Hansard

House of Commons Debate
Vol 123 No. 8 1st session 31st parliament

Official Report
Thurs Oct 18 1979

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Hansard

P. 326

Mr. Derek Blackburn (Brant):

tornado devastated parts of Oxford, Brant & Haldimand-Norfolk counties in Sw Ont

"causing a total of $60 million in damage to crops, orchards, livestock, barns, homes, equipment, and so on, of which $26 million was uninsured ..."

EPILOGUE: TORNADO, OXFORD CENTRE

by Peter Chen

(Peter Chen, Alain Caillet, Billie Taylor and Bill Kiely were at Oxford Centre the morning after the tornado passage, to examine and photograph the damage)

Wednesday morning, August 8, 1979

Clean up was well underway in this small southwestern Ontario community near Woodstock. Grey skies and a few light showers were the setting of this morning after. At approximately 6:30 EDT of the previous evening, severe thunderstorms associated with a cold front moved through southern Ontario. One massive cell in particular generated several tornadoes. The most devastating funnel had tracked from southeastern outskirts of Woodstock, southeastward toward Lake Erie, scarring the earth over 30 kilometers long. Oxford Centre was its first major victim among several communities struck; here a swath over 700 meters wide evidenced the tornado's passage.

Very soon after the first plans and approval to examine and photograph the tornado damage, we were on the highway to Oxford Centre, ready with camera and film, note paper, map and, fresh in our minds, the "what to look out for" instructions we received just before departing Downsview. Our first stop was at the Ontario Provincial Police Station outside of Woodstock. (A wise decision, in retrospect, since we would have had difficulties to cross police blocks). There we were informed of the traffic conditions and given special passes (handwritten on the back of yellow "unattended vehicle" tags) to enter the blockaded damaged areas. Immediately passed the few police blockades, the damage area literally jumped into view. The boundary of the tornado damage was incredibly sharp. The stories heard, pictures seen of past tornado events became very real.

Our first view said it all; the damage was next to total. A roofless two storey brick house stood among the debris from its own structure and from the broken maple and poplar trees. Corregated tin siding blown from a collapsed barn were seen wrapped around large standing and fallen tree limbs and trunks. Missiles (projectiles carried by the wind) such as wooden boards and tree branches were embedded in the rear wooden wall of the building. A row of established trees were stripped and "uniformly" sheared of their tops. Examples of straw embedded in tree trunk bark were easily found. The tornado had passed to the west, a few hundred meters away.

A glance southward from this first site revealed the extensiveness of the damage which the evening tornado had brought. For nearly four hours we walked through this small community, among the broken houses, barns, thrown cars, fallen tombstones, fallen and stripped corn fields, lawns pitted with scars caused by blown debris, and the broken, twisted, and some uprooted trees, some partially stripped of their bark. The damage was indeed awesome. Virtually every building of Oxford Centre was destroyed, including churches, the general store, 100 year old community center, and thirty houses.

It is somewhat difficult to be objective in retrospect. Nonetheless, the busy activity of clean up was prevalent, yet generally quiet, interrupted occasionally by buzzing chainsaws, and aircraft overhead. The feeling appeared mixed as we talked with a few of the residents. Although no one we spoke to actually witnessed the "twister", their recollection of the evening's events were vivid and convincing. The feelings of disbelief and amazement were common. One never thought that "it would happen to us!" In addition, a common impression was the quickness with which the storm had struck and left, giving virtually no time to be prepared.

The sky was clearing by mid afternoon. Summer was not over.

HT'S DEATH-DEALING TORNADO

nsands into dark

Hydro has to put up their lines before Bell can get in to put up theirs," said a Bell spokesman, "and then we've got that labor problem — Bell called out its management people last night."

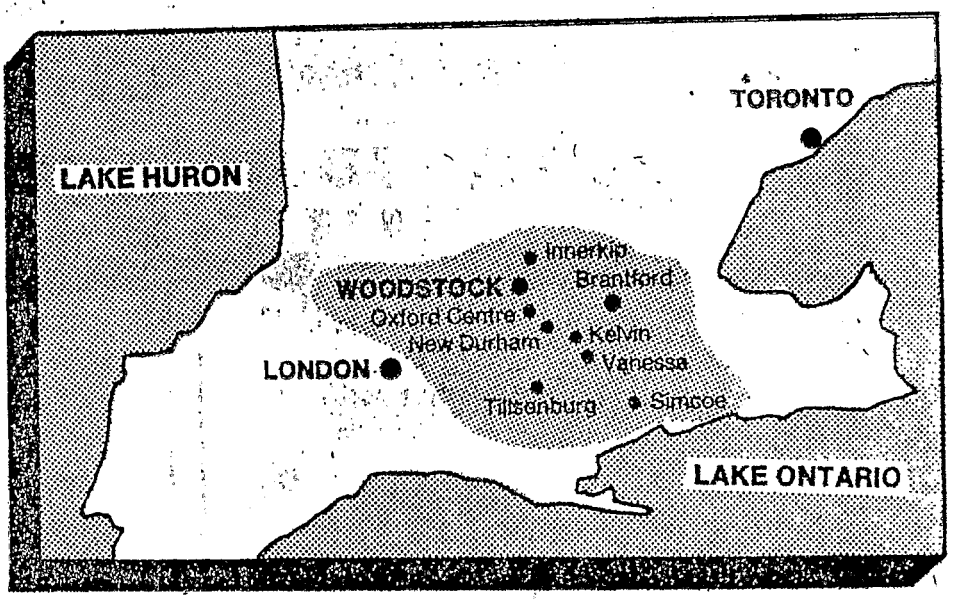
Rotating strikes by 1,700 repairmen and installers for Bell Canada continued in unaffected areas yesterday and today, a union spokesman said.

Bell lockouts countered strikes in Windsor and London yesterday, said D.A. Braniff, Bell's general and commercial manager, but "There will be no lockout in the affected area."

Both sides said crews would be working, but union representative Bob Lamb said the overtime ban was still in effect.

Members who wished to work would have to ask permission of the local executive, most of whom are in Montreal negotiating.

Braniff said Bell would send a management crew to the affected area and "we may have to bring in others."



Map shows area devastated by tornadoes

MIKE SLAUGHTER/TORONTO STAR

...storm, which struck without warning about 6 p.m. yesterday pounded the city with rain, hail and winds of up to 73 miles (117 kilometres) per hour.

There were no reports of serious injury, although some people were taken to hospital after being hit by flying glass.

Meteorologist Ken Johnson said a twister wasn't seen from the airport weather office, "but there were reliable reports of a tornado in the city."

Two schools were heavily damaged and windows of downtown businesses were smashed.

Rudy Horn, manager of a furniture store, said furniture was sucked out onto the street.

Despite pleas by police to stay home, residential streets were choked with curiosity seekers. Streets in several subdivisions were closed until work crews cleared away the mess.

Warnings of the storm did not come from the weather office until after it had struck. Forecasting services were moved to Winnipeg earlier this year as part of the federal Liberal government's spending restraint program.

Johnson said the warnings were late because the storm developed very quickly.

...some of the warnings not getting out, Barber said.

Large radar echo

He said the weather office doesn't have weather observation sites in the Woodstock area so at about 6.15 p.m. — when there was a "very large echo on radar" — he tried to telephone the provincial police detachment there.

But the telephone lines were out of order.

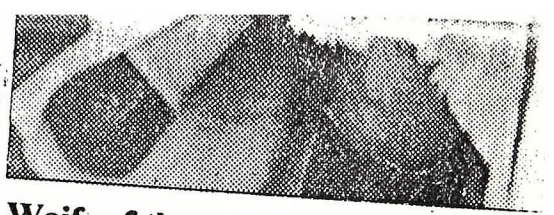
He said the purpose of his call was a combination "of giving a warning and finding out what was happening."

The earliest estimate of when the tornadoes touched down was 6.30 p.m. Barber said it was 7.55 p.m. before his office confirmed there were tornadoes in the Woodstock area.

Preliminary information from the weather office earlier pinpointed the first tornado as touching down just north of Woodstock. It passed through Oxford Centre to the south and more or less followed Highway 59 as far as Norwich.

Tornado No. 2 hit around Bright, northeast of Woodstock, and travelled southeast to Burford, west of Brantford.

The third tornado touched down just north of Vanessa and followed an almost straight line southeast through Waterford and south to Naticoke.



Waifs of the storm, six-year-old Jenn

Stay away, p

By John Munch Toronto Star

Crowds of ghoulish sightseers played havoc yesterday with the efforts of overworked police units battling to bring normality back to the tornado-ravaged region centred on Woodstock.

"We're trying to make sure only people living in the affected areas get in but at particular times the streets of Woodstock have been crowded with people who don't live here," said a spokesman for the 42-strong Woodstock police force.

Ontario Provincial Police reinforcements from detachments at Port Credit, Downsview, Orillia and Bracebridge were drafted into the disaster area yesterday to help with the big clean-up.

"We're appealing to all people who are

not r
hamp
cer sa
But
OPP's
that m
the co
death-
"The
many
they're
who've
neighb
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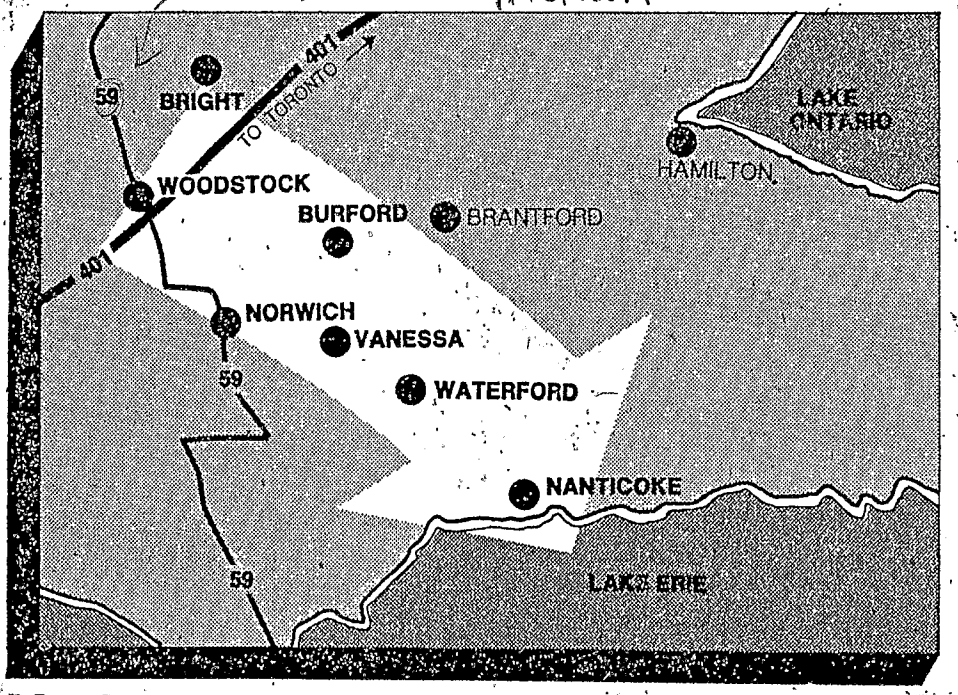
McCa
continui

Toronto Star Aug 9/79 A7

TORNADO AFTERMATH -- HEARTBREAK IN A DE

The sole survivor (

Hickson too



Map shows area devastated by tornadoes

Did the tornado victims have enough warning?

An investigation will be held to see whether sufficient warning was given to residents of Oxford County, walloped by three tornadoes Tuesday.

But Attorney-General Roy McMurtry, chairman of the cabinet's emergency planning committee, said yesterday the weather office probably did everything possible.

Ken Webster, of Tillsonburg, warden of Oxford County council, said he understands there was a warning of one hour.

He said "these acts of nature are devastating but I understand it is very difficult to tell ahead of time" what is coming.

Norm Barber, shift supervisor at the Ontario Weather Centre at Toronto International Airport, said last night there were radar observations of heavy thunderstorms and "damaging winds" up to 75 miles an hour (120 kilometres) heading for southern Ontario Tuesday afternoon.

Barber said the area facing the greatest danger was narrowed to the counties of Waterloo, Oxford and Perth and a weather "watch" was put out between 3.30 and

Now giant storm rocks Regina

REGINA (CP-Special) — Residents are

Sandy's h

WOODSTOCK (UPC) — The ho
Mrs. Sandy Barber is the only o
standing on Norwich Ave. on the ou
of Woodstock.

All other houses on both sides
road were wrecked by the tornad
devastated part of this city of 30,0
parts of several southwestern Onta
lages.

Mrs. Barber, interviewed by
light in her living room after the
said everything around the house w
stroyed.

"My back yard is non-existent. T
rage is levelled and we had a 22-foot
trailer out there that we haven't be
to find."

She believed her house may hav
saved because she had opened all th
dows during the brooding calm bef
storm hit.

She refused to complain abou
losses. "I feel fine. I have no comp
We have our own lives, the lives
two children, even our two dogs."

THE SUN
Sun aug 8 p.4

Bob Morrow (Civil Nyds duty officer): towers are generally built to withstand winds of 100 mph felled 2 metal transmission towers damaged others

star aug 8
80-ft (?) towers
nr Hi
59
outside
Woodstock

G+M aug 8 (+Sun)
pay at least 3 people killed
at least 146 injured
twister swung in C shape
striking a 15-block area
in the SW corner of
Woodstock but leaving
much of the rest of the
town undamaged
[other pay SE corner]

Most say SW corner.

Star Ed ** Aug 5

three howling, black tornadoes killed at least 3 people & injured more than 130 others

twisters, spinning at 200 kmph (120 mph) blasted Woodstock & surrounding communities

2:7 pm

120 rotational speed
65 translational speed

SW Woodstock

roofs, cars, trees, 60 km SE (Woodstock) Oxford centre > 40 homes & barns levelled. 3 churches, community centre & store. 2 x 4 ply thru hallway, smash thru one wall of kitchen & imbed itself in another wall 12" just above kitchen sink"

Truck tossed 100 yds off C.

Star 5 started Aug 8.
at least 2 people killed
injured > 130
1 15-block area of SW Woodstock
75 homes ~~dam~~ destroyed
250 badly damaged
+ 8 factories
Power lines snapped
rolled over big mooring mains

2 killed for sure
reports of 3 other deaths in
Hickson, Oxford Centre
New Durham

Vanessa: at least a dozen stone
& brick houses worth > $100,000
each were levelled to the grnd.
- other houses badly damaged.
truck & driver picked up & set down a few
feet away
- in some cases little was left
of foundations

40' trees with trunks 3' in diam were split in 2 like matches. Those left standing were littered with shredded clothing & encased in twisted metal for roofs cars & farm machinery

Star aug 9 300 bldgs in Woodstock
300 " " rest of Oxford County
damaged or destroyed

1,000 phones out of service

Royal Ins Co of Cda "ballpark"
est of damage $3 → $5 million

27 of the injured (11 children)
still in hospital
3 in serious cond.

in Norwich 3 dead
in Nanley 3

P. A6 Doris [illegible] Cleary
$8,000 truck & five-wheel trailer
(retirement home)
was on its side, smashed and
ripped apart by the tornado
as it sat in Aunt Gladys
driveway.
Michigan
FORD (Truck)

Daily Times Brampton Aug 8

2 dead

early reports indicated 3 dead, but police said confusion arose from conflicting reports

Aug 9

damage may total $10 million

est. range 7-10 million

for 300 bldgs incl 5 factories

damaged or destroyed in area

bicycle wrapped around telephone pole.

Inconsistent
~~Place affected~~ (Tornado Paths)

R.F.P ① 33 (53 km) mile long ¼ mile wide from Woodstock to areas S. of Jarvis (?)

② 20 mile long W-E thru Bright & Hickson

⇒ not likely direction

Star Aug 7
prelim info fm wx office
3 tornadoes
① just N of Woodstock thru Oxford Centre to Norwich
dist = ~16mi 26km
② hit and Bright then SE to Burford
③ just N of Vanessa thru Waterford & S to Nanticoke.

What about Hickson?

Climat Resp 3 tornadoes
① Oxford Centre to Waterford 32 km.
I think but same one went thru Woodstock [actually ≈ 38km]

WLF

Places Norwich, Harley, Ox Centre,
SW (or SE?) Woodstock,
Bright, Hickson, Vanessa,
Scotland (R.R.2)
New Durham
10 sq mile area N of Hickson
(RR Davistock)
crossed highway 59 ≈ 3 km
N of Hickson
Waterford
Climat Perspec mentions Davistock
which is further N
(actually refers
to RR Davistock
N of Hickson)

Otar Burford

Maybe
Hickson → Wood – O.C. → Norwich (New Durham)
20 mi 32 km

Bright → Buford 16 mi
Vanesa → Waterford & S. ?
≈ 12 mi ?

The details of the tornado tracks will be discussed in a forthcoming report from the O.W.C.. The extended longest track (which thru O.C.) is about 32 km (20 mi) with almost complete destr. occurring in a path width varying from 0.4 km to 0.8 km (AES, 1979).

1.1 1 m = 3.3 ft = 1.1 yd

1760 yds / mi

$\frac{1760}{1.1} = 1600 \frac{m}{mi} = 1.6 \frac{km}{mi} = \frac{8}{5} \frac{km}{mi}$

1/50,000 (.6 mi / 1 km) estimate ≈ 1 km total path width

28 mi Wood → water ⇒ 45 km ≥ 75 mph winds

Outline

Missile Impacts on Structures p. 153

- penetration (& spalling)
- perforation

flight parameters
excessive structural response

p. 33

Since there were no actual obs. of the windspeeds during the tornadoes, attacked it was nec. to estimate the tornadic windspeeds from other obs.

p. 32

Minor et al (1977) present several obs. to support the contention that "The effects of atmic p change play minor roles, rel. to wind effects, in the failure of conven structures. (Minor et al, 1977).

Mean Like Minor
the effect

Get another estimate of

height
length
depth
} of fallen part of gravestone

height
length
depth
} of unfallen part

Need coeff of friction
Net pressure coefficient

a rough est.

#4 roll 4 (of part blown over)

$h \approx (5')$

$l \approx \frac{1}{2} h$

$d \approx \frac{1}{2} l$

$h \approx \frac{1}{2} \times 5' = 2\frac{1}{2}'$

$h \approx 2\frac{1}{2}'$

$l \approx 1\frac{1}{4}'$

$d \approx \frac{5}{8}'$

$\Rightarrow N = (155 pcf)(2.5')(1.25')(\frac{5}{8}')$

$= 302.73\ p.$

$F \approx (.35)(302.73p) = 105.96p$

$$P = \frac{F}{h \times l} = \frac{105.96p}{2.5' \times 1.25'} = 33.91 psf$$

$\frac{h}{l} \approx 2 \qquad p = 0.00256 (C_f) V^2$

$C_f \approx 1.3$

$$V^2 = \frac{33.91 \text{ psf}}{(0.00256)(1.3)}$$

$$V = 100.94 \text{ mph}$$

part not blown over:

$h' = 5' = 2h$

$$\Rightarrow \begin{aligned} N' &= 2N \\ F' &= 2F \\ p' &= 2p \\ V'^2 &= 2V^2 \\ V' &= \sqrt{2}\, V = 142.75 \text{ mph} \end{aligned}$$

photo essay

- pictures 5x7 or 8x10 in album
- captions re: damage
- large folded map to scale showing where pictures were taken & direction (N at top)

Bill Kiely ACTF — Audio-Visual Section of Scientific & Special Service Division Training Branch (SD.

Billie Taylor (CCAI/I) Energy & Industrial applications Section applications & Impact Division Climat appl Branch, CCC

~~call~~ L. Klaponski

Shorne says:

- make notes all along path thickness of walls, planks etc.
- get map drafted, N at top

prelim report

brief: our est of wind speed using Fujita scale

ie wind > —
but prob < ——

some examples of calc.
eg house trailer

[phys. descrip of it
width, length, time etc.
how fast moving
[Ont Hydro at Fraser
by determining time
of ~~outages~~ successive power outages
=> 45 mph]

Document types of missile
- straw
snowmobile - planks
- cars how far they fly
- etc.

see Thorne's book re: hardness of surfaces.

Threshold windspeed

eg. gravestone

dead weight stone 155 pcf

dimensions of large stones

[estimate] $h \times l \times d$

$$\Rightarrow \text{weight} = N = (155\,\text{pcf})(h \times l \times d)$$

$$=$$

coefficient of friction μ
stone on stone
[try ref book list. Rubber Co.]

$$\text{force} = F = \mu N$$

$$\text{wind pressure} = p = \frac{F}{(h \times l)} \quad \text{psf}$$

$$\text{and } p = 0.00256\, C_f\, V^2$$

need C_f = net pressure coefficient
[ref (1)]

NOAA Tech Memo ERL NSSL-82 1977

Damage Documentation Processes

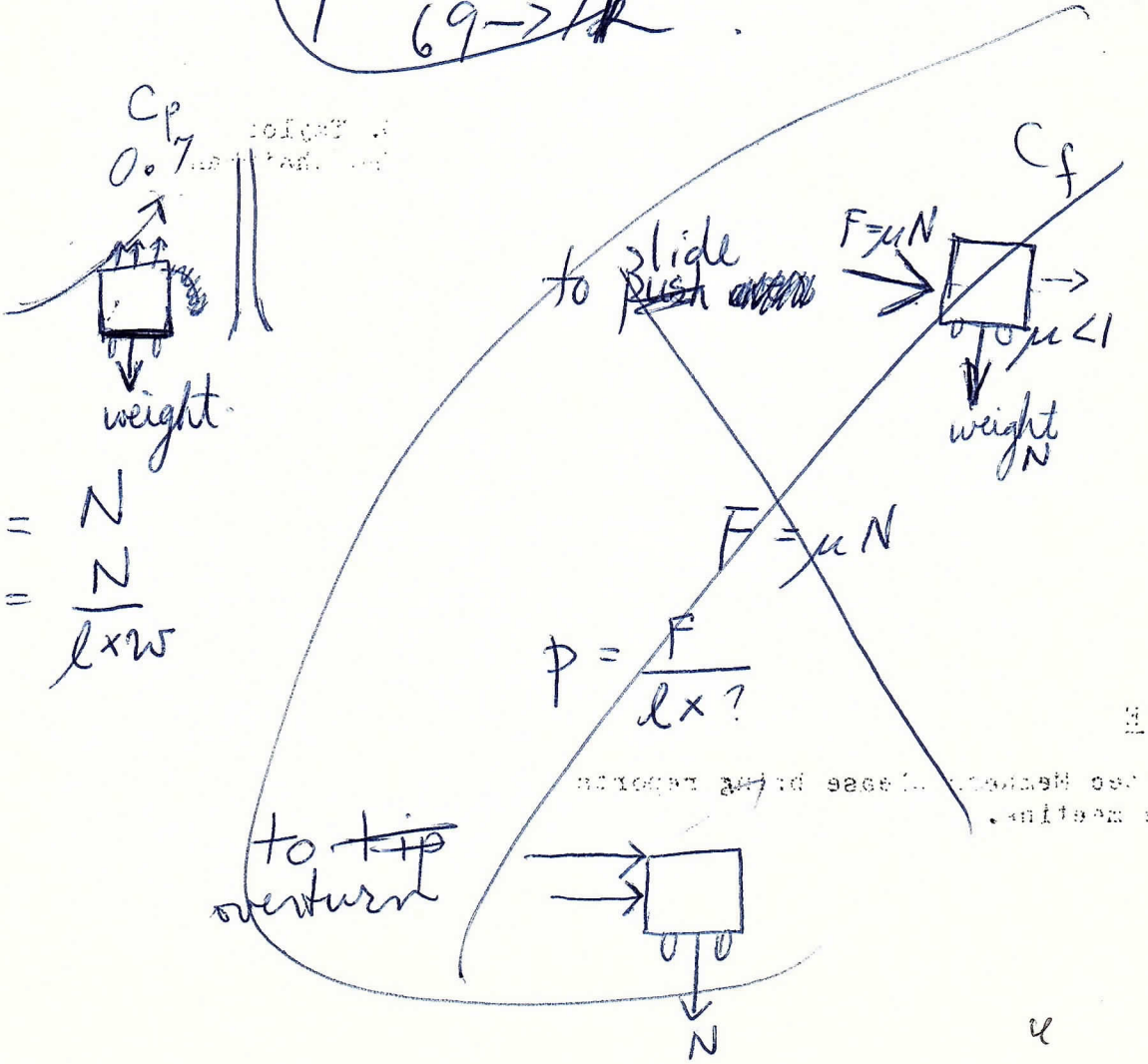
p. 6 → 14

II Tornadic Windspeeds

p. 51, 54, 55

~~Fall~~ FOPP accident report.

p. 68
69 → 72



Tornadic Windspeeds

Chap IV

summarize

perform calc.

Near-Grnd. Tornadic Windfield

p. 84

Chap V

extreme wind & their loc in the windfield p. 87

(also Eagleman et al)

Performance of Housing Chap VI

p. 103

wind dirn, tornado path width

windspeed

analysis of structural failure, not debris patterns

width

p. 104

Windspeed of 75 mph is value at which damage begins to occur to hsing

minor roof damage (shingles)

glass breakage

limb breakage. trees

wind speeds p. 105

general estimates in lower windspeed ranges, some coarse distinctions btn mod & severe winds for higher windspeed ranges.

Table IV p. 107 Fig 46 p. 109.

(if housing of general quality typical of cities with bldg codes & strng codes enforcement pgm).

We saw windspeed range (5) & (6)

however, some places looked more like range (3) or (4)

Not sure of quality of bldg.

Fig. 47 Fujita scale good agreement up to 125 mph then Fujita too strng

ranges (5) & (6)
windspeed F3, F4

p. 108 degrees of indiv housing damage are unreliable indicators of tornadic windspeeds.

Rural housing is a very poor indicator of tornadic windspeeds

necessary to examine several houses in a grp before making windspeed assessments for ranges (1), (2), (3).

Develop of coarse distinctions btn mod windspeeds (125-150) & severe (150-200) involves more than viewing indiv hou
⊗ or assessments of the appa
of damage in aerial photos.

Behaviour of Housing in Windstorm
p. 111

p. 129 shielding by trees
but localized damage

Missile events. p. 133.

Atmic P Change p. 143
Chap VII

limiting value: 2 atm
(≈ 3 psi)
most much less

If sealed bldg, flat roof
at 150 mph, pressure due to
p. change 40.3 psf
uplift p. on roof 40.1 psf

Tornado-Generated Missile
Chap VIII. p. 149

Summarize note those
observed in Oxford
Centre.

factors that affect missile flight trajectories: p. 149

p. 152: In some instances the missle may not become airborne, but may roll or slide along the grd

(after aerodynamic lift)

flight parameter: same as p. coeff?

$$P_F = \frac{C_D A}{W}$$

tendency to fly once it is injected into a windfield

$C_D = 2.0$ for trailer + truck

p 174 Straw into wood.

soft wood, bark with fissures which accepted the straw or very slight penetration

straw impact velocities ranging from 143 mph to 450 mph will penetrate wood samples ranging from soft to hard.

– if straws penetrating into certain types of hardwoods can be documented factually, knowledge of upper bnd limits on tornadic windspeeds can be extended.

Keller + Vonnegut

- threshold speeds to drive broom straws into soft wood (pine, fir) are only 145 - 165 mph.

- mostly field straw impacting cedar fence posts, with the straw seemingly wedged btn fibers on the bark.

Draft Report Outline

1. & 2. Intro

2. Description of Met event (brief as in Climat Perspectives) ref to forthcoming QJRMS report

as in ~~use this for draft~~ Climat Perspp. 'quote'

3. Description of the Tornadoes
ALSO use L.F. Press report

4. Our visit ~~(Ground truth~~ to Ox Co (based on ~~Use~~ Peter's epilogue)

5. Pictures & damage captions
[Map]
[to be added later: air pictures & from the Klaus Woodside etc.

6. Est. of Max Wind Speed in the most intense Tornado of Aug 7
[Mehta et al, etc.]

- An essay summarizing pts on tornado-bldg/structure interaction.

rewrite climat resp for report

not typed

F

Pscale

mean length, width

~~one~~ ext speed

trans speed.

from Rick

map, damage

missles

pictures

no details

1 of each (get them together)

Library

- ☐ Mehta K. et al Natl Ac Science 1975 Final Report 110 pp Engineering aspects of the tornadoes of Apr 3-4/74.
- ☐ BAMS '75 56(4) 464-467.
- ☐ Zrnic & Doviak JAM '75 14(8), 1531-1539
- ☐ map of Ont.
- ☐ Fujita, T et al Research Paper No. 69 U of Chicago, Dept of Geophysical Sci, Satellite & Mesonet Research Project Oct 1967.
  ⇒ (in Mehta 1976)
- ☐ Wx & climate Modif. WN Hess ed. Wiley & Sons 1974 "Tornadoes" Davis Jones & Kessler.

⇒ QC 929 .H47

☐ Mo Wx Rv. 88(5) 1960 167-180
Hoecker

☐ Wxwise 27(2) apr'74 Moller et al

☐ American Ntl Stndard Inst, N.Y. 1972
ANSI A58
"Am Ntl Stndard Bldg Code Requirement
for Min. Design Loads in Bldgs
& Other Structures".

Coeff

TABLE IV

TORNADO DAMAGE TO RESIDENCES

Windspeed Range	Damage Description	Windspeed Range (mph)	Equivalent F-scale
(1)	TV antennae bent; a few roof shingles blown off; light weight awnings and canopies damaged.	40-75 (18-34 m/s)	F0
(2)	Windows broken by flying debris; large sections of shingles removed from roof corners and eaves; residential chimneys collapsed.	75-110 (34-49 m/s)	F1
(3)	Sections of roofs and porches damaged, especially if inadequately anchored; large sections of gabled roofs may be torn off on leeward side; carport roofs lifted; extensive damage to garage roofs, if door is on windward side.	110-130 (49-58 m/s)	F2
(4)	Entire roofs removed and carried away by the wind, leaving first floor walls standing; roof removed from two story houses, some second story exterior walls collapsed. Roofs undamaged only if extraordinary anchorage precautions have been taken, such as the use of hurricane clips.	130-160 (58-72 m/s)	F2-F3
(5)	Two-story residences almost completely destroyed; exterior walls on single story dwellings collapsed with only well supported interior walls standing.	160-200 (72-89 m/s)	F3
(6)	Little remains intact; debris scattered down path of the tornado.	>200 (>89 m/s)	F4

Fujita T-T. Wxwise
1973 (26)
pp56-62, 79-83
tornado scale

~~scale~~

Keller, Vonnegut
(*) wind to drive straw
into wood.
JAM 15 899-901
1976

map of Ont

Eagleman / Muirhead / Willems

Camille 1969 $v \geq$ ~~200 mph~~

loud noise has source within tornado or lower part of R> since noise is present with)(that do not touch grd.; may be supersonic ~~noise~~ winds within tornado

speed of Sound $\geq$ 700 mph !! arg.

how can air go faster than sound since sound is integral for air? Not supported by other author

p. 278 max core inflow vel in large tornadoes 300 → 600 mph.

a design vel. of 200 mph would allow bldgs to withstand the greatest winds in most tornadoes.

P. 1 the speed of tornado winds & the low p within the core have not been measured accurately. [also Mehta et al 1976 paper]

est or calculated from various structural damage give speeds fm 65 → 200 mph [refs 1953 & 1960]

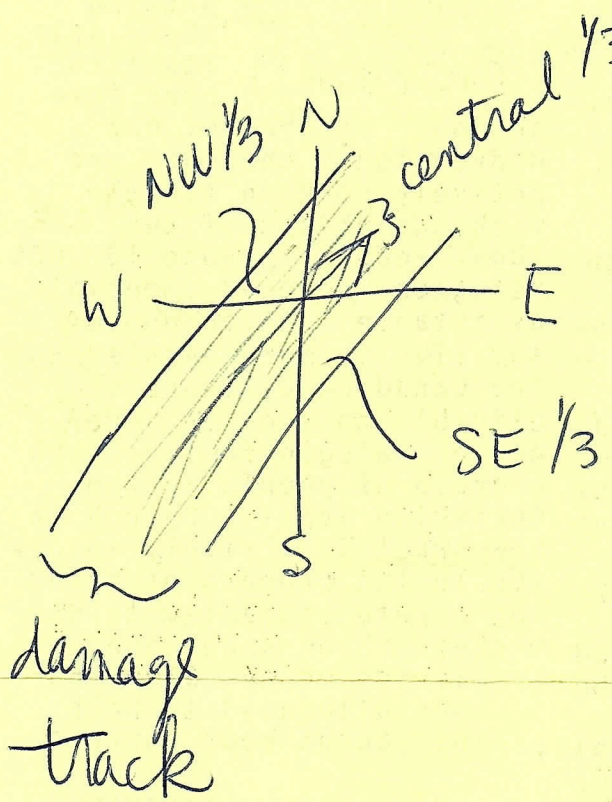
copy p. 38, 40, 41 (2) Eagleman et al.
(walk-out basements facing SW [like earth sheltered homes]

p. 33 direction of damaging winds during tornado.
Damage patterns have shown that trees fell in the general dir'n of the storm movement on both sides of the centre of the damage path.
Exception occurred as the tornado funnel lifted off the gnd. In this case a convergent pattern of wind dir'n was indicated toward the pt where the tornado lifted.

damage to 1st floors.

P. 40 Houses located in NW 1/3 of tornado from SW might be expected to have more damage to the N part of houses since the should be the windward side because of the cyclonic circle of the wind.

Eagleman



The smaller rooms were consistently safer and rooms away from tornado approach or in central part of bldg.

bark stripped from trees p. 59 & 60 (E)
— not readily apparent whether the bark was removed by abrasive action of particles in the wind or by other forces such as bending & twisting action of the winds.

Ground Tracks p. 151 & Fig 7-13

Lab Model

* The max flow speed occurred about 2/5 of the track width from the right side of the track with cyclonic rotation.

The width of the max flow area is ≈ 1/5 the width of the damage track.

On both right & left sides of max flow area, dirn of movement is inward & indirn of translation.

the max movement in the core center rgn was from 2 to 4 times that in the rotational rgn
⇒ the predominant or most serious flow fm a damage pt. of view was the gnd flow into the core in dirn of core movement.
Correlation with Gnd Obs

"The wax paths of the tornado model vortex present excellent correlation with the ground damage patterns observed by the authors."

Investigation of Wind Pon Representative Houses
P. 189 eval of damage to houses caused by tornadoes ⇒ severe straight wind is primary cause of damage to bldgs. Houses on either side of damage path are damaged by winds in same general dirn as funnel movement at that location.

dynamic pressure — air pressure

$q = (\gamma/2) p M^2$ (6.23)

p. 121

(γ for air (Ratio of specific heats)) — Mach #

The force per unit area on a structure is $\propto$ to dynamic p. Also f'n of aerodynamic shape (coefficients) of the object.

p. 216 theory in windtunnels indicate that winds in major damage area of a tornado may be of order of 500 mph.

Surface Damage Path

p. 264 – 271

Construction Practices p. 279

many of the home-bldging methods presently used rely upon the dead weight of the structure to [illegible] members.

eg: poured concrete foundation (7)
that was apparently not bolted to
the wall plates with the assump
that the weight of the house
would hold it in place.

Sudbury tornado sec 764

0830 EDT Aug 20/70 reached Sudbury
W to E track from ~~Ad~~ of Elliot
Lake to Quebec border 170 mi.
semi-continuous strip
narrow path 1/8 to 1/4 mile in width

urban areas: - many bldgs structurally
damaged to pt of uselessness
- utilities dislocated
- considerable amt of
debris transported by wind
away fm settled areas: tree damage
significant orientation &
fallen trees

Damage to Ntrl Features

on N side of ~~tho~~ path, wind was
fm E & NE; on S side fm W & SW
counterclockwise circln.
trees uprooted rather than broken
off
where breakage: 4 to 8 ft abv gnd
14 in. diametre at breast ht.

Dec 764

effects on Bldgs & Utilities

750 people homeless
roofs removed
wall bombarded
window glass removed
Power lines toppled
some masonry walls collapsed
objects as large as cook stove transported some distance
65 houses unfit for habitation
damaged autos fm debris
in general, bldgs well exposed to W & SW were destroyed or badly damage by force of wind, flying debris & explosion due so severe p change
roofs with overhanging eaves were frequently lifted.

Guideline to Tornado Damage Survey

Department of Civil Engineering
Texas Tech Univ., Lubbock, Tex. 1972

- guidelines describe: ① prestorm preparation
② composition of survey teams
③ necessary equipment
④ specific techniques for documenting damaged and failed structures

[reported in Mehta, K.C. et al
Journal of the Structural Division
ASCE
Vol 102, No ST 9, Sept 1976.

② ask Thorne
① ask Library

Dergarabedian & Fendell

rotational speed usually do not exceed 200 mph or so

(same order of mag of max wind speeds in fully developed hurricanes)

Mehta et al 1976

max windspeed est. presented in this paper (based on damage analyses) < 300 mph

- need details of structural design (including details of connections in the structure)

- need pressure or drag coefficients

Analyses based on determinations of wind pressures required to fail or to damage the structural systems under consideration

NSSL report

p. 17 max tornado winds in neighborhood 250-300 mph

p. 25 intense tornadoes have max vel in neigh 100 m/s (234 mph)
Extreme vert vel of 60 m/s (134 mph)
have been observed in the lowest 100 m above grd

Peter

200 kts (230 mph)
[>150 kts in typhoon in Taiwan
over 30 km long, damage swath >700 m wide
Chinook Mag 1(1) p. 8

Chinook Mag

only very small fraction of all tornadoes fall into severest category (~~<~~ <1%)
p. 10 2 severe storms of 1978 sounds similar to this one

Wka Sudbury Tornado
Aug 20/70 10 dead
200 injured
$5 million damage
[Clim Resp 5 deaths, >$10 million, 750 homeless;
path 200 m to 400 m wide; Elliot Lake to Quebec border]

Bruce

pictures of this tornado look like the ground damage & width is similar to Sudbury

CBC man

This is as bad as Sudbury tornado

Clim Resp Vol. 1 No. 27 aug 17/79

2 fatalities, 142 injured (8 serious)
> 1000 homeless
> 300 homes destroyed & others heavily damaged
livestock killed, crops damaged.

3 tracks

Oxford Centre: 32 km
almost complete destr 0.4 to 0.
Trees .5m to .6m (diam) snapped off
≈ 1.8 m above grnd.

$tens of millions

Shannon

Manitoba tornadoes

path length 200 ft – 20 mi
av ≈ 5 mi.

path width ≤ 20 → 150 ft.

winds 150 mph
rotational speed (less violent than ones in States ≥ 225 mph)

translational speed
20–80 mph, av. ≈ 30 mph

hydro poles able to withstand winds 100 mph blown over twisted off

Type of damage indicative of severity of storm
amt depends on amt & type of settlement along path.

Purpose: to estimate upperbound
ground level windspeed of tornado aug 7/7
using a national method, so
that ~~structures~~ engineers can
develop design for tornadic
loadings for 5^{m} Ont.

Points made by Mehta et al (1976):

3 techniques for estimating windspeeds in tornadoes

(1) Analysis of grd marks
(2) " " motion picture films
(3) Survey & analysis of damaged & failed structures

Last one widely used by engineers
First 2 by meteorologists

Documentation of the Damage

- reach scene as soon as possible after the occurrence of the storm
- complete & thorough documentation if results of data evaluations are to be meaningful.
- descriptions of the structural respons of the failed structure, notes on dirn of wind, descriptions of the damage in immediately surrounding area.
- windspeed analysis can be performed only if the details of the structural design, including details of connections in the structure, are known. Need structural drawing

Windspeed Analysis

- Need thorough understandings of

appropiate pressure or drag coefficien
- Simple and "clean" structural system yield more reliable windspeed estimate than more complex structural system

- Free standing Structures, such as light standards, monuments, flag poles and chimneys are ~~classified as precedents~~ readily analyzed with respect to damaging windspeed If > 30 ft in height, variation of windspeed with hight should be taken into account.

- Buildings such as residential structures and rural structures are difficult to utilize for gaining dependable windspeed estimate
- Windspeed estimates based on missiles are less reliable than the estimates based on structures.

Therefore, to estimate the upperbound windspeeds of the Aug 7 tornado thru Oxford Centre:

(A) pick some free standing structures near the centre of the path through Oxford Centre

(i) grave stones (large ones)

(ii) large trees twisted, broken off

(iii) light standard in ball park

(iv) silos were destroyed in places.

(v) any free-standing structure not destroyed or damaged.

(B) understand appropriate pressure or drag coefficients

-get Ref. 1 ANSI A58 1972

$$p = (C_p \text{ or } C_{pi} \text{ or } C_f)(0.00256V^2)$$

[Boyd uses 0.00257]

p = wind pressure psf

V = windspeed mph

C_p, C_{pi}, C_f = external, internal, net pressure coefficients.

The coefficients depend on: $\frac{h}{d}$

h height above ground or building

d outside diametre

and wind angle on structure

The wind pressure must be determined from consideration of structure:

wind load moment is equated to fracture stress.

winds normal to structure:

$p(d)(h)(\ ?'\ )(\frac{1}{2}d)/(\ ?^2\ )$ ck Shorke's book

= (modulus of rupture strength + axial compressive stress) $\times 144 \frac{si}{sf}$

psi psi

for appropriate construction material

winds diagonal to structure:

$p(d')(h)(\ ?'\ )(\frac{1}{2}d')/(\ ?^2\ )$

= as above

d' = diagonal ~~distance~~ dimension of structure

$d' = \sqrt{2}d$ for square.

then solve for p

$$p = \frac{(\text{modulus of r.s.} + \text{axial c.s.}) \times 144}{d\,h(\ )(\frac{1}{2}d)/(\ )}$$

in psf

need to know weight of construction material, dimensions of structure, etc

to determine axial compressive stress

$$acs\ (psi) = \frac{(h)(\text{dead load of construction material})}{144\ si/sf}$$

eg dead load brick = 120 pcf

$h = 46$ ft.

$$acs = \frac{(46\ ft)(120\ pcf)}{144\ si/sf}$$

$\frac{\$t\ \frac{p}{\$t^2}}{\frac{i^2}{ft^2}}$

$$= 38.3\ psi$$

dead weight of stone 155 pcf

modulus of rupture strength of chimney masonry $\approx$ 100 psi.

[Sahlin, S. Structural Masonry, Prentice-Hall, Inc. 1971, pp. 138-145]

It looks like the details on structural design required for the calculation of P are not known well enough to perform these calculations. Ck Thorne's book for any more advise.

uplifted roof (if roof is not attached to beams)

p. 171 →

total dead load of roof resisting uplift (psf) $= C_p (0.00256) V$

- if windows not broken before uplift
- " " broken $\Rightarrow (C_p + C_{pi})$ openings mostly in windward wall

To ~~push over~~ slide a clean structure

weight = N

coefficient of friction μ

net pressure coefficient C_f

surface area of structure: depth of structure (height) × length

force required to slide

$$F = \mu N$$

uniform wind pressure to develop force F

$$p = F/(d \times l) \quad [psf]$$

$$\Rightarrow p = 0.00256\, C_f V^2$$

$$\Rightarrow V = \sqrt{\frac{p}{.00256\, C_f}} \quad [mph]$$

threshold wind speed to slide structure (or push sideways)

Light standard roll 5 # 7

bent over at point where wind pressure (psf) = strength of material

- Could probably get net pressure coefficient for light standard (ref (1))
- estimate height, diameter
- construction material

$$p = 0.00256\, C_f V^2$$

- how to arrive at strength of standard at that height

not good structure to use

[NOAA report]

re write use Keller's from zephyr

We approached the hamlet of Oxford Centre from the Northwest along the main road, which runs parallel to Highway 59. Until this time, we had seen no damage, ~~since~~ because we had come along Highway 401 from the East. Prior to this, we had stopped at the OPP station near Highway 401 for directions and for permission to enter the devastated area. It had been roadblocked to prevent sightseers from entering the area.

The first house at the northern edge of Oxford Centre was a large old ~~for~~ two-storey farm house which ~~was~~ had been surrounded by large trees.

pace distance from centre
+/or edge of track
to main damage
area

sign of air borne missile
& distance it flew

ck for heavy object tumbling look at ground for scour ~~skip~~ marks
& examine

direction from track

look for evidence of counterclockwise vortex

(*) want to assess wind speed

- assess damage

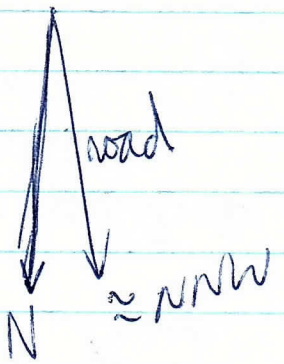
construction & material
brick
brick facing
cement
wood
& age of structur

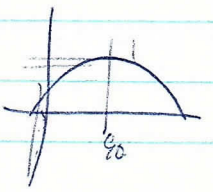
& photograph of damag

✓ Carol K to measure diameter of snapped off trees & distance of cans from original spots & any twisting

direction of main road thru Oxford Centre

1/50,000 topo map





$\sin\alpha = \frac{x}{y}$

$= \frac{4/16}{15/16}$ " from topo map

$1 - \frac{1}{16} = \frac{4}{15}$

$\sin\alpha = 4/15 = .26\dot{6}$

$\Rightarrow \alpha = 15.466009953\dot{3}^\circ$

$15^\circ \; 27.96\,06'$

$\approx \boxed{15^\circ \; 28'}$

$\Rightarrow$ the main road is $15^\circ 28'$ to the West of North

ie $360^\circ - 15^\circ 28' = 344^\circ 32'$

ie NNW

Tornado Damage at Oxford Centre, Ontario on August 7, 1979

employees of the Atmospheric Environment Service

The following made a field trip to Oxford Centre, approximately 4 miles Southeast of Woodstock, on August 8, 1979:

Alain Caillet and Peter Chen
Professional Development Division
Training Branch
Central Services Directorat

Bill Kiely
Audio-Visual Section
Scientific and Special Servic Divisio
Training Branch
Central Services Directorat

Billie Taylor
Energy and Industrial Applications Sectio
Applications and Impac Division
Climatological Applicatio Branch
Canadian Climate Centr

Our first view said it all; the damage was next to total. A roofless two storey brick house stood among the debris from its own structure and from the broken maple and poplar trees. Corregated tin siding blown from a collapsed barn were seen wrapped around large standing and fallen tree limbs and trunks. Missiles (projectiles carried by the wind) such as wooden boards and tree branches were embedded in the rear wooden wall of the building. A row of established trees were stripped and "uniformly" sheared of their tops. Examples of straw embedded in tree trunk bark were easily found. The tornado had passed to the west, a few hundred meters away.

A glance southward from this first site revealed the extensiveness of the damage which the evening tornado had brought. For nearly four hours we walked through this small community, among the broken houses, barns, thrown cars, fallen tombstones, fallen and stripped corn fields, lawns pitted with scars caused by blown debris, and the broken, twisted, and some uprooted trees, some partially stripped of their bark. The damage was indeed awesome. Virtually every building of Oxford Centre was destroyed, including churches, the general store, 100 year old community center, and thirty houses.

It is somewhat difficult to be objective in retrospect. Nonetheless, the busy activity of clean up was prevalent, yet generally quiet, interrupted occasionally by buzzing chainsaws, and aircraft overhead. The feeling appeared mixed as we talked with a few of the residents. Although no one we spoke to actually witnessed the "twister", their recollection of the evening's events were vivid and convincing. The feelings of disbelief and amazement were common. One never thought that "it would happen to us!" In addition, a common impression was the quickness with which the storm had struck and left, giving virtually no time to be prepared.

The sky was clearing by mid afternoon. Summer was not over.

EPILOGUE: TORNADO, OXFORD CENTRE

by Peter Chen

(Peter Chen, Alain Cailett, Billie Taylor and Bill Kiely were at Oxford Centre the morning after the tornado passage, to examine and photograph the damage)

Wednesday morning, August 8, 1979

Clean up was well underway in this small southwestern Ontario community near Woodstock. Grey skies and a few light showers were the setting of this morning after. At approximately 6:30 EDT of the previous evening, severe thunderstorms associated with a cold front moved through southern Ontario. One massive cell in particular generated several tornadoes ~~(Figure 1)~~. The most devastating funnel had tracked from southeastern outskirts of Woodstock, southeastward toward Lake Erie, scarring the earth over 30 kilometers long. Oxford Centre was its first major victim among several communities struck; here a swath over 700 meters wide evidenced the tornado's passage.

Very soon after the first plans and approval to examine and photograph the tornado damage, we were on the highway to Oxford Centre, ready with camera and film, note paper, map and, fresh in our minds, the "what to look out for" instructions we received just before departing Downsview. Our first stop was at the Ontario Provincial Police Station outside of Woodstock. (A wise decision, in retrospect, since we would have had difficulties to cross police blocks). There we were informed of the traffic conditions and given special passes (handwritten on the back of yellow "unattended vehicle" tags) to enter the blockaded damaged areas. Immediately passed the few police blockades, the damage area literally jumped into view. The boundary of the tornado damage was incredibly sharp. The stories heard, pictures seen of past tornado events became very real.