Confirmed Tornado
Barrie, Ontario
May 31, 1985

Date- Local: Friday, May 31st, 1985.
UTC: Friday, May 31st, 1985.
Time-Local: 17:00
UTC: 21:00
Location: Barrie
Region: Barrie – Orillia - Midland
Classification: Confirmed Tornado
Category: A
Casualties: 8
Track Length: ~15km (part of track is out over water and therefore estimated)
Width: 600m
Motion: 241°
Damage Estimate: $150 million (for the 5 tornadoes in this storm)
F-Scale Rating: F4
Code: AH/VF/IB
Damage Survey: yes
Spotter Reports: None
Other Documents:

Logged event citing tornado, part of Barrie Tornado.
The May Thirty-First Tornado Outbreak in Southern Ontario report.
Video showing the destruction along path, both aerial footage and on the ground footage.

Tornado F-Scale Assessment

Marci Vanhoucke
Tornado Data Production Assistant, Environment Canada
July 21, 2005.

Classification: Confirmed Tornado
Date: Friday, May 31st, 1985.
Location: Barrie, Barrie – Orillia – Midland

Assessment: F4
F-Code: AH/VF/IB
Explanation of Assessment: There is a Tornado Outbreak report stating that along the damage path there were cars found blown hundreds of meters into the bush, at least 12 factories destroyed near hwy 400, a townhouse complex destroyed (in video evidence, the top story is taken off and in some cases part of the bottom story) and 35 sail boats completely disappeared. Due to the damage cited, this tornado is rated an F4.

CLASSIFICATION: Severe Thunderstorm
SOURCE/WATCHER ID:
EVENT TIME (UTC): 21-00 **EVENT DAY:** 31.0 **MONTH:** 5.0 **YEAR:** 1985.0 **EVENT DURATION (HR):** 0.0 **(MIN):** 0.0
DAY OF THE WEEK:
EVENT LOCALE: Barrie
ASOCTD PUBLIC RGN: Barrie-Huronia
DETAILED DESCRIPTION: infamous Barrie tornado, 8 killed, tens of millions of dollars in damage
INITIAL ASSESSMENT: YES
SPL WX STATEMENT IN EFFECT ?: UKN **STATEMENT LEAD TIME (HR):** **(MIN):**
WATCH IN EFFECT ?: UKN **WATCH LEAD TIME (HR):** **(MIN):**
WARNING IN EFFECT ?: UKN **WARNING LEAD TIME (HR):** **(MIN):**
TORNADO:
WINDSPEED: ?
RAINFALL: ? MM **RAIN DURATION:**
HAIL DIAMETER: MM **HAIL DESCRIPTION:**
EVENT DESCRIPTION: Tornado
Mesoscale ?: **Synoptic ?:** **Big Event ?:**
Statement Est Hit/Miss:
Watch Est Hit/Miss:
Warning Est Hit/Miss:
Separate Event (30km/30min): YES
Vetted by:
Vetted date:

698522 ✓ A F=4

TORNADO PROJECT SUMMARY SHEET

1. DATE AND TIME: May 31, 1985 1657 EDT

2. LOCATION OR PATH (attach map): Essa-Barrie, Ont.

3. PATH LENGTH: ☐ NOT KNOWN ☐ <1mi; ☐ 1-4mi; ☐ 5-10mi; ☐ 11-50mi; ☐ LENGTH IF>50mi

4. PATH WIDTH: 300 avg (600 max.)

5. TORNADO PART OF SQUALL 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) sky green then black 7) many described a "loud roar"

9. LIST ANY ASSOCIATED PHENOMENA (Such as hail, vivid lightning heavy rain, no rain, etc.): Heavy rain.

10. TOTAL DAMAGE ESTIMATE $ 117,000,000

11. TOTAL DEATHS 8

12. TOTAL INJURED 155

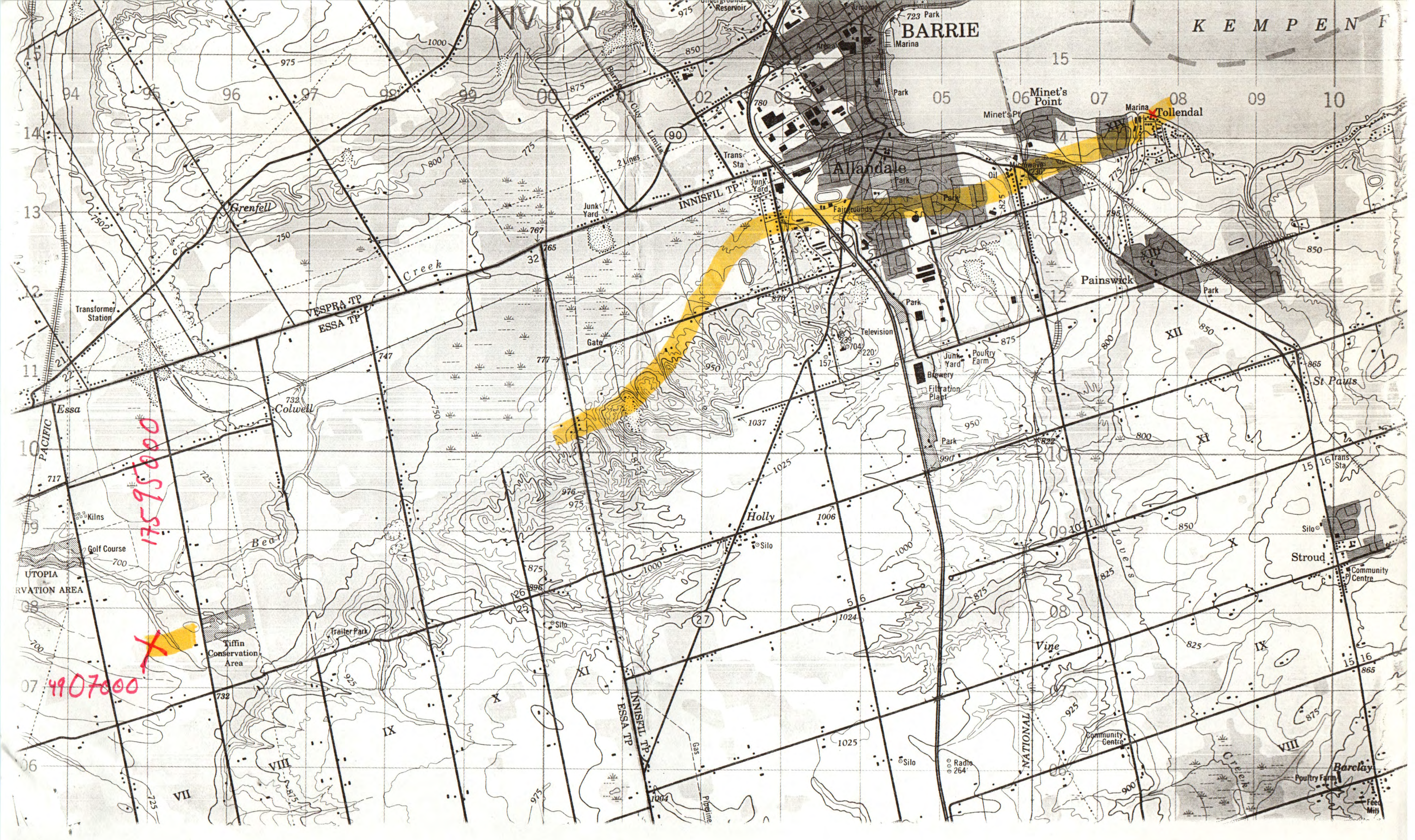
13. TOTAL HOMELESS 800

14. LIST ALL REFERENCES

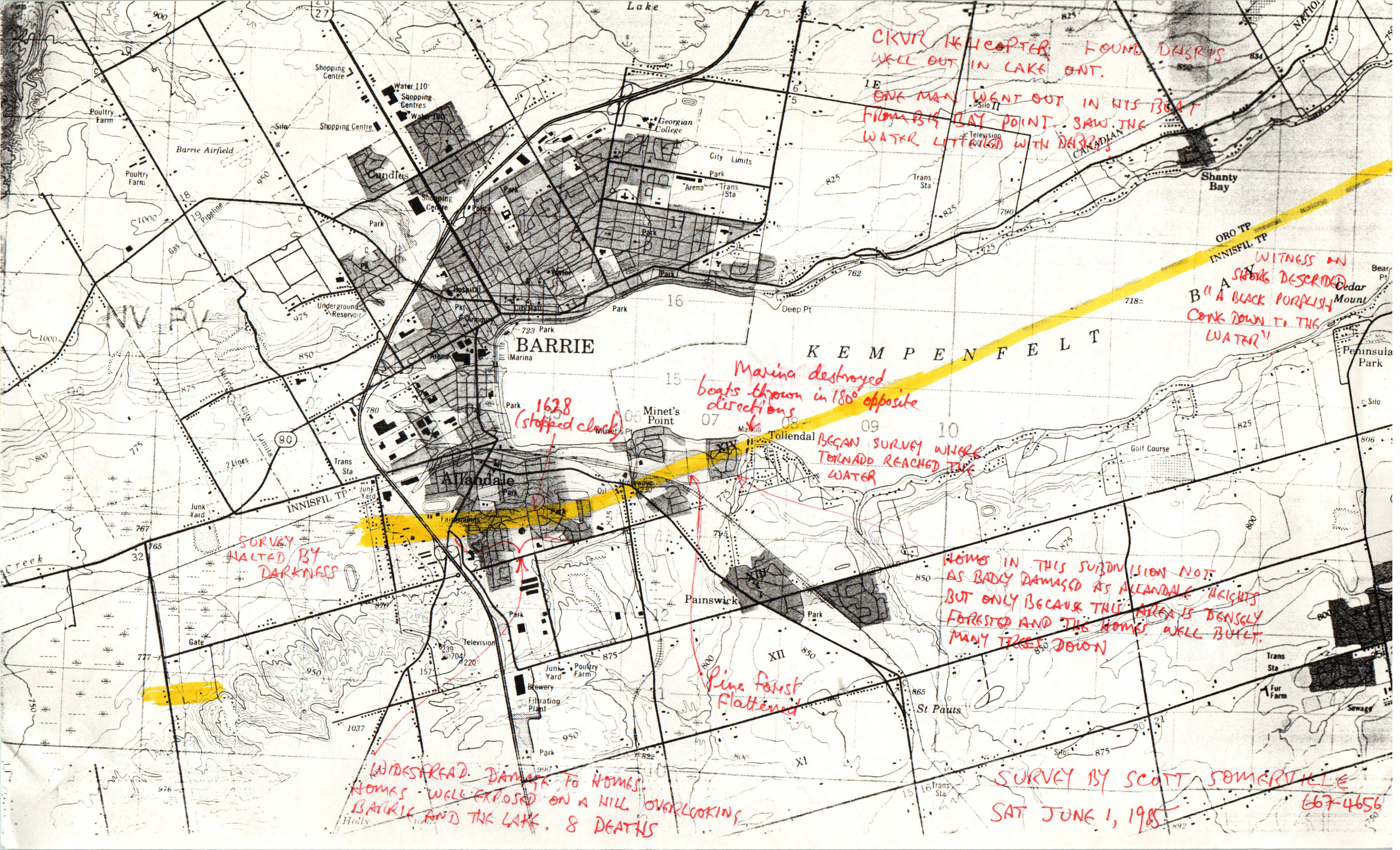
15. SUMMARIZE REMARKS PERTAINING TO (a) FUNNEL; (b) INTERESTING OR CAPRICIOUS EVENTS.

a) Black funnel shaped cloud.

b) Total of 605 houses severely damaged, 265 of which were uninhabitable. Cars blown hundreds of meters. Boats lifted out of water at marina pulling out anchors cemented in bottom of lake. Debris was spotted 5 km out into Lake Simcoe. Industrial buildings totally demolished. P.T.O.



BARRIE
KEMPENF
Allandale
Minet's Point
Tollendal
Painswick
Grenfell
Colwell
Essa
UTOPIA
RVATION AREA
Golf Course
Kilns
Transformer Station
Tiffin Conservation Area
Trailer Park
Holly
Stroud
St Pauls
Vine
Barclay
Fairgrounds
Television
Brewery
Filtration Plant
Poultry Farm
Community Centre
VESPRA TP
ESSA TP
INNISFIL TP
Creek
Lovers
NATIONAL
4907000
175 95000


CKVR HELICOPTER FOUND DEBRIS WELL OUT IN LAKE ONT.
ONE MAN WENT OUT IN HIS BOAT FROM BIG BAY POINT. SAW THE WATER LITTERED WITH DEBRIS
WITNESS ON SHORE DESCRIBED "A BLACK PURPLISH CONE DOWN TO THE WATER"
Marina destroyed boats thrown in 180° opposite directions
1628 (stopped clock)
BEGAN SURVEY WHERE TORNADO REACHED THE WATER
SURVEY HALTED BY DARKNESS
HOMES IN THIS SUBDIVISION NOT AS BADLY DAMAGED AS ALLANDALE HEIGHTS BUT ONLY BECAUSE THIS AREA IS DENSELY FORESTED AND THE HOMES WELL BUILT. MANY TREES DOWN
Pine Forest Flattened
WIDESPREAD DAMAGE TO HOMES. HOMES WELL EXPOSED ON A HILL OVERLOOKING BARRIE AND THE LAKE. 8 DEATHS
SURVEY BY SCOTT SOMERVILLE
SAT JUNE 1, 1985
667-4656
Lake
BARRIE
KEMPENFELT
BAY
Allandale
Minet's Point
Tollendal
Painswick
Shanty Bay
Cundles
Georgian College
Barrie Airfield
Poultry Farm
Shopping Centre
City Limits
Deep Pt
Cedar Mount
Peninsula Park
Golf Course
ORO TP
INNISFIL TP
St Pauls
Junk Yard
Brewery
Filtration Plant
Television
Trans Sta
Fur Farm
Sewage
Creek
Gate
Silo
Park
Marina

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HEADLINE: Barrie area tornadoes under study

BARRIE, Ont-- Witnesses of a series of tornadoes that ripped through the Barrie area nine years ago are being asked to help researchers plan for more natural disasters.

** An atmospheric environmental research group with the Ministry of Environment is doing a case study on the tornado that killed eight people and devastated the south end of the city in 1985.

The study is part of a Canada-wide tornado project that looks at 2,289 tornadoes between 1918 and 1992.

"The project will be of benefit to municipal planners, insurance companies and disaster planners," said Eric Brun, one of three researchers working on the study, expected to be finished by the end of the summer.

** By dividing the country into grids, the group hopes to determine the likelihood of a tornado hitting each area.

The Barrie-area grid, which covers about 2,000 square kilometres, gets hit once every three or four years on average. In the 74-year study period, 21 tornadoes were recorded.

The Barrie study will include an examination of municipal and county emergency plans, insurance coverage for victims, building code changes after the event and the perceptions of residents before and after the tornado.

"We want to know the awareness people had of tornadoes before it happened and if it changed after," Mr. Brun said.

Southwestern Ontario, including Barrie, is a hot spot for tornadoes, Brun explained. Other tornado targets are the southern portions of Alberta and Saskatchewan.

SEARCH TERMS ENVIRONMENTAL; GROUP

*** END OF STORY ***

THE "BLACK FRIDAY" TORNADO OUTBREAK IN ONTARIO

A Forecaster's View of the Events of May 31, 1985

by Michael Leduc, Ole Jacobsen and Barry Greer

During the afternoon of May 31, 1985 a well-marked cold front moved through southern Ontario triggering a series of very damaging tornadoes. Twelve people were killed and scores of others injured as the storms crossed the Province. Property damage is estimated at well over $100 million (see article by Mark Ransom on pages 4–5).

METEOROLOGICAL CONDITIONS

On May 30th very warm, humid tropical air became established across the central United States. The air was also very unstable, meaning that with any sort of lifting mechanism very intense thunderstorms could develop. During the early afternoon a weak disturbance crossed Lake Erie and allowed some of this tropical air to enter extreme southwestern Ontario.

Another weak disturbance during the morning of May 31st pushed the warm humid air northeastward producing thunderstorms across all of southern Ontario. No damage was reported from these thunderstorms in Ontario but the arrival of the warm, very unstable air mass set the stage for the very dramatic events of later that day.

While the warm humid air was becoming established across the south half of Ontario an intense spring storm was developing just west of the Great Lakes. A low pressure centre with a strength more typical of a midwinter storm tracked across upper Michigan during the morning of May 31st to north of Sudbury by evening. A very sharp cold front trailed southward from this low pressure system.

The morning analysis at Environment Canada's Ontario Weather Centre (OWC) indicated that the thermodynamic and dynamic features necessary for the possible development of severe thunderstorms were present. The thermodynamic instability of the air mass was confirmed from the radiosonde reports east of the cold front crossing Michigan. The air layer above one kilometre was very dry and cool while the tropical air mass near the surface was very hot and moist. The dynamic features (triggering mechanisms) were strong, that is, a sharp cold front and a sharp upper trough crossing Michigan and a very strong westerly jet stream above 10 km with winds close to 400 km/h (200 knots). The cold front and upper trough were expected to cross southern Ontario during the afternoon and early evening.

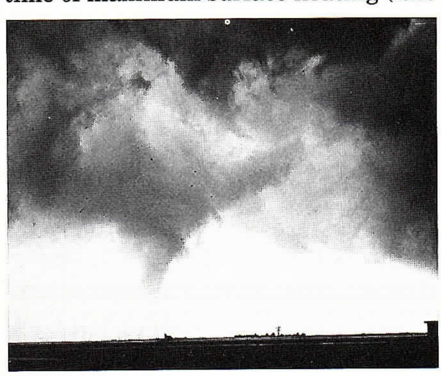
SEVERE WEATHER WATCHES

As a result, the Severe Weather Watch originally issued at 2:40 a.m. on May 31st, was updated and extended for all of southern Ontario at 7:00 a.m., 9:20 a.m. and 1:50 p.m. advising of the potential for the development of severe thunderstorms later in the afternoon and early evening. It was anticipated that these thunderstorms would be very strong since the cold front and trough were crossing the province near the time of maximum surface heating (late afternoon), which would produce the maximum thermodynamic instability in the air mass.

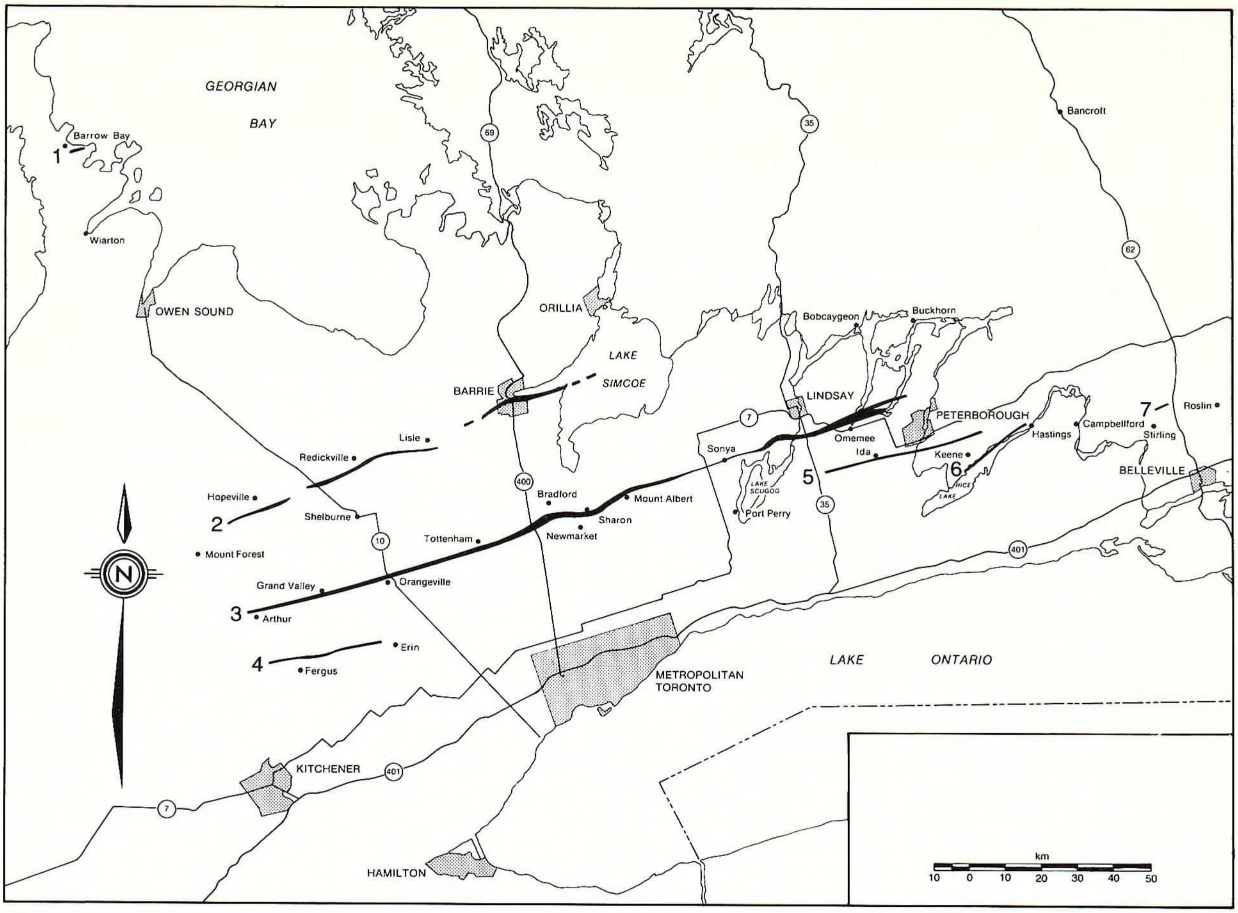
By noon on the 31st the thunderstorm activity associated with the weak disturbance that had affected southern Ontario overnight had virtually ceased. Radar reports presented no evidence of any thunderstorms along the cold front approaching the Bruce Peninsula from Lake Huron.

THE SEVERE WEATHER EVENT AND THE SEVERE WEATHER WARNINGS

At 1:40 p.m., radar showed the first thunderstorm cells developing west and north of the Bruce Peninsula. By 2:20 p.m. a line of potentially severe storms was indicated by radar (Figures 1, 2 and cover) to extend from the mouth of the French River to just off the Bruce Peninsula, with more cells beginning to form farther south. The first severe thunderstorm warnings were issued for Bruce County and Parry Sound District at 2:25 p.m. These severe thunderstorm warnings issued by the Ontario Weather Centre contained the statement: "Remember, some severe thunderstorms produce tornadoes." The line of severe storms continued to develop. Warnings were issued for Huron, Perth, Grey, northern Wellington and northern Waterloo Counties at 3:15 p.m. (Figures 3–6). The most severe storms on radar appeared to extend from Meaford to Perth County. Initial on-site observations of the severity of the storms were



Genesis and evolution of a tornado that occurred at Winnipeg International Airport on August 3, 1969 at 7:30 p.m. CDT (Photographs: John Alcock).



The damage tracks of the May 31, 1985 tornado outbreak as of June 16, 1985. Statistics of each track can be found in Table 1.

received by the Ontario Weather Centre at about 4:00 p.m. indicating that 2-cm hail and very high winds had occurred near Meaford and in the Dundalk area. However, no damage was reported up to that time.

Around 4:00 p.m., radar (Figures 7 and 8) revealed a line of severe thunderstorms from near Collingwood to eastern Perth County, which was moving east at 60 to 70 km/h. At 3:45 p.m. severe thunderstorm warnings were in effect to cover areas downstream as far east as Simcoe County and northern Peel County. Between 4:20 and 4:40 p.m. (Figures 9 and 10) there were indications that the southern end of the line was intensifying, so that warnings were issued at 4:53 p.m. to cover the counties along the west end of Lake Ontario from Hamilton-Wentworth to Durham and Victoria Counties. Following a confirmed report of a tornado at Shelburne, a tornado warning was issued at 5:00 p.m. for southern Simcoe, northern Peel and York Counties (Figure 12).

Reports of the tornadoes at Grand Valley and Barrie were received by the Ontario Weather Centre at 5:00 and 5:20 p.m., respectively. Tornado warnings were issued at 5:40 p.m. for the downstream areas of northern Durham, Victoria and Haliburton Counties. Radar reports between 5:20 and 5:40 p.m. (Figure 11) also indicated the very rapid development of storms moving across eastern Lake Erie to the Niagara Peninsula. As a result, at 5:50 p.m. severe-storm warnings were issued for the Haldimand-Norfolk and Niagara Regional Municipalities.

Further details on tornadoes in Orangeville and in the Tottenham area came into the Ontario Weather Centre between 5:30 and 6:00 p.m. Based on the continuing strength of the radar echoes, tornado warnings were extended to southern Durham and Peterborough Counties at 6:05 p.m., and to Haliburton, Northumberland, Prince Edward and Hastings Counties at 6:25 p.m. At 7:00 p.m. all watches and warning messages were cancelled for all regions except for Haliburton County and Lake Ontario east of Oshawa. Between 6:40 and 7:20 p.m., reports were received about tornadoes just southwest of Peterborough and in Rawden Township of southern Hastings County (Figures 13 and 14).

At 7:10 p.m. the tornado warning was extended east again to include Lennox and Addington, Renfrew and Frontenac Counties, which mark the easternmost areas served by the Ontario Weather Centre. At about the same time, the Québec Weather Centre in Montréal, which handles forecasts for Ottawa-Cornwall and vicinity, was notified of the continuing presence of tornadoes in the storms headed their way. Finally at 9:20 p.m. the remaining watches were cancelled for eastern Ontario.

TORNADO PATHS AND TIMES

The tornado path and time estimates contained in this report were determined from aerial surveys and on-site investigations of the tornado paths carried out by staff from the Ontario Weather Centre and various Regional and Headquarters units, provincial police reports, photographs, newspaper clippings, weather watcher reports, and eyewitness accounts.

Numerous reports of large hail and damaging winds were received on May 31st as the severe thunderstorms developed and moved across southern Ontario. In particular, over the southern Niagara Peninsula hail as large as softballs was reported. Fortunately, these storms missed the fruit belt north of the escarpment. However, in the Welland and Port Colbourne areas there were numerous reports of damage

Table 1 Preliminary summary of damage statistics. The values are not definitive, but only indicate the order of magnitude of the damage dimensions, tornado times and strengths.

Track Number	Damage Dimensions: Overall Length (km)	Average Width (m)	Area (km^2)	Maximum Strength (F-Number)	Estimated Time (p.m.): Touchdown	Lift-off	Number Killed
1*	2	unknown	unknown	strong (F2)	3:00	unknown	0
2	85	300	25	violent (F4)	4:10	5:00	8
3	190	300	60	violent (F4)	4:15	6:15	4
4	33	50	2	violent (F3)	4:20	unknown	0
5	45	70	3	violent (F3)	6:15	unknown	0
6*	11	unknown	unknown	strong (F2)	6:25	unknown	0
7*	1	15	<0.1	strong (F2)	6:35	unknown	0

Notes:

a) An asterisk (*) indicates damage tracks that had not been completely field surveyed as of June 16, 1985.

b) Damage to trees was reported at Lyndhurst (downtrack from number 7).

c) Damage to trees and trailers was reported in the vicinity of Stony Lake and north of Bobcaygeon (exact locations unavailable). This could be an extension of track number 2.

d) Damage to farm property and light airplanes was reported in and near Ottawa.

e) Softball-size hail was reported near Welland and Port Colborne.

f) A possible tornado touchdown was reported at St-Canute, Québec (near Mirabel) at about 10:30 p.m.

to cars and property due to the extremely large hailstones. An estimated 40 people suffered minor cuts due to flying glass. Preliminary estimates of hailstorm damage were in excess of $1 million.

The general area affected by severe thunderstorm activity is depicted in the map of southern Ontario, which also shows the approximate locations of all confirmed tornadoes.

The accompanying table provides a detailed comparison of the times of tornado occurrence in each county with the times of issue of severe thunderstorm warnings and tornado warnings. For counties west of Lake Simcoe severe thunderstorm warnings were issued 45 minutes to one hour in advance of the occurrence of the tornadoes. From Lake Simcoe eastward, once tornadoes had been reported, tornado warnings were issued 15 to 45 minutes in advance of the tornado occurrences.

County	Issue Times (p.m.): Severe Thunderstorm Warning	Tornado Warning	Time of Tornado Occurrence
Northern Bruce	2:25	—	3:00, Rush Cove tornado
Northern Wellington	3:15	—	4:15, Tornado touchdown near Arthur
Dufferin	3:54	—	4:28, Grand Valley 4:45, Orangeville
Southern Grey	3:15	—	4:17, Tornado touchdown near Corbetton
Southern Simcoe	3:54	5:00	5:18, Holland Landing
Northern Simcoe	3:54	—	5:00, Barrie
Northern York	4:53	5:00	5:25, Holt
Northern Durham	4:53	5:20	5:40, Wagner Lake
Southern Victoria	N/A	5:20	6:05, Reaboro
Southern Peterborough	N/A	6:05	6:20, Cavan 6:25, Birdsall
Southern Hastings	N/A	6:25	6:35, Minto

AWARD-WINNING PERFORMANCE

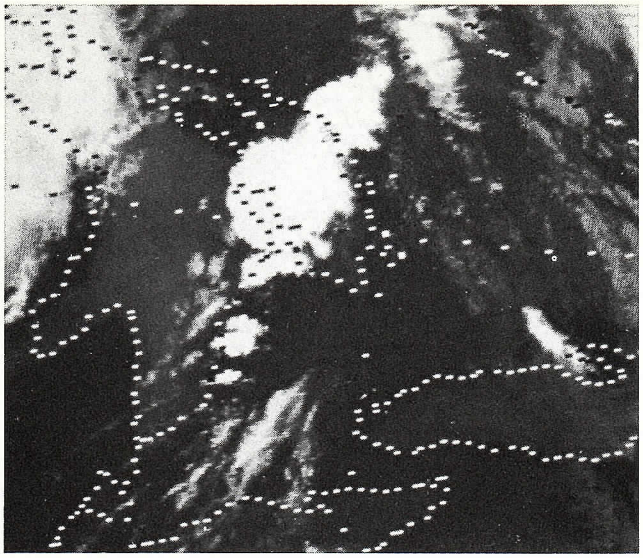
On July 18, 1985, Jim Bruce, the Assistant Deputy Minister responsible for the Atmospheric Environment Service, presented AES Achievement Awards to staff of the Ontario Weather Centre. The Award, the first of its kind in the Service, recognized the outstanding manner in which the OWC forecast team handled the severe weather event of May 31st. Mr. Michael Leduc, the senior Summer Severe Weather Meteorologist at OWC, was singled out for an individual award for his outstanding skill and leadership.

Figures overleaf in colour Radar charts corresponding to the adjacent satellite photographs. The radar instrumentation is located at King City (north of Toronto) operating at a wavelength of 5 cm.

The MAXR (Maximum Rainfall Rate) charts (Figures 6, 9 and 11) indicate the strongest radar returns in a vertical column. The chart colour scheme is in the upper left-hand corner. Each colour represents a range of precipitation rates or echo top heights. For example, blue indicates rainfall rates between 8.0 and 15.9 mm/h or highest radar returns between 10.0 and 11.9 km. The numbers in the lower left show the areas corresponding to the colours, along with the total area.

The ECHO TOPS charts (Figures 2, 4 and 7) indicate the heights of the highest radar returns, and represent the vertical distribution of rainfall.

The green numbers and letters lying outside the red circle (220 km from the centre) indicate the lightning flash occurrences in the adjoining 10-degree sectors during the five minutes prior to chart time. Each number must be doubled to obtain the actual number of flashes, e.g., 8 indicates 16 flashes; A, 20; and C, 24.



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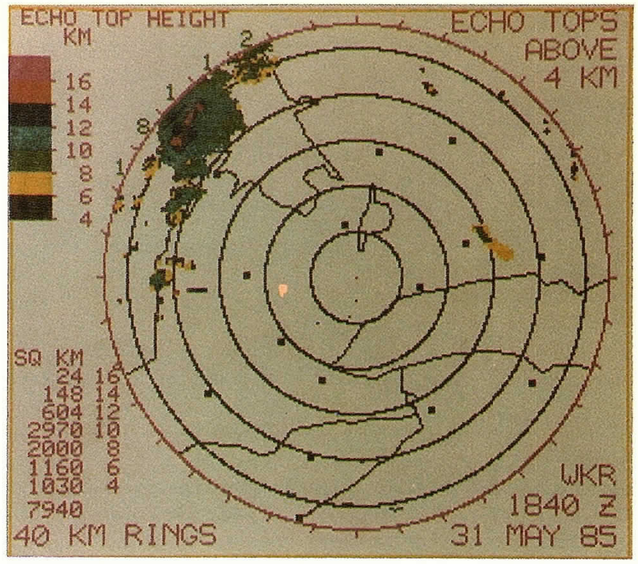

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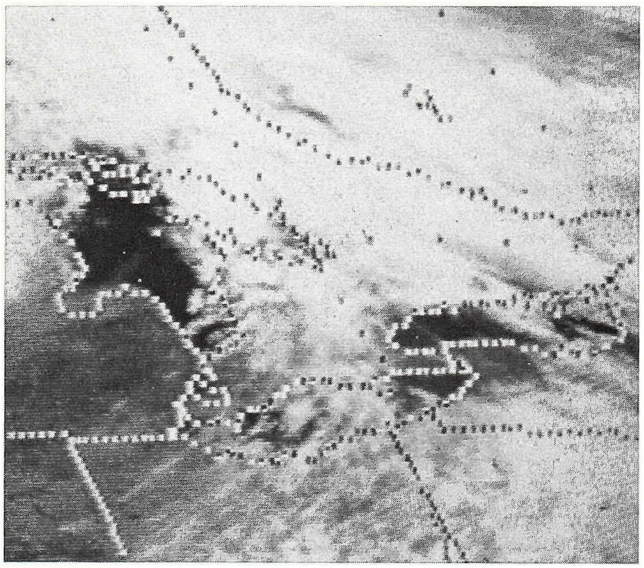

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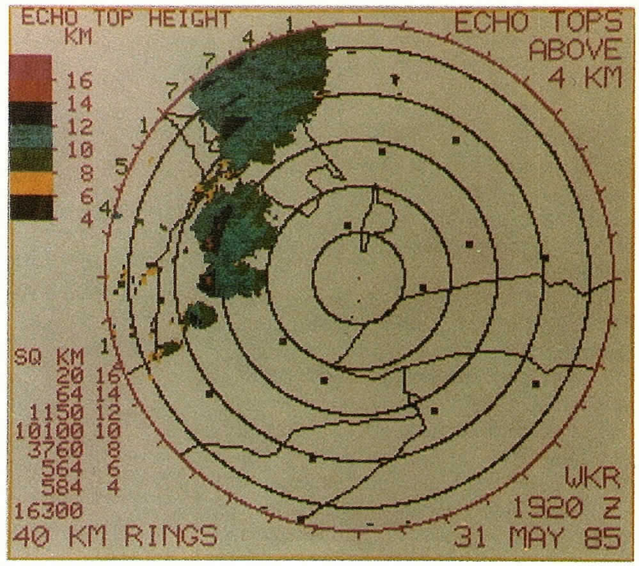

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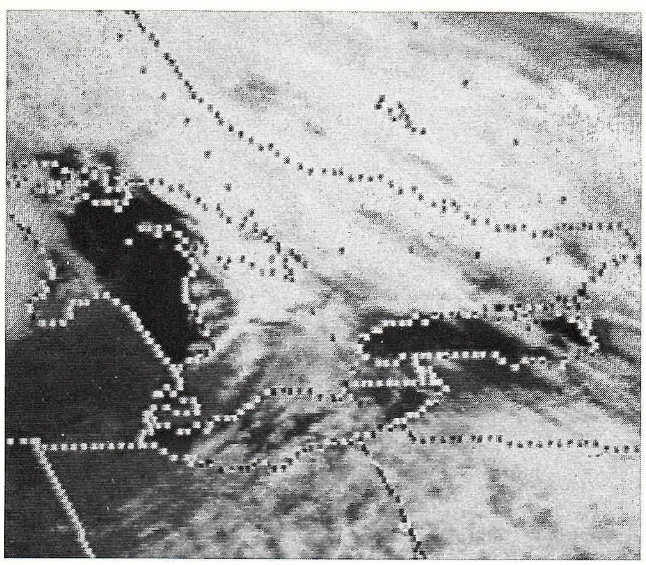

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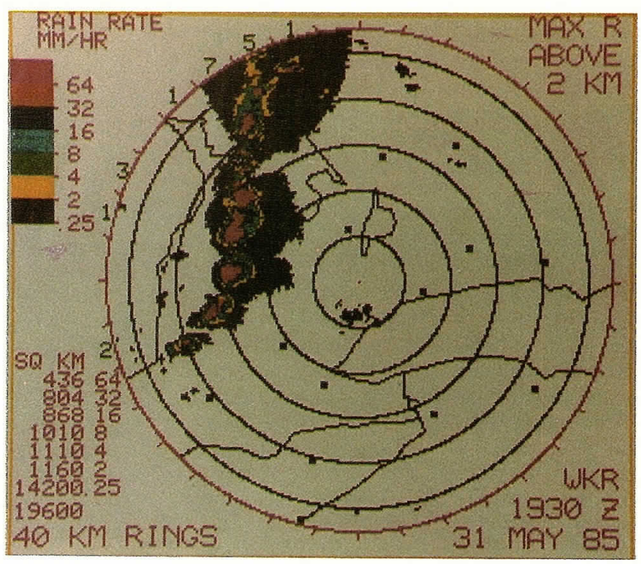

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Satellite photographs and colour radar charts illustrating the movement and the development of the line of severe thunderstorms on May 31, 1985. *Figure 1* The NOAA-9 near-infrared (11-micrometre) image at 2:54 p.m. showing the line of developing thunderstorms extending from Sudbury across the Bruce Peninsula. *Figure 3* The GOES (Geostationary Satellite) image at 3:01 p.m. showing the clearing wedge behind the developing line of thunderstorms. *Figure 5* The line of severe thunderstorms at 3:31 p.m.,

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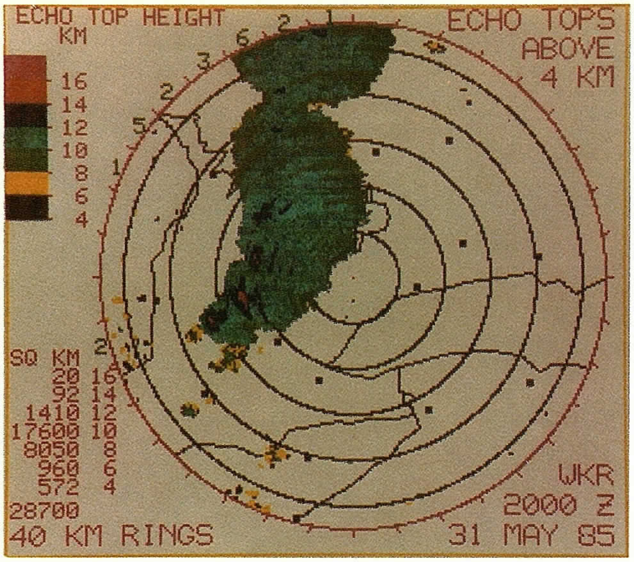

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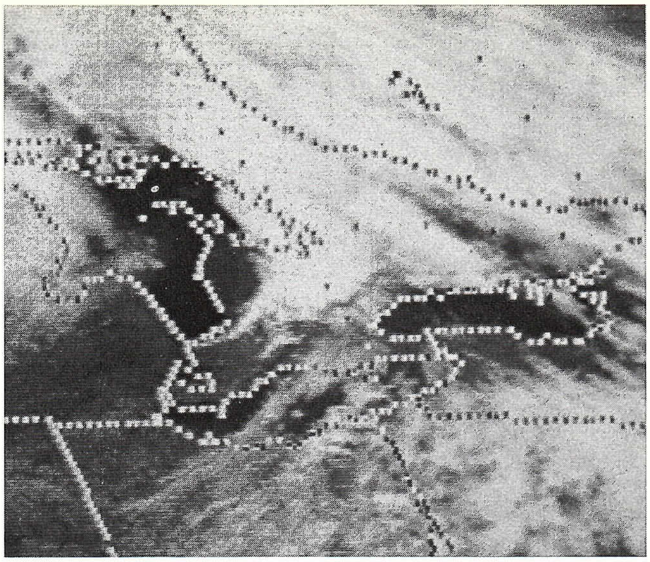

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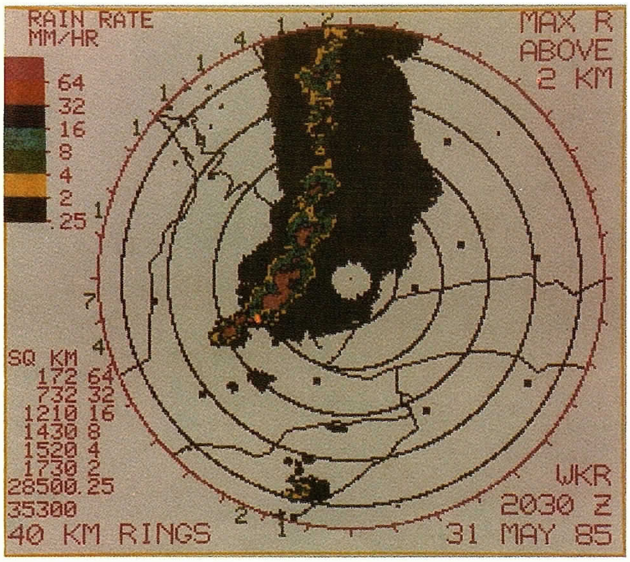

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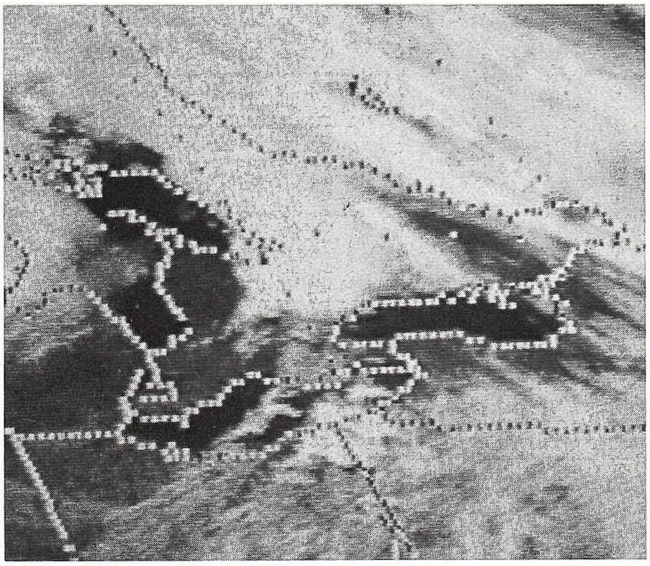

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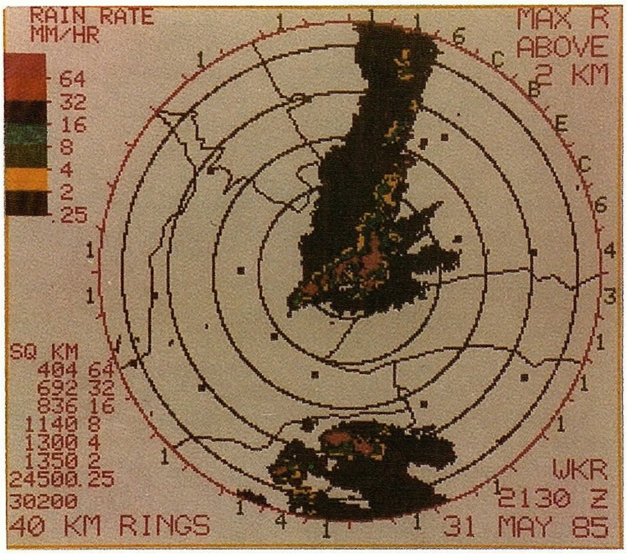

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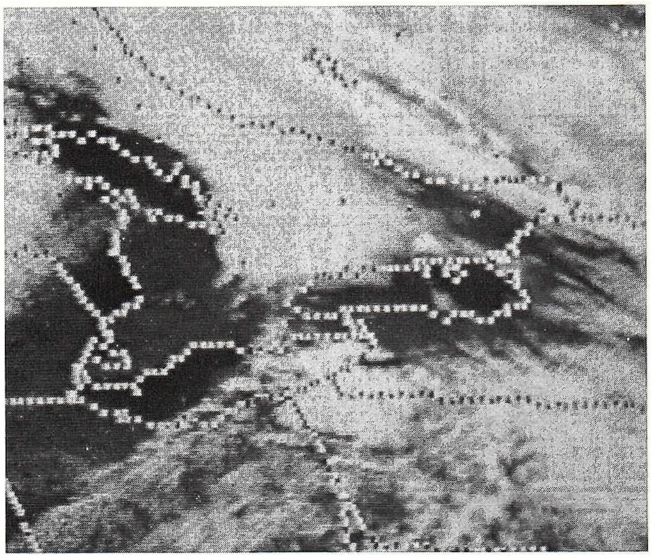

east of the Bruce Peninsula. *Figure 8* At 4:01 p.m. the sharp back edge of the line of severe storms is clearly shown. *Figure 10* The tornadic storms at 4:31 p.m. moving eastward north of Toronto. Also notice two developing lines of thunderstorms across Lake Erie and moving through northern Ohio and Pennsylvania. *Figure 12* The 5:01 p.m. GOES image shows the storms when reports of tornadoes at Grand Valley and Barrie were received. The line of thunderstorms over eastern Lake Erie and northwestern Pennsylvania have reached the severe stage.

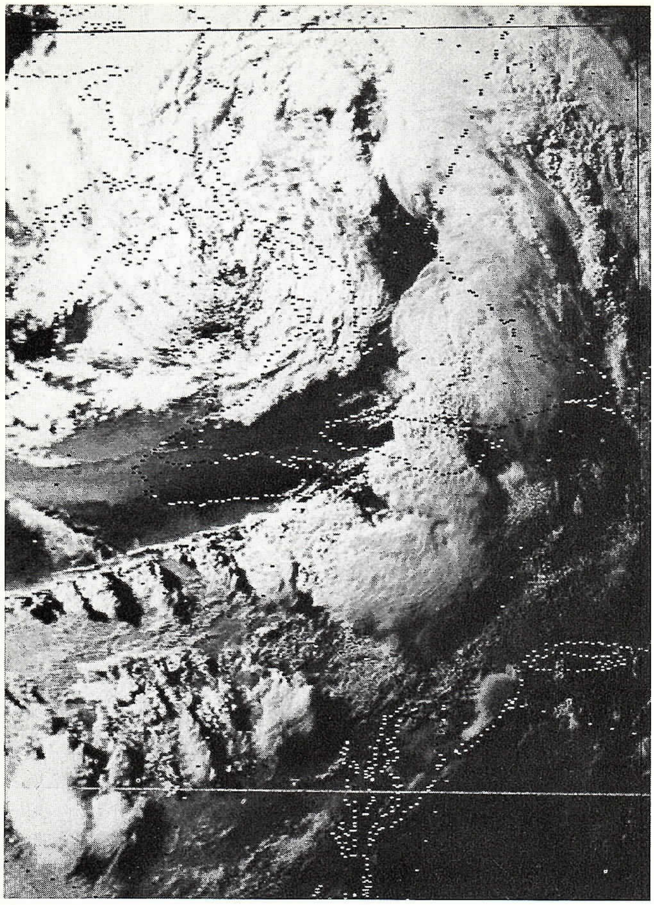

Figure 13 Visual.

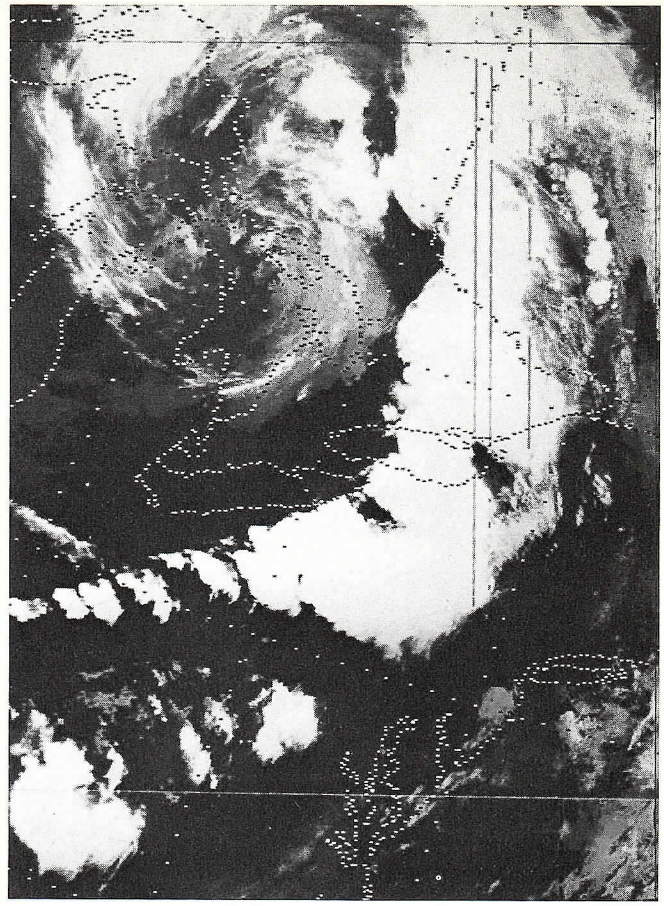

Figure 14 Near-infrared (11 micrometres).

NOAA-6 images for 7:05 p.m. Figure 13 very clearly shows the line of severe thunderstorms and the eastward shadows of the anvils over northern Ohio, Pennsylvania and New York States. Figure 14 illustrates the cold, high-level thunderstorm tops as bright areas. A line of developing thunderstorms can be identified in both figures over La Verendrye Provincial Park in southwestern Québec (at upper right).

FURTHER READING

Fujita, T.T., 1973: Tornadoes Around the World. *Weatherwise*, Vol. 26, 58–60.

Lawrynuik, W.D.; B.D. Greer, M.J. Leduc and O. Jacobsen, 1985: The May Thirty-First Tornado Outbreak in Southern Ontario. Ontario Region Technical Notes ORTN 85-3, Atmospheric Environment Service, Toronto, Ontario., 16 pp.

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Michael Leduc is senior Severe Weather Meteorologist at the AES Ontario Weather Centre. He is a veteran forecaster at the Centre and has served as Senior Forecaster and Shift Supervisor.

Ole Jacobsen is a recent graduate from the Meteorologist Operational Course assigned to the Ontario Weather Centre as an intern forecaster. He was previously employed as a Meteorological Technician in western and Arctic Canada.

Barry Greer is the Chief Meteorologist at the Ontario Weather Centre. He has many years of experience in initial forecaster training and in organizing operational workshops.

Staff from the following units of the Atmospheric Environment Service contributed to the content and details of this article: Ontario Weather Centre, Ontario Region Scientific Services Division, and the Peterborough and Kingston Weather Offices. The article is in part adapted from the preliminary OWC report by Lawrynuik et al. (1985).

RÉSUMÉ *La tornade dévastatrice qui a frappé le nord de Toronto le 31 mai 1985 s'est formée suite à une combinaison favorable des facteurs dynamiques et thermodynamiques, dans l'atmosphère. De l'air chaud et humide à la surface devant un front froid, en combinaison avec un creux en altitude et un fort courant-jet d'ouest ont entraîné le développement d'orages violents tôt dans l'après-midi. Le personnel du Centre météorologique de l'Ontario a observé sur radar, à intervalles de 20 minutes, la formation de ces orages dans la péninsule Bruce et leur évolution vers l'est dans l'après-midi.*

Une veille de temps violent a été diffusée à 2h40, puis mise à jour à 7h00, 9h20 et 13h50. À 14h25, le premier avertissement d'orages violents qui était diffusé pour les comtés de l'ouest incluait le message suivant : « certains orages violents produisent des tornades ».

Vers la fin de l'après-midi, des tornades étaient signalées et l'on émettait des avertissements de tornades.

L'article décrit dans un certain détail la progression des prévisions, des veilles et des avertissements pour cette journée; on emploie aussi les cartes radar et les images satellitaires appropriées. Les trajectoires de plusieurs tornades sont aussi décrites. Ailleurs dans ce numéro, on trouvera des articles en francais sur le temps violent en été ainsi que des conseils sur la sécurité.

FROM THE EDITOR'S DESK

This first issue of Volume 8 highlights one of the more spectacular and dramatic weather events: the tornadic outbreak of May 31, 1985 in the area of Ontario centred on Barrie. We are pleased to offer readers a perspective of the phenomenon and the events on that day recounted by a grade 12 student; also, the minute-by-minute activities of the Severe Weather Team of the Ontario Weather Centre. Finally, helpful hints and directions regarding severe weather events are presented.

A fascinating view of the oceans from space shows the complex but important interactions between ocean, atmosphere and land.

We are pleased that through the cooperation of the National Survival Institute and the Atmospheric Environment Service we are able to include this issue of *Chinook* with the Resource Kit on atmosphere, weather and climate, supplied to educators across Canada.

The next issue will introduce a new feature aimed at secondary school programs. A series of plotted weather charts will be provided containing conventional information, such as pressure, temperature, wind, precipitation, current weather and sky data. It is our hope that this series can be useful in geography and science classes dealing with atmospheric processes.

Hans VanLeeuwen

COVER

Intense thunderstorm development is shown crossing from Lake Huron into the Bruce Peninsula and the western counties of southern Ontario. The picture shows the NOAA-9 satellite near-infrared image for 2:45 p.m. on May 31, 1985. For more details see the article on page 13 describing the associated tornado outbreak.

COUVERTURE

Cette image satellitaire permet de suivre l'évolution d'orages violents, du lac Huron à la péninsule Bruce puis dans la partie ouest des comtés du sud de l'Ontario. L'image, prise dans la bande quasi-infrarouge, le 31 mai 1985 à 14h45, provient du satellite NOAA-9. Pour de plus ample détails, se référer à l'article de la page 13 qui décrit la tornade qui s'en est suivie.

Chinook

Winter/Hiver 1986 Vol. 8 No. 1

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MAY 31 TORNADO

by Mark Ransom

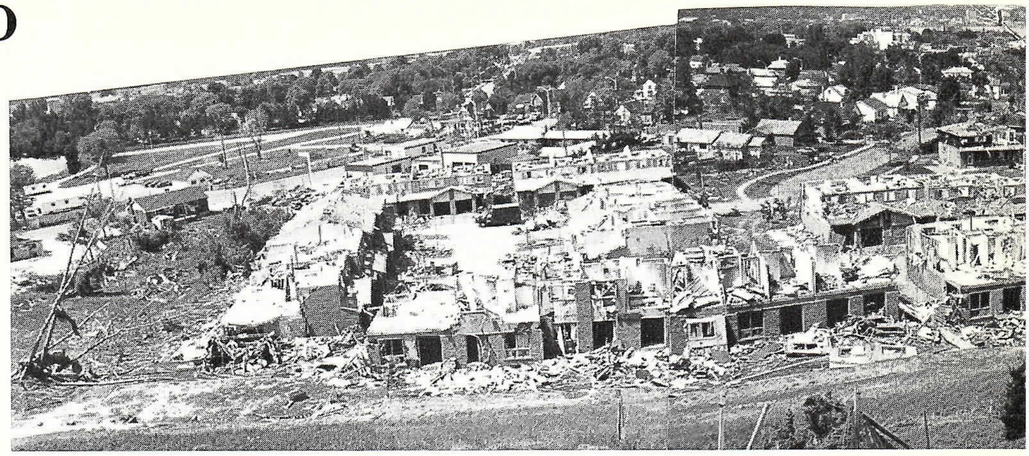


Figure 1 Panoramic view of the catastrophic destruction in Barrie as a result of the late afternoon tornadoes on May 31, 1985. It shows the Adelaide Street townhouses with Kempenfelt Bay in the background. The selective and narrow path of the tornadic impact should be noted (Photograph: Frank Boddy).

On Friday May 31, 1985, a rare and unpredictable disaster hit central Ontario. Many locations were affected by a number of severe storms and tornadoes. The total number of tornado touchdowns is not known for sure, and probably never will be, simply because accurate surveying of the sites affected was not possible. Several cities, towns and small communities suffered differing amounts of damage, but a common effect of the storms was the type of damage and emotional tragedy that was sustained. This article will examine the characteristics of a tornado, and present eyewitness accounts of the destruction caused by the Barrie tornado. Centred on the City of Barrie, these accounts can be applied to almost any area or settlement that has been or will be hit by a tornado. I hope that, as an amateur meteorologist who lives in Barrie, these descriptions will verify further the awesome power and destructive capabilities of tornadoes.

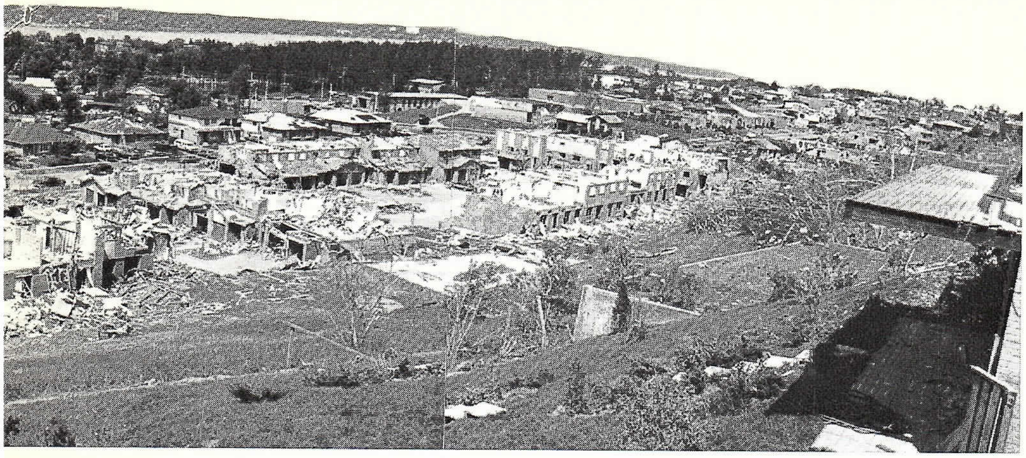
Although tornadoes have no set geographical boundaries, they do occur in some areas more frequently than in others. Tornadoes usually occur at the boundary of two extremely different air masses (warm/cold), or in hot and humid air that is forced to rise. When this happens cumulonimbus clouds or thunder-clouds are formed. High-topped cumulonimbus clouds can spawn tornadoes, however, not every cumulonimbus cloud does so, since temperature and humidity conditions must be just right. In Canada, tornadoes usually occur during June, July and August when the air is warm, and the land is influenced by warm and moist tropical air masses. Few tornadoes develop in the late spring or early fall, and are very unlikely in winter. During the summer, most tornadoes develop and strike during the late afternoon or early evening, because the air at that time is very unstable due to heat build-up during the day, which causes the very warm air to rise. This lifting action combined with the interplay of two different air masses can produce some intense cumulonimbus clouds. These conditions form one set of criteria that make the possibility of a tornado even greater. The horizontal movement of a tornado is about 40–65 km/h and its internal wind speeds can be as high as 400–500 km/h. The average length of the path of destruction is very hard to measure because it varies so much in size and strength. For instance, on March 18th 1925, a tornado whose path was 350 km long affected three American states. However, small tornadoes have travelled as little as 800 metres. No matter how far the tornado travels its force can still remain the same. The danger with the smaller tornadoes, unfortunately, is the near impossibility of providing any advance warnings; therefore, they catch people by surprise.

In the hours before the tornado hit on Friday, May 31st, severe storm warnings had been issued over the radio. Despite these warnings most people in Barrie and other communities put little faith in them, and went about their normal 4:30 Friday afternoon routines. The memories and fears of the last tornado that hit Barrie over 70 years ago had long since been forgotten.

The 1985 tornado developed southwest of the city. Strong winds toppled major power transmission lines and tripped a load generation rejection system, cutting power to many regions in southern Ontario. The tornado had intermittently touched down southwest of the city. The first touchdown point in Barrie was a pine reforestation area where the wind snapped many of the trees at the 2-metre level, and permanently bent many others. From there the tornado moved northeasterly where it totally erased one square block of older frame homes, causing three deaths.

The next area hit was an industrial zone, where as many as 12 factories were destroyed, and several others on the outer edge of the tornado suffered heavy damage. Roofs were ripped open and blown away. When the roof was gone, the walls which had no support collapsed in almost every direction. Steel beams were bent and twisted under the enormous force. On some of the still standing walls that had faced the unbelievably strong winds, many small splinters of wood had been driven into the mortar – some with such force that they made fracture marks in the blocks. In the industrial area, miraculously only one person was killed. The tornado then travelled due east crossing Highway 400.

"I was driving home from work, the sky was aqua green in colour, it was really weird. I came to a stop behind several cars that were waiting for the light to turn green. I can't really remember what I was doing, I was just sitting there, when suddenly it got really dark. I looked around, and to my left I saw this wide wall of blackness coming towards me. I knew it was a tornado. I thought about pulling out around the cars in front of me, but before I could do anything debris started hitting my car. I lay down on the front seat and pulled my coat over my head. Soon after that the windows in the car were blown out, glass and debris were flying around hitting me, and the car was rocking and bouncing. I was thrown to the floor. The thing I can remember the most is the



noise – it sounded like a train. Before I knew it the whole thing was over. I got up from the floor of the car to find another world...." The person who experienced this was situated almost directly across from the Barrie Raceway just off Highway 400. The cars that were hit by the strong winds were tossed about like toys. Many cars had small bullet-size holes and large dents that were caused by flying debris. Roofs and the glass-viewing-windows of the Raceway were torn apart and smashed. Homes situated downwind of the Raceway were coated with mud and manure from the horse stalls, causing health officials to be concerned. One eyewitness situated near the Raceway saw a horse lifted from one of the stalls, carried through the air and set down gently on a nearby road. This horse has been nicknamed "Twister Resistor" and has won several races at the Raceway since the tornado.

The next area to be affected was in an easterly direction – a large cluster of townhouses (Figure 1). The total destruction of the upper floors was a common sight throughout Barrie and many of the other communities hit by the centre of a tornado. The width of the path of significant destruction close to the centre of the tornado was about 350 m. Much of the damage was due to the extremely high winds, but another contributing factor was the sudden and extreme drop in air pressure associated with the storm. Normally, the pressure inside a house is the same as the air pressure outside. But during the passage of a tornado the air pressure drops very rapidly as the giant vacuum funnel sucks up air. Unless people have time or the foresight to open windows and doors, the house will simply explode from the inside.

This is evident from a close examination of the townhouses in Figure 1. The debris is spread around the outside of the homes, as though a bomb had exploded inside. The illustration shows the tornado travelled from the left to the right, as verified by the way the tree in the left-hand corner had been bent. In most cases the homes that were in the direct path of the tornado lost their roofs. Pieces of wood that had been hurled through the air by the strong force penetrated roofs and walls. At one particular home the sleeping compartment of a large transport truck was deposited on top of the chimney. Highway guardrails had been carried for several hundred metres and then were wrapped around trees and buildings like ribbons. The houses on the outer edge of the tornado suffered damage from high winds and flying debris. It was quite evident that the damage was less severe the farther you move from the centre of the tornado path. However, severe and moderate damage is separated by a distinct line along which air pressure differences disappeared.

Other occurrences were related to the pressure drop. One family struggled to descend a flight of stairs to reach the safety of their basement – it was difficult to make headway down the stairs, not because of the wind or an updraught, but because of a force pushing them back. Also a number of car tires were left flattened that Friday. Examination of the tires showed they had obviously not been punctured by flying debris. It appears, however, that they exploded because the outside air pressure dropped suddenly. The tires expanded beyond their capacity and exploded much like the houses.

After moving up a hill and through another established subdivision, the tornado continued almost due east for another 3 kilometres. It destroyed several more houses by ripping off roofs, tearing down brick walls, and rolling cars down the street like tumbleweeds. Hundreds of trees were uprooted, and many homes were pushed off their foundations. The tornado then continued northeasterly hitting a marina on the shore of Kempenfelt Bay. Then the tornado seemed to lose much of its energy as it moved out over the cool water. Behind it was left an unbelievable path of destruction. It is impossible to describe or portray the true extent of the damage. How can you describe the eerie calmness after the tornado, when people crawled out of the rubble like ants to find themselves completely surrounded by destruction? Homes, that people worked so hard for, were destroyed in a few seconds. Financial aid was provided to those who lost their homes. However, you cannot buy back a life. Words or pictures cannot reveal the emotional aspect of the disaster. It is something that one would have to experience before knowing the true meaning of disaster. The tornado claimed four more lives when it raced across the southeast end of town leaving a long and lasting scar in the minds or many.

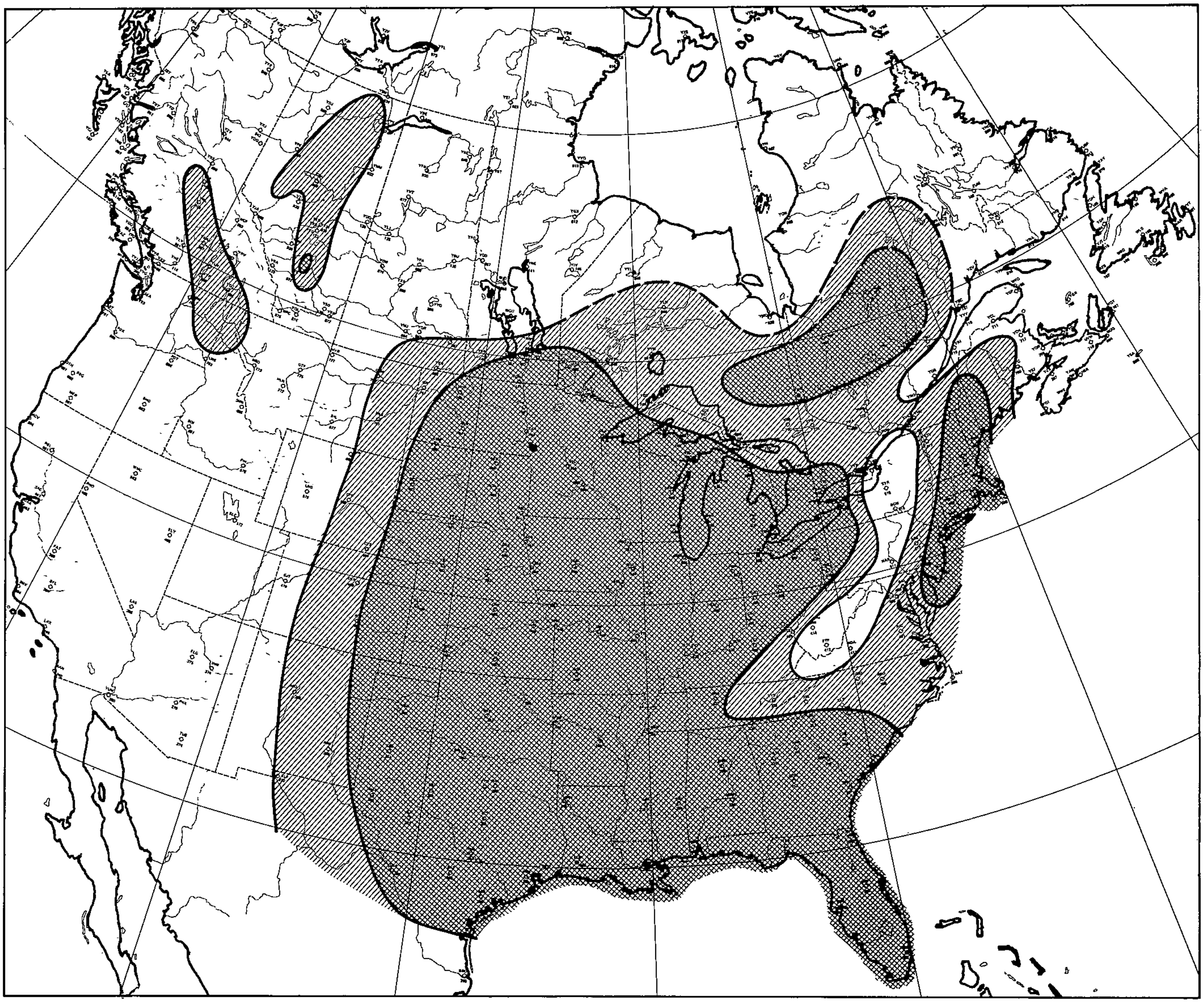
This rare occurrence of May 31, 1985 has happened before and will undoubtedly recur. It is important to learn more about tornadoes and what to do if you suspect one is likely to occur. The major problem of concern to authorities is how to pass on tornado warnings to the general public. For now, the only thing you can do is watch for threatening weather, listen to the radio for weather warnings, and if the weather conditions deteriorate keep a sharp eye out.

Mark Ransom is a Grade 12 student at Innisdale Secondary School in Barrie, Ontario. His article is one result of a project in the senior Geography course.

RÉSUMÉ *On décrit les conséquences de la tornade du 31 mai 1985, qui a touché la région du nord et du nord-ouest de Toronto, telles que perçues dans la région de Barrie. Un étudiant de la douzième année du secondaire, Mark Ransom, donne un aperçu des conditions de base nécessaires à la formation d'une tornade. On donne une description détaillée des dégâts considérables causés par la tornade principale qui a balayé les secteurs urbain et industriel de Barrie. Les récits de quelques témoins oculaires décrivent de façon poignante l'expérience angoissante de ce terrible désastre.*

TORNADO CLIMATOLOGY

by Michael Newark



Map of the tornado-prone regions of North America. In the lightly shaded zones one tornado can be expected on the average every two years in an area 100 km by 100 km. In the darker areas, at least one tornado per year on the average can be expected per 10,000 km^2. Although tornadoes have occurred in every populated part of Canada, the more devastating ones are found mostly in areas eastward from the Rocky Mountains to New Brunswick. "Tornado Alley" is a term commonly applied to the Oklahoma-Kansas area of the United States, but few realize that parts of Canada are also included in the tornado-prone region of North America.

Recent tornadic events such as the disastrous tornado outbreak of May 31, 1985 in southern Ontario and neighbouring Québec, and the St-Sylvère, Québec tornado of June 18, 1985, underscore the danger facing Canadians due to this type of storm.

Michael Newark is the founder-editor of Chinook (1978–1984). He was for many years a forecaster in the Ontario Weather Centre and the Centre's Summer Severe Weather Meteorologist. He is currently head of the Climate Monitoring and Prediction Section of the Canadian Climate Centre.

THE MAY THIRTY-FIRST TORNADO OUTBREAK IN SOUTHERN ONTARIO

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Acknowledgements:

We wish to acknowledge the contribution of all staff from the Ontario Weather Centre, Scientific Services Division, Peterborough Weather Office and the Kingston Weather Office who conducted on site investigations or aerial surveys of the tornado paths during the week following the tornado outbreak.

THE MAY THIRTY-FIRST TORNADO OUTBREAK IN SOUTHERN ONTARIO

by

W. Lawrynuik - Chief, Forecast Operations
B. Greer - Chief Meteorologist
M. Leduc - Severe Weather Meteorologist
O. Jacobsen - Meteorologist

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1. Introduction

During the afternoon of May 31, 1985 a powerful cold front moved through Southern Ontario triggering a series of very damaging tornadoes. Twelve people were killed and scores of others injured as the storms moved across the Province. Property damage is estimated well over $100 million.

This report will outline the weather pattern of May 31 which led to the storms as well as the Ontario Weather Centre's response to the real time events of the day. The report will document through detailed maps the tracks of all the tornadoes confirmed to this date (June 10). A general description of the damage and a best estimate of the time of the tornadoes will be included. Some preliminary recommendations are put forward as a consequence of the May 31st tornado outbreak.

2. Meteorological Conditions and Severe Weather Watches

On May 30th hot, humid tropical air became established across the Central United States. The air was also very unstable meaning that with any sort of lifting mechanism very intense thunderstorms could develop. During the early afternoon of May 30th a weak disturbance moved across Lake Erie and allowed some of this tropical air to move into extreme southwestern Ontario.

Another weak disturbance during the morning hours of May 31st pushed the warm humid air northeastward producing thunderstorms across all of Southern Ontario. No damage was reported from these thunderstorms in Ontario but the arrival of the warm very unstable airmass set the stage for the very dramatic events of later that day.

While the warm humid air was becoming established across the south half of Ontario an intense spring storm was developing just west of the Great Lakes. A low pressure centre with strength more typical of a mid winter storm tracked across upper Michigan during the morning of May 31st to north of Sudbury by evening. A very sharp cold front trailed southward from this low pressure system.

The morning analysis at Environment Canada's Ontario Weather Centre indicated that the thermodynamic and dynamic features necessary for the possible development of severe thunderstorms were present. The thermodynamic instability of the airmass was confirmed from the radiosonde reports east of the cold front crossing Michigan. The air above one km was

2. **Meteorological Conditions and Severe Weather Watches** - Cont'd...

very dry and cool while the tropical airmass near the surface was very hot and moist. The dynamic features (triggering mechanisms) were strong, that is, a sharp cold front and a sharp upper trough crossing Michigan and a very strong westerly jet stream above 10 km with winds of approximately 400 km/h (200 knots). The cold front and upper trough were expected to cross Southern Ontario during the afternoon and early evening.

As a result, the severe weather watch originally issued at 2:40 a.m. May 31st, was updated and extended for all of Southern Ontario at 7:00 a.m., 9:20 a.m. and 1:50 p.m. advising of the potential for the development of severe thunderstorms later in the afternoon and early evening. It was anticipated that these thunderstorms would be very strong since the cold front and trough were crossing the province about the time of maximum surface heating (late afternoon), which would produce the maximum thermodynamic instablity in the airmass.

By noon on May 31st the thunderstorm activity associated with the weak disturbance which had affected Southern Ontario overnight had virtually ceased. There was no evidence from radar reports of any thunderstorms along the cold front approaching the Bruce Peninsula from Lake Huron.

3. **The Severe Weather Event and the Severe Weather Warnings**

At 1:40 p.m. radar indicated the first thunderstorm cells developing west and north of the Bruce Peninsula. By 2:20 p.m. a line of potentially severe storms was indicated by radar from the mouth of the French River to just off the Bruce Peninsula with more cells beginning to form further south. The first severe thunderstorm warnings * were issued for Bruce County and Parry Sound District at 2:25 p.m. The line of severe storms continued to develop. Warnings were issued for Huron, Perth, Grey, Northern Wellington and northern Waterloo Counties at 3:15 p.m. The most severe storms on radar appeared to be from Meaford to Perth County. Initial on site observations of the severity of the storms were received by the Ontario Weather Centre at around 4:00 p.m. indicating that 2 cm hail and very high winds had occurred near Meaford and in the Dundalk area. However, no damage was indicated up to that time.

Around 4:00 p.m. radar revealed a line of severe thunderstorms from near Collingwood to Eastern Perth County. The line was moving east at 60 to 70 km/h. At 3:45 p.m. severe thunderstorm warnings were in effect to cover areas downstream as far east as Simcoe County and northern Peel Counties. Between 4:20 and 4:40 p.m. there were indications that the southern end of the line was intensifying and at 4:53 p.m. warnings were issued to cover the counties along the west end of Lake Ontario from Hamilton-Wentworth to

*** These severe thunderstorm warnings issued by the Ontario Weather Centre contained the statement: "Remember some severe thunderstorms produce tornadoes."**

3. **The Severe Weather Event and the Severe Weather Warnings** - Cont'd...

Durham and Victoria Counties. Following a confirmed report of a tornado at Shelburn, a tornado warning was issued at 5:00 p.m. for Southern Simcoe, Northern Peel and York Counties.

Reports of the tornadoes at Grand Valley and Barrie were received by the Ontario Weather Centre at 5:00 and 5:20 p.m. respectively. Tornado warnings were issued at 5:40 p.m. for the downstream areas of Northern Durham, Victoria and Haliburton counties. Radar reports between 5:20 and 5:40 p.m. also indicated the very rapid development of storms moving across Eastern Lake Erie to the Niagara Peninsula. As a result at 5:50 p.m. severe storm warnings were issued for the Haldimand-Norfolk and Niagara Regional municipalities.

Further details on tornadoes in Orangeville and in the Tottenham area came in to the Ontario Weather Centre between 5:30 and 6:00 p.m. Based on the continuing strength of the radar echoes, tornado warnings were extended to Southern Durham and Peterborough Counties at 6:05 p.m. and to Haliburton, Northumberland, Prince Edward and Hastings counties at 6:25 p.m. At 7:00 p.m. all watches and warning messages were cancelled for all regions except for Haliburton and Lake Ontario east of Oshawa. Between 6:40 and 7:20 p.m. reports were received of tornadoes just southwest of Peterborough and in Rawden Township of Southern Hastings county.

At 7:10 p.m. the tornado warning was extended east again to include Lennox and Addington, Renfrew and Frontenac counties which mark the eastern most areas served by the Ontario Weather Centre. At about the same time the Quebec Weather Centre in Montreal, which handles forecasts for the Ottawa - Cornwall and vicinity, was notified of the continuing presence of tornadoes in the storms headed their way.

Finally at 9:20 p.m. the remaining watches were cancelled for Eastern Ontario.

4. **Tornado Paths and Estimated Time of Occurrence**

The tornado paths and time estimates contained in this report were determined from aerial surveys and on-site investigations of the tornado paths by Ontario Weather Centre staff, from provincial police reports, photographs, newspaper clippings, weather watcher reports, eye witness accounts, etc. Only information assembled before June 10th was available to prepare this report.

General information concerning all tornadoes and other related reports of severe weather are given in this section mostly in map form. Detailed accounts for individual tornadoes are provided in the next section.

4. **Tornado Paths and Estimated Time of Occurrence** - Cont'd...

Numerous reports of large hail and damaging winds were received on May 31st as the severe thunderstorms developed and moved across Southern Ontario. In particular, over the Southern Niagara Peninsula hail as large as softballs was reported. Fortunately, these storms missed the fruit belt north of the escarpment. However, in the Welland and Port Colbourne areas there was numerous reports of damage to cars and property due to the extremely large hailstones. An estimated 40 people suffered minor cuts due to flying glass. Preliminary reports are that damage in excess of $1 million resulted from this hail storm.

The general area affected by severe thunderstorm activity as determined from reports received to date is depicted in Figure 1. This figure also shows the approximate location of all tornadoes confirmed to date.

Figures 2, 3 and 4 depict the tornado paths in different parts of Southern Ontario as determined from the investigation using all information sources. Estimated times of occurrence (Eastern Daylight Saving Time) are also shown for various points along the tornado paths. In most cases these were determined from eye witness accounts or weather watch reports. The lengths of the individual tornado paths are also shown in these figures. It should be noted that the tornado paths from Mount Forest to Barrie may have resulted from different tornadoes formed under the same severe thunderstorm complex.

Table I provides a detailed comparison of the time of occurence of tornadoes in each county with the time of issue of severe thunderstorm warnings and tornado warnings. For counties west of Lake Simcoe severe thunderstorm warnings were issued 45 minutes to 1 hour in advance of the occurrence of the tornadoes. From Lake Simcoe eastward, once tornadoes had been reported, tornado warnings were issued 15 to 45 minutes in advance of the tornado occurrences.

5. **Damage and Descriptions of Individual Tornadoes**

Investigations over the past week have brought to light 9 separate damaging tornadoes across Ontario on May 31, 1985. The following is a description of each of these storms in the chronological order they first touched down. Figures 2 through 5 show the tracks of these storms.

5.1 **Rush Cove Tornado - Figure 4**

About 3:00 p.m. a small tornado touched down about 1.6 km southwest of the coast of Georgian Bay near Rush Cove and moved northeast out over Barrow Bay. Rush Cove is located about 25 km due north of Wiarton. One barn and three outbuildings were completely destroyed. One older house had its chimney blown off, siding torn off, and windows blown out. A 9 metre sailboat was lifted from a trailer and dropped 1200 metres away. There were no reports of any personal injuries with this storm.

5.2 Barrie Tornado - Figure 2

About 4:10 p.m. a funnel cloud dipped down from a severe thunderstorm in Egremont Township about 4 km southwest of Hopeville. For the next 50 minutes the severe thunderstorm travelled east-northeastward at 75 km/h over a distance of 85 km. It appears to have generated a series of 5 tornadoes which culminated in the devastating storm which struck southern portions of the city of Barrie. It is also conceivable that the damage paths could have resulted from one or two tornadoes touching down more than once.

a) Damage Area 1 (Hopeville)

Three concessions southwest of Hopeville to near Grey County Road 8.
Path Length: 17 km (the storm may have skipped occasionally)
Time: about 4:10 p.m.
Description of Damage: numerous barns and outbuildings were destroyed or severely damaged. Only minor damage to houses was indicated. No injuries were reported.

b) Damage Area 2 (Corbetton)

From 1 km southwest of Corbetton, a village southeast of Dundalk on Highway 10, to near Randwick at the intersection of Airport Road and the 25th Sideroad of Mulmur.
Time: struck Corbetton area at 4:17 p.m.
Path Length: 35 km
Description of Damage: the width of the damage path averaged 200 to 300 metres to just south of Honeywood where it narrowed to 50-100 metres. Through this area about 15 barns or outbuildings were destroyed and about 10 houses were heavily damaged. Cars and trucks were tossed around with some moved 60 metres. The storm continued to just south of Ruskview where it appears that a split occurred. A weakening portion appears to have lifted off the ground and moved northeast. Debris was found several km north of Ruskview. One sign which originated near Highway 24 was discovered near the the hamlet of Glencairn. It had travelled about 20 km. The southern part of the storm moved from south of Ruskview to south of Randwick where it also appears to have lifted off the ground.

c) Damage Area 3 (Lisle)

Two concessions east of Randwick the tornado appears to have touched down again. Tree damage is reported as far east as Camp Borden. Two barns were destroyed near Lisle. Investigators were not allowed onto Camp Borden but reports from the Base Police and aerial surveys indicate little damage on the Base and no damage further east.

d) **Damage Area 4 (Essa)**

South of Essa.
A brief touchdown occurred just South of Essa. A half km long track of tree damage was evident from aircraft investigations. Apparently no buildings were damaged.

e) **Damage Area 5 (Barrie)** - Figure 5

The final and most dramatic touchdown began about 2 km northwest of Holly. The path of the tornado through the city of Barrie is given in Figure 5. The tornado crossed Ardagh Road about 1 km west of Crawford Road. In this area a plantation of 10 metre pine trees was totally destroyed. Aerial photographs indicate that the damage path was at least 600 metres wide in this area. Moving eastward the tornado was extremely strong with winds likely in excess of 400 km/h. Crossing Crawford Road towards Patterson the storm totally destroyed many houses. Cars were blown hundreds of metres into the bush. Further east with a width of 350 to 450 metres the storm crossed towards Highway 400. Twelve factories were destroyed just west of Highway 400 while at least 4 others near the edge of the track were heavily damaged. The storm moved just south of the Barrie racetrack with heavy damage to the horse barns and grandstand.

The tornado then moved into the Hillsdale subdivision. A townhouse complex on Adelaide was destroyed. Heavy damage occurred on Debra Crescent. Heavy damage was reported in a 300 metre swath from Marshall Street to Joanne Crescent. East of Tower Crescent the damage path narrowed abruptly to about 50 metres. Homes on Briar Road received only minor damage indicating the tornado may have lifted up somewhat. Yet at Trillium Crescent, the next street east, heavy property damage resulted. Further east the storm moved into an industrial area. Four warehouses were destroyed near Highway 11. The tornado crossed Yonge Street at Minets Point Road and headed towards the CNR tracks cutting a 100 metre wide swath through the trees. The storm hit the northwest corner of the Royal Oak Subdivision and felled many large trees. There was much less damage to houses here than in the Hillsdale Subdivision. The tornado next hit the Minet Point Marina. According to police reports thirty-five sailboats have completely disappeared. Amazingly, the heavy cement anchors embedded in the bottom of the lake holding the boats are also gone. Debris from the storm was spotted 5 km from shore on Lake Simcoe. No damage has been discovered on the opposite shore, although reports of debris from the tornado have been received from Oro township along the north shore of Lake Simcoe, Orillia and south of Bracebridge.

5.3 The Grand Valley-Tottenham Tornado - Figure 2

At 4:15 p.m., only a few minutes after the start of the storm which would hit Barrie, another tornado touched down just north of Arthur. This same tornado remained on the ground for an incredible 90 km as it tracked east-northeast at 85 km/h to the east end of the Holland Marsh. It then skipped along a further 17 km before lifting off for good near Mount Albert.

The damage path width varied from about 150 metres to 400 metres occasionally up to 600 metres wide. Nearly all structures within this track were damaged. Well over 100 homes were seriously damaged or destroyed with at least that many barns and outbuildings destroyed.

From Arthur to Grand Valley the damage path ranged from 150 to 400 metres wide. Estimates are that 40 buildings were seriously damaged or destroyed. In the town of Grand Valley an estimated 40 to 50 homes near the centre of the tornado track were destroyed. Winds with the tornado are estimated to have exceeded 400 km/h. Dozens of other buildings on the edge of the track suffered varying degrees of damage. One indication of the intensity of the storm was the roof of the Library being lifted and thrown 200 metres before crashing down on a house. Two people were killed in the town.

From east of Grand Valley to Orangeville the swath of damage continued 150 to 300 metres wide. The most noteworthy damage was at Mono Plaza north of Orangeville. The plaza was levelled. East of Orangeville all the way to Holland Marsh the damage swath continued with a similar degree of damage occurring. Particularly hard hit was the area just south of Tottenham where about 15 homes were extensively damaged or levelled and two deaths were reported. There was some evidence all along the track of a second weak swath of tree damage a few hundred metres south of the main track but little property damage has been noted.

The tornado moved down into the Holland Marsh just southeast of Dunkerron and followed the canal road eastward and then northeastward about 5 or 6 km. It destroyed hundreds of trees along the canal and did considerable damage to buildings along the north canal road. The tornado then headed directly eastward across the marsh hitting the village of Ansnorveldt after destroying three hydro transmission towers. East of the Holland Marsh the storm began skipping with less serious intermittent damage reported. The storm appears to have lifted off for the last time near Mount Albert.

5.4 **Alma Tornado - Figure 3**

Time: approximately 4:15 - 4:30 p.m.
Path Length: 33 km (continuous damage over 8 km skipping over remaining 25 km) Details of Damage: In Peel Township near Alma 4 houses were extensively damaged, 10 barns and outbuildings destroyed, some damage to 1 other house and 2 boats.
From East of Lake Belwood to just southeast of Dufferin County road 3 - a narrow path of damage - 1 house reported destroyed.
From County Road 3 to east of Hillsburgh - light damage, the tornado appeared to be aloft most of the time.

5.5 **Wagner Lake Tornado - Figure 3**

Time: 5:40 p.m.
Path Length: 5 km
Details of Damage: 1 barn demolished, some tree damage

5.6 **Reaboro Tornado - Figure 3**

Time: 6:05 p.m.
Path Length: 8 km
Details of Damage: 2 barns heavily damaged, 1 shed levelled, scattered tree damage.

5.7 **Ida Tornado - Figure 3**

Time: 6:20 p.m.
Path Length: 9 km
Details of Damage: Church 1 km south of Ida badly damaged. Stone home across street completely destroyed, spotty barn and tree damage further east along track.

5.8 **Rice Lake Tornadoes - Figure 3**

Time: 6:20 - 6:30 p.m.
Path Lengths: 7 km and 11 km
Details of Damage: 5 barns destroyed. House trailers blown over, several boats sunk, several cabins destroyed, hundreds of trees with diameters up to 1 metre downed. Estimates of damage of to $2 million mainly in Birdsall Beach area.

5.9 **Minto Tornado - Figure 3**

Time: 6:35 p.m.
Path Length: 1 km
Details of Damage: very narrow path of damage 10 - 15 metres wide. Two large barns and two wooden sheds destroyed.

6. Recommendations

The following recommendations are made as a result of the preliminary investigation conducted by the Ontario Weather Centre.

6.1 A public education program needs to be undertaken to make people more aware of the nature of severe storms. For example there seems to be a widespread misconception that severe thunderstorms and tornadoes are independent events. Also, the public in general, and emergency officials in particular, need to understand the steps they should take when a watch is in effect; when a warning is in effect; or, when a severe storm appears imminent.

6.2 The methods in use for distributing warnings to the public and to emergency officials needs to be reviewed in detail.

a) Consultation with the media and emergency officials should be an integral part of this review.

b) Evaluation of the public awareness of and reaction to Environment Canada's weather watches and warnings should be undertaken.

6.3 The Weather Centre needs to improve its ability to detect severe thunderstorms and tornadoes:

a) Doppler Radar has been shown to be a fairly effective, though far from a foolproof method of detecting severe thunderstorms which may produce tornadoes. Research should be accelerated to assess the abilities of the newly acquired Doppler Radar at King City.

b) Additional severe weather watchers in rural areas of Ontario especially upstream of population centres need to be recruited.

c) The Ontario Weather Centre should undertake a development project with a view to identifying any new knowledge resulting from this survey and report the data collected on this storm that would improve future forecasts.

d) The Ontario Weather Centre will review its severe weather procedures in consultation with other regional units in view of the May 31st experience.

7. Conclusion

Tornadoes do occur in Southern Ontario though the majority of them are fairly weak and small scale. Storms of the power of the May 31st, 1985 event, though much less frequent, have occurred in the past and will occur again. As populations through Ontario increase, especially in more and more centres, the odds will increase of further major tornado events occurring in populated centres. Through education and further research, Environment Canada's goal should be to give the public a better understanding of the nature of these storms, and in conjunction with other federal and provincial agencies, and the media, a longer warning time in which to take action, and a knowledge of the steps to take to protect themselves in the event of severe storms.

TABLE I

Time of Occurrence of Tornadoes by County

Counties	Issue Time of * Severe Thunderstorm Warning	Issue Time of Tornado Warning	Time of Actual Storm
Northern Bruce	2:25 p.m.	-	3:00 p.m. Rush Cove Tornado
Northern Wellington	3:15 p.m.	-	4:15 p.m. Tornado Touchdown near Arthur
Dufferin	3:54 p.m.	-	4:28 p.m. Grand Valley 4:45 p.m. Orange-ville
Southern Grey	3:15 p.m.	-	4:17 p.m. Tornado Touchdown near Corbetton
Southern Simcoe	3:54 p.m.	5:00 p.m.	5:18 p.m. Holland Landing.
Northern Simcoe	3:54 p.m.	-	5:00 p.m. Barrie
Northern York	4:53 p.m.	5:00 p.m.	5:25 p.m. Holt
Northern Durham	4:53 p.m.	5:20 p.m.	5:40 p.m. Wagner Lake
Southern Victoria	N/A	5:20 p.m.	6:05 p.m. Reaboro
Southern Peterborough	N/A	6:05 p.m.	6:20 p.m. Cavan 6:25 p.m. Birdsall
Southern Hastings	N/A	6:25 p.m.	6:35 p.m. Minto

* These severe thunderstorm warnings issued by the Ontario Weather Centre contained the statement: "Remember some severe thunderstorms produce tornadoes."

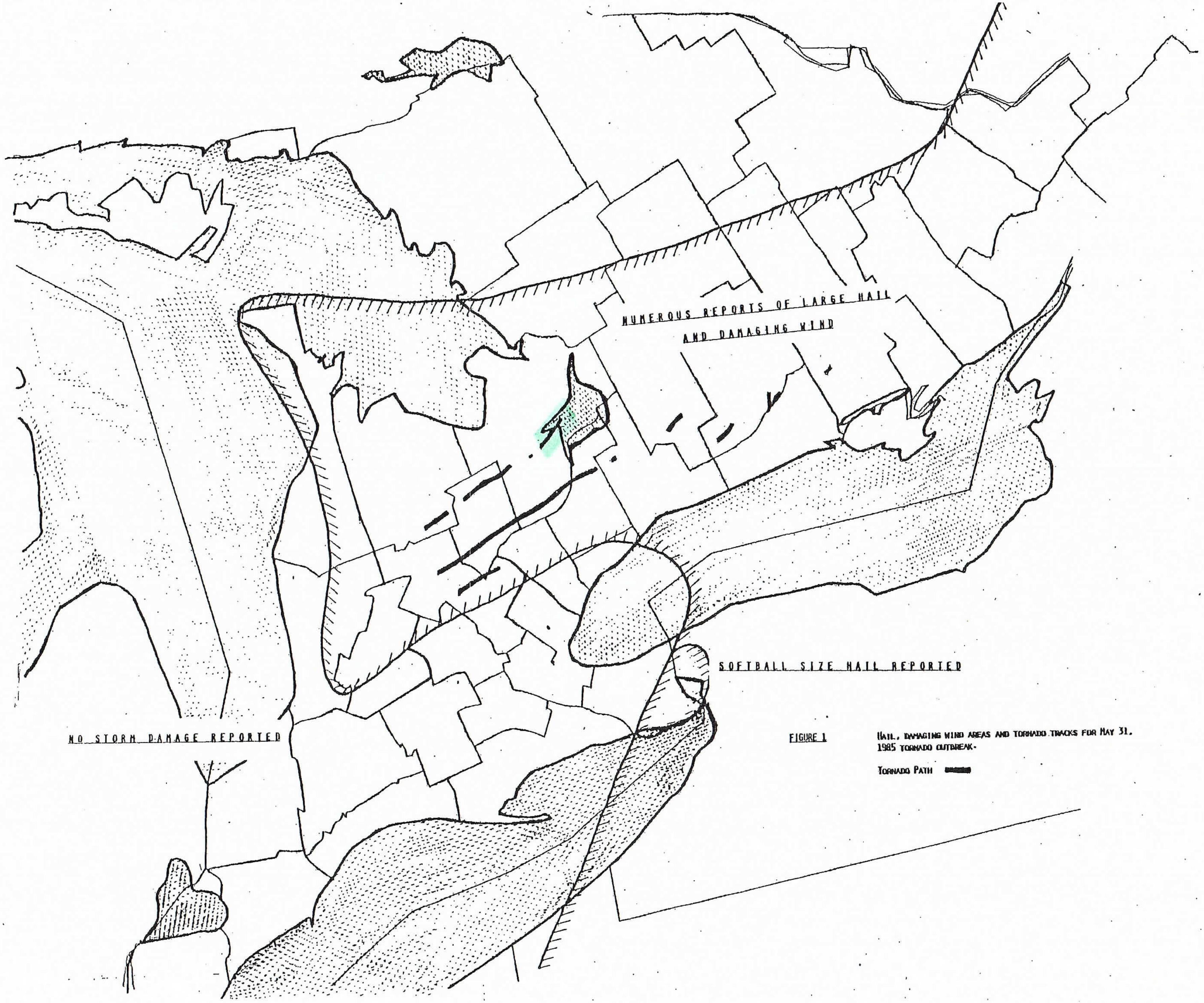


FIGURE 1 Hail, damaging wind areas and tornado tracks for May 31, 1985 tornado outbreak.

Tornado Path

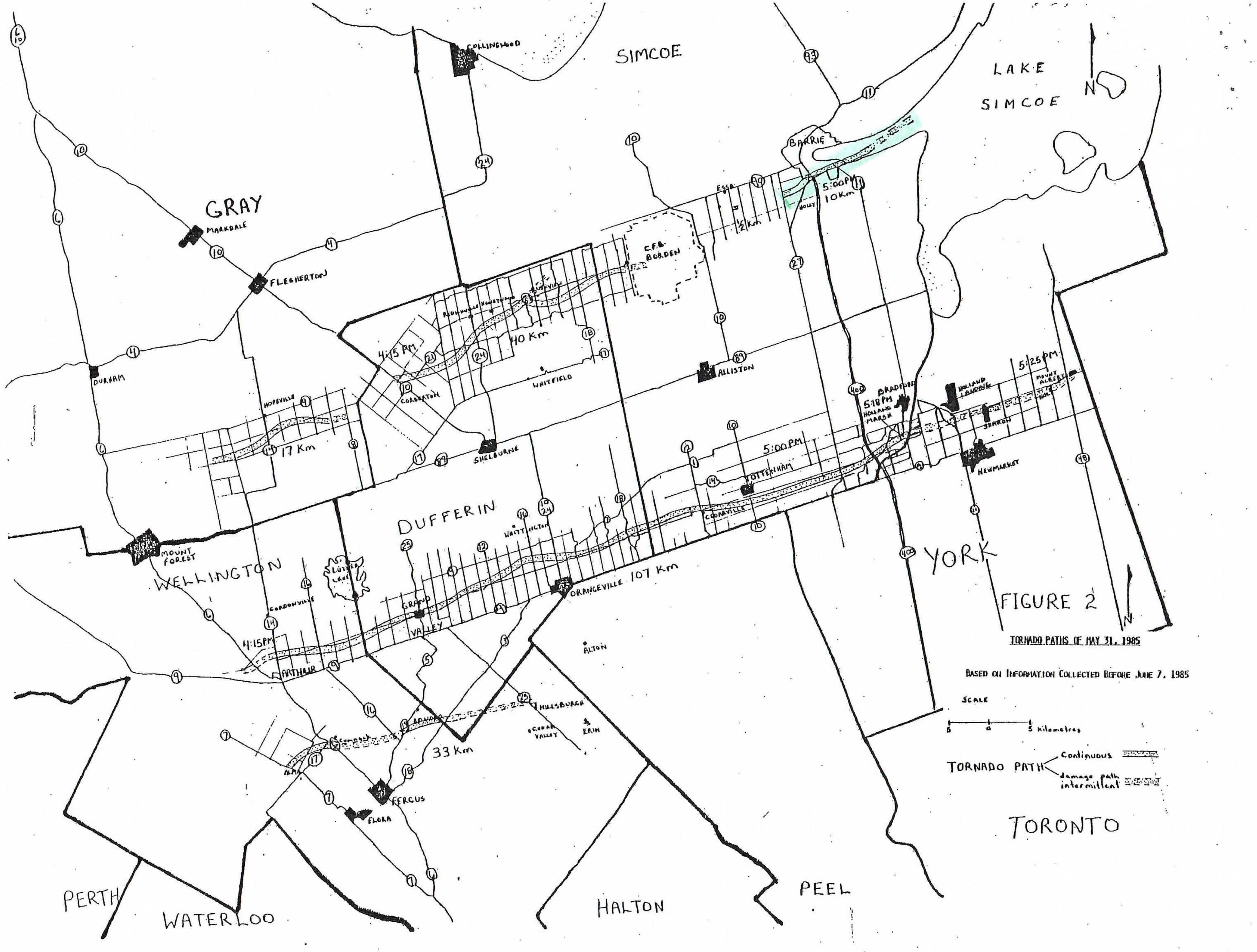


FIGURE 2

TORNADO PATHS OF MAY 31, 1985

BASED ON INFORMATION COLLECTED BEFORE JUNE 7, 1985

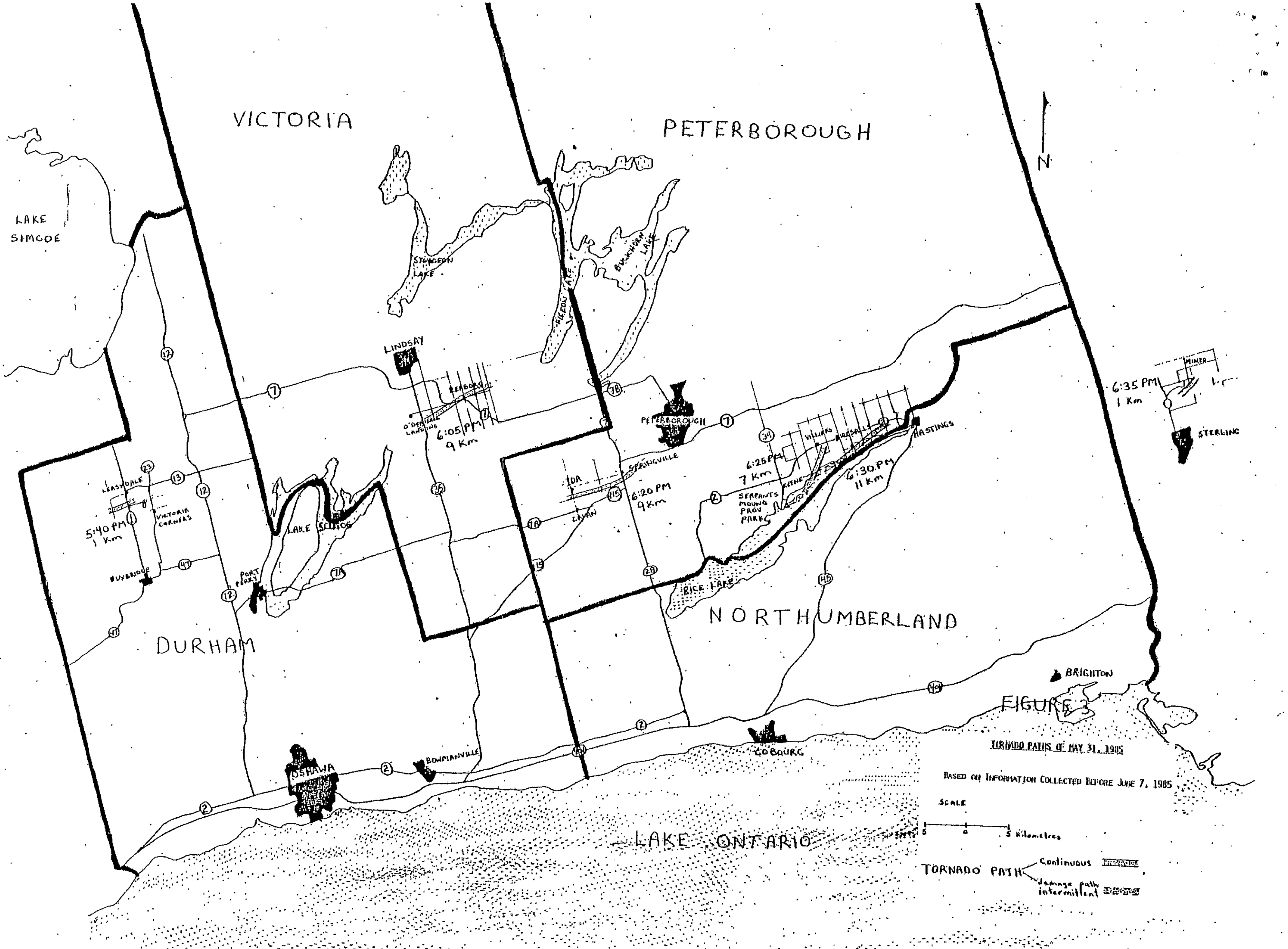

VICTORIA
PETERBOROUGH
N
LAKE SIMCOE
STURGEON LAKE
PIGEON LAKE
BUCKHORN LAKE
LINDSAY
PETERBOROUGH
6:05 PM
9 Km
O'DEMPSEY LANDING
IDA
SPRINGVILLE
CAVAN
6:20 PM
9 Km
6:25 PM
7 Km
VILLIERS
KEENE
SERPANTS MOUND PROV PARK
6:30 PM
11 Km
HASTINGS
6:35 PM
1 Km
MINTO
STERLING
LEASKDALE
VICTORIA CORNERS
5:40 PM
1 Km
UXBRIDGE
PORT PERRY
LAKE SCUGOG
RICE LAKE
NORTHUMBERLAND
DURHAM
BRIGHTON
OSHAWA
BOWMANVILLE
COBOURG
LAKE ONTARIO
TORNADO PATHS OF MAY 31, 1985
BASED ON INFORMATION COLLECTED BEFORE JUNE 7, 1985
SCALE
5 Kilometres
TORNADO PATH
Continuous
damage path intermittent

FIGURE 3

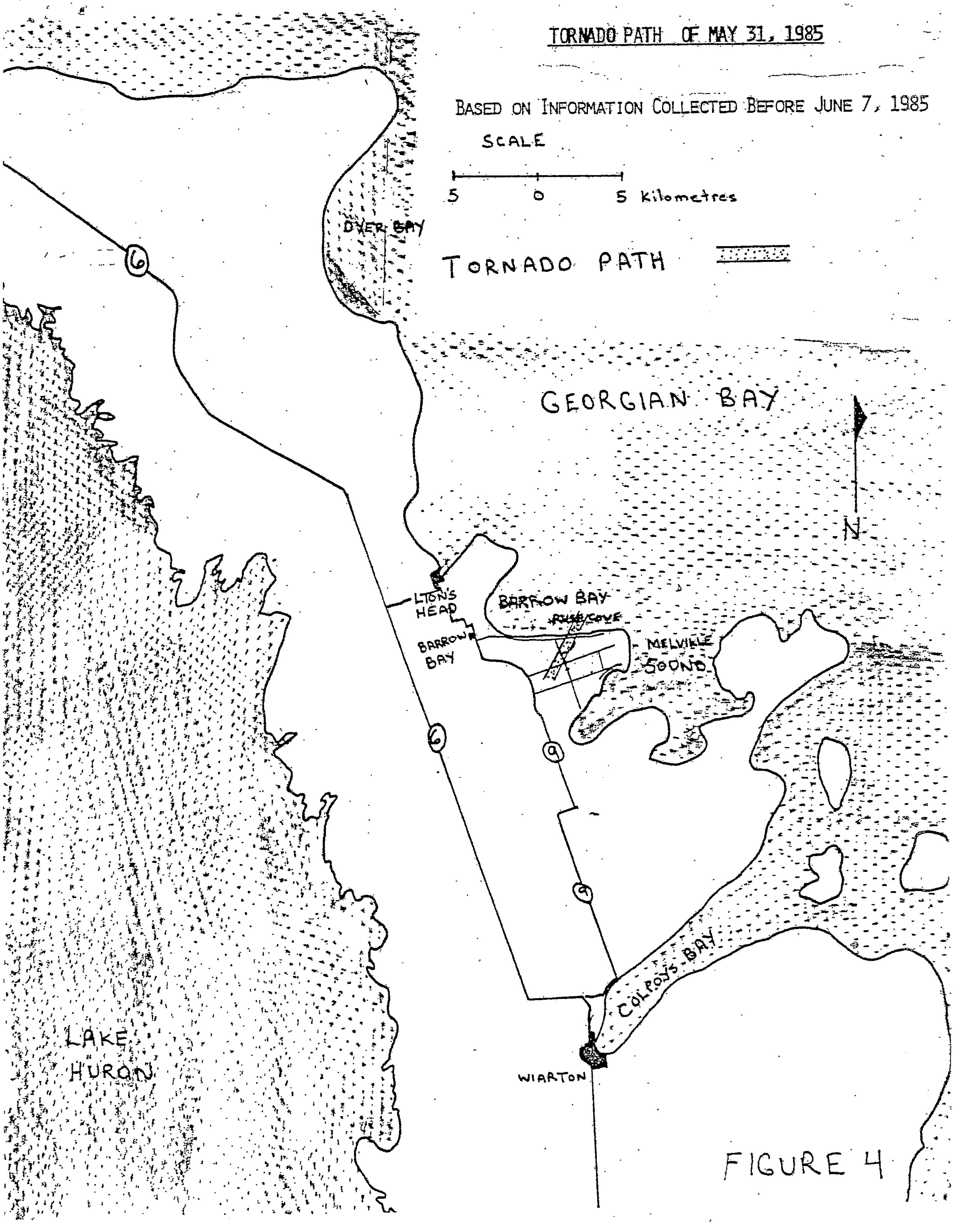
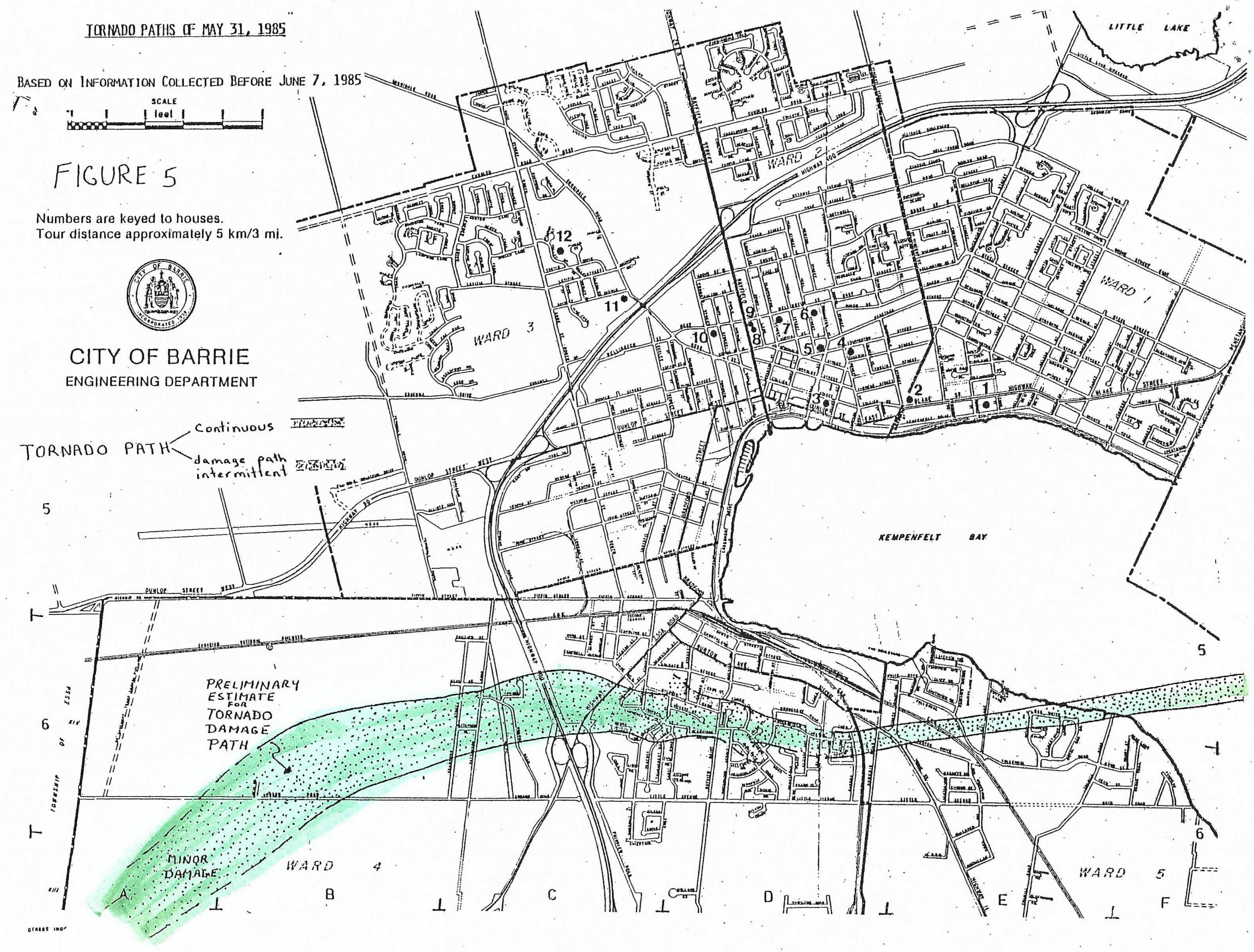

TORNADO PATH OF MAY 31, 1985
BASED ON INFORMATION COLLECTED BEFORE JUNE 7, 1985
SCALE
5 0 5 Kilometres
TORNADO PATH
DYER BAY
GEORGIAN BAY
N
LION'S HEAD
BARROW BAY
BARROW BAY
MELVILLE SOUND
COLPOYS BAY
WIARTON
LAKE HURON
6
6
9
9

FIGURE 4


TORNADO PATHS OF MAY 31, 1985
BASED ON INFORMATION COLLECTED BEFORE JUNE 7, 1985
SCALE
feet
FIGURE 5
Numbers are keyed to houses.
Tour distance approximately 5 km/3 mi.
CITY OF BARRIE
ENGINEERING DEPARTMENT
TORNADO PATH
continuous
damage path intermittent
PRELIMINARY ESTIMATE FOR TORNADO DAMAGE PATH
MINOR DAMAGE
WARD 1
WARD 2
WARD 3
WARD 4
WARD 5
KEMPENFELT BAY
LITTLE LAKE
DUNLOP STREET WEST
HIGHWAY 400
A
B
C
D
E
F
5
6
1
2
3
4
5
6
7
8
9
10
11
12