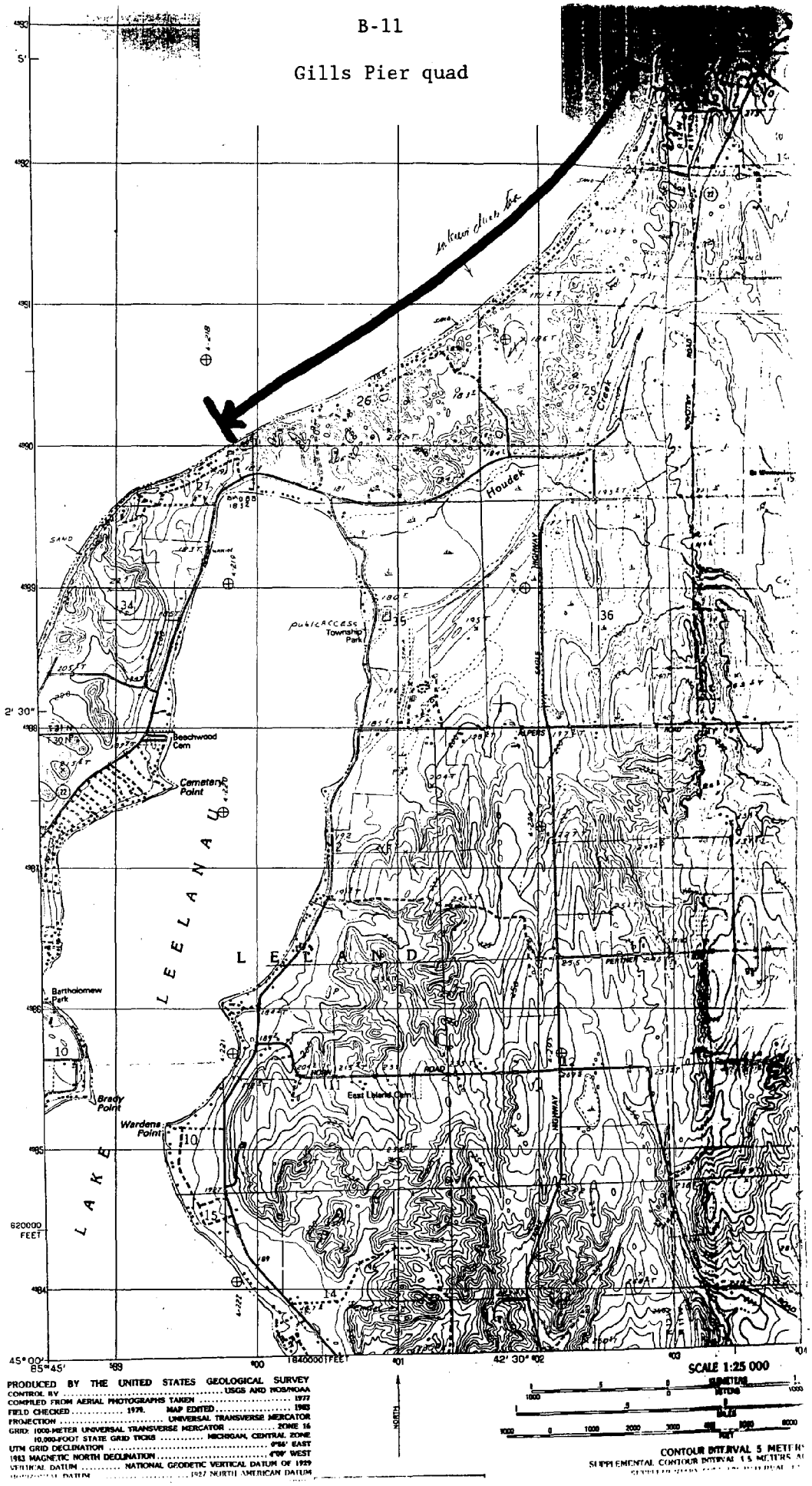
AND THE GEOLOGICAL SURVEY DIVISI
MICHIGAN DEPARTMENT OF NATURAL RESOURCES, LANS

B-11

Gills Pier quad



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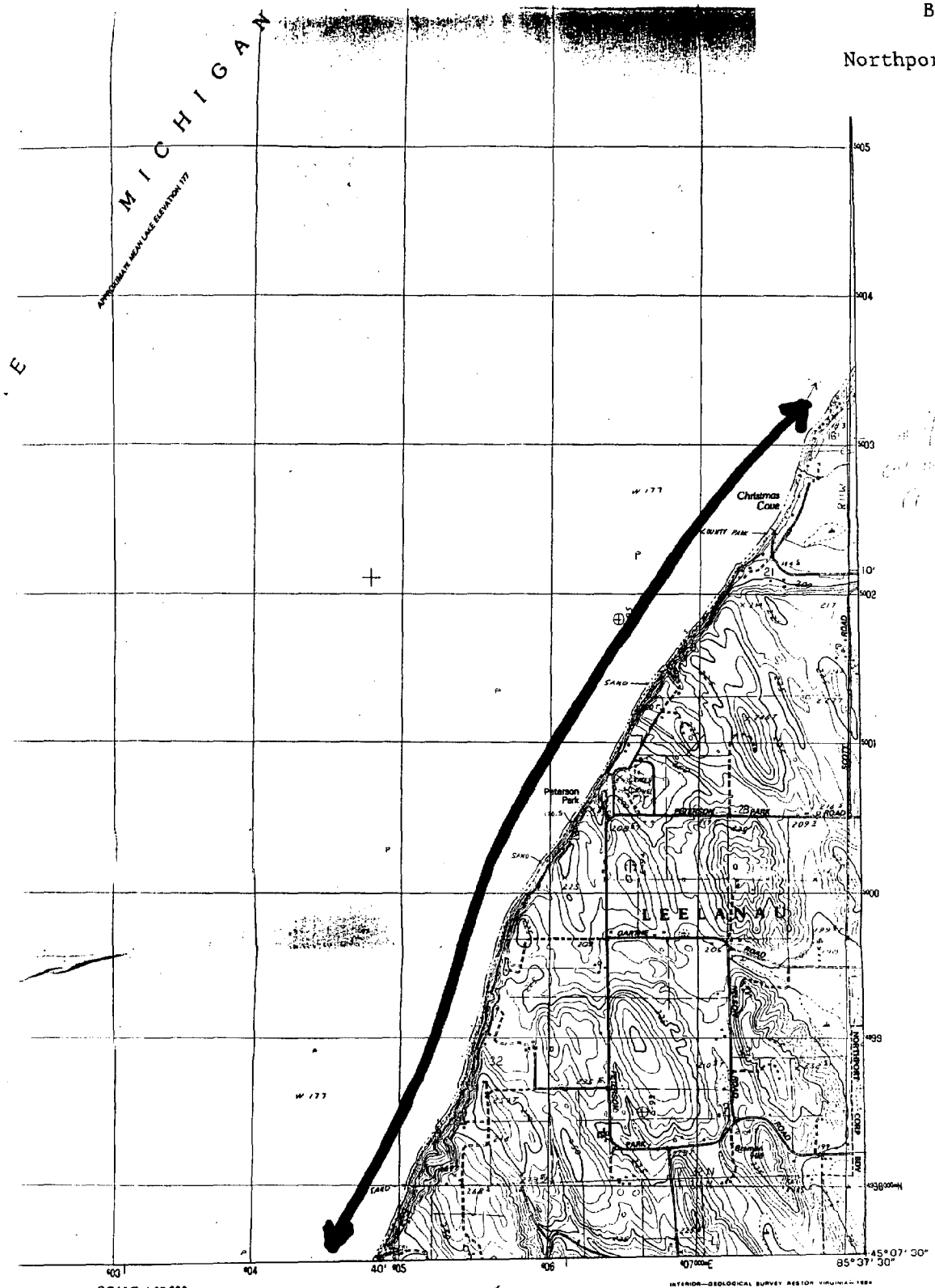
CONTROL BY ..... USGS AND NOS/NOAA
COMPILED FROM AERIAL PHOTOGRAPHS TAKEN 1977
FIELD CHECKED ..... 1978. MAP EDITED 1983
PROJECTION ..... UNIVERSAL TRANSVERSE MERCATOR
GRID: 1000-METER UNIVERSAL TRANSVERSE MERCATOR ..... ZONE 16
10,000-FOOT STATE GRID TICKS ..... MICHIGAN, CENTRAL ZONE
UTM GRID DECLINATION ..... 0°56' EAST
1983 MAGNETIC NORTH DECLINATION ..... 4°09' WEST
VERTICAL DATUM ..... NATIONAL GEODETIC VERTICAL DATUM OF 1929
HORIZONTAL DATUM ..... 1927 NORTH AMERICAN DATUM

SUPPLEMENTAL CONTOUR INTERVAL 1.5 METERS

Northport NW quad



SCALE 1:25 000

KILOMETERS 0 1 2
METERS 0 1000 2000
MILES 0 1
FEET 2000 3000 4000 5000 6000 7000 8000 9000 10 000

CONTOUR INTERVAL 5 METERS
SUPPLEMENTAL CONTOUR INTERVAL 1.5 METERS ALONG SHORELINE
CONTROL ELEVATIONS SHOWN TO THE NEAREST 0.1 METER
OTHER ELEVATIONS SHOWN TO THE NEAREST 0.5 METER

To convert meters to feet multiply by 3.2808
To convert feet to meters multiply by .3048

MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
PRODUCED BY U.S. GEOLOGICAL SURVEY, RESTON, VIRGINIA 22092
AND THE GEOLOGICAL SURVEY DIVISION
DEPARTMENT OF NATURAL RESOURCES, LANSING, MICHIGAN 48909

MICHIGAN
QUADRANGLE LOCATION

ADJOINING 7.5' QUADRANGLE NAMES
1 2 3
4 5 Northport
6 Leland
7 Gills Pier
8 Omena

CONTOURS AND ELEVATIONS IN METERS

ROAD LEGEND

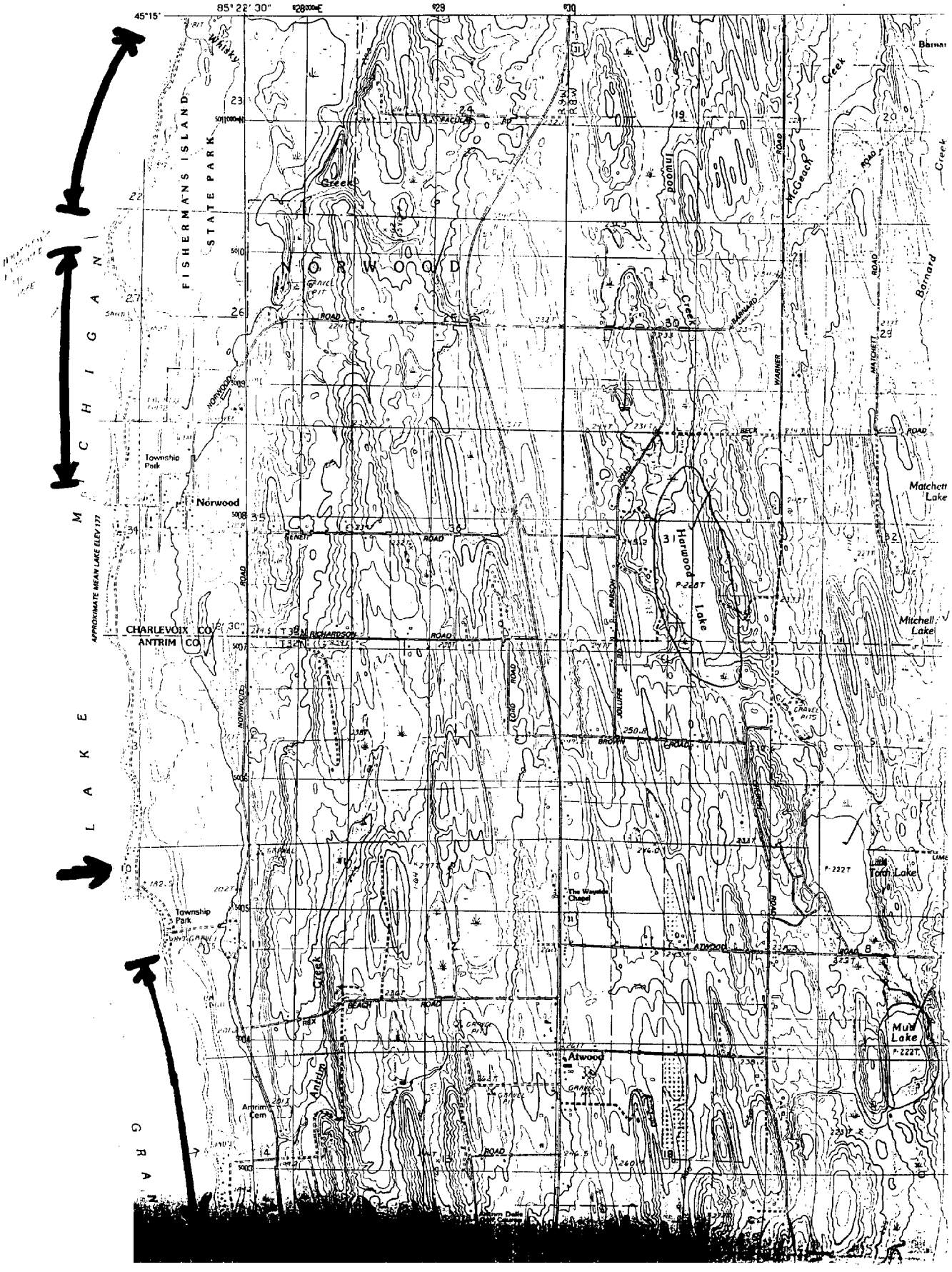
Improved Road .....
Unimproved Road .....
Trail .....
Interstate Route U.S. Route State Route

NORTHPORT NW, MICHIGAN
PROVISIONAL EDITION 1983
45085-B6-TM-025

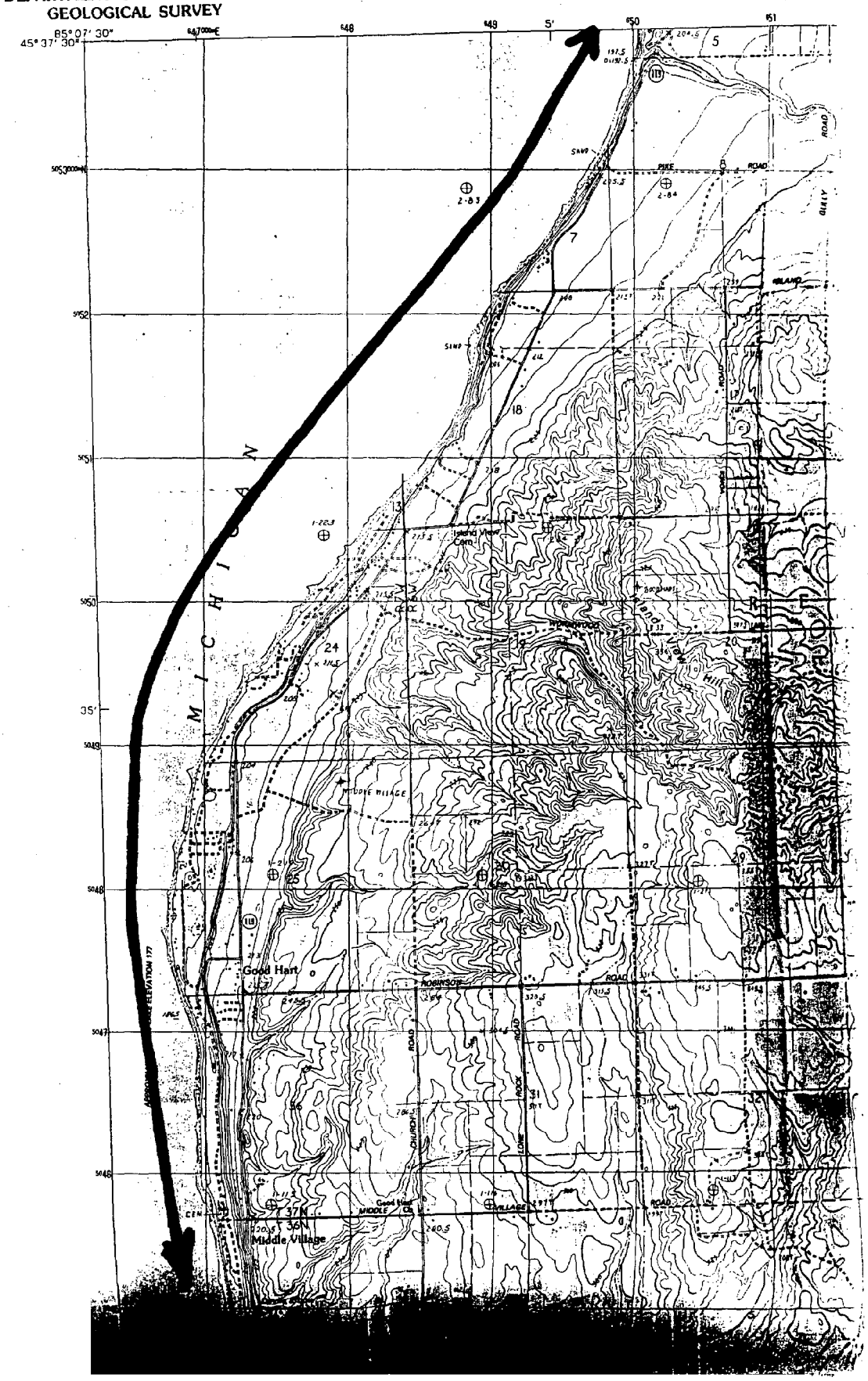
4508521

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Atwood quad

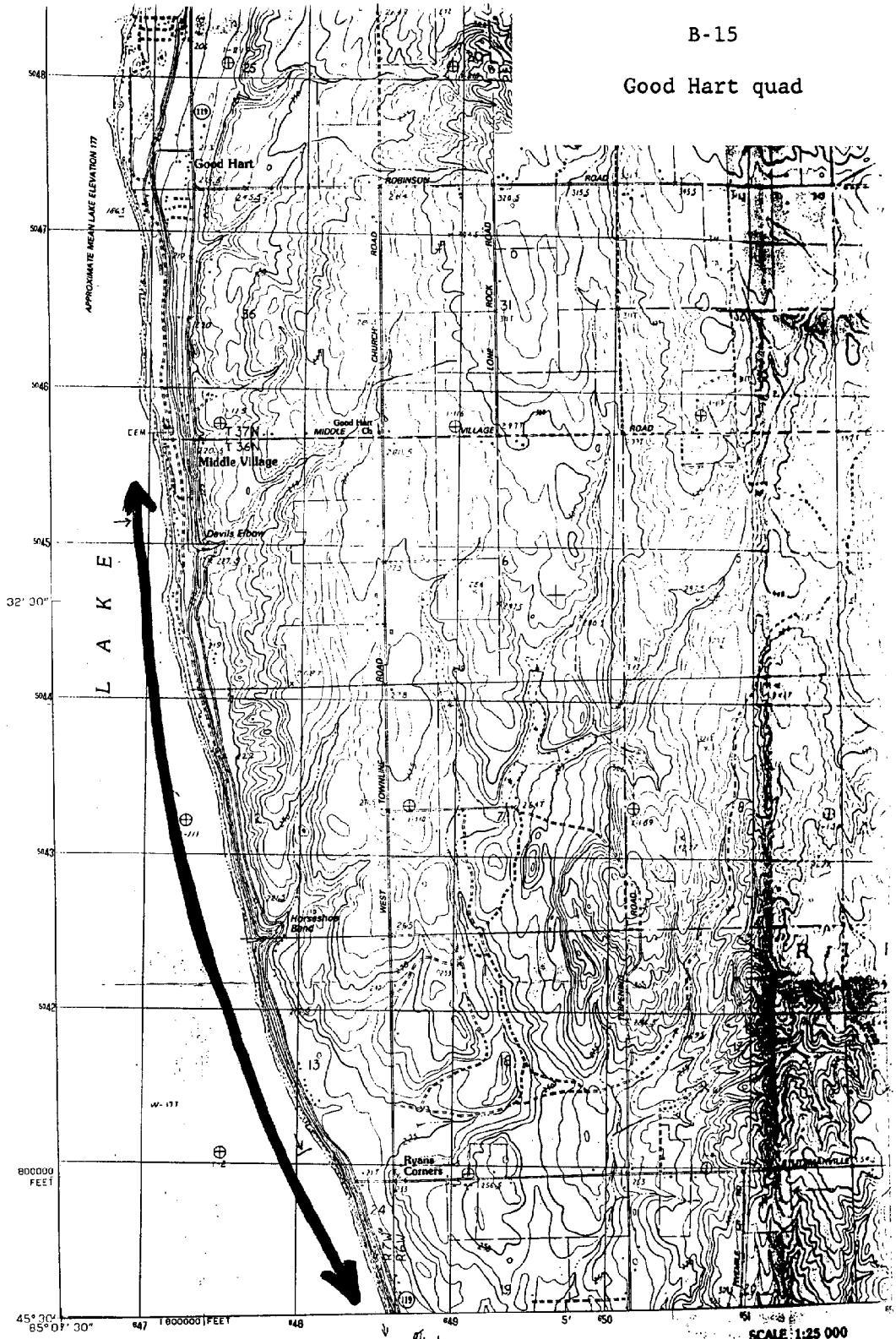


Good Hart quad



B-15

Good Hart quad



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CONTROL BY ..... USGS AND NOS/NOAA
COMPILED FROM AERIAL PHOTOGRAPHS TAKEN 1977
FIELD CHECKED ..... 1979. MAP EDITED 1982
PROJECTION ..... LAMBERT CONFORMAL CONIC
GRID: 1000 METER UNIVERSAL TRANSVERSE MERCATOR ..... ZONE 16
10,000-FOOT STATE GRID TICKS ..... MICHIGAN, CENTRAL ZONE
UTM GRID DECLINATION ..... 1°23' EAST
1982 MAGNETIC NORTH DECLINATION ..... 4°30' WEST
VERTICAL DATUM ..... NATIONAL GEODETIC VERTICAL DATUM OF 1929
HORIZONTAL DATUM ..... 1927 NORTH AMERICAN DATUM

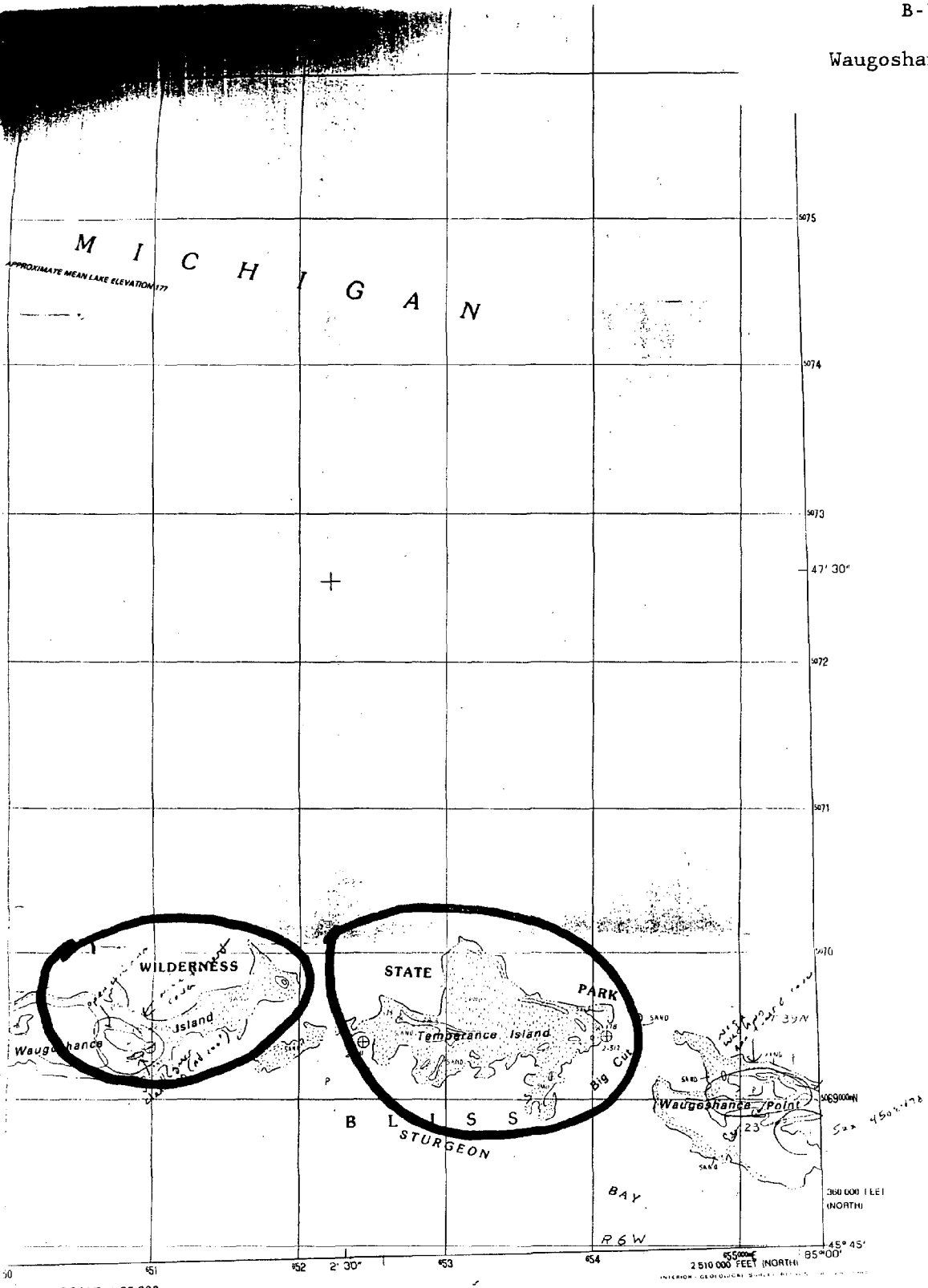
To place on the predicted North American Datum of 1983 move the projection lines as shown by dashed corner ticks (3 meters north and 3 meters east)

There may be private inholdings within the boundaries of any Federal and State reservations shown on this map

PROVISIONAL MAP
Produced from original manuscript drawings. Information shown as of date of field check.

B-16

Waugoshance quad



SCALE 1:25 000

KILOMETERS 0 1 2
METERS 0 1000 2000
MILES 0 1
FEET 3000 4000 5000 6000 7000 8000 9000 10 000

CONTOUR INTERVAL 1.5 METERS

ROAD ELEVATIONS SHOWN TO THE NEAREST 0.1 METER
OTHER ELEVATIONS SHOWN TO THE NEAREST METER
To convert meters to feet multiply by 3.2808
To convert feet to meters multiply by .3048

COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
U. S. GEOLOGICAL SURVEY, RESTON, VIRGINIA 22092
AND THE GEOLOGICAL SURVEY DIVISION
DEPARTMENT OF NATURAL RESOURCES, LANSING, MICHIGAN 48909

MICHIGAN
QUADRANGLE LOCATION

1	2	3	1 2 3 Point Aux Chenes
4		5	4 5 Big Stone Bay
6	7	8	6 7 Cross Village 8 Bliss

ADJOINING 7.5' QUADRANGLE NAMES

CONTOURS AND ELEVATIONS IN METERS

ROAD LEGEND

Improved Road .....
Unimproved Road .....
Trail .....
Interstate Route U. S. Route State Route

WAUGOSHANCE ISLAND, MICHIGAN

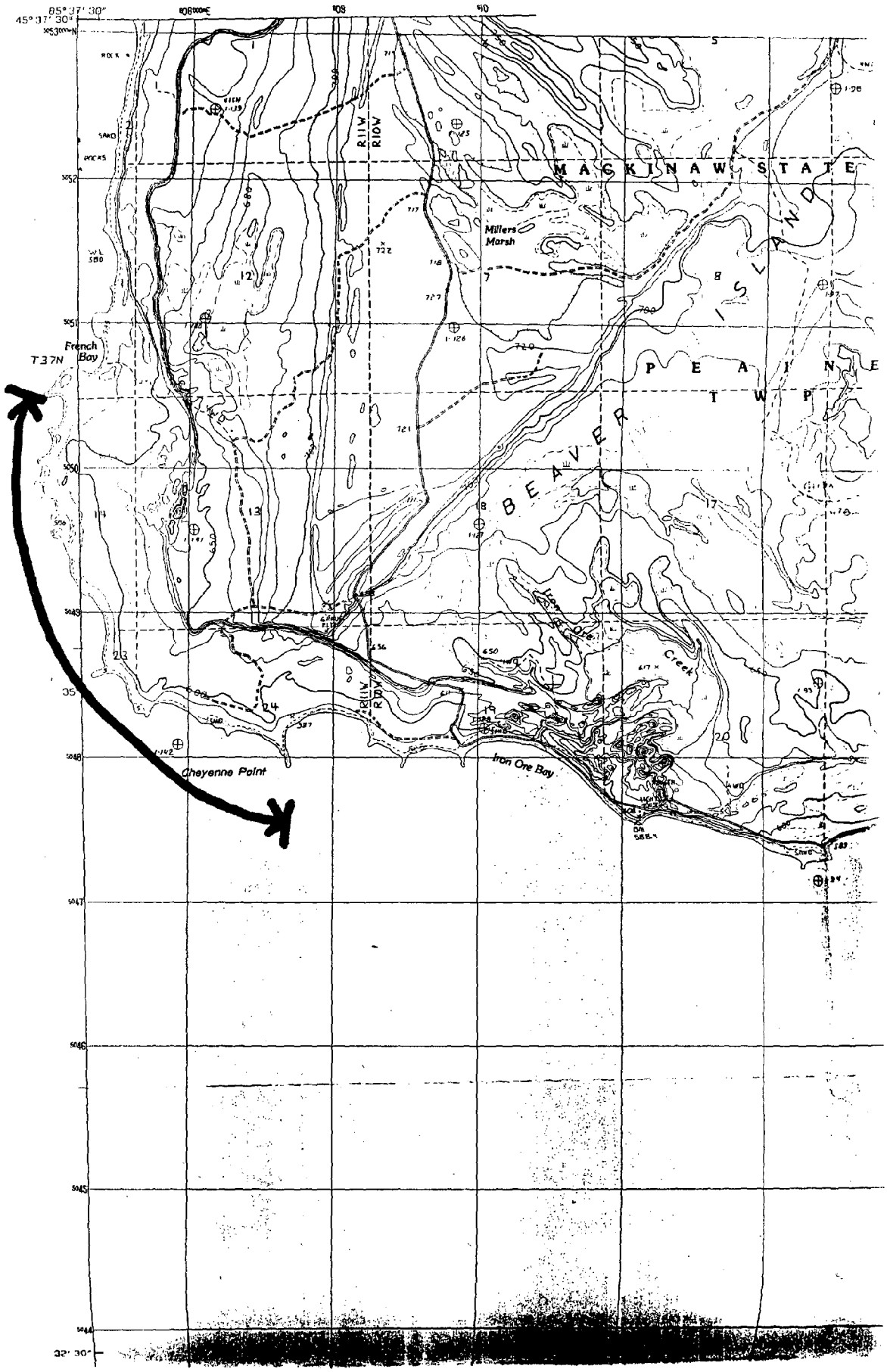
PROVISIONAL EDITION 1982

45085-GI-TM-025

MICHIGAN NATURAL FEATURES INVENTORY PROGRAM

4508571

Beaver Island South quad

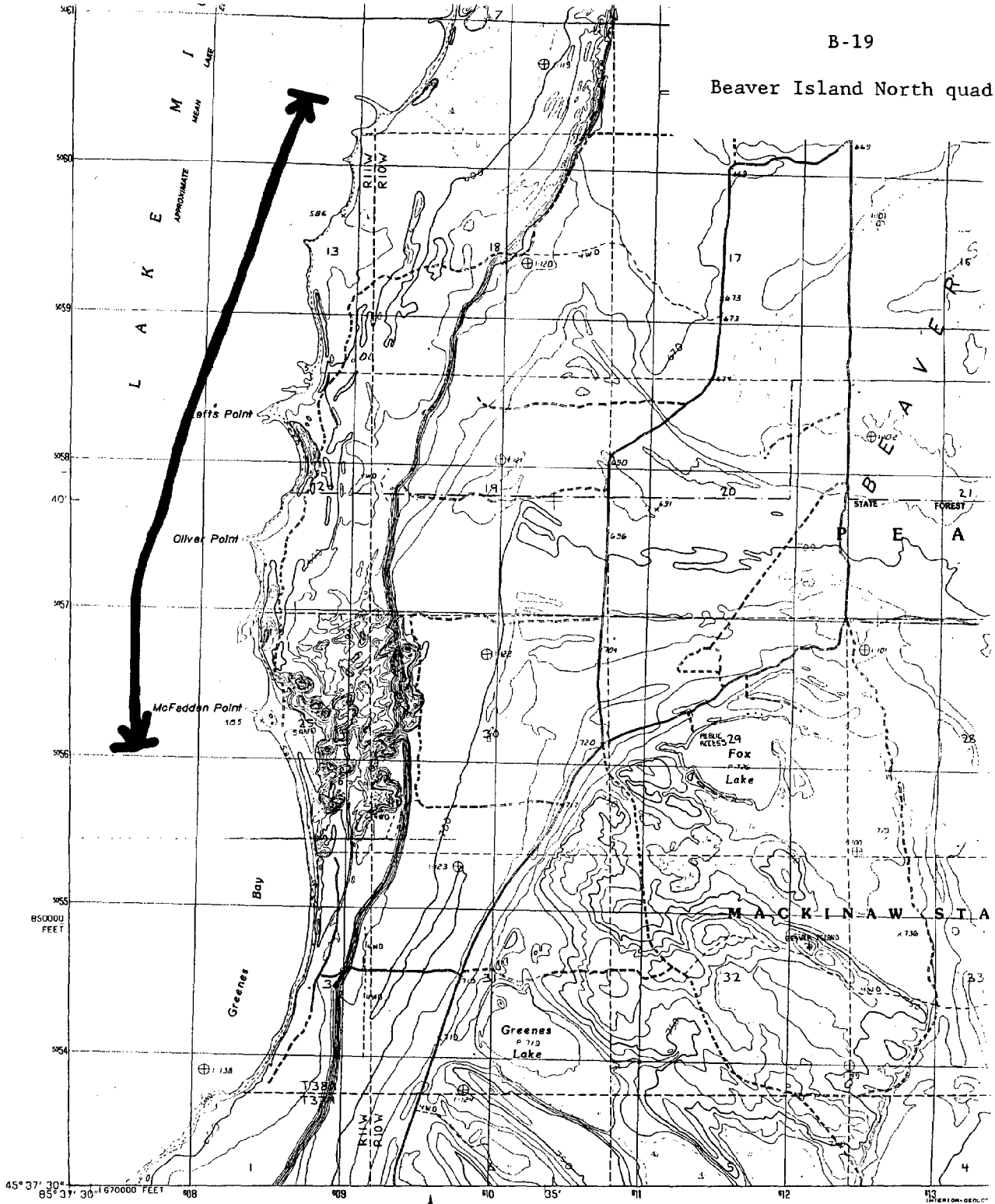


B

Beaver Island South quad

B-19

Beaver Island North quad



PRODUCED BY THE UNITED STATES GEOLOGICAL SURVEY
CONTROL BY ..... USGS AND NOS/NOAA
COMPILED FROM AERIAL PHOTOGRAPHS TAKEN 1983
FIELD CHECKED ..... 1984. MAP EDITED 1986
PROJECTION ..... UNIVERSAL TRANSVERSE MERCATOR
GRID: 1000-METER UNIVERSAL TRANSVERSE MERCATOR ..... ZONE 16
10,000-FOOT STATE GRID TICKS ..... MICHIGAN, CENTRAL ZONE
UTM GRID DECLINATION ..... 1°02' EAST
1986 MAGNETIC NORTH DECLINATION ..... 4°00' WEST
VERTICAL DATUM ..... NATIONAL GEODETIC VERTICAL DATUM OF 1929
HORIZONTAL DATUM ..... 1927 NORTH AMERICAN DATUM
To place on the predicted North American Datum of 1983, move the projection lines as shown by dashed corner ticks (4 meters north and 5 meters east)
There may be private inholdings within the boundaries of any Federal and State Reservations shown on this map
No distinction made between houses, barns, and other buildings

PROVISIONAL MAP
Produced from original manuscript drawings. Information shown as of date of photography. 1

1 .5 0 MILES
1000 0 1000 2000 3000 4000 5000 6000 7000 8000 FEET
1 .5 0 1 KILOMETERS
1000 0 1000 METERS

CONTOUR INTERVAL 10 FEET
SUPPLEMENTARY CONTOUR INTERVAL 5 FEET
CONTROL ELEVATIONS SHOWN TO THE NEAREST 0.1 FOOT
OTHER ELEVATIONS SHOWN TO THE NEAREST FOOT
To convert feet to meters multiply by .3048
To convert meters to feet multiply by 3.2808

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
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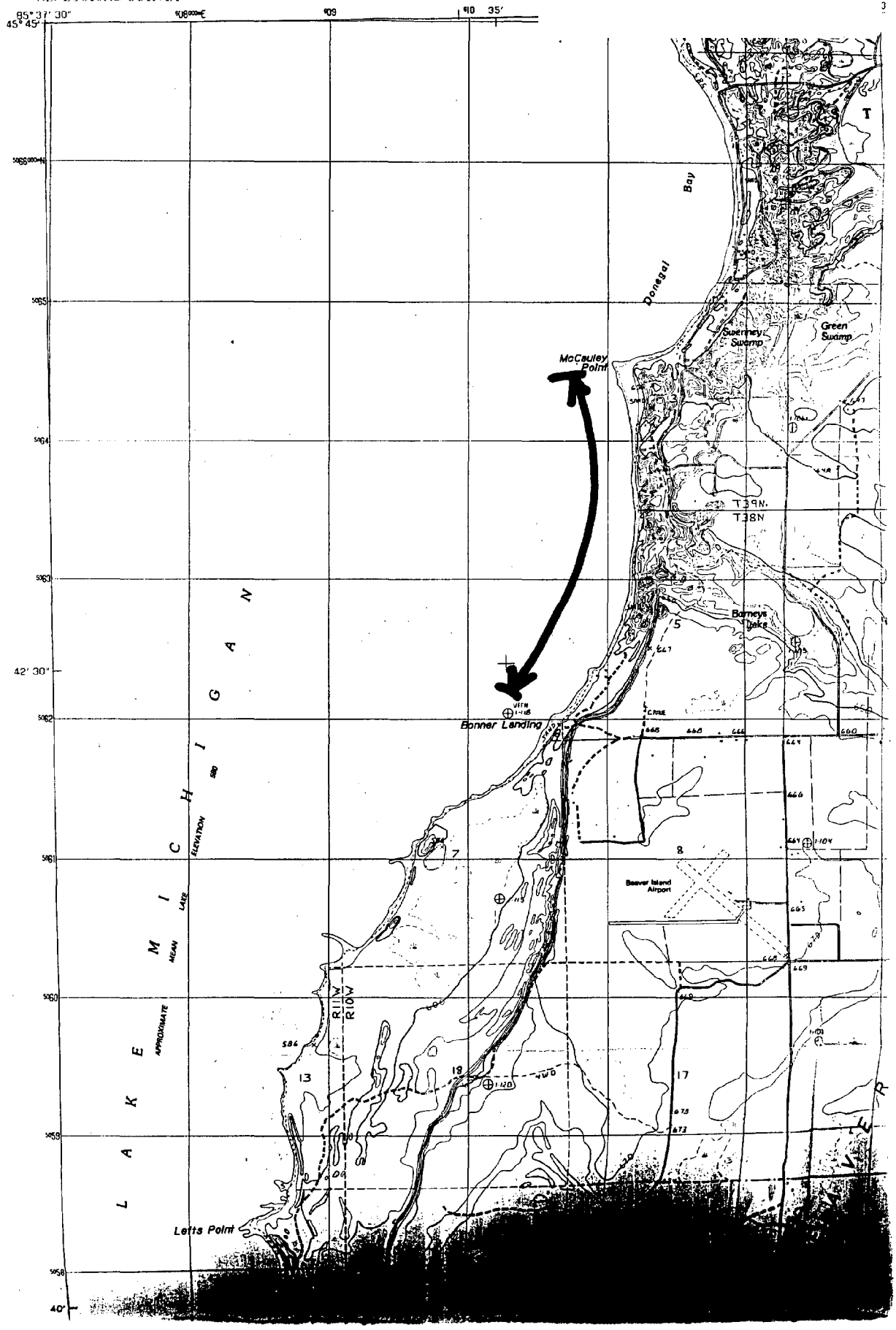
AND GEOLOGICAL SURVEY DIVISION
MICHIGAN DEPARTMENT OF NATURAL RESOURCES, LANSING, MICHIGAN 48909

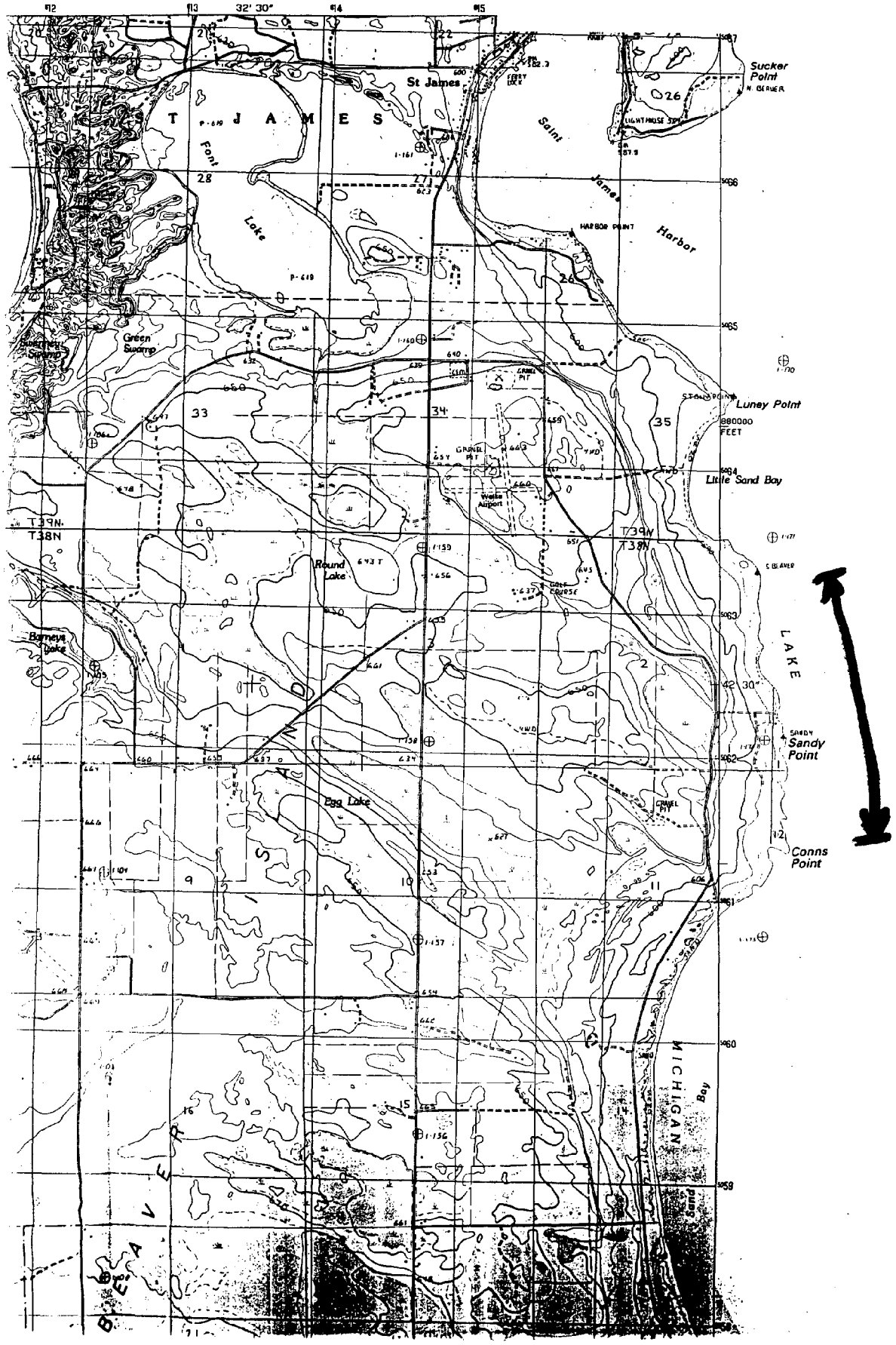
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Beaver Island North quad



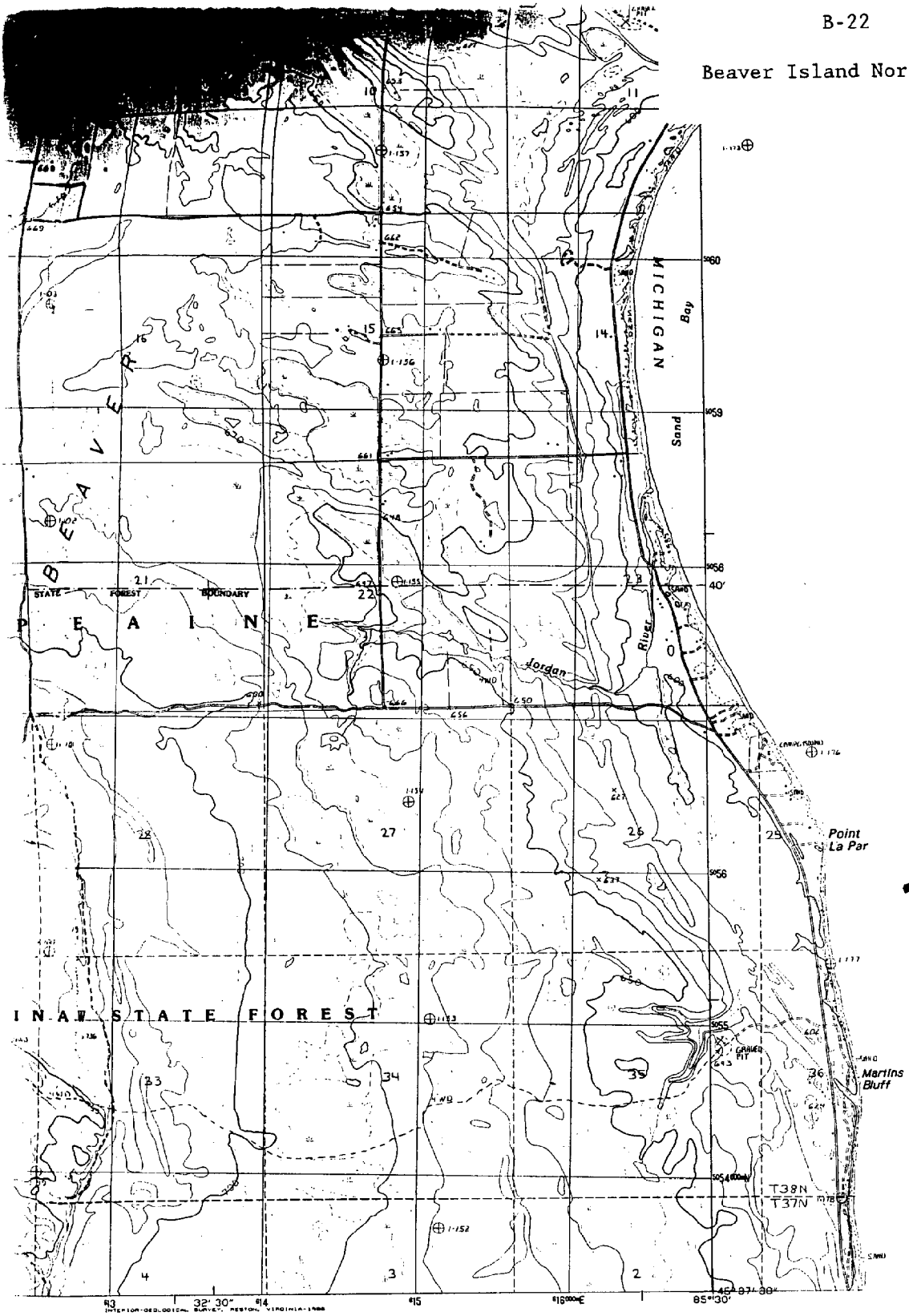
B

Beaver Island North quad



B-22

Beaver Island North quad



QUADRANGLE LOCATION

1	2	3	1 Trout Island 2 Garden Island West 3 Hog Island West 4 High Island 5 6 7 Beaver Island South 8
4			
	7		

ADJOINING 7.5' QUADRANGLE NAMES

ROAD LEGEND

Improved Road . . . . . ——
Unimproved Road . . . . . - - - - - -
Trail . . . . . - - - - - -

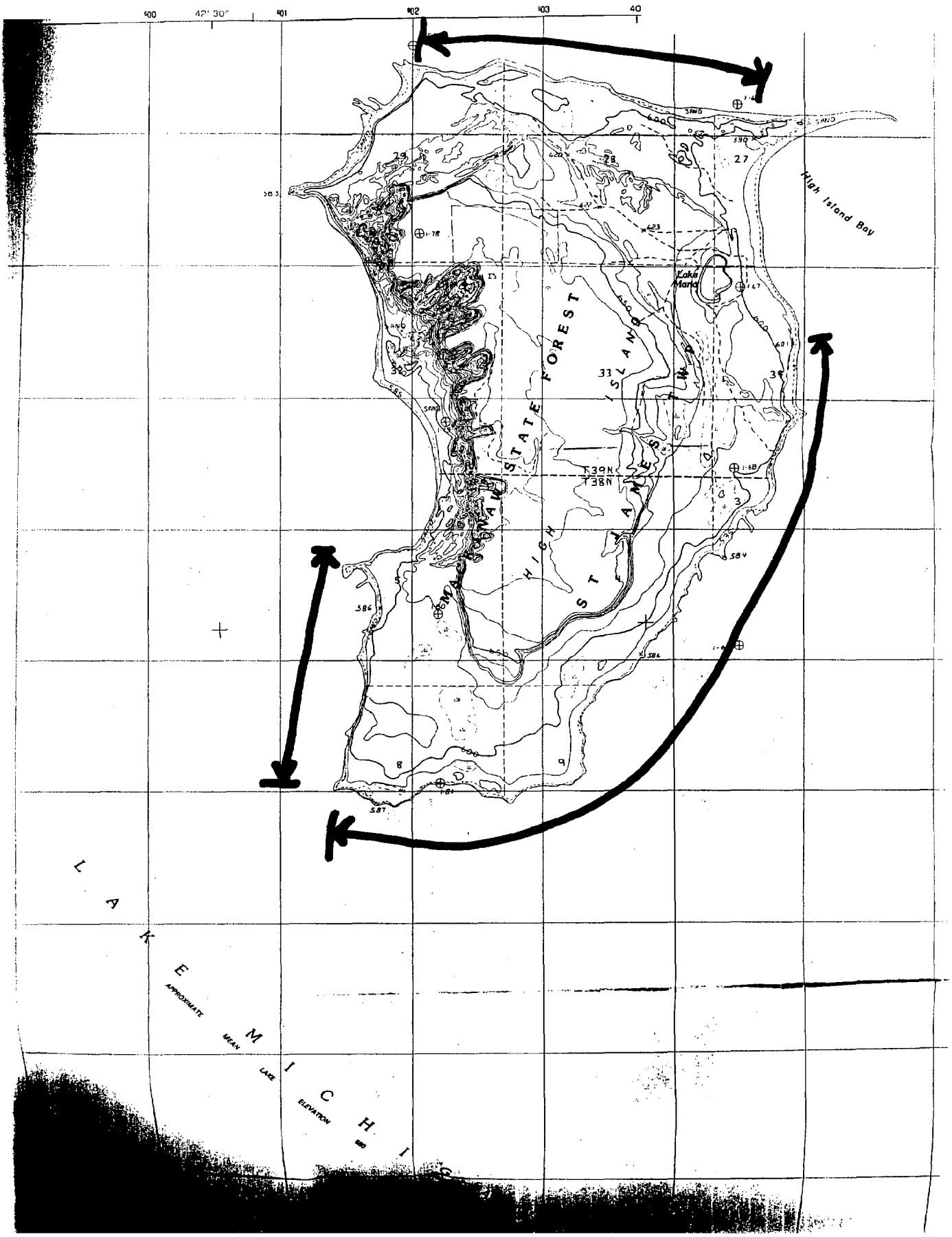
Interstate Route U.S. Route State Route

BEAVER ISLAND NORTH, MICHIGAN
PROVISIONAL EDITION 1986

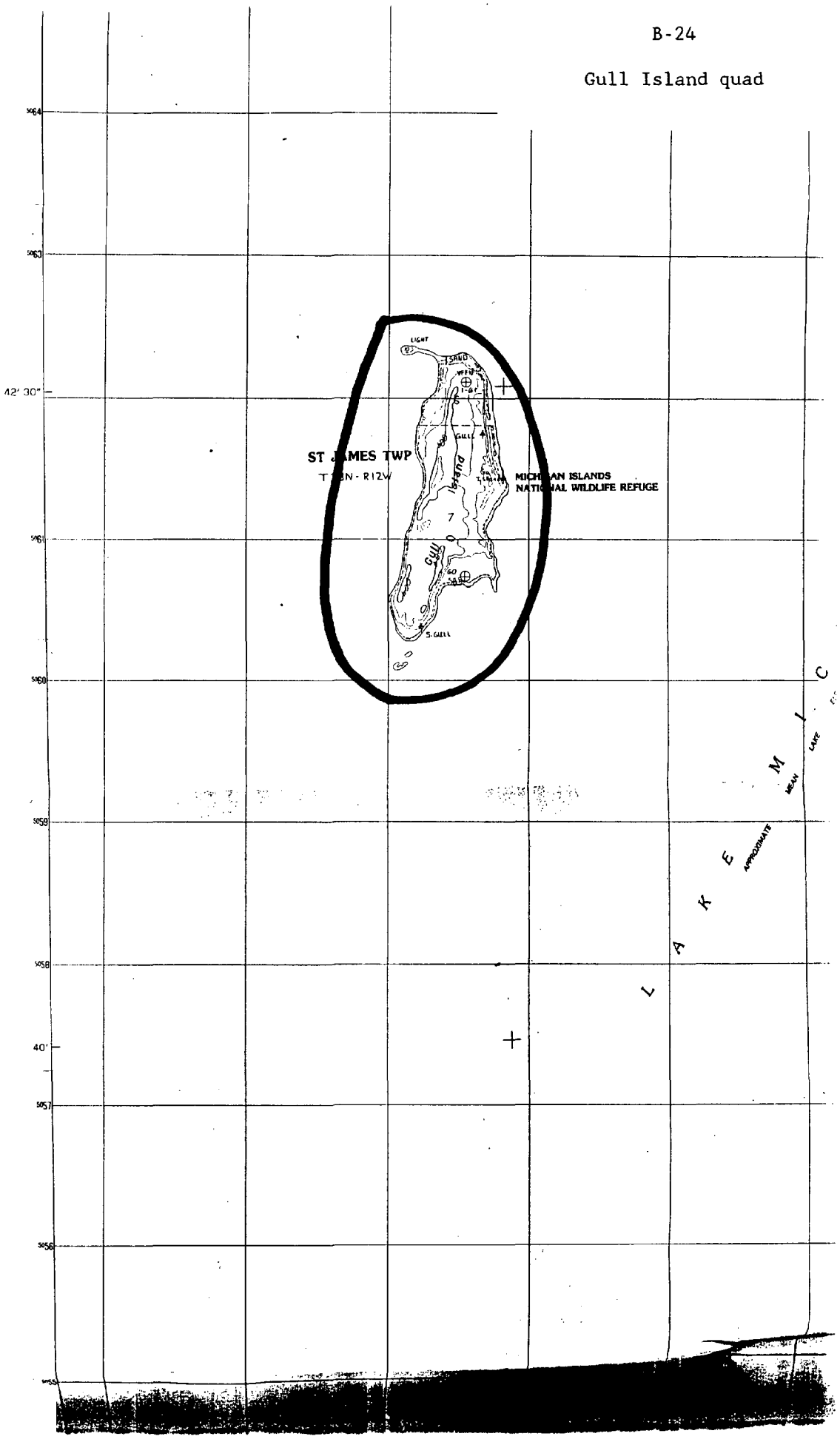
45085-F5-TE-024
MICHIGAN NATURAL FEATURES
INVENTORY PROGRAM

45085.565

High Island quad

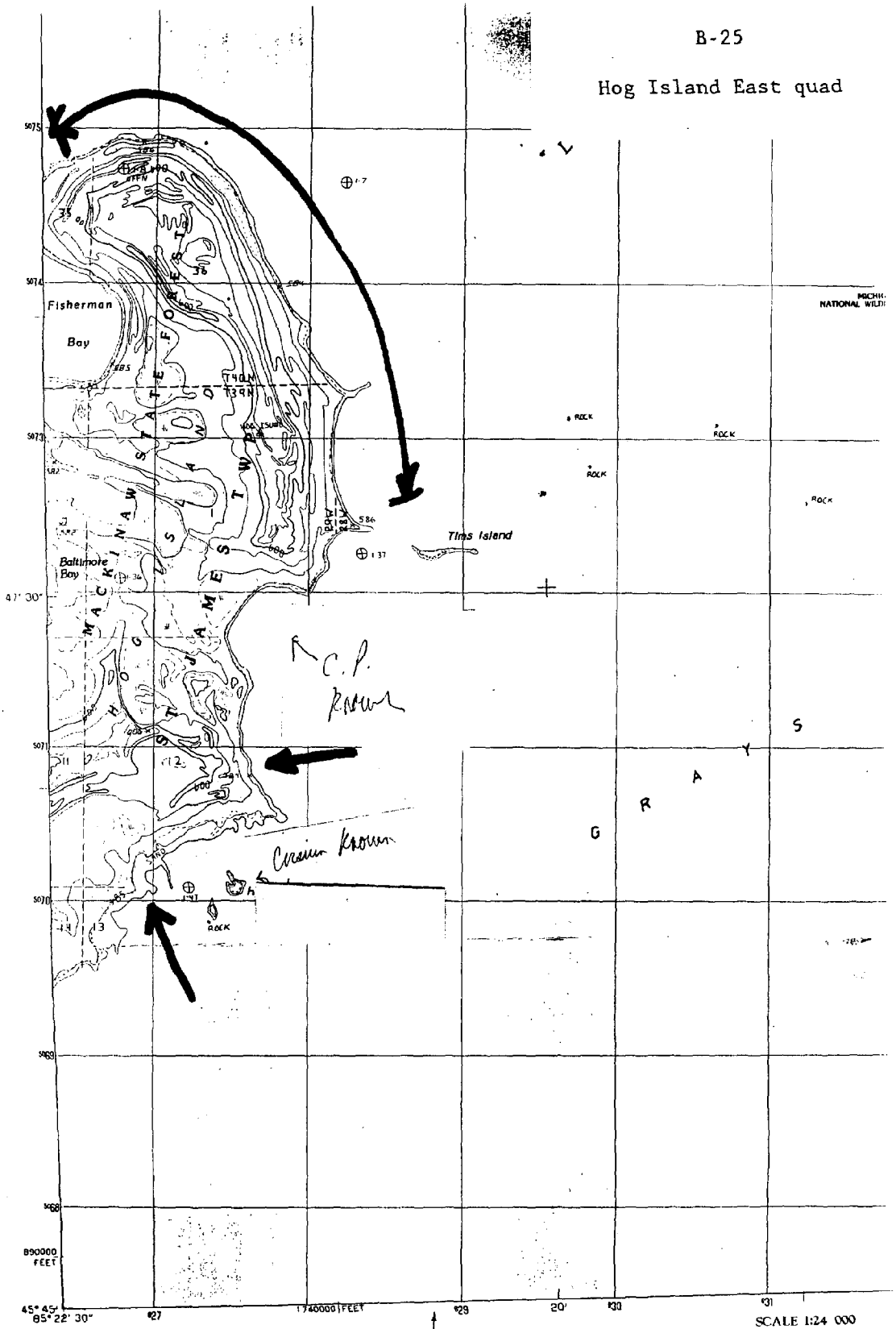


Gull Island quad



B-25

Hog Island East quad



PRODUCED BY THE UNITED STATES GEOLOGICAL SURVEY
CONTROL BY ..... USGS AND NOS/NOAA
COMPILED FROM AERIAL PHOTOGRAPHS TAKEN 1983
FIELD CHECKED ..... 1984 MAP EDITED 1988
PROJECTION ..... UNIVERSAL TRANSVERSE MERCATOR
GRID 1000-METER UNIVERSAL TRANSVERSE MERCATOR ..... ZONE 16
10,000-FOOT STATE GRID TICKS ..... MICHIGAN, CENTRAL ZONE
UTM GRID DECLINATION ..... 1°15' EAST
1984 MAGNETIC NORTH DECLINATION ..... 4°30' WEST
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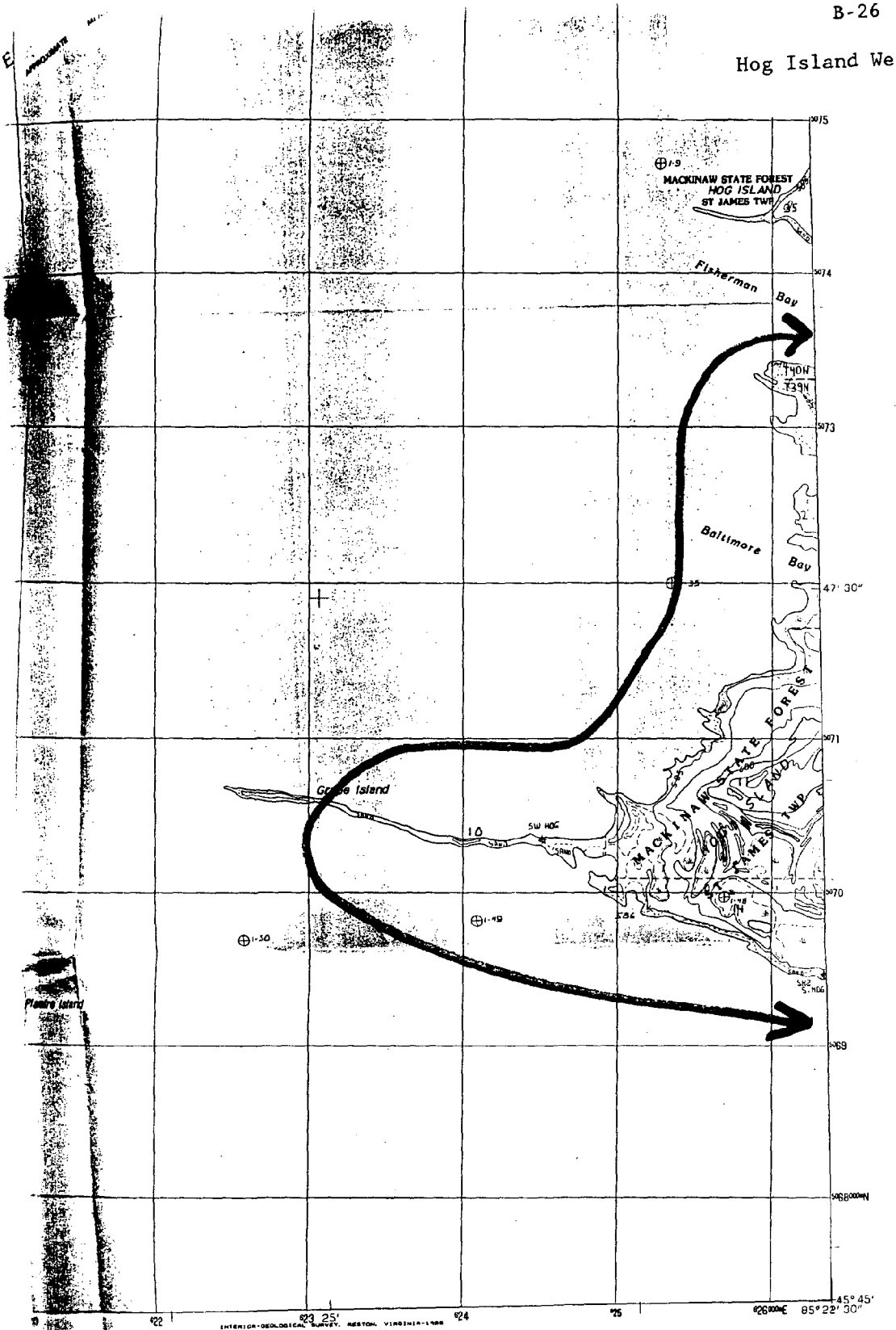
No distinction made between houses, barns and other buildings

PROVISIONAL MAP
Produced from original manuscript drawings. Information shown as of date of photography. 1

THIS MAP COMPLIES WITH NATIONAL MAP ACCURA
FOR SALE BY U.S. GEOLOGICAL SURVEY, RESTON,
AND GEOLOGICAL SURVEY DIVISIO
MICHIGAN DEPARTMENT OF NATURAL RESOURCES, LA

Hog Island West quad



SCALE 1:24 000

MICHIGAN

QUADRANGLE LOCATION

ADJOINING 7.5' QUADRANGLE NAMES

ROAD LEGEND

Improved Road
Unimproved Road
Trail

Interstate Route U.S. Route State Route

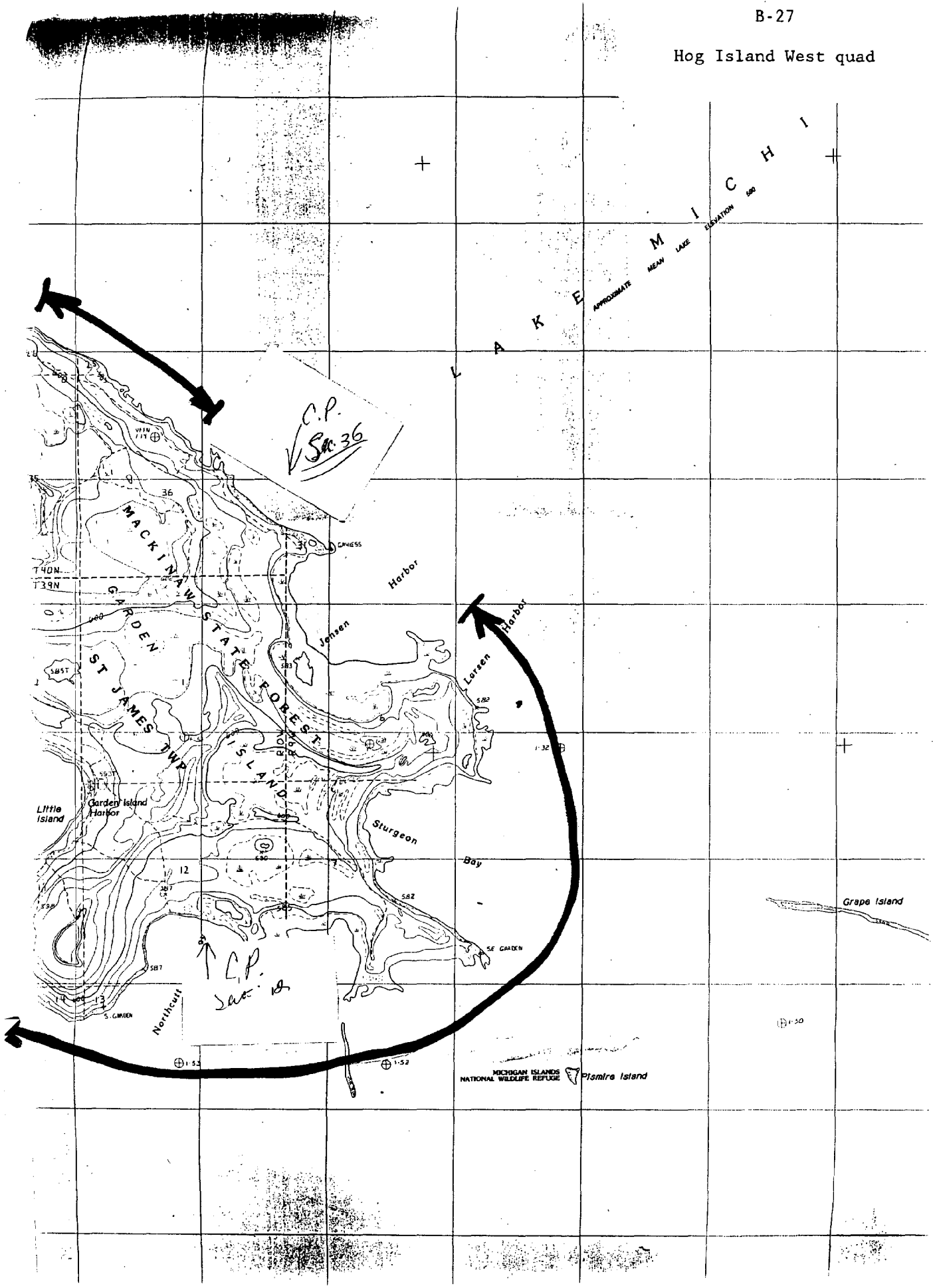
HOG ISLAND WEST, MICHIGAN
PROVISIONAL EDITION 1986

45085-G4-TF-024

MICHIGAN NATURAL FEATURES INVENTORY PROGRAM

4508.574

Hog Island West quad



Appendix C

Photos of survey sites

(attachment)