

UPDATED

Was the Goderich - Collingwood event.

**Confirmed Tornado
Formosa - Markdale, Ontario
July 9, 1965**

Date- Local: Friday, July 9th, 1965

UTC: Friday, July 9th, 1965

Time- Local: 1520

UTC: 1920

Location: Formosa (SW of Walkerton) – NW of Markdale

Region: Grey - Bruce

Classification: Confirmed Tornado

Category: -999

Casualties: 5 animals dead

Track Length: 50000 m

Width: None available

Motion: 235 degrees

Damage Estimate: \$1 million

F-Scale Rating: F3

Code: AH, BS

Damage Survey: None

Spotter Reports: None

Other Documents:

Phone interview notes with damage victims

Several newspaper articles

Map of tornado track

Newark summary sheet

Tornado F-Scale Assessment

Brad L. Rousseau

Tornado Data Production Assistant, Environment Canada

January 26th, 2011

Classification: Confirmed Tornado

Date: Friday, July 9th, 1965

Location: Formosa (SW of Walkerton) – NW of Markdale, Huron – Perth
Region

Assessment: F3

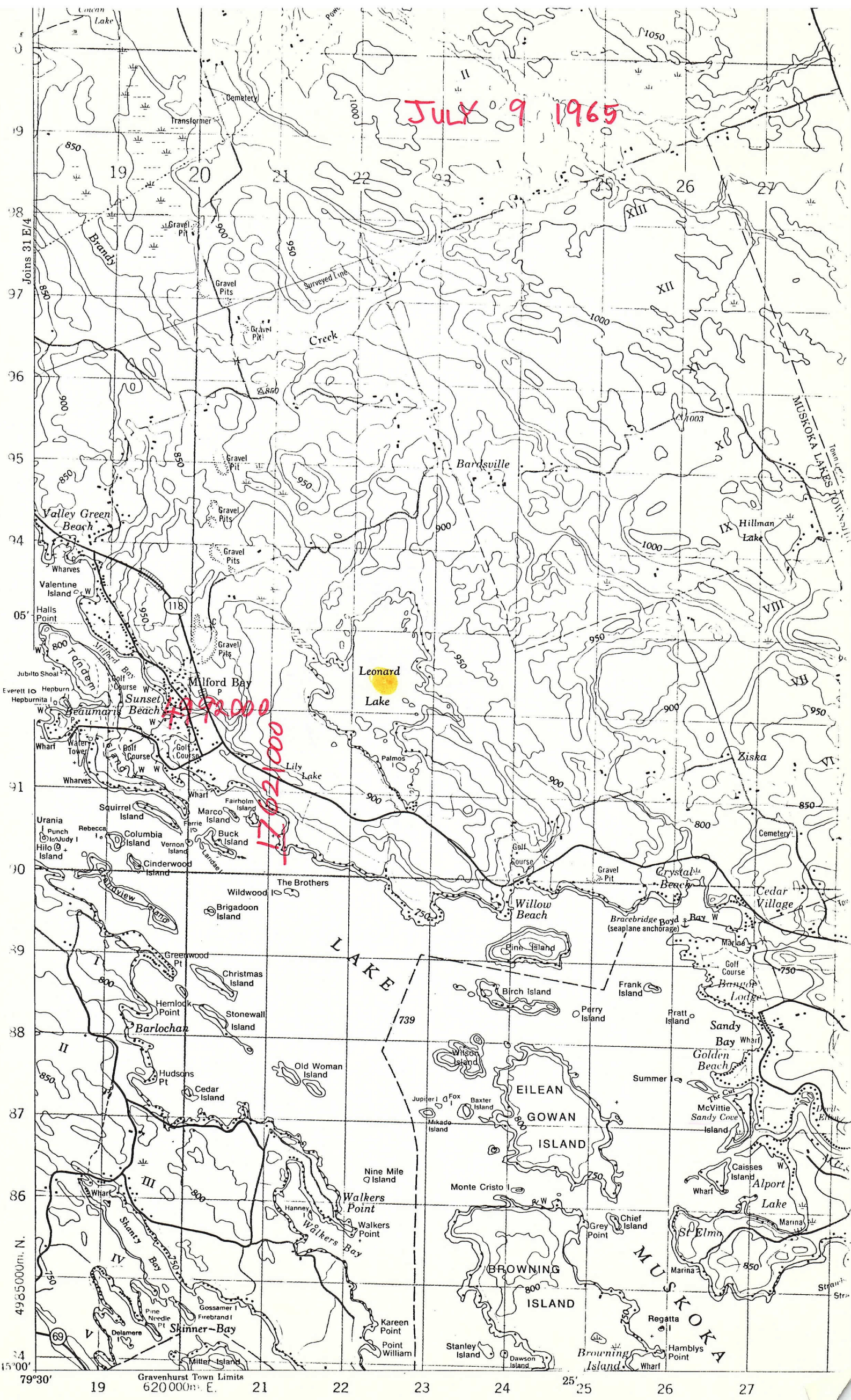
F-Code: AH, BS

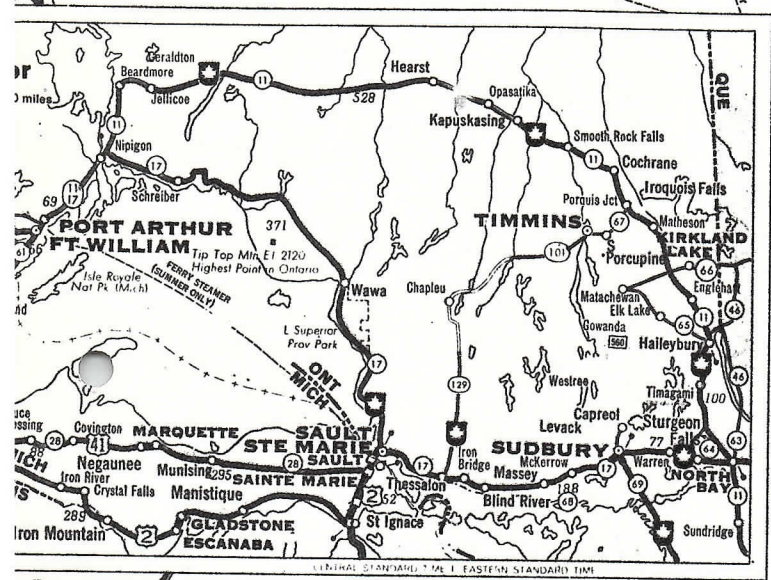
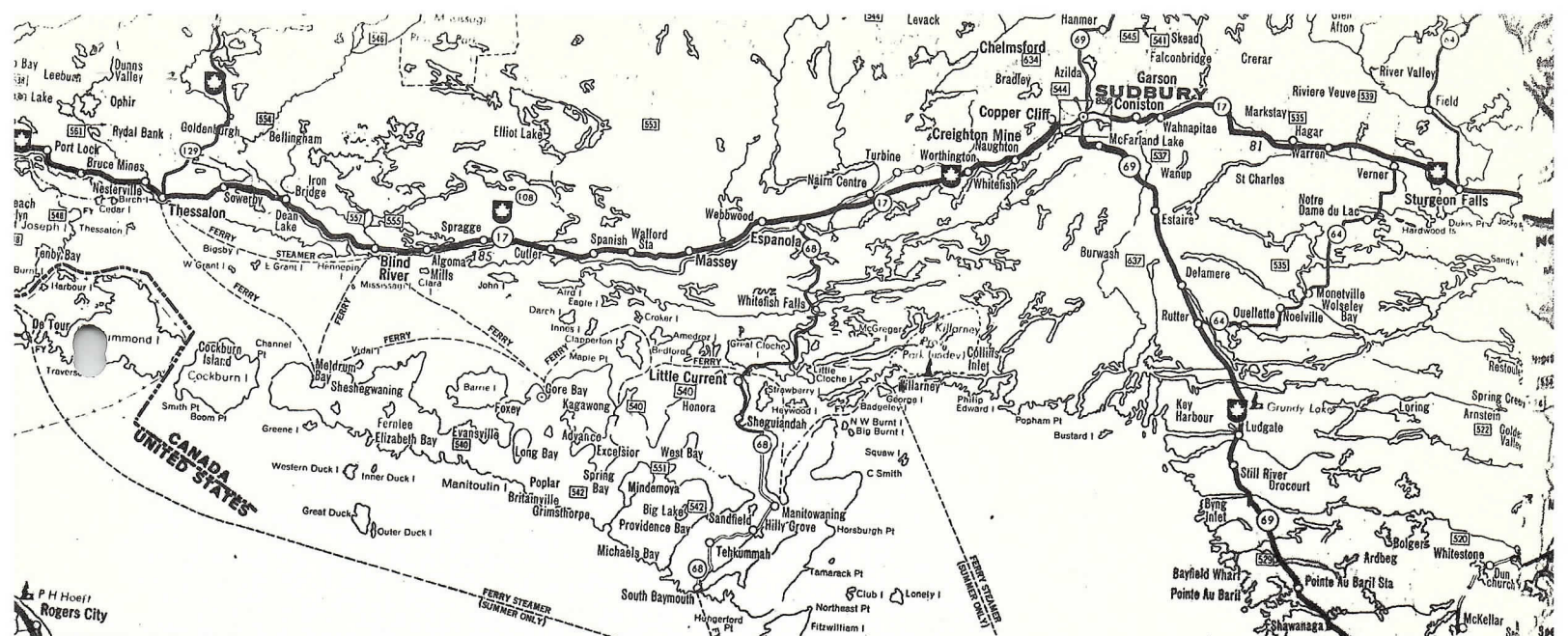
Explanation of Assessment: House with roof removed and a brick wall shattered and a barn was picked up and scattered. Car was thrown 75 ft and another thrown 200 ft and some cows were also thrown.

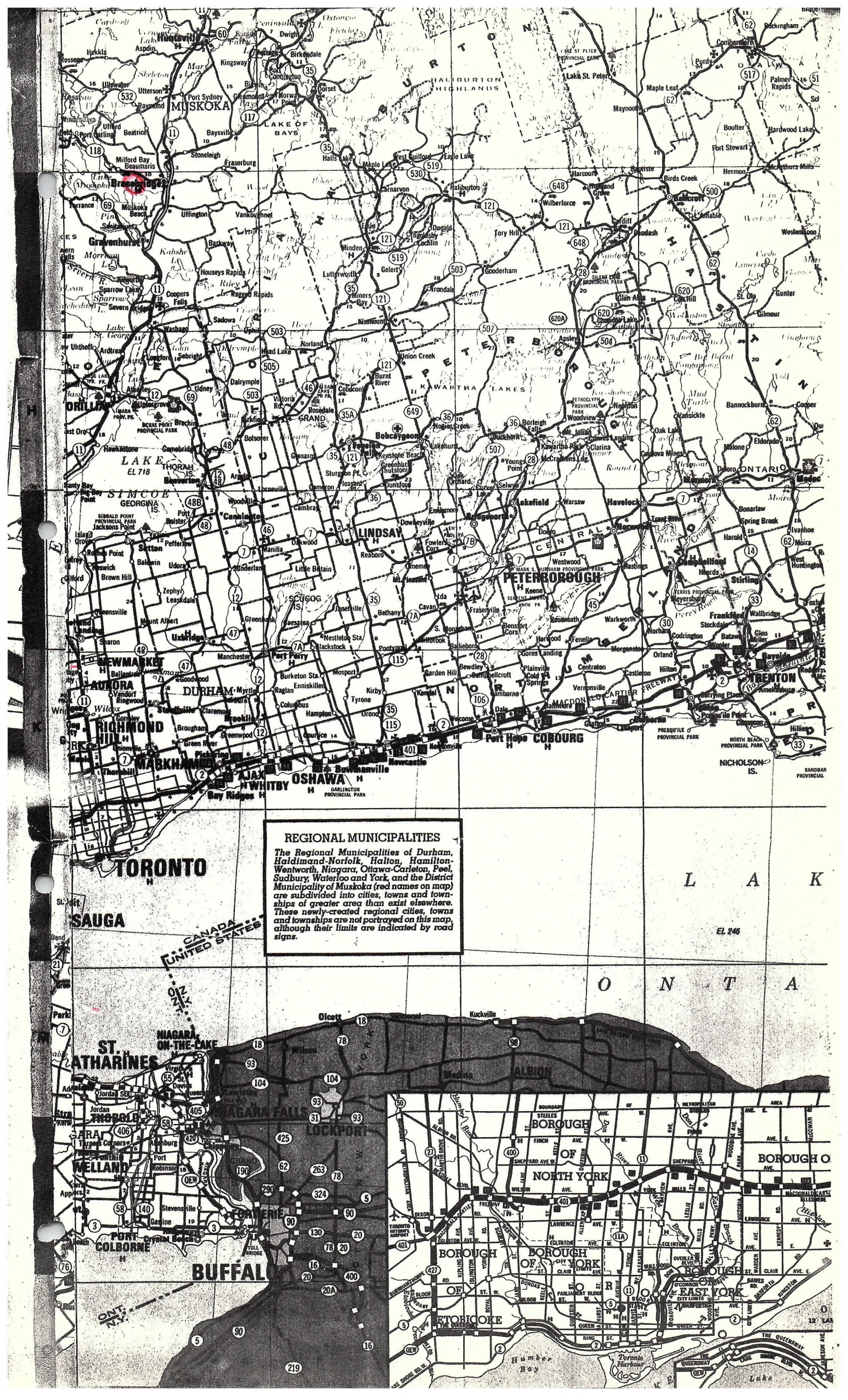
JULY

1. DATE AND TIME 9.7.1965 ① 1520 EDT ① Formosa - Markdale
2. LOCATION OR PATH (attach map) ① GODERICH TO ROLLINGWOOD (NW MARKDALE)
TOUCHDOWNS AT ② BRODNAGLEN, ③ LEONARD'S LAKE (WEST BRACEBRIDGE).
F=2
3. PATH LENGTH ☐ NOT KNOWN ☐ <1mi; ☐ 1-1mi; ☐ 5-10mi; ☒ 11-50mi; ☐ LENGTH IF >50mi
4. PATH WIDTH ☒ UNKNOWN 5. TORNADO PART OF DUST LINE? ☐ YES; ☐ NO; ☒ UNKNOWN:
6. ANY UNUSUAL COLORATION? ☒ YES; ☐ NO; ☐ UNKNOWN
7. ANY UNUSUAL SOUND? ☒ YES; ☐ NO; ☐ UNKNOWN
8. IF ANSWER TO 6 OR 7 YES, ELABORATE; 6 "EVERYTHING OUTSIDE BECAME WHITE" BLACK AS NIGHT (①)
7 "TERRIBLE ROAR" (①)
"A LOUD BUT BRIEF ROARING SOUND"
9. LIST ANY ASSOCIATED PHENOMENA From STOPPED CLOCKS, TORNADO WAS
(Such as hail, vivid lightning, heavy rain, no rain, etc.) TIMED WITH TRAVEL VELOCITY OF 22 MPH.
10. TOTAL DAMAGE ESTIMATE \$1 MILLION 11. TOTAL DEATHS 4 CATTLE
12. TOTAL INJURED NONE 13. TOTAL HOMELESS NONE
14. LIST ALL REFERENCES GLOBE AND MAIL, JULY 10 1965
DAILY STAR, TORONTO, JULY 10 1965
TORONTO TELEGRAM, JULY 10 1965
THE LONDON FREE PRESS, JULY 10 1965
THE WALKERTON HERALD TIMES, JULY 15 1965
15. SUMMARIZE REMARKS PERTAINING TO (a) FUNNEL; (b) INTERESTING OR CAPRICIOUS EVENTS.
- (a) "TORNADO NORTHEASTERLY COURSE WAS MARKED BY LARGE UPROOTED
BROKEN AND SPLINTERED TREES EXTENDING ACROSS THE COUNTRYSIDE
AS FAR AS THE EYE COULD SEE.
- (b) ① A VERY LARGE BARN 62X92 FT LIFTED IN ITS ENTIRETY FROM ITS
FOUNDATION AND LITTERED OVER A LARGE ADJOINING FIELD. ROOFING
FOUND 1 1/2 MILES AWAY IN FENCES AND TREES. A PIG PEN (40X50 FT)
AND A DRIVING SHED (40X60) CONTAINING A FULL LINE OF FARM
MACHINERY (MANY NEW) LITERALLY EXPLODED AND SPLINTERED INTO
MATCHWOOD. THE FARMER'S WIFE IN A HOUSE NEARBY, AND HER
SON WORKING IN A DISTANT FIELD KNEW NOTHING OF WHAT
WAS HAPPENING. A CAR CARRIED 75 FEET, A COW HURLED
20 FEET INTO A TREE AND A COW NEARLY DECAPITATED BY
FLYING DEBRIS. AN APPLE ORCHARD UPROOTED WITH LARGE
BRANCHES CARTWHEELING THROUGH THE AIR GOING UP THE
PASTURE. ON ANOTHER FARM A CAR CARRIED 90 FEET
AND BURIED WITH SUCH FORCE INTO A BARN FOUNDATION THAT IT
MADE A LARGE HOLE IN THE STONE AND CONCRETE WALL.
NEAR WALKERTON A PET DOG SNATCHED FROM HIS OWNERS
ARMS LATER FOUND DEAD IN A GRAIN FIELD. CONCRETE SILO
FLATTENED NEAR MARKDALE.
- ③ BOATS ON THE LAKE PICKED UP, OVERTURNED AND SMASHED. ONE
COTTAGE WAS LIFTED OFF ITS FOUNDATION AND TURNED
UPSIDE DOWN.

JULY 9 1965







REGIONAL MUNICIPALITIES
The Regional Municipalities of Durham, Haliburton-Norfolk, Halton, Hamilton-Wentworth, Niagara, Ottawa-Carleton, Peel, Sudbury, Waterloo and York, and the District Municipality of Muskoka (red names on map) are subdivided into cities, towns and townships of greater area than exist elsewhere. These newly-created regional cities, towns and townships are not portrayed on this map, although their limits are indicated by road signs.



①

Additional information gleaned from telephone conversations by M. J. Newark and P. Elm on Aug 29 1980, for the tornado of July 9 1965. The following people were contacted:

KENNETH LOVE, near Markdale. (519) 986-2065

MELVIN TEBBET " " (519) 986-3237

ROBERT RICHARDSON.

VICTOR WILEY near Kimberley.

CLERK OF BENTINCK TOWNSHIP OFFICE (519) 364-1909
(Spoke to road superintendent LARRY HEIPEL).

HAROLD FISK (519).

SEE MAP FOR PROPERTY OWNERS.

VICTOR WILEY: Barn unroofed and trees down.

KENNETH LOVE: Barn badly damaged.

MELVIN TEBBET: The driveway was unroofed and then the remaining walls were twisted out of shape. All of the orchard, consisting of thirty apple trees, was destroyed. All uprooted.

Maple trees were "screwed off" at the ground. One maple tree "went over the corn". Windows were broken in the house and the barn shifted off its foundation.

GORDON WILSON, Was not home at the time of the tornado. Had his barn damaged.

CLARENCE VAUGHN Farm just north of Townsend Lake.

Trees were blown down between the farm and the lake.

BRUCE BOYCE Roof taken off the barn and the south end wall blown out.

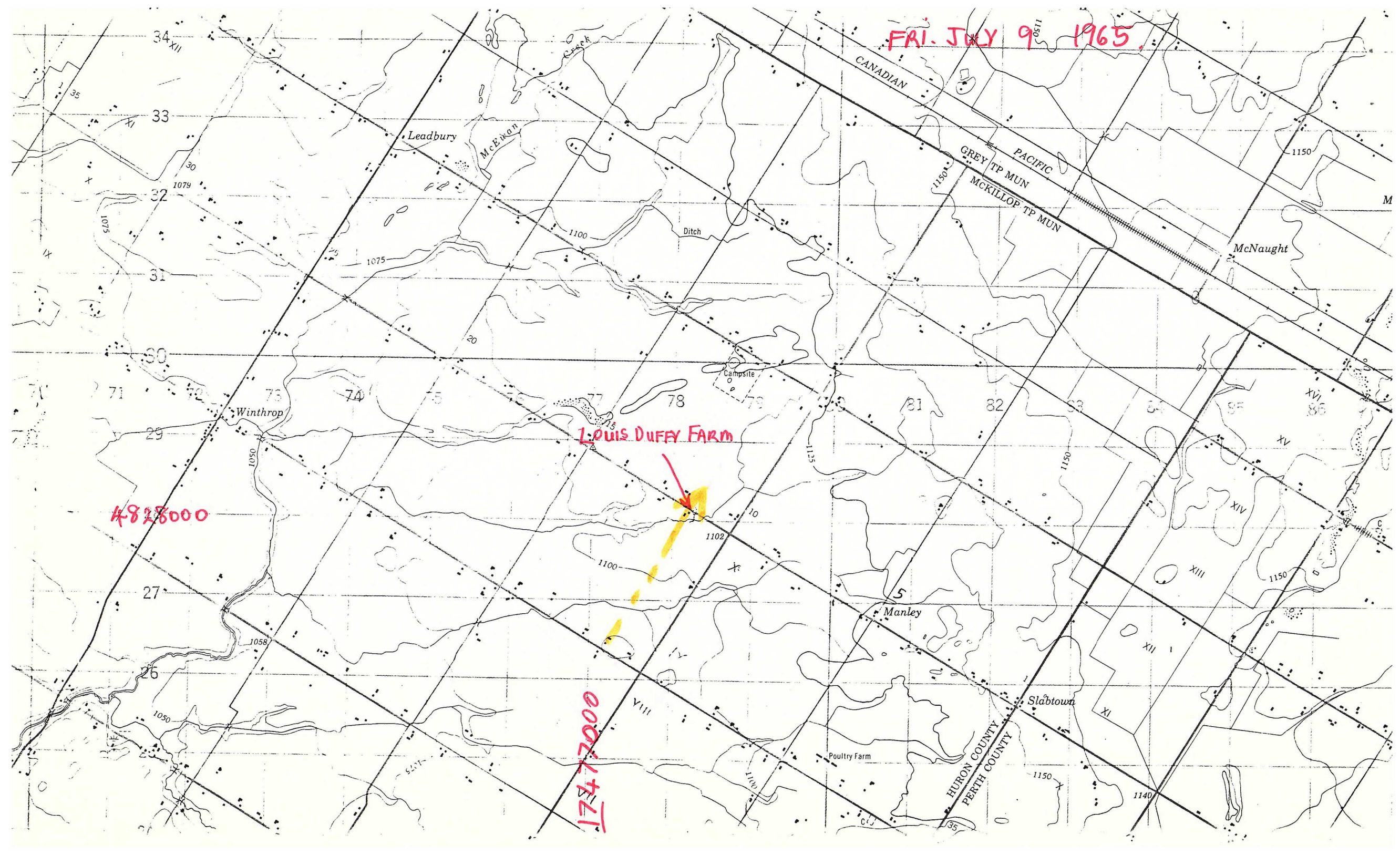
EARL ANDERSON. Barn shifted off foundation and roof removed.

BENTINCK TOWNSHIP MACHINERY BUILDING Cement block and steel roof construction. Roof was removed and steel roofing was carried as far as the Earl Anderson farm to the northeast.

A cottage situated on the south side of the road, on a hill, just west of the machinery building was so badly damaged it was not rebuilt.

ROBERT RICHARDSON. after damaging this farm the tornado struck the farm of William Morgan across the road to the east. The tornado then went through a bush and apparently lifted after this but touched down again further to the northeast.

FRI. JULY 9 1965



LOUIS DUFFY FARM

4828000

17477000

Conversation with MR Louis DUFFY (CON 10, LOT 12, MCKILLOP
TOWNSHIP, HURON CO.), by P. Elms, Sept 8 1980.

MR Duffy said he was working in the fields when the storm came up. He thought it was going to be an "ordinary rainstorm" and took shelter in the lower part of the barn.

The roof was taken off the barn and blown to the "North" (Northeast).

He heard of other damage on the line to the S.W. of his property, but could not remember the location.

71-1

Ontario Hydro Press Clipping Service

Paper
Date

Toronto Globe and Mail (Final)

JUL 10 1965

LEONARD LAKE
FRI JULY 9 1965

Baby Twister Wrecks Cars, Flips Cottage

Special to The Globe and Mail

BRACEBRIDGE — Three unoccupied cars were crushed by a giant maple and a cottage was overturned last night when a small twister swooped down on Leonard Lake, about seven miles west of here.

The twister came in the midst of a heavy storm and lasted for less than three minutes. No one was reported hurt, but Bracebridge OPP are checking cottages for damage and possible injuries.

Boats on the lake were picked up, overturned, and smashed, and many cottage windows were broken. A cottage on an island in the middle of the lake was turned upside down and tossed to the water's edge.

Most hydro and telephone lines were knocked out.

4pm FRI JULY 9 1965
Twister batters W. Ontario
damage estimated at \$1,000,000

Special to The Star

WALKERTON—A freak twister cut a swath of destruction 50 miles long through this part of Western Ontario yesterday, causing an estimated \$1,000,000 damage, but injuring no one.

Beginning at Kincardine and ending at Markdale, it killed livestock, tore up barns, blocked highways, and pulled out hydro poles.

The twister, which started at 4 p.m., missed the towns and farm homes on its route.

Kenneth Johnson, a Walkerton farmer, said he was sitting on his porch when the storm hit, tearing out both of his barns.

"It suddenly got black as night," he said. "I could hear this terrible roar. About all I could see was a

whole tree flying past the house."

Harry Fisk, whose farm is north of Hanover, said the wind flattened his barn like a "huge hand had squashed it."

A barn on the farm of Kenneth Love, near Markdale, was hurled 500 feet. His cement block silo was demolished.

A car owned by Mel Tibbett, a neighbor, was picked up by the twister and thrown through a barn.

The Wingham, Formosa and Kincardine area was without electric power for three hours last night.

Boats on Lake Leonard, near Bracebridge, were overturned and cottage windows smashed in another storm. A cottage on an island in the middle of the lake was turned upside down and tossed to the waters' edge.

In Fort Erie, lightning which accompanied heavy rainstorms was blamed for a \$20,000 fire which burned out a hardware store.

Ontario Hydro Press Clipping Service

Paper
Date

Toronto Telegram — Night Edition

JUL 10 1965

FRI JULY 9 1965**\$1,000,000
Twister Hit
Western Ont.**

In Western Ontario, during yesterday's storm, a twister caused an estimated \$1,000,000 damage along a 50-mile path near Walkerton and Markdale.

Several barns were destroyed and there were reports of livestock killed between Kincardine and Markdale. One car was tossed through a barn wall.

Fallen hydro poles blocked highways and country roads.

Rain and wind lashed most of Southern Ontario last night, damaging property and dumping about three quarters of an inch of rain, making driving hazardous.

Numerous minor traffic accidents were reported in Metro. There were no serious injuries.

The storm hit hardest in the Muskoka district where cottages were damaged, boats overturned and hydro and telephone lines knocked out.

Winds estimated at 50 miles an hour turned over a cottage on an island near Bracebridge. About 40 large pine trees were uprooted.

71-2
[Signature]

402.50412

P

Ontario Hydro Press Clipping Service

Paper The London Free Press
Date July 10, 1965
Source Western Region

FRI JULY 9 1965

Roofs Lifted, Hydro Disrupted By Wind, Electrical Storm

An electrical storm, with winds gusting up to 50 miles an hour hit Western Ontario yesterday, lifting roofs from barns and snuffing out hydro in many areas.

The storm brought an inch of rain to the Walkerton area and half an inch to Wingham.

Wingham and District Hospital operated for three hours with an emergency generator when power was cut off. CKNX television in Wingham did not broadcast for the three hours while CKNX radio broadcasted on an emergency generator.

A silo and a barn were flattened by the high winds on the farm of Kenneth Love, Concession 11, 2½ miles north of Markdale. The roof of the barn was carried 500 feet.

Four miles northwest of the Love farm, the barn of Melvin Tebbet was shifted by the winds and the roof of a shed was blown off.

The roof was also blown from a cottage on Highway 10 eight miles north of Markdale.

Teeswater, Wingham and Kincardine and rural areas in the vicinity were without power when a main transmission line between Hanover and Walkerton was knocked out.

Trees fell across highway 9 near Greenock causing a detour around the hamlet. Power was also disrupted in Clinton and Goderich for about an hour. The area from Amberly up the Lake Huron shoreline was also affected.

Rain fell for about half an hour at Chesley. The Meaford-Owen Sound area had rain for 45 minutes. Hydro was off in the entire community of Chesley for half an hour.

The Mount Forest weather station reported six-tenths of an inch of rain during the afternoon — with four-tenths of an inch coming in 10 minutes. Winds at the station reached 33 miles an hour and officials said winds would be higher in the Markdale area where the storm seemed to be centered.

A number of trees were blown

down in Goderich and power was off in the east-central section of town for an hour. Trees were also spread across highway 4 between Brucefield and Clinton.

The storm struck Kitchener-Waterloo about 5 p.m. and blew in three windows at St. Anne's Separate School in Waterloo. Hydro was off in downtown Waterloo for 45 minutes early last night.

Part of an elm tree came down in Exeter and brought down electrical lines. Businesses in one block were without hydro. All but three shops had service again within an hour at 4 p.m. and the remainder by 6:30 p.m.

Several trees were blown down near Brodhagen. The roof of a barn owned by Louis Duffy, in McKillop Township, was blown off.

No rain fell in Chatham, Sarnia or the Petrolia areas but winds were reported gusting to about 40 miles an hour.

The London weather office said .21 of an inch of rain fell in London where winds gusted to 22 miles an hour.

In Woodstock, .65 of an inch of rain fell, and will help the second growth of hay and pasture, according to Oxford County agricultural representative, D. A. Taylor.

Both St. Thomas and Simcoe reported .12 of an inch of rain.

ROBERT RICHARDSON. (519) 881-1468

KENNETH LOVE NR. MARKDALE

MELVIN TEBBET

KENNETH JOHNSON. (WALKERTON). (705)

HARRY FISK N. OF HANOVER. (705)

LOUIS DUFFY.

WILFRED BRUDER. WALKERTON. x519-881-2377

ROSS JOHNSON WALKERTON. x519-881-0358

ROGER KNAPP. (519) 364-3888

LOUIS DUFFY (BRODHAGEN). (519) 345-2218.

DRAG.

Left

File

402-5041

Flavence
Vaughan
trees uprooted

30 apple trees - blown to

P

P

Page 2 of 2
 6/13/71-2
 JUL 26 1965

Ontario Hydro Press Clipping Service

Paper The Walkerton Herald Times

Date July 15, 1965

Source Georgian Bay Region

FRI JULY 9 1965 3:20pm
 1520 EDT.

Trees

Demolished Barns, Uprooted Mark Path Of Miniature Tornado

Great Loss In At Least One Instance
 Said Not Covered By Wind Insurance

CUTS THIRTY-FIVE MILE SWATH

A trail of destruction, composed of demolished barns, uprooted trees, overturned vehicles and farm implements, as well as dead cattle, was left in the wake of a miniature tornado which cut through Greenock, Brant and Bentinck Townships on Friday afternoon. While the damage inflicted by the twister, along its path extending for about 35 miles, amounted to many thousands of dollars, there was fortunately no loss of human life, with likewise no injuries having been reported.

The twister commenced its work of devastation at approximately 3:20 p.m. as it touched down to earth northwest of Formosa. The first farm to be hit was that of the Wilfred Bruder Estate, situated on Highway 4 & 9, about 4½ miles west of Walkerton, and operated by the deceased's sons, John, Peter and Jerome Bruder.

Here the baby tornado wreaked total destruction, as one of the largest barns in Bruce County, such being of exceptional height and measuring 62 x 92 feet, was lifted in its entirety from its foundations, and littered over the large adjoining field, which bordered the highway many hundred feet distance. As far away as one and a half miles, northeast of the site of the erstwhile barn, which was said to have been "equipped like a palace," large pieces of its aluminum sheet roofing were to be found in fences and trees.

Simultaneously on the same Bruder farm, an adjoining pig pen, about 40 x 50 feet in size, and a driving shed, 40 x 60, itself as large as many rural barns, and containing a full line of farm implements, with many new units, literally exploded and with the main barn, came to earth in the form of timbers and beams, splintered like matchsticks, with boards and roofing being carried like kites and strewn over nearby fields by the swirling winds of the tornado.

In the same great turbulence, a car on the farm was carried 75 feet, landing on its roof; a calf was hurled 20 feet into a tree; three cattle beasts were killed, one of which was almost decapitated by flying debris, and two more had to be later destroyed. It is thought that some may have been struck by lightning.

Untouched by the utter havoc inflicted by the twister was the log house, in which the widow, Mrs. Wilfred Bruder, was present at the time the tornado struck. She did not see the destruction taking place, but did go to the back door to close it after it had come open by "a gust of wind," and with so doing, the front door opened, she said.

Mrs. Bruder only witnessed the disaster which had visited the premises, when she later went outdoors. Her sons, working in a distant field, did not know a twister passed through, the first sign of the catastrophe being the sight from afar of rubble which before had been the large farm buildings.

The Bruders carried no wind insurance whatever on the demolished structures.

Highway Was Blocked

Several huge elm trees and a Manitoba maple in the vicinity of the devastated Bruder farm, in Greenock, were uprooted and thrown across Highway 4 & 9, necessitating the detouring of traffic around the blocked concession. Highway and hydro crews immediately set about the big task of restoring highway travel and electric power.

Highway employees working, with power saws, trucks and cables finally had the obstructing trees cleared from the provincial highway, and the traffic flow recommenced through the damaged area, around 7 p.m.

While Walkerton was without power for about 35 minutes in

mid-afternoon on Friday last, Wingham and other centres to the west of the hydro line break, were without electricity for three hours. Such receive their power through the hydro sub-station at Hanover, to the east.

The power interruption at Walkerton occurred during a thunder and rainstorm, which cleared up within the space of about a half hour.

The neighbour to the east of the Bruder farm, Stephen Kraemer, had several trees blown over. Some windows in his house were also broken by flying debris from the distant Bruder farm structures, and the private garage was shifted on its foundation.

The electric clocks at the Kraemer home stopped at 3:20 p.m., the time that the twister struck.

Apple Orchard Hit

From the Bruder premises, the tornado's northeasterly course was marked by large uprooted, broken and splintered trees, extending across the countryside as far as the eye could see.

The next farm to be hit by the tornado, was that occupied by Ross Johnston, situated two and three-quarter miles directly west of Walkerton, and about two miles distant from the first scene of destruction. Here twelve apple trees were uprooted, with many large branches gouging the pasture as they cartwheeled for a distance of about five hundred feet. The barn was demolished, with windows in the nearby house being broken by flying boards. Aluminum

barn roofing littered the area, some becoming entangled in the fences and hydro wires.

Car Carried 200 Feet

Just across the road, and again in line with the northeasterly course of the twister, the farm of Earl Johnston became the next victim.

Mr. Johnston states that he was sitting in the glassed-in sunporch of his house, talking with some people, when everything became white outside, as though during a blizzard. This was followed by a few seconds of roaring sound and all was over.

File 402.50412

P

STEPHEN KRAEMER

ROSS JOHNSTON

P

Page 2 of 7 JUL 26 1965

FRI JULY 9 1965

Ontario Hydro Press Clipping Service

Paper The Walkerton Herald Times
Date July 15, 1965
Source Georgian Bay Region

JUL 26 1965

GB 71-42 (operation)

Page 2

Likewise over at the same instant, were five or six large trees near the house, some of which struck the dwelling. All the window panes on the west side of the home were smashed, as were those in the sunporch. A large nearby tree was broken off at its base, and carried six hundred feet by the wind, before being deposited in the middle of a field.

A car parked in the Johnston lane beside the house, was carried northward 200 feet, and thrust with such force into the barn foundation that it put a large hole in the stone and concrete wall.

The barn was shattered by the spiralling winds, while flattened were a pig pen and hen house. On an adjoining farm, the former Henry Ernest premises, also owned, along with the other two farms by Earl Johnston, the roof was torn off of the barn.

Went To Close Window

Still in a northeasterly direction, the trail of destruction continued, with the rural property of Harry Fisk, on the 5th sideroad of Brant, two miles northwest of Walkerton, being in the path of the relentless twister, which travelled at between 20 and 25 miles per hour.

Mrs. Fisk, in the house at the time, heard the rushing of wind and hurried to shut the upstairs windows. There was a loud but brief roaring sound and then silence. Though realizing that a strong wind had hit the premises, Mr. Fisk was however astounded to see his driving shed levelled and the barn practically demolished.

The next farm buildings to be hit by the twister were those of Bob Richardson, on the 10th sideroad of Brant, the next concession over, and 2 miles directly north of Walkerton. Here the winds lifted the roof of a drive-shed adjoining the barn, which miraculously was left untouched by the twister. A large maple crashed into a rear section of the Richardson home, separating it partially from the house proper.

It was at exactly 3:35 p.m. that the tornado hit the Richardson farm, as such was the time that the electric clocks in the home stopped. Thus fifteen minutes were required for the twister to travel from the Wilfred Bruder farm to the Richardson premises, a distance of five and a half miles, indicating that the tornado travelled across the area at approximately 22 miles

per hour. The speed of a tornado's spiralling winds however is often estimated in terms of hundreds of miles per hour.

Only Direct House Damage

The sole instance, where the tornado's force directly damaged a residence, to any notable extent, was at the former William Morgan home across the road from, and to the east of the Richardson farm, and which the twister next visited. Here the brick wall of the summer kitchen was shattered and the roof lifted off.

So many fallen and uprooted trees littered the premises that the whole lawn was practically hidden. Three huge spruce trees, which bordered the driveway, and spaced about eight feet apart, were chopped off at a height of 10 feet from the ground, attesting to the tremendous power and the weird behaviour of the tornado.

Eccentricities Of Storm

Mrs. David Gateman, R.R. 1, Walkerton was holding a pet dog when the violent windstorm struck. The animal was snatched from her arms, and was later found in a grain field.

In Bentinck Township, where the twister next hit, six 4,000-volt hydro poles were shorn off, north of Hanover, causing a short-circuit that resulted in the operation of the railway crossing flashing lights near Hanover.

The roof of the township machinery building had its roof torn off. The oil furnace and a portion of the cement block wall were also ripped out by the winds.

At the farm premises of Robert Knapp, just west of the said township garage, the storm flattened the barn and drive shed.

A summer cottage, about a half mile distant, was twisted on its foundation, while a few miles still further east, the barn of Bruce Boyce of Bentinck was demolished.

The tornado finally blew itself out in the northeastern part of Grey County, but not before it had flattened the barn and a new concrete silo on the farm of Kenneth Love, near Markdale.

(Pictures on Page Eleven.)

Hydro line cut.
N of Hanover.

summer cottage
Robert Knapp Hanover

Bruce Boyce.

Robert Richardson farm, clock stopped 3:35 p.m.

WORKSHEET

IDTO 06965-05

① ORIGIN x 17622400
 y 4992300

⑤ Standard Error S_x
 $0 = 750m$

② LIFT-OFF x_1
 y_1

⑥ Standard Error S_y

③ $(x_1 - x) =$

④ $(y - y_1) =$

⑦ DAMAGE LENGTH

$L = [(x_1 - x)^2 + (y - y_1)^2]^{1/2}$

⑧ $\alpha = \tan^{-1} \frac{|y - y_1|}{|x - x_1|}$

③ + ④ $\rightarrow r, \theta =$

$x \leftrightarrow y =$

⑨ Standard Error $S_L = (S_x^2 + S_y^2)^{1/2}$

⑤ + ⑥ $\rightarrow r, \theta =$

⑩ $\beta = \frac{\tan^{-1} S_L}{L}$

⑦ + ⑨ $\rightarrow r, \theta$
 $x \leftrightarrow y =$

NE Quad $\phi = 90 - \alpha$
 NW Quad $\phi = 270 + \alpha$
 SW Quad $\phi = 270 - \alpha$

SE Quad $\phi = 90 + \alpha$

⑪ $\phi =$

WORKSHEET

IDTO 06965-03

① ORIGIN x 17442000
 y 4852300

⑤ Standard Error S_x
 $C = 6000m$

② LIFT-OFF x_1 17554350
 y_1 4929950

⑥ Standard Error S_y
 $C = 2000m$

③ $(x_1 - x) = 112350$

④ $(y - y_1) = 77650$

⑦ DAMAGE LENGTH

$L = [(x_1 - x)^2 + (y - y_1)^2]^{1/2}$

⑧ $\alpha = \tan^{-1} \frac{|y - y_1|}{|x - x_1|}$

③ + ④ $\rightarrow r, \theta = 136572$

$x \leftrightarrow y = 35^\circ$

⑨ Standard Error $S_L = (S_x^2 + S_y^2)^{1/2}$

⑤ + ⑥ $\rightarrow r, \theta = 6324$

⑩ $\beta = \frac{\tan^{-1} S_L}{L}$

⑦ + ⑨ $\rightarrow r, \theta$
 $x \leftrightarrow y = 3^\circ$

NE Quad $\phi = 90 - \alpha$

NW Quad $\phi = 270 + \alpha$

SW Quad $\phi = 270 - \alpha$

SE Quad $\phi = 90 + \alpha$

⑪ $\phi = 235^\circ$

WORKSHEET

IDTO 06965-04

① ORIGIN x 17477250
 y 4826450

⑤ Standard Error S_x
 $R = 289$ $L = 2000$
 $\omega = 500$

② LIFT-OFF x_1 17478450
 y_1 4828450

⑥ Standard Error S_y
 $C = 200$

③ $(x_1 - x) = 1200$

④ $(y - y_1) = 2000$

⑦ DAMAGE LENGTH

$L = [(x_1 - x)^2 + (y - y_1)^2]^{1/2}$ ⑧ $\alpha = \tan^{-1} \frac{|y - y_1|}{|x - x_1|}$

③ + ④ $\rightarrow r, \theta = 2332$

$x \leftrightarrow y = 59.1$

⑨ Standard Error $S_L = (S_x^2 + S_y^2)^{1/2}$

⑤ + ⑥ $\rightarrow r, \theta = 351. R$

⑩ $\beta = \frac{\tan^{-1} S_L}{L}$

⑦ + ⑨ $\rightarrow r, \theta$
 $x \leftrightarrow y = 8$

NE Quad $\phi = 90 - \alpha$

NW Quad $\phi = 270 + \alpha$

SW Quad $\phi = 270 - \alpha$

SE Quad $\phi = 90 + \alpha$

⑪ $\phi = 211$

WORKSHEET

IDTO 0696001

① ORIGIN x 17385000
 y 4762000

⑤ Standard Error S_x
C 200

② LIFT-OFF x_1 17394600
 y_1 4760650

⑥ Standard Error S_y
C 200

③ $(x_1 - x) = 9600$

④ $(y - y_1) = 1350$

⑦ DAMAGE LENGTH

$L = [(x_1 - x)^2 + (y - y_1)^2]^{1/2}$ ⑧ $\alpha = \tan^{-1} \frac{|y - y_1|}{|x - x_1|}$

③ + ④ $\boxed{\rightarrow r, \theta} = 9694 \text{ m}$

$\boxed{x \leftrightarrow y} = 8^\circ$

⑨ Standard Error $S_L = (S_x^2 + S_y^2)^{1/2}$

⑤ + ⑥ $\boxed{\rightarrow r, \theta} = 28.2 \text{ m}$

⑩ $\beta = \frac{\tan^{-1} S_L}{L}$

⑦ + ⑨ $\boxed{\rightarrow r, \theta}$
 $\boxed{x \leftrightarrow y} = 2^\circ$

NE Quad $\phi = 90 - \alpha$

NW Quad $\phi = 270 + \alpha$

SW Quad $\phi = 270 - \alpha$

SE Quad $\phi = 90 + \alpha$

⑪ $\phi = 278^\circ$

WORKSHEET

IDTO 0696002

l 200
w 1000

① ORIGIN x 17 3384000
 y 47 10300

⑤ Standard Error S_x
 R 129

② LIFT-OFF x_1 17 3392600
 y_1 47 09700

⑥ Standard Error S_y
 R 129

③ $(x_1 - x) = 8600$

④ $(y - y_1) = 600$

⑦ DAMAGE LENGTH

$L = [(x_1 - x)^2 + (y - y_1)^2]^{1/2}$ ⑧ $\alpha = \tan^{-1} \frac{|y - y_1|}{|x - x_1|}$

③ + ④ $\rightarrow r, \theta = 8621 \text{ m}$

$x \leftrightarrow y = 4^\circ$

⑨ Standard Error $S_L = (S_x^2 + S_y^2)^{1/2}$

⑤ + ⑥ $\rightarrow r, \theta = 18.2 \text{ m}$

⑩ $\beta = \frac{\tan^{-1} S_L}{L}$

⑦ + ⑨ $\rightarrow r, \theta$
 $x \leftrightarrow y = 1^\circ$

NE Quad $\phi = 90 - \alpha$

NW Quad $\phi = 270 + \alpha$

SW Quad $\phi = 270 - \alpha$

SE Quad $\phi = 90 + \alpha$

⑪ $\phi = 274^\circ$