NORTHEAST TEXAS SIP
APPENDIX B

Report - 'Selection of Episodes for East Texas Photochemical Model development"
October 7, 1998, Environ International

ENVIRON

MEMORANDUM

To: Mark Sweeney, ETCOG

From: Greg Yarwood, Till Stoeckenius

Date: 7 October 1998

cc:

Subject: Selection of episodes for East Texas photochemical model development

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A key element of any modeling protocol is the selection of ozone episode days to be simulated. EPA modeling guidance (EPA, 1991, 1996) requires that episodes selected for modeling be representative of the range of meteorological and emission conditions associated with ozone exceedances in the study region. While the 1991 guidance strongly suggested that the highest ozone day during the most recent three year period be included among the selected episodes, the revised 1996 guidance modifies this requirement in recognition of the fact that the most extreme ozone events may occur so infrequently (i.e., much less than once per year) as not to impact the attainment status of the area under study. Thus, episodes representative of conditions that occur roughly once per year and with ozone concentrations close to but just above the design value for the modeling domain are to be given higher priority than more extreme but much less frequently occurring episode types. Other factors to be considered in the selection of episodes for modeling include the availability and quality of routine and supplemental air quality, meteorological, and emissions data, the spatial and temporal extent of ozone exceedances, availability of supporting regional modeling analyses such as the Dallas/Ft. Worth modeling study, and the degree to which good model performance can be expected for selected episodes. Note that sufficient data were unavailable for this protocol development to numerically rank the relative ozone formation potential of each exceedance day so the detailed four step procedure described in EPA's revised 1996 guidance was not followed here.

Initial Review of Meteorological Conditions During High Ozone Events

Morning (06:00 to 09:00) and afternoon (14:00 to 16:00) average wind speeds and resultant wind directions at Longview and Tyler were examined for all days from 1/1/95 to 9/27/98 on which the maximum 1-hour average ozone concentration at either location was greater than 0.1 ppm. Meteorological conditions associated with high ozone days in East Texas were evaluated by examining these wind data in conjunction with synoptic weather patterns displayed in the "daily weather maps" publication produced by the National Oceanographic and Atmospheric Administration (NOAA). As one would expect, these high ozone days were dominated by light winds. Of the 73 days examined, morning wind speeds were less than 5 mph on all but 6 days at Longview (2 days at Tyler). With increased vertical mixing brought on by daytime heating of the Earth's surface, afternoon winds averaged slightly higher but were still less than 10 mph on all but 3 days at Longview; the maximum afternoon speed at Tyler on these days was only 9 mph. Our review of the daily weather maps confirmed this overall pattern of light winds with very weak pressure gradients, no precipitation and high temperatures over the area. Upper level winds as evidenced by the 500 mb charts included in the daily weather map series were also light and variable in most cases with a handful of significant exceptions (described below). These fair, humid, warm summer days typical of East Texas are highly conducive to ozone formation.

Although the general meteorological pattern described above was similar for nearly all of the high ozone days, a more detailed examination of the surface wind data and daily weather maps revealed the existence of two somewhat different types of events associated with high ozone in East Texas:

> Stagnation events were most frequent and are characterized by calm or near-calm winds (averaging less than about 3 mph) throughout the day and typically a 500 mb ridge centered over the area.
>
> Weak Easterlies events were slightly less common and are characterized by afternoon winds ranging from NNE to ESE at Longview and Tyler. Morning winds tended to be from the same general direction but usually averaged less than 3 mph. These days were occasionally associated with a very weak easterly or southeasterly subtropical flow aloft seen on the 500 mb charts although this feature was not universal.

While a clear distinction cannot always be drawn between these two types of days, they provide an important division between days which are unlikely to be heavily influenced by transport of ozone or precursors from outside the Tyler/Longview/Marshall area and days with at least a potential for transport influences.

Several of the days examined in this analysis did not fit into either of the two categories identified above. Two of these days produced exceedances of the 1-hour ozone NAAQS: May 29, 1998 and June 15, 1998. May 29, 1998 was characterized by southwest winds; ozone levels on this day may have been influenced by smoke from several very large wildland fires burning in northern Mexico. June 15, 1998 was characterized by unusually strong WNW winds throughout the day at Longview with NNW to NNE winds at Tyler. A broad trough at the 500 mb level was centered over the norther Plains producing strong zonal (west to east) flow over East Texas.

Summary of 1-Hour Ozone NAAQS Exceedance Days

Table 1 lists all days with exceedances of the 1-hour NAAQS at Longview (i.e., days with maximum 1-hour averages greater than 0.124 ppm). There were no exceedances of the 1-hour standard at Tyler between 1/1/95 and 9/27/98. Also listed are all additional days in 1997 and 1998 with exceedances of the 8-hour NAAQS (i.e., 8-hour concentrations greater than 0.084 ppm).

Back trajectories for air parcels arriving at Longview at 15:00 CST (21:00 UTC) were constructed using the NOAA HY-SPLIT trajectory model run on the eta model wind fields (see http://www.arl.noaa.gov/ready/hysplit4.html). Trajectories were examined to confirm the appropriateness of the meteorological classification for each day and the general source regions of emissions impacting the Longview monitor. Trajectories for most stagnation days showed relatively little movement of air with same day and often overnight transport primarily from within the Tyler/Longview/Marshall area. Easterly days, on the other hand, tended to show transport of air parcels from northern Louisiana or southern Arkansas.

Time series of hourly ozone concentrations on each 1-hour exceedance day were constructed and examined for the time of occurrence and shape of the daily ozone peak. Some days (e.g., June 23, 1995) exhibited a sharp 1-hour peak resulting in a low ratio of the daily maximum 8-hour to the daily maximum 1-hour concentration while other days (e.g., August 28, 1998) exhibited a broad peak with high 8-hour to 1-hour ratios. In general, days with broader peaks are likely to have been influenced by precursor sources that are more distant or cover a wider area than days with sharp 1-hour peaks. Therefore, it is important to include both types of days in our modeling analysis. We note that no obvious relationship between the meteorological pattern and the 8-hour to 1-hour concentration ratios are apparent, although it is not possible to rule out such a relationship given the limited data examined in this study.

Back trajectories and ozone concentration time series compiled for each 1-hour and 8-hour exceedance day shown in Table 1 are included in chronological order in the attachment.

Recommendations

Based on the results presented above, we recommend that the following four episodes be considered for modeling in East Texas:

June 20-23, 1995
August 27-29, 1998
July 16, 1997
September 2-3, 1998.

Our rational for recommending these episodes is described in the following paragraphs.

Maximum 1-hour ozone concentrations during the study period occurred during the June 20-23, 1995 episode with significant 8-hour exceedances on each day and 1-hour exceedances on the 20th and 23rd. Examination of the surface wind data, daily weather maps, and back trajectories indicates this is a well-defined multi-day stagnation event. An unusual feature is the 1-hour ozone spike associated with the 0.145 ppm maximum on the 20th which occurred at 10:00 CST. The spike has an amplitude of about 45 ppb and is consistent with the impact of a well defined plume from a nearby industrial facility. While this particular feature may be difficult to reproduce in a photochemical model run, the June 1995 episode as a whole is a significant one and appears to be typical of high ozone occurring under stagnation conditions in the Tyler/Longview/Marshall area. In addition, this episode coincides with a Dallas/Ft. Worth model episode so regional scale meteorological and air quality fields are available for development of a fine grid model of the Tyler/Longview/Marshall area.

A more recent multi-day stagnation episode occurred on August 27 - 29, 1998. Based on data through September 28, 1998, the 1-hour maximum of 0.129 ppm on August 28th corresponds to the 1996-1998 1-hour NAAQS design value at Longview (a maximum of 0.129 ppm was also recorded on June 15, 1998 but, as noted above, meteorological conditions on this day were not typical of most high ozone days in East Texas). Although the maximum 1-hour concentration on the 28th (0.129 ppm) is just slightly above the NAAQS, significant 8-hour exceedances occurred on each day (the maximum 8-hour concentration of .114 ppm during this episode is slightly higher than the 0.110 ppm value attained during the June, 1995 episode). Thus, ozone time series during this period showed relatively broad peaks without the sharp 1-hour spikes seen in June 1995.

July 16, 1997 is the 1995-1997 design value day for the 1-hour NAAQS at Longview and therefore important from an attainment demonstration standpoint. This is another stagnation event with a fairly sharp 1-hour ozone peak. Unfortunately, ozone data was missing for a portion of the afternoon of the 16th at Tyler. An instrumented aircraft from Baylor University flew over the area on July 17, potentially providing important information about the three-dimensional structure of the boundary layer during this time that is unavailable for any of the other episodes examined here.

A good example of an easterly ozone episode occurred on September 2-3, 1998 with a 1-hour exceedance on the 3rd and 8-hour exceedances on both days at both Longview and Tyler. As with the August 27-29, 1998 event, these two days were characterized by broad ozone peaks. Trajectories for both days showed parcels arriving at Longview in the afternoon originating to the northeast although travel distances were much shorter on the 2nd compared to the 3rd.

References

EPA, 1991. Guideline for the regulatory application of the Urban Airshed Model. U.S. Environmental Protection Agency, EPA-450/4-91-013, July 1991.

EPA, 1996. Guidance on the use of model results to demonstrate attainment of the ozone NAAQS. U.S. Environmental Protection Agency, EPA-454/B-95-007, June 1996.

Table 1. 1-Hour ozone NAAQS exceedance days at Longview and Tyler (1995 - 1998) and associated 8-hour exceedance days (1997-1998 only). Exceedances are shown in bold.

	Max 1-Hour O3 (ppm)		Max 8-Hour O3 (ppm)		
	Longview	Tyler	Longview	Tyler	
6/20/95	**.145**	.109	**.110**[1]		Stagnation conditions 6/20 - 6/23 with light SW winds 6/23; 10:00 ozone spike at Longview on 6/20.
6/21/95	.108	.100	**.101**[1]		
6/22/95	.120	.097	**.102**[1]		
6/23/95	**.145**	.096	**.103**[1]		
7/18/95	**.144**	.073	.081[1]		Easterly event; trajectories show afternoon parcels arriving from the NE
5/29/98	**.142**	--	**.112**	--	Possible influence of smoke from Mexico wildland fires; surface winds from the SW.
7/16/97	**.139**	--	**.087**	--	Stagnation conditions; 1-hour design value day for Longview (1995-1997); unusually low 8-hour max to 1-hour max ratio 7/16.
7/17/97	.104	.083	**.091**	.073	
7/18/97	.117		**.103**	.085	
7/7/95	**.130**	.077	.081[1]		Stagnation conditions.
6/15/98	**.129**	.098	**.100**	.086	Unusually windy (WNW at Longview) for exceedance day; strong zonal flow aloft.
8/16/98	**.127**	.085	**.088**	.077	Easterlies; sharp 1-hour peak at Longview.
8/26/98	.108	.075	**.085**	.068	Primarily stagnation event with light northerlies on 8/29; Some showers on 28th and 29th; 28th ozone peak corresponds to 1996-1998 1-hour design value; broad ozone peaks 8/28 (high 8-hr max to 1-hr max ratios)
8/27/98	.119	.093	**.104**	.084	
8/28/98	**.129**	.096	**.114**	.087	
8/29/98	.123	.093	**.096**	.083	
9/2/98	.089	.109	**.086**	**.099**	Easterlies; broad ozone peaks 9/3.
9/3/98	**.126**	.100	**.107**	.091	

[1]Maximum of values at Longview and Tyler assumed to have occurred at Longview.

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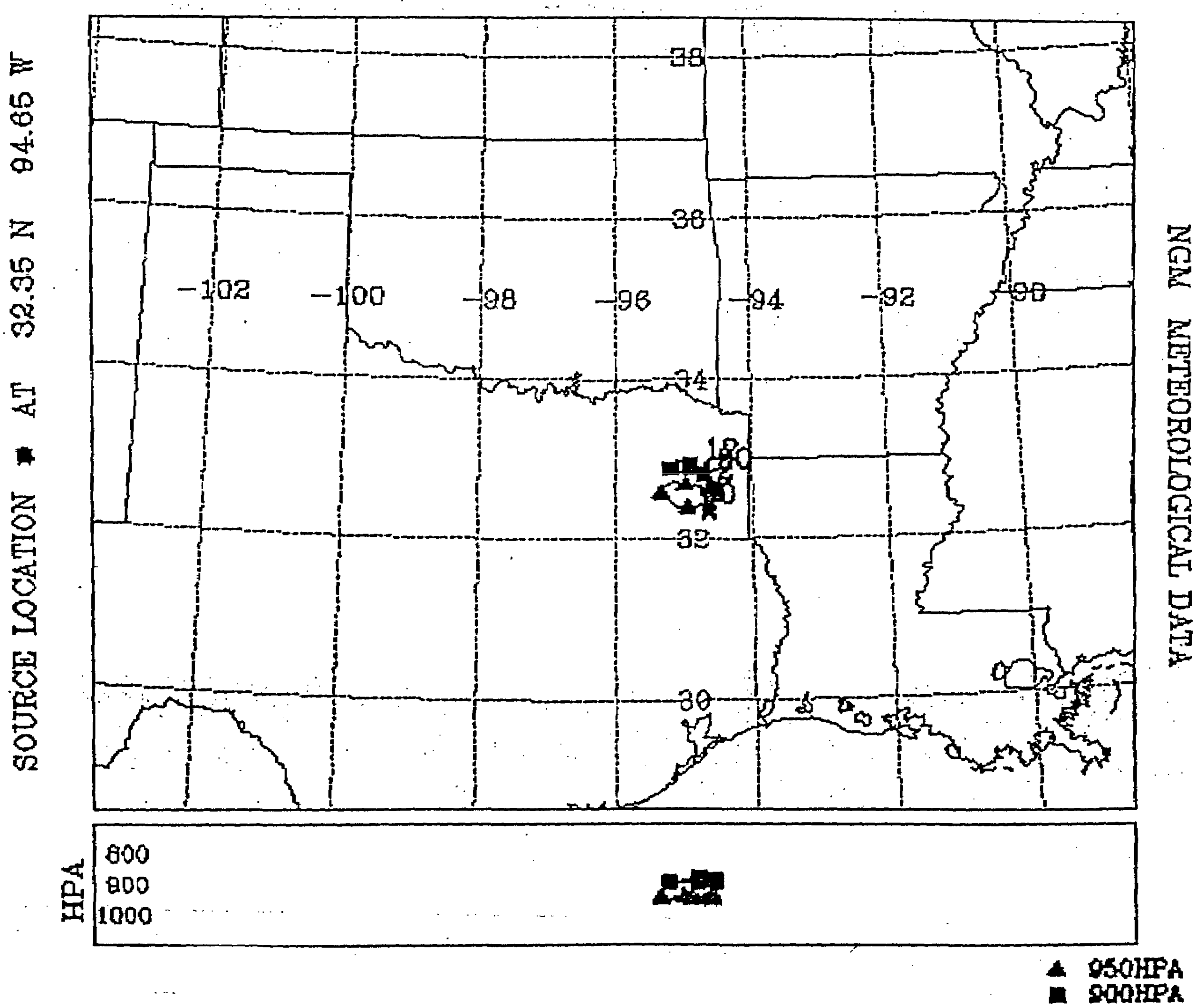

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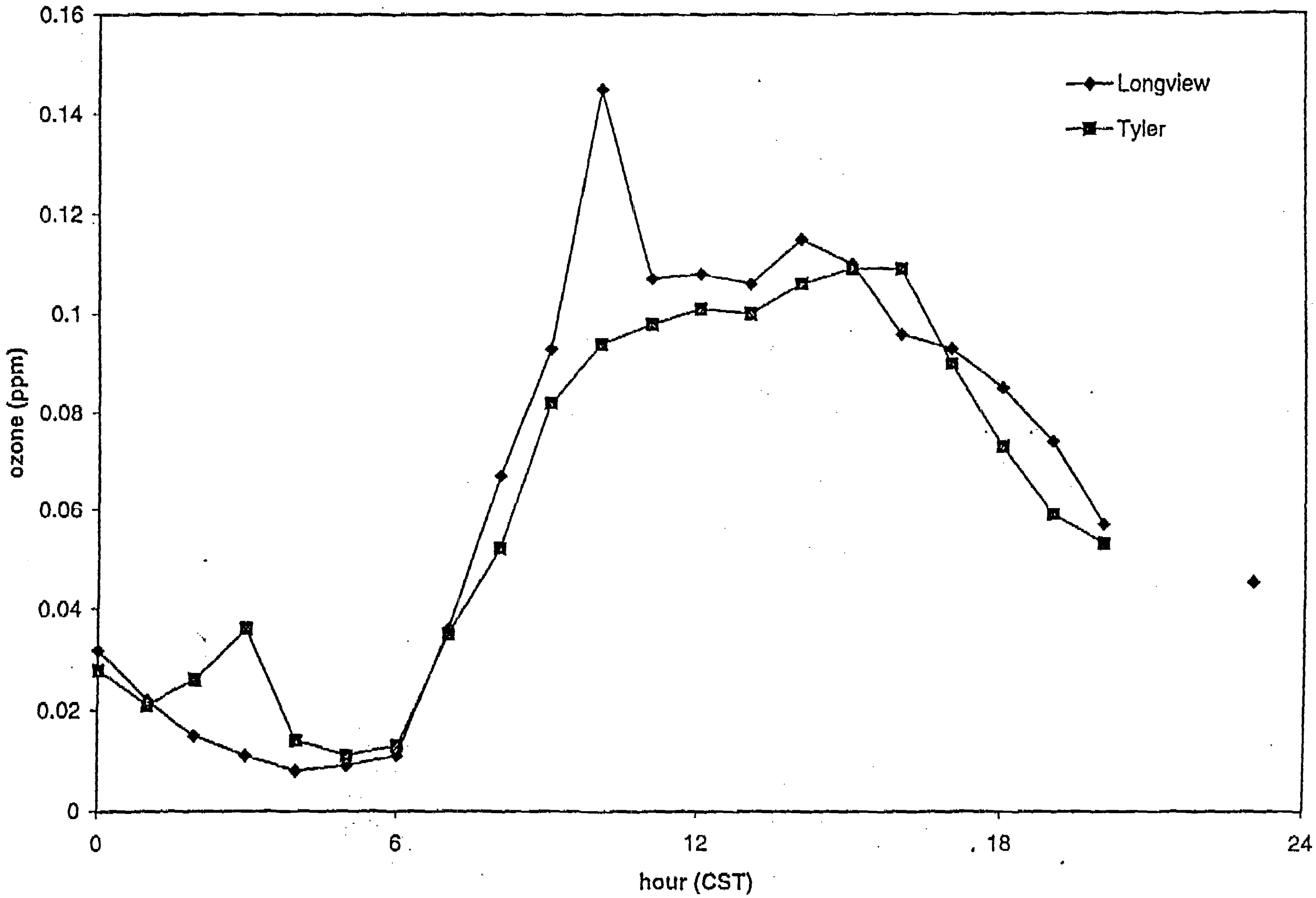
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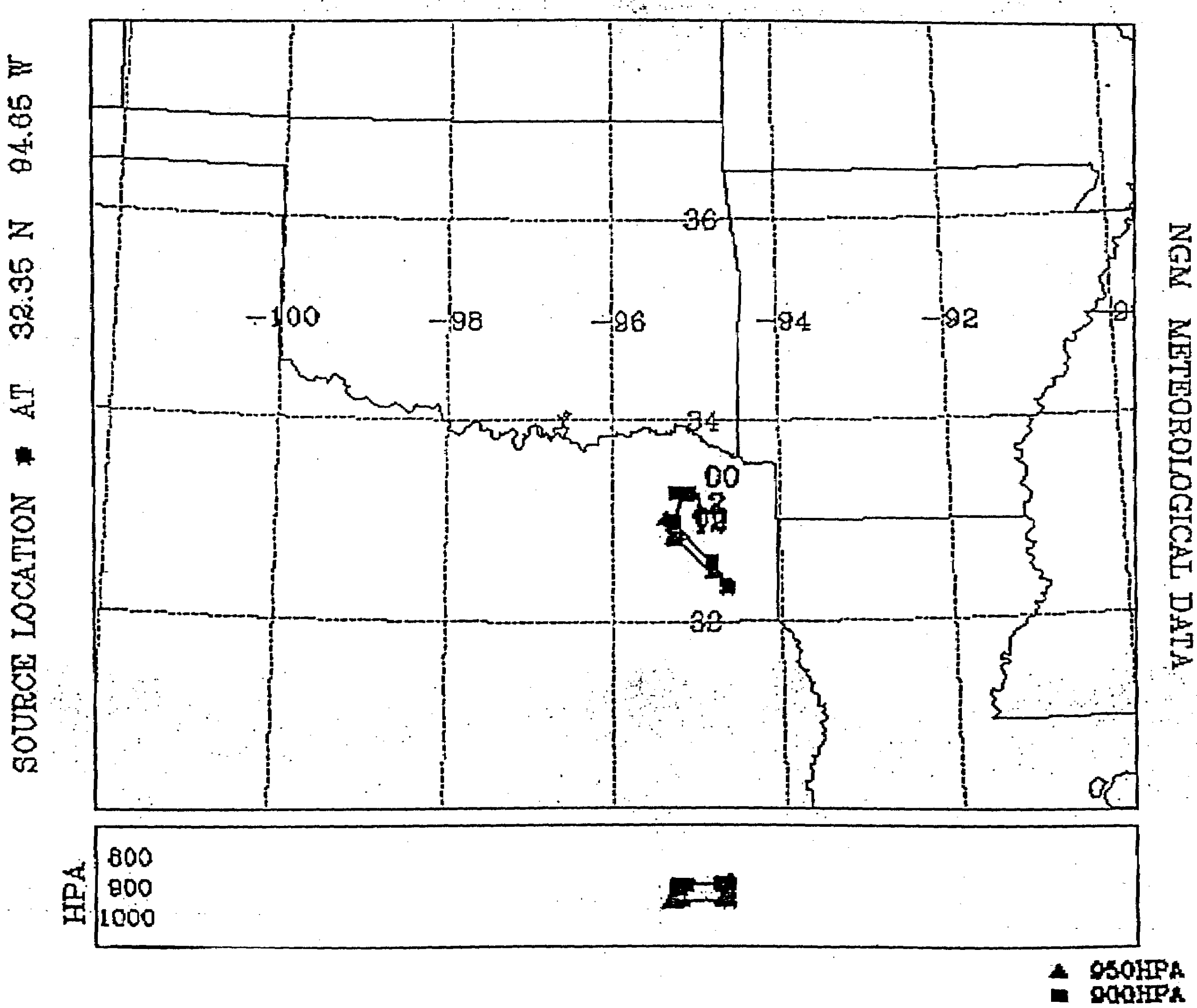

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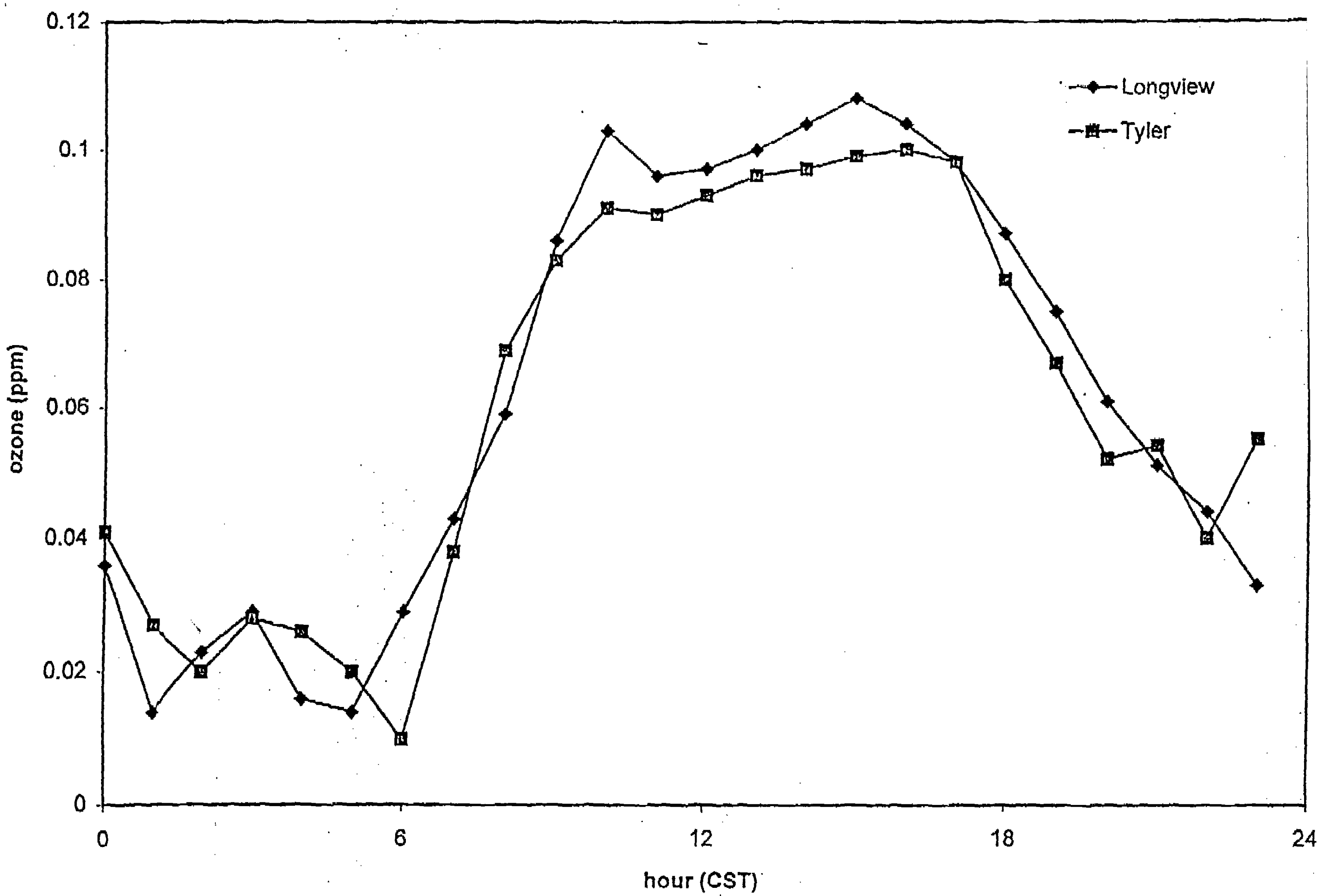

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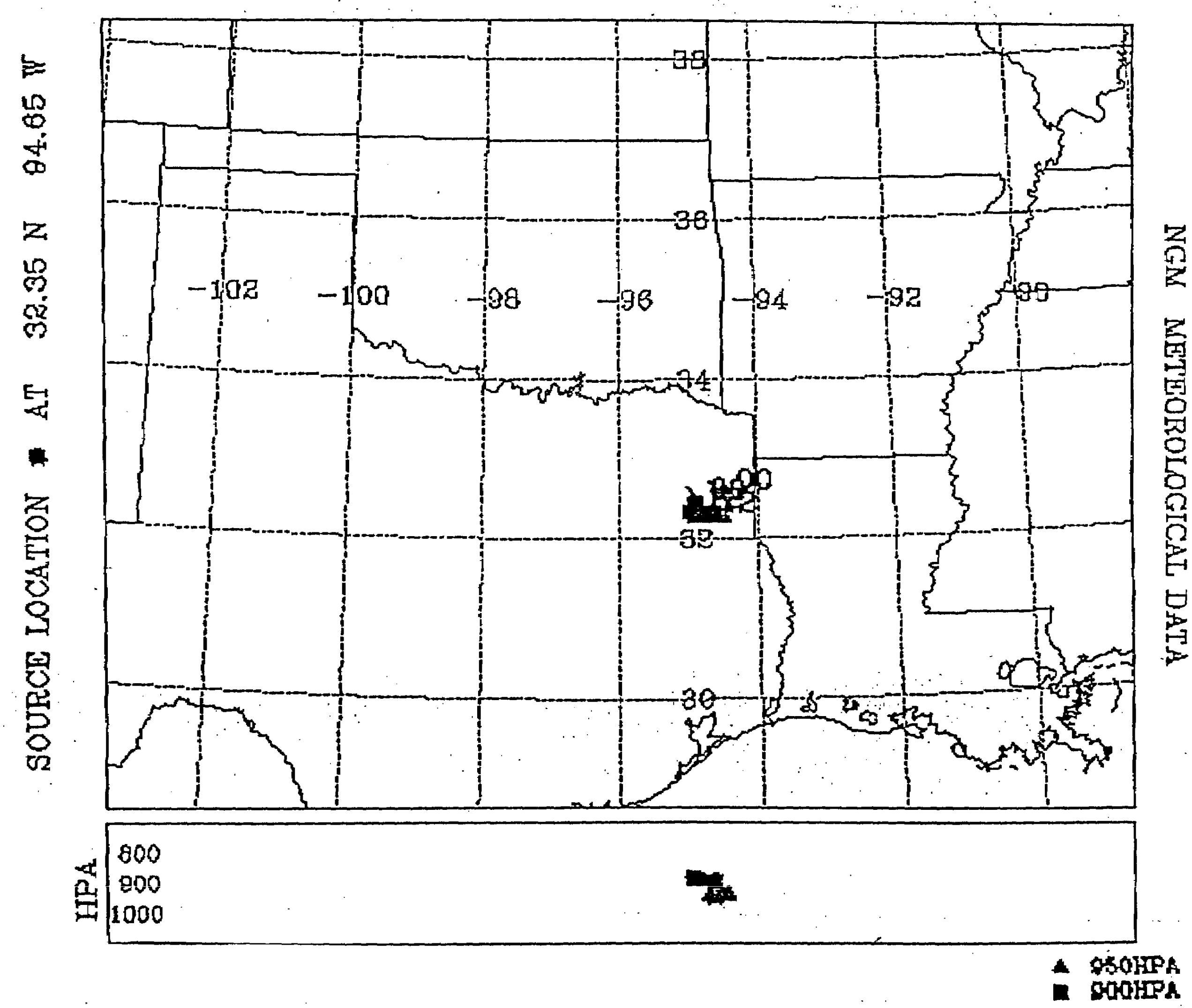

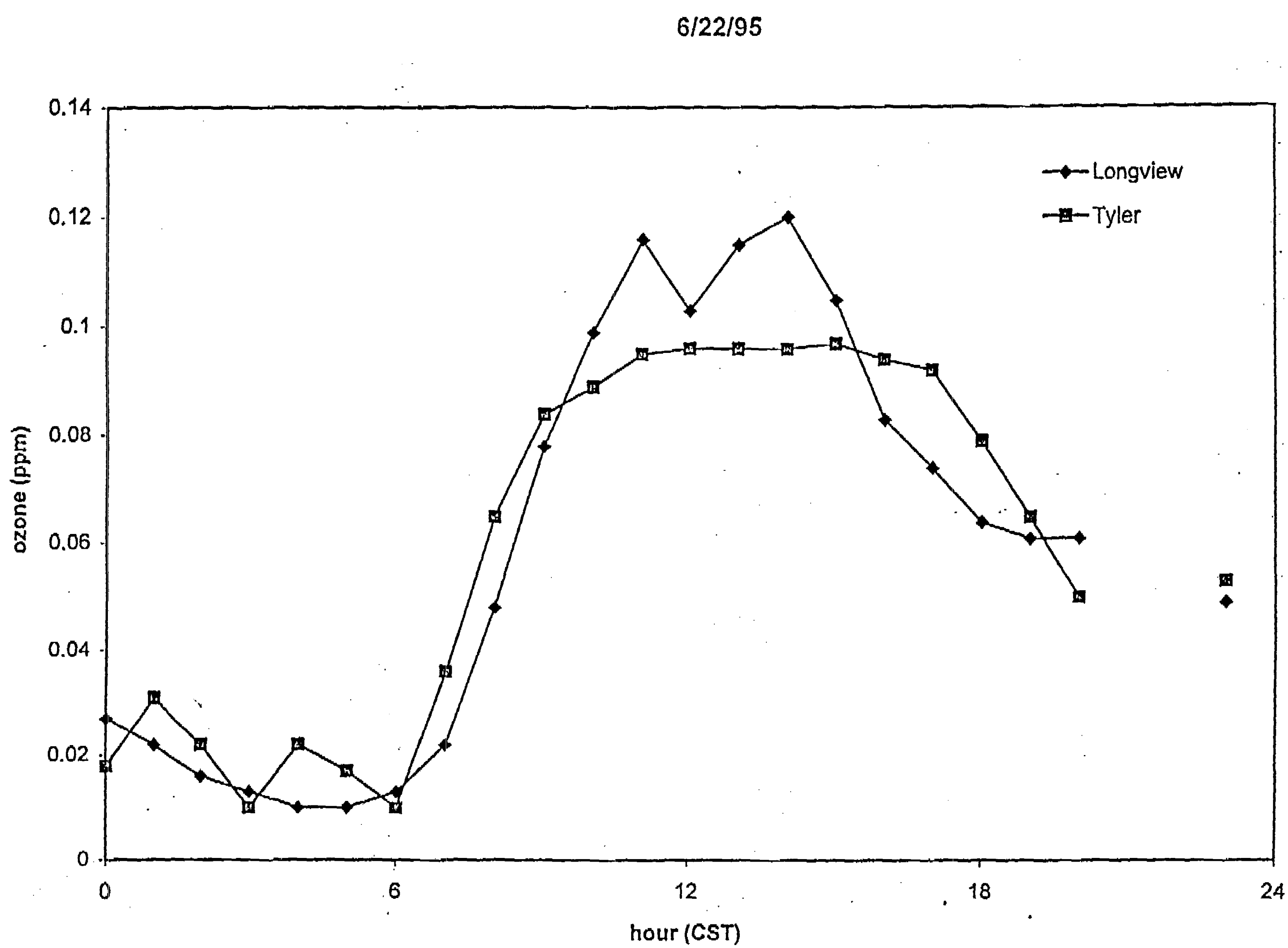
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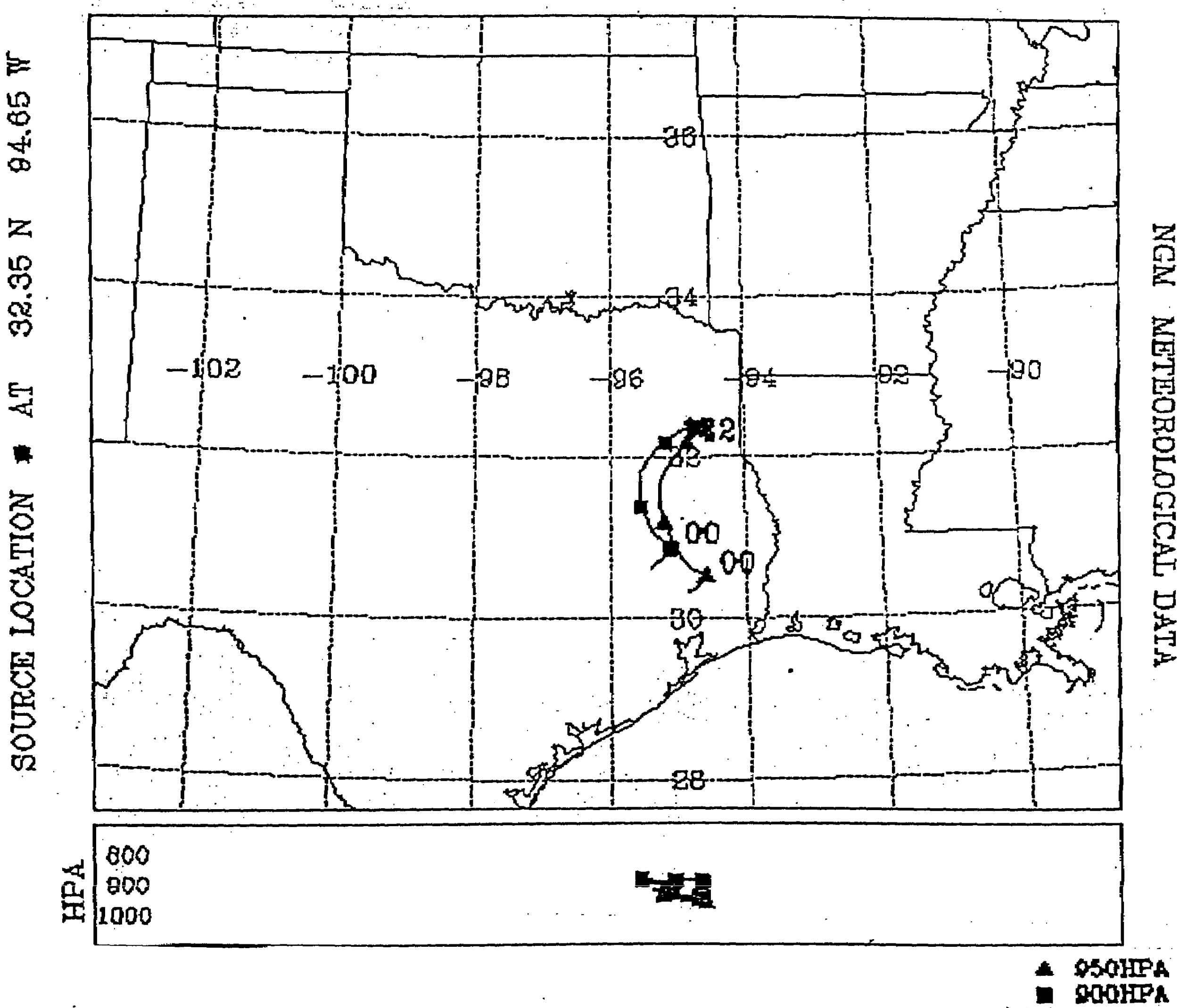

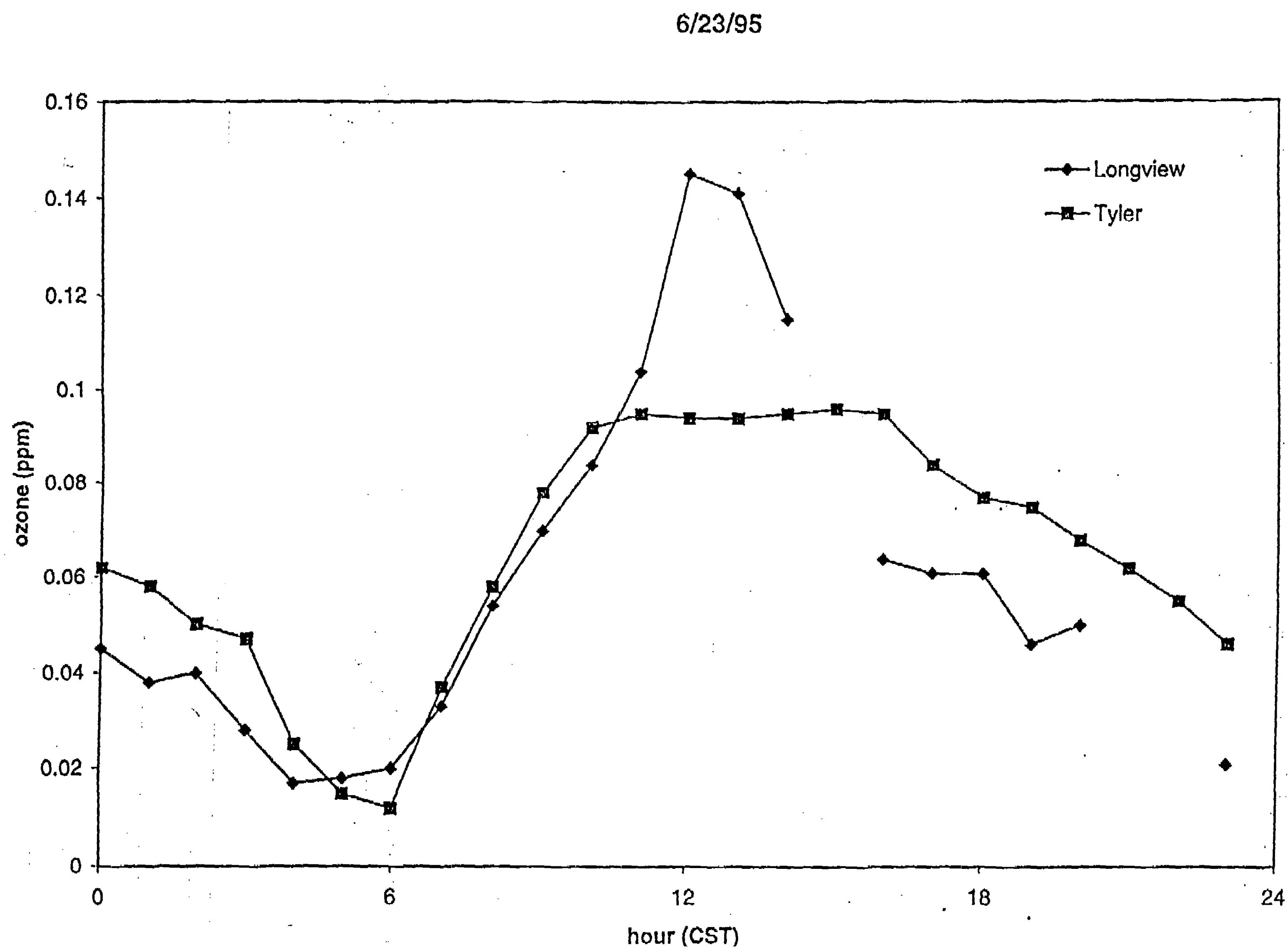

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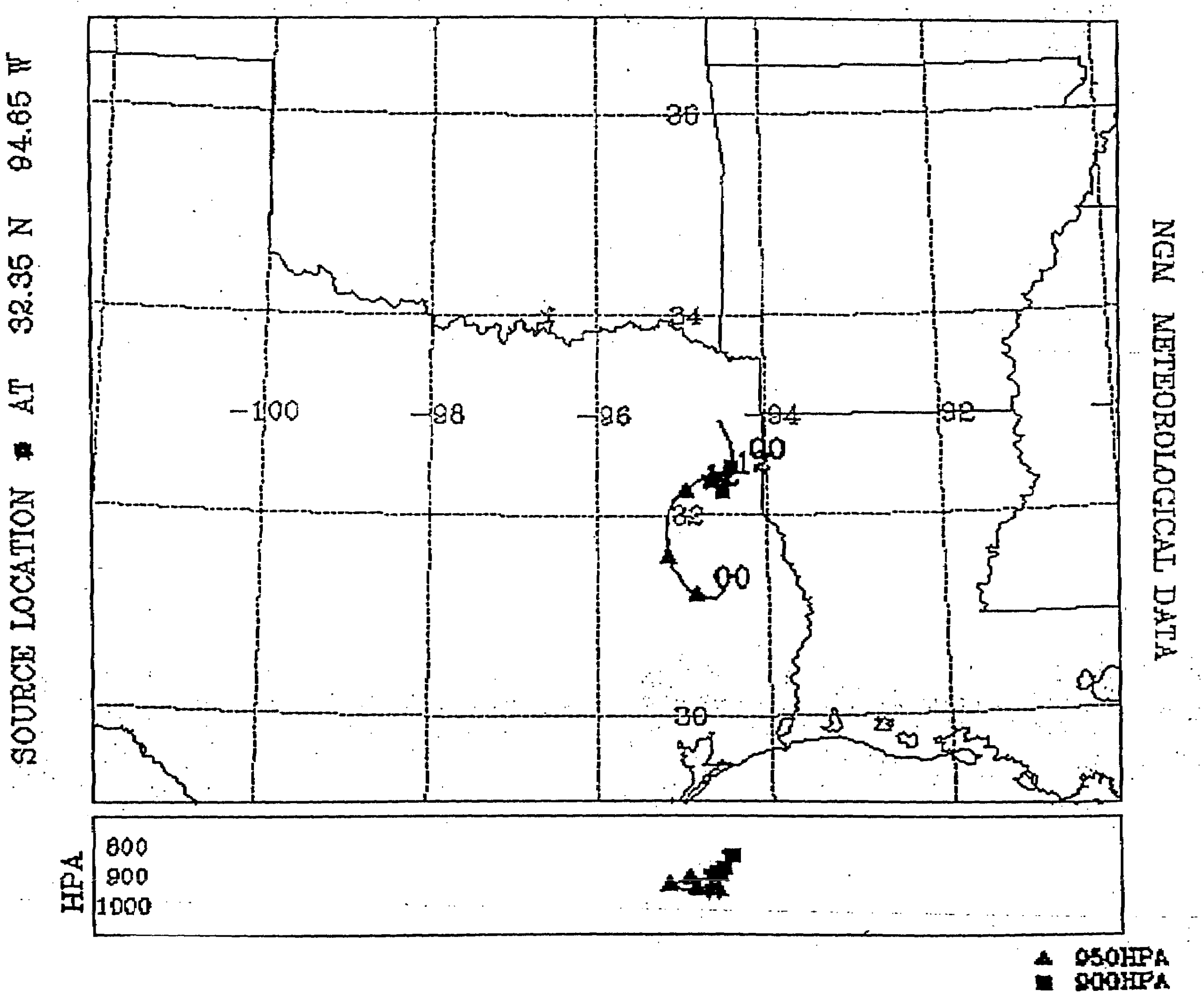

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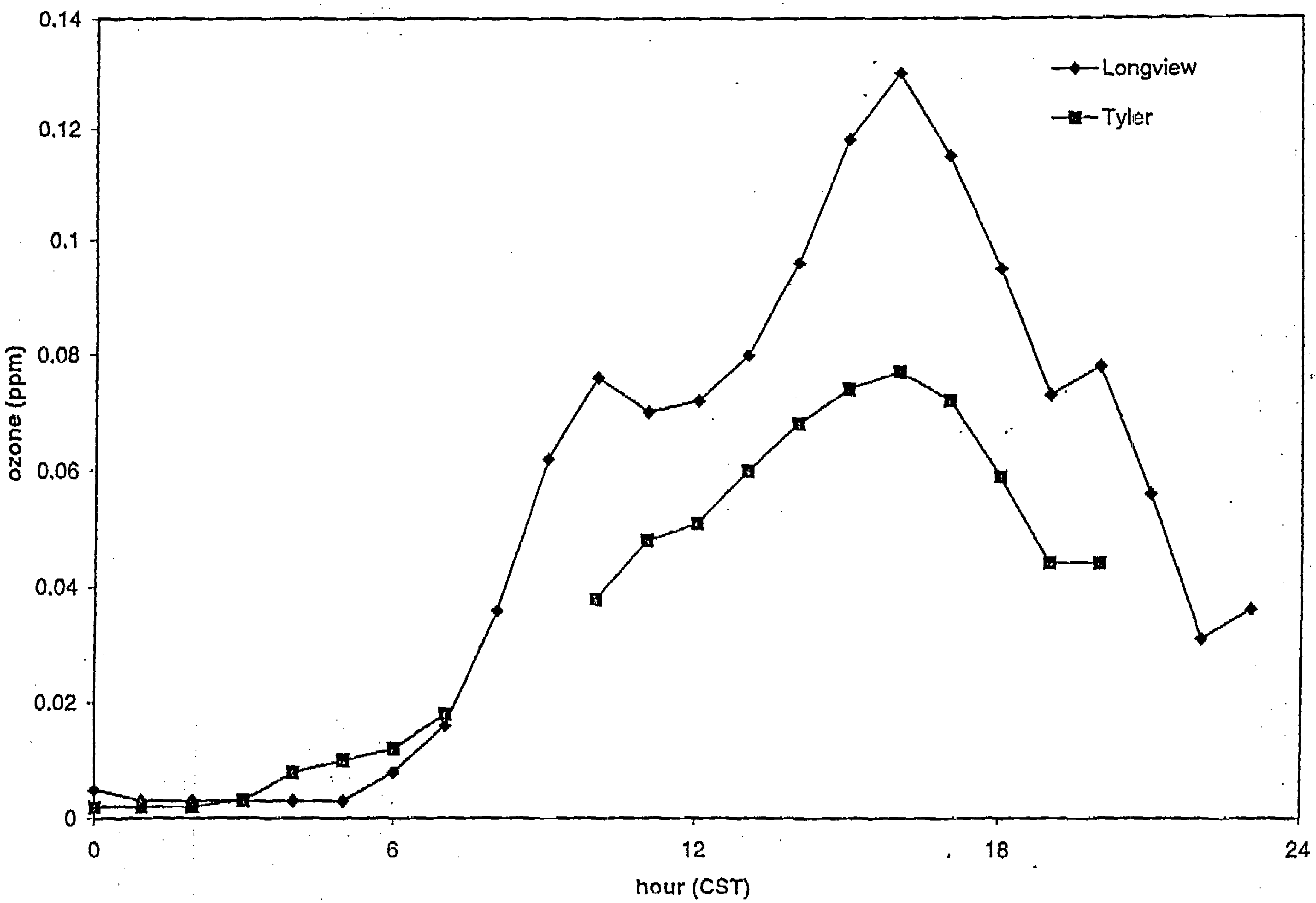
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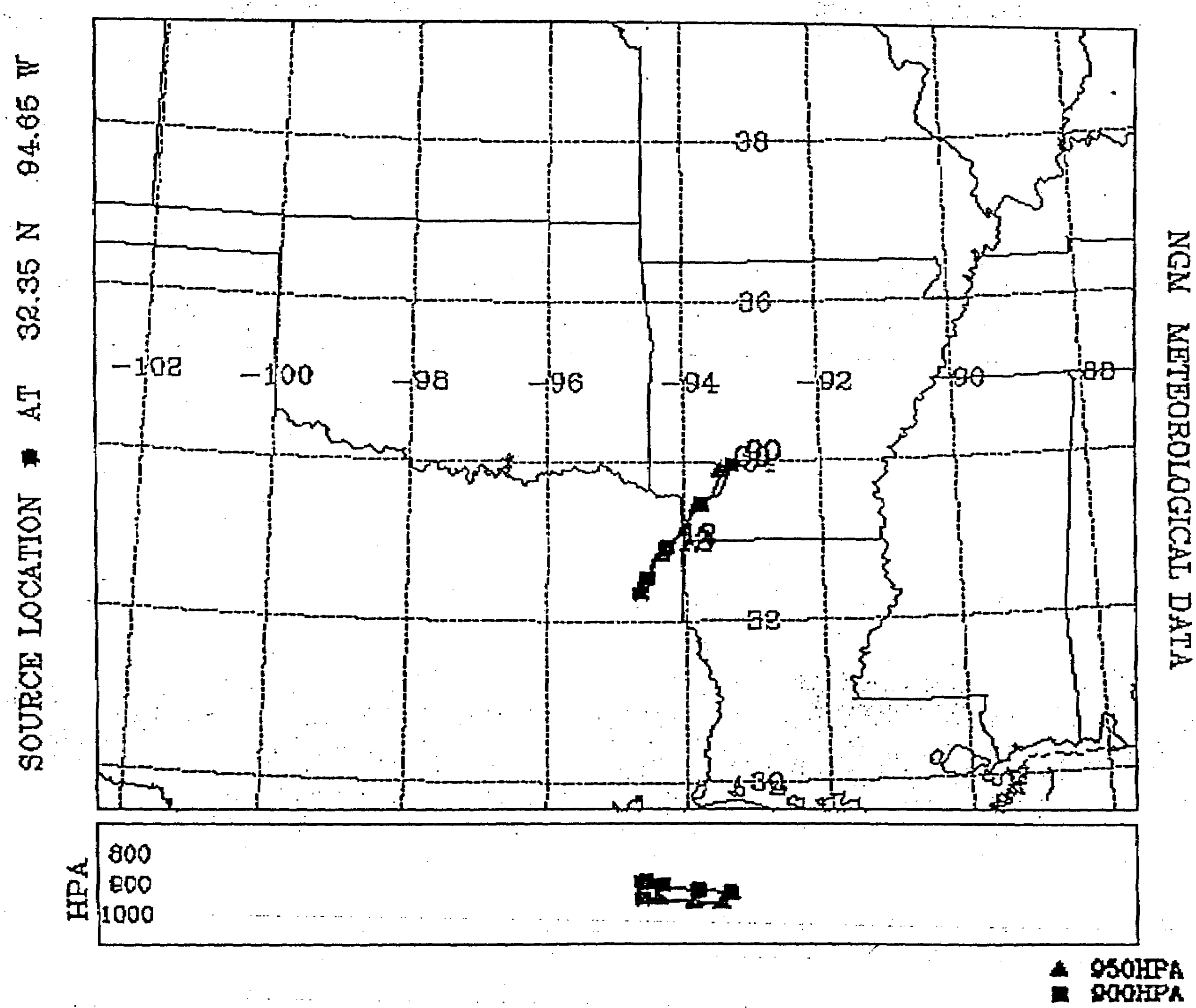

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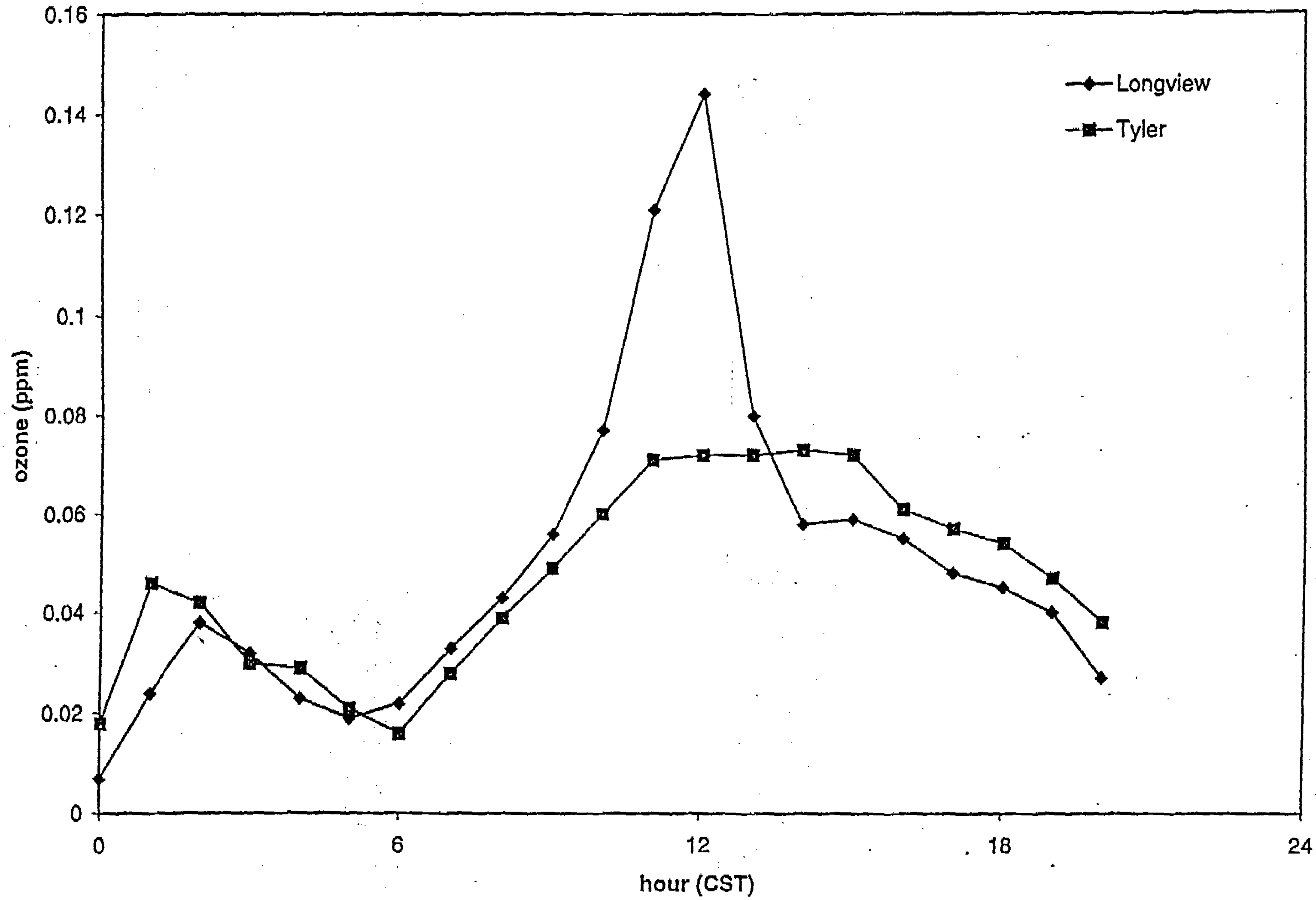

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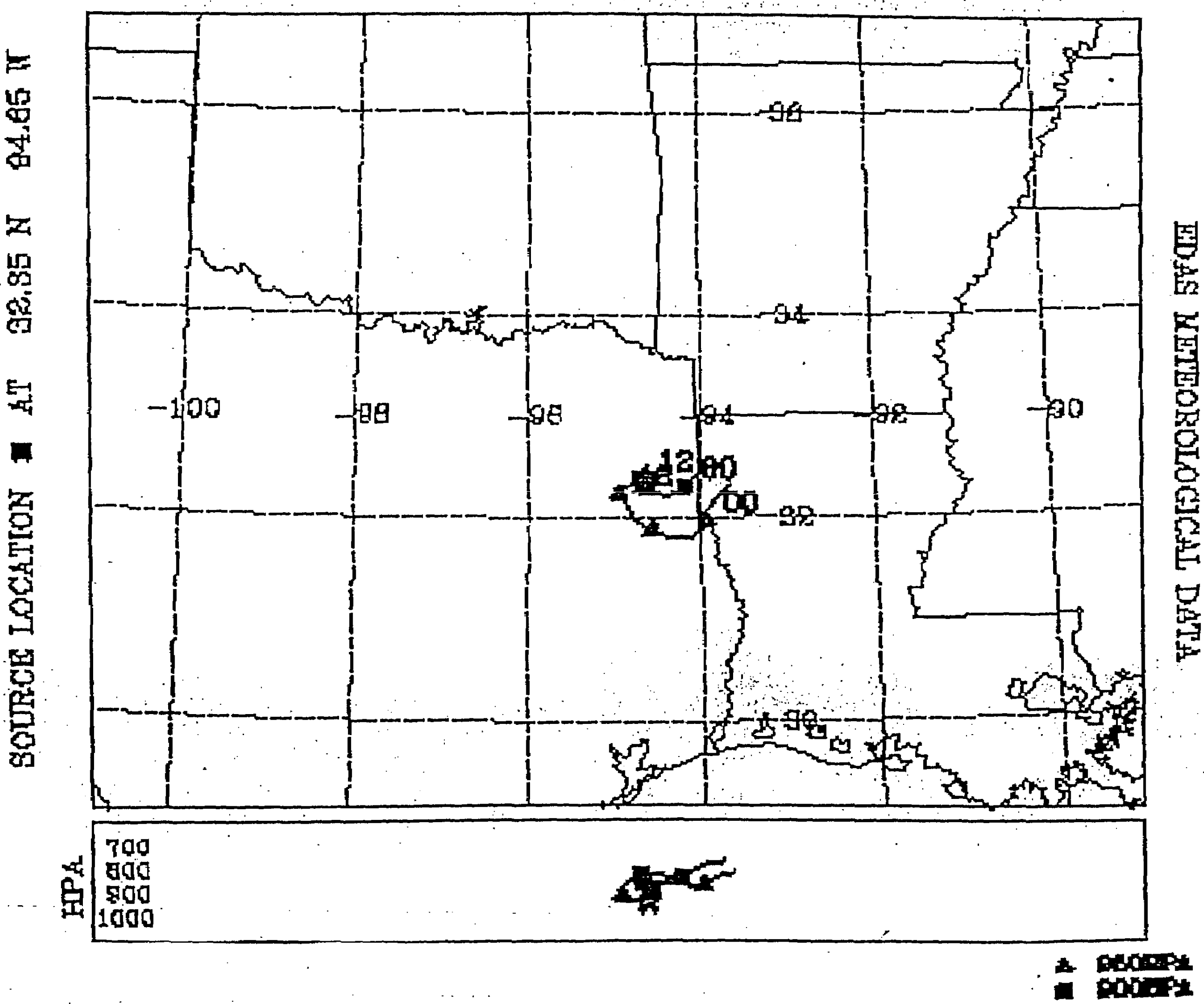

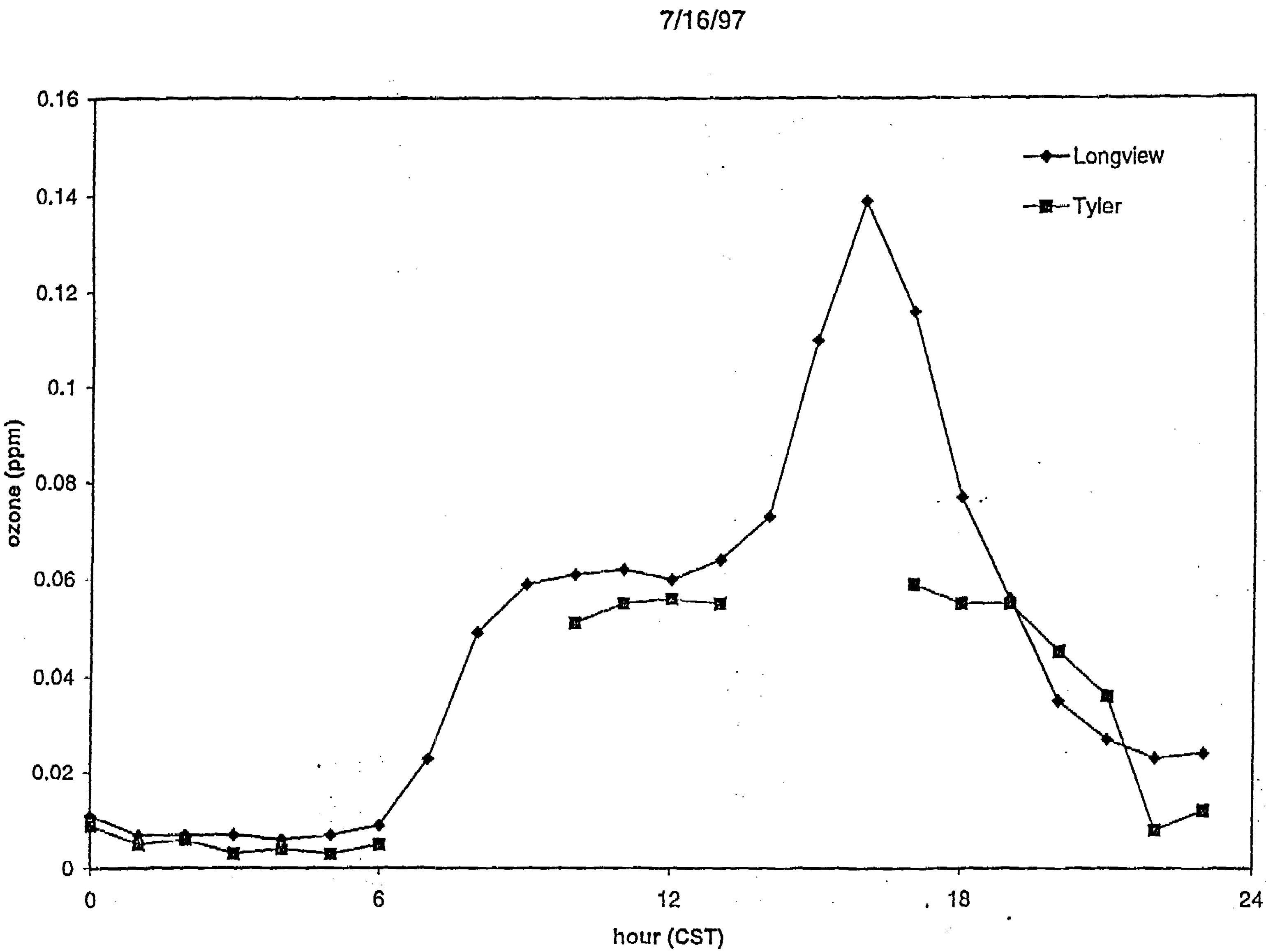
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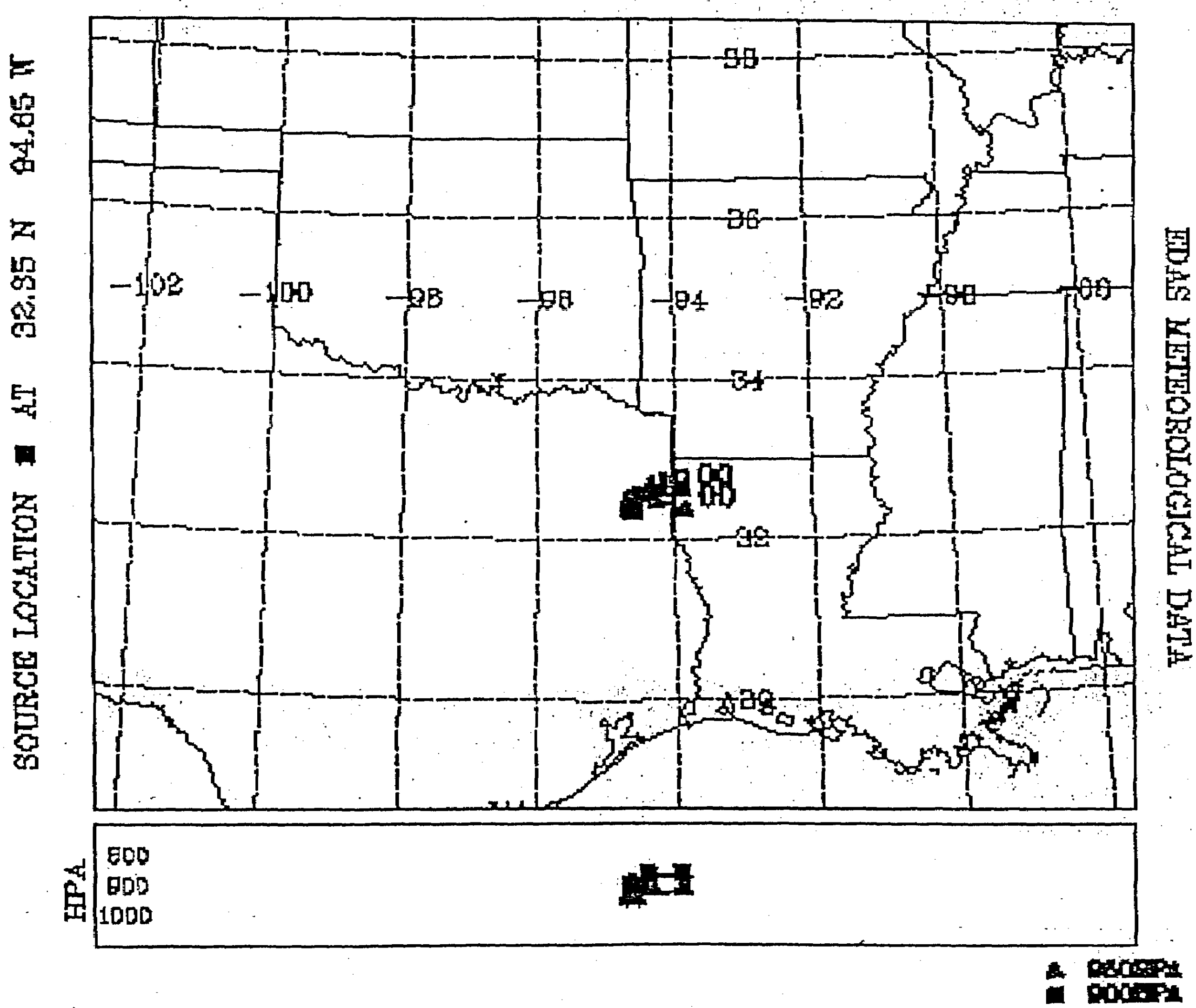

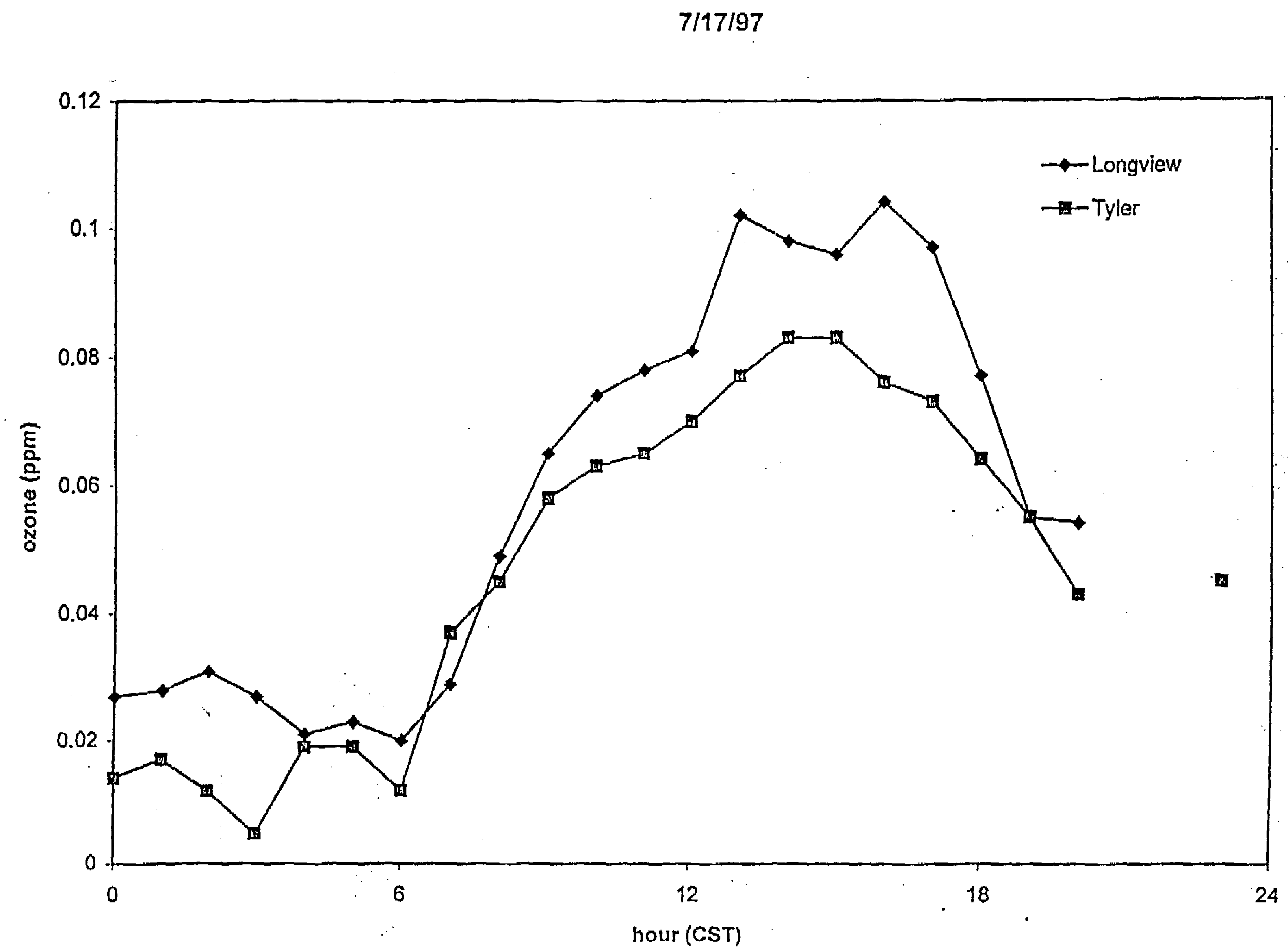
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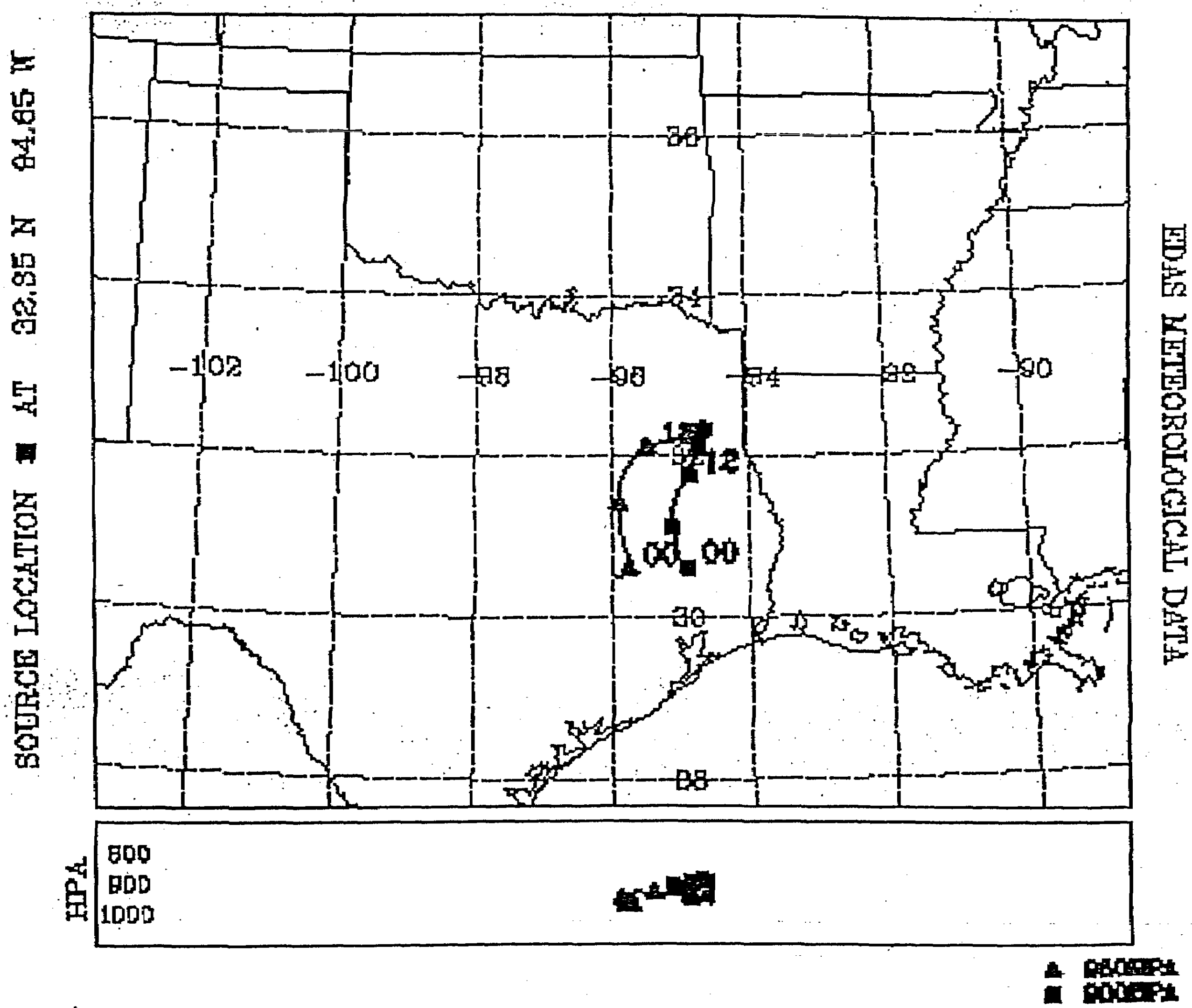

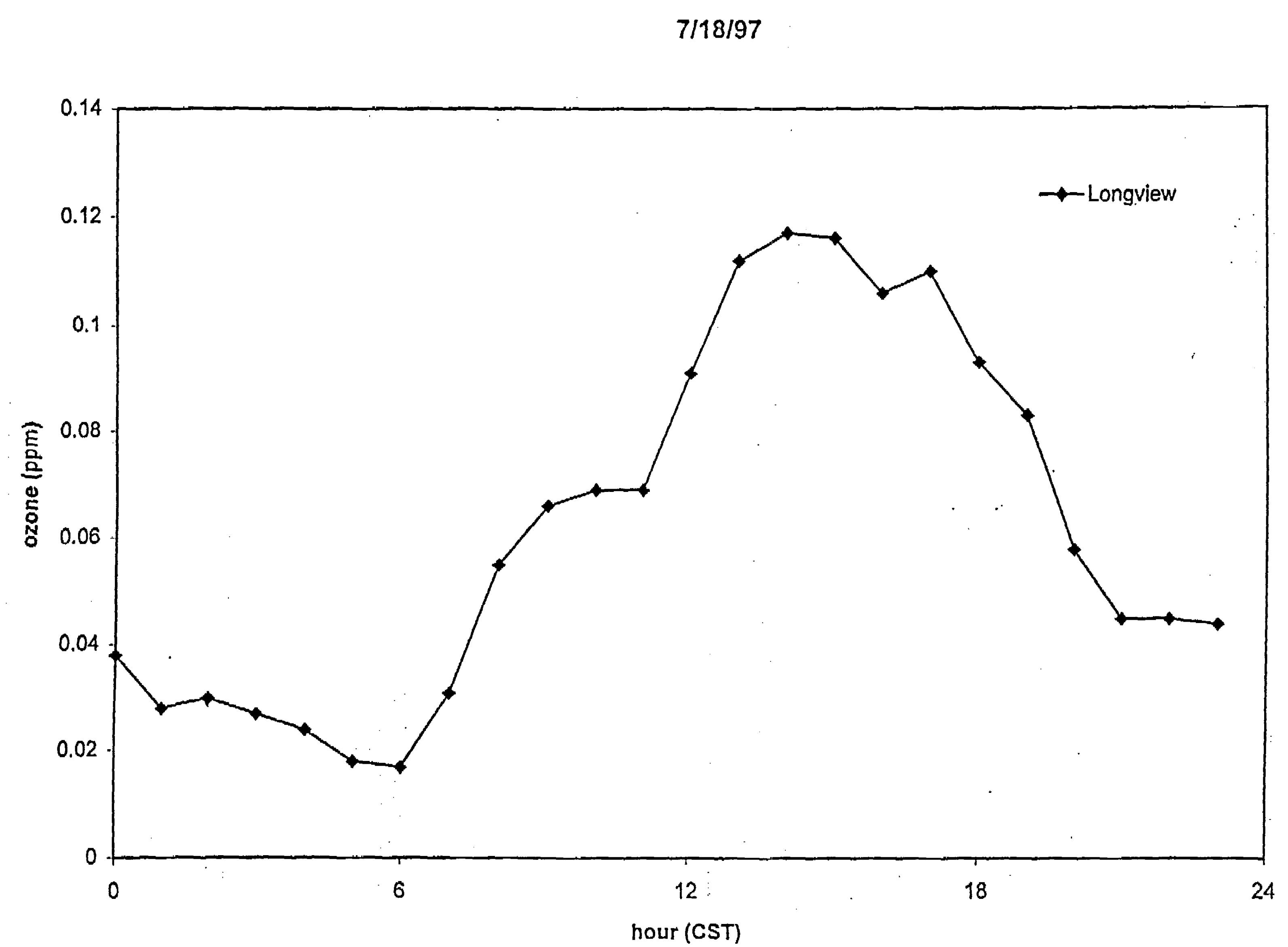
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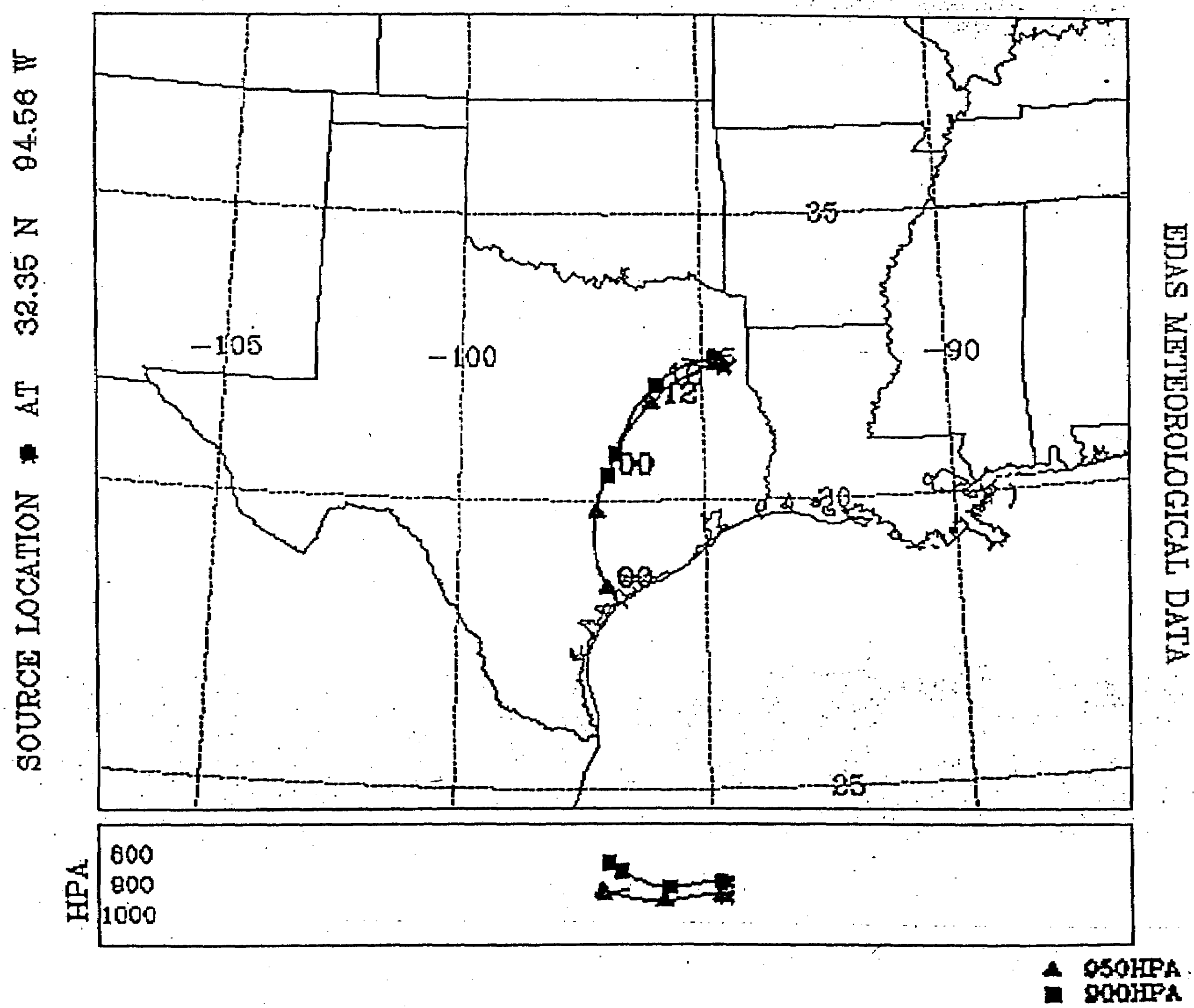

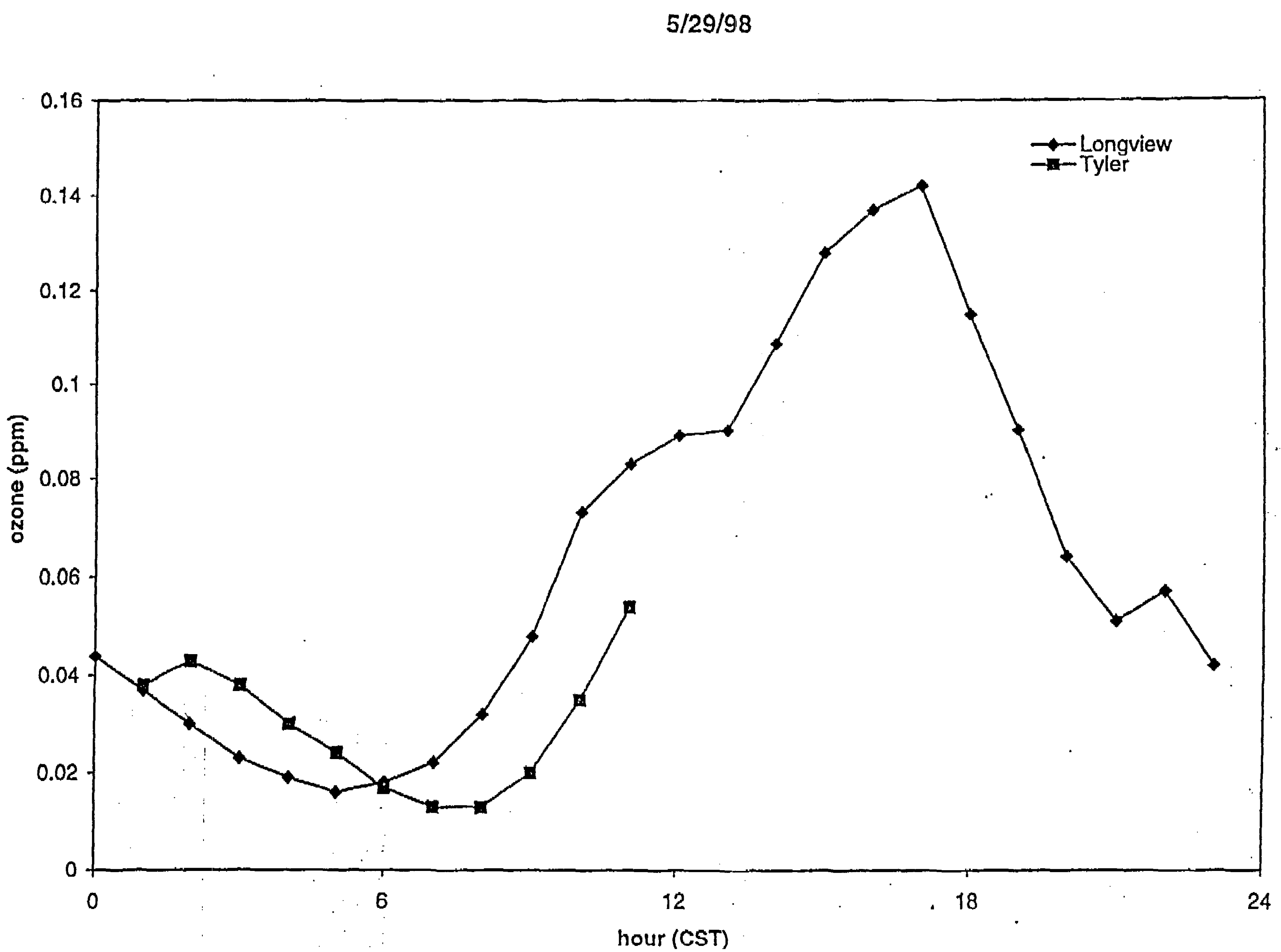
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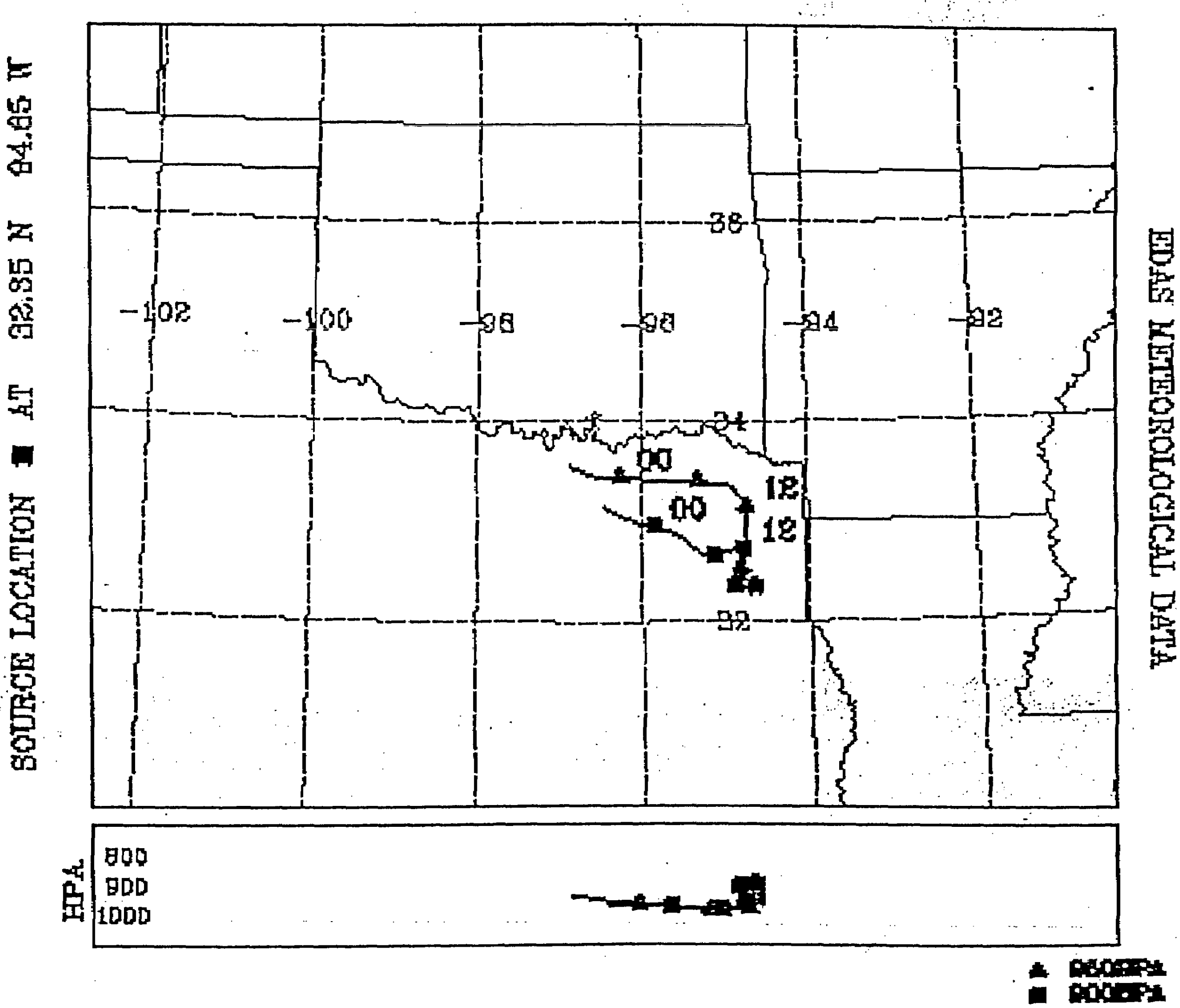

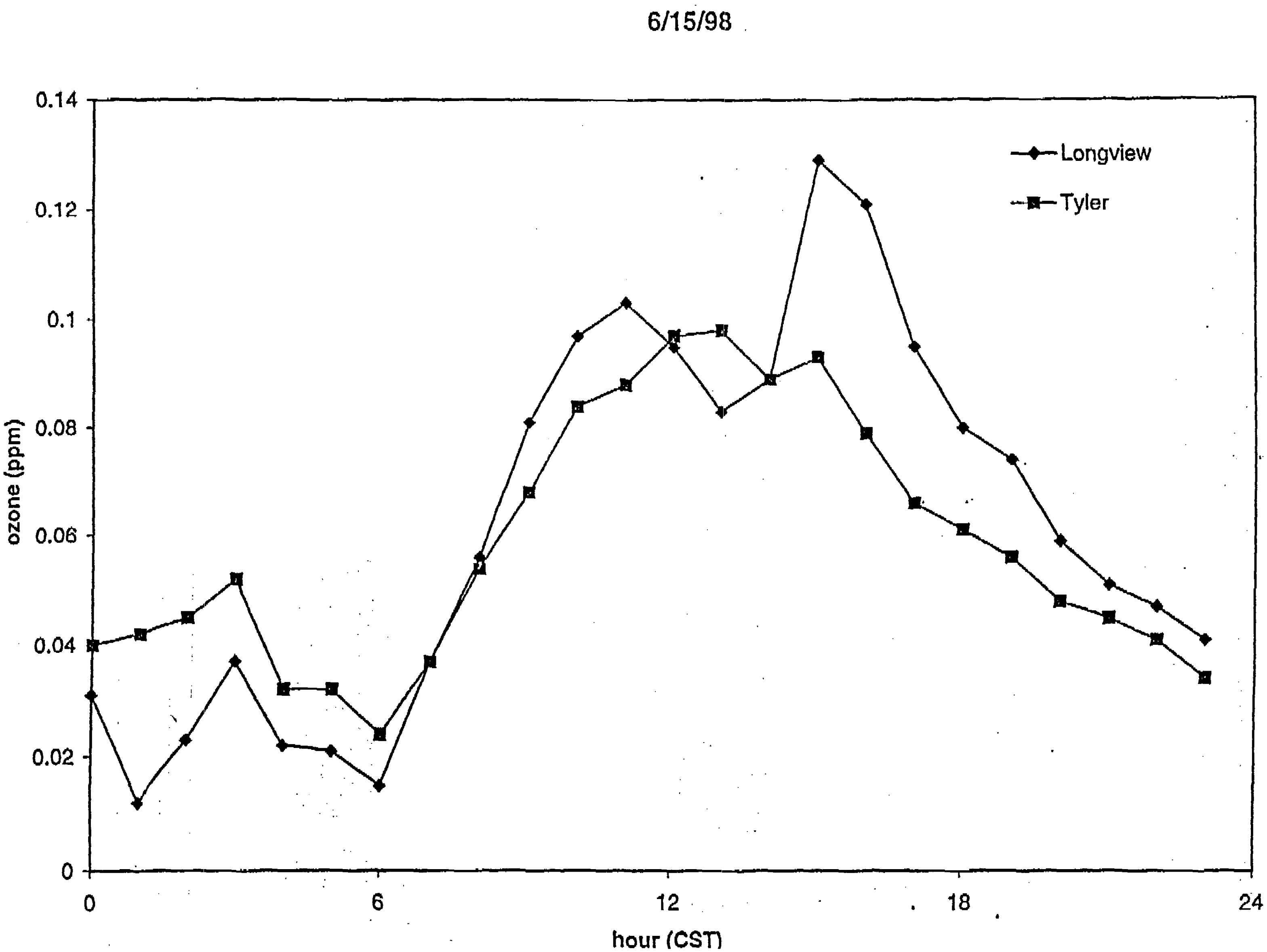
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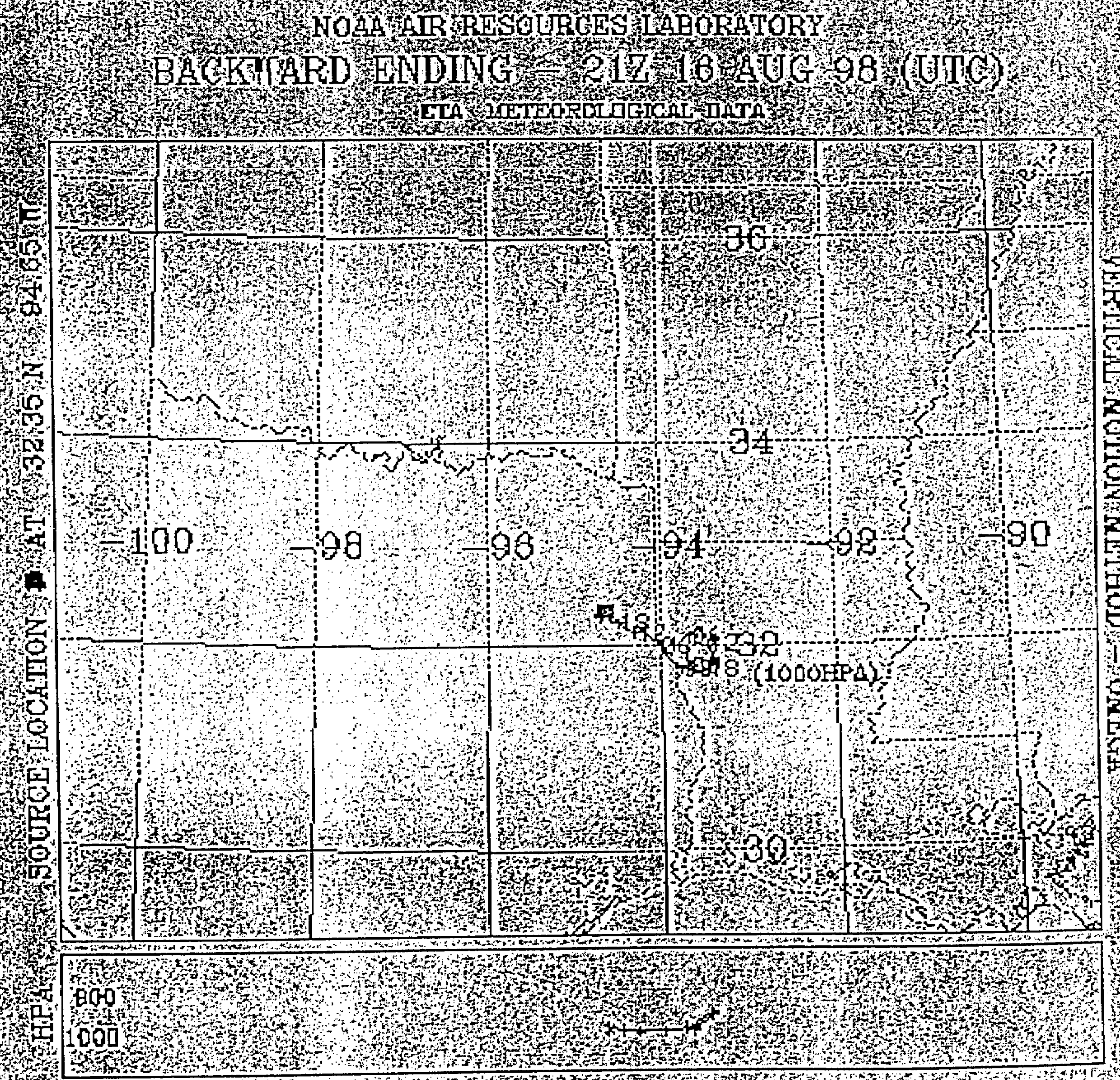
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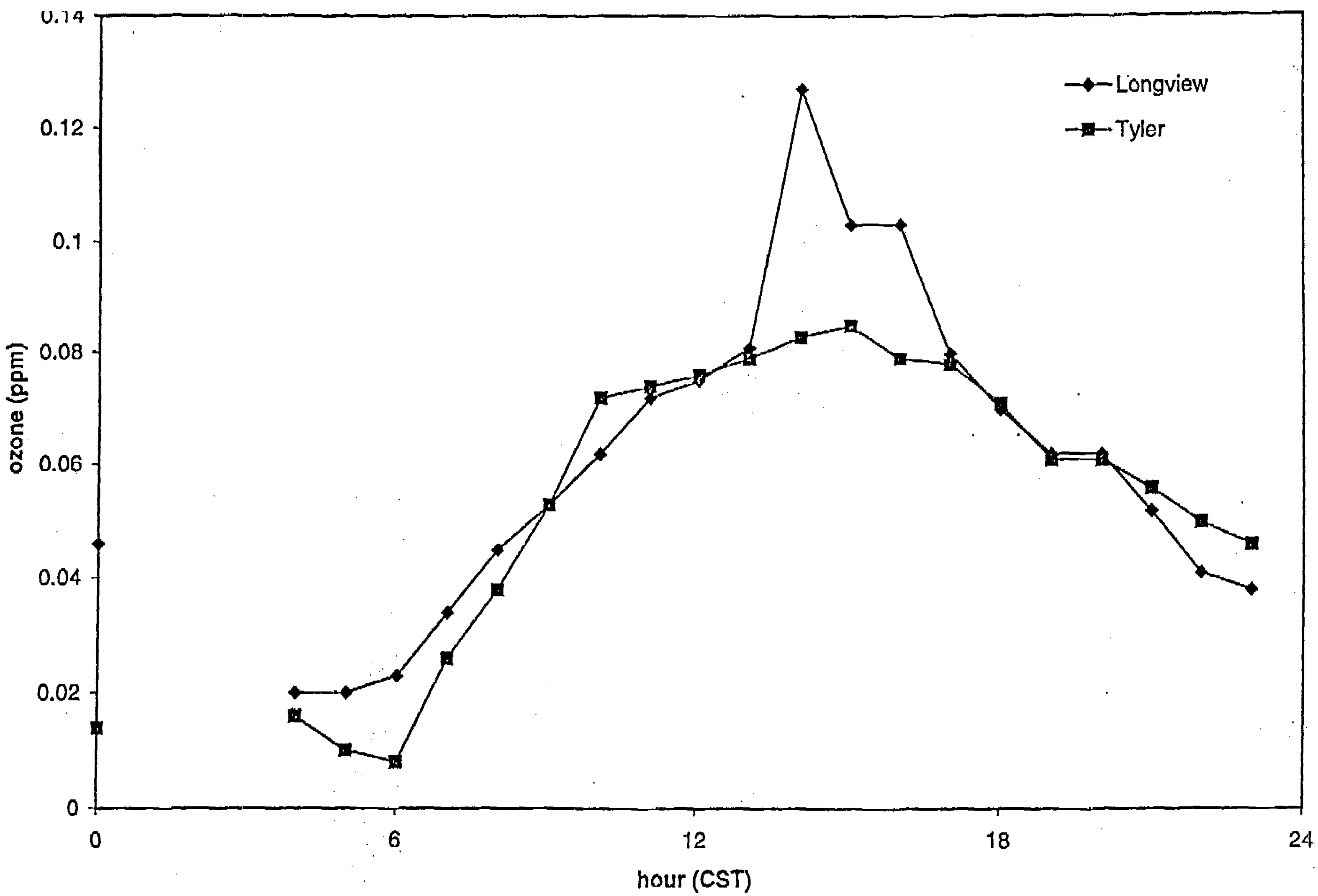

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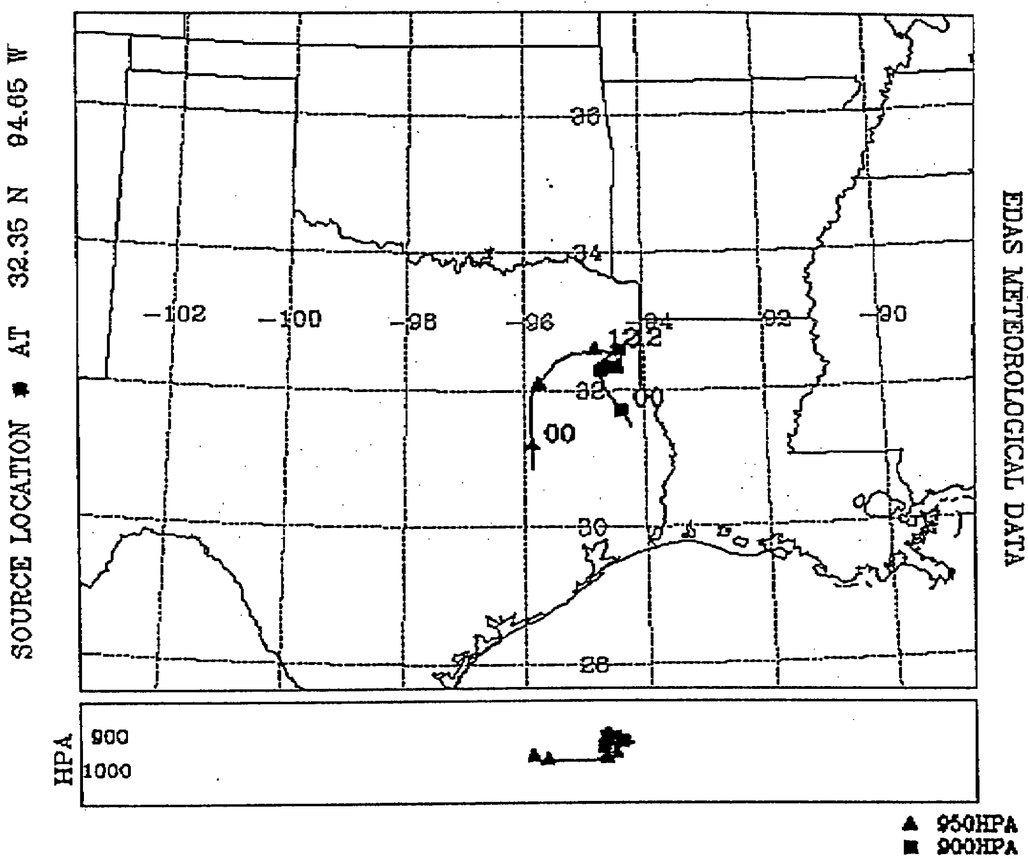

NOAA AIR RESOURCES LABORATORY

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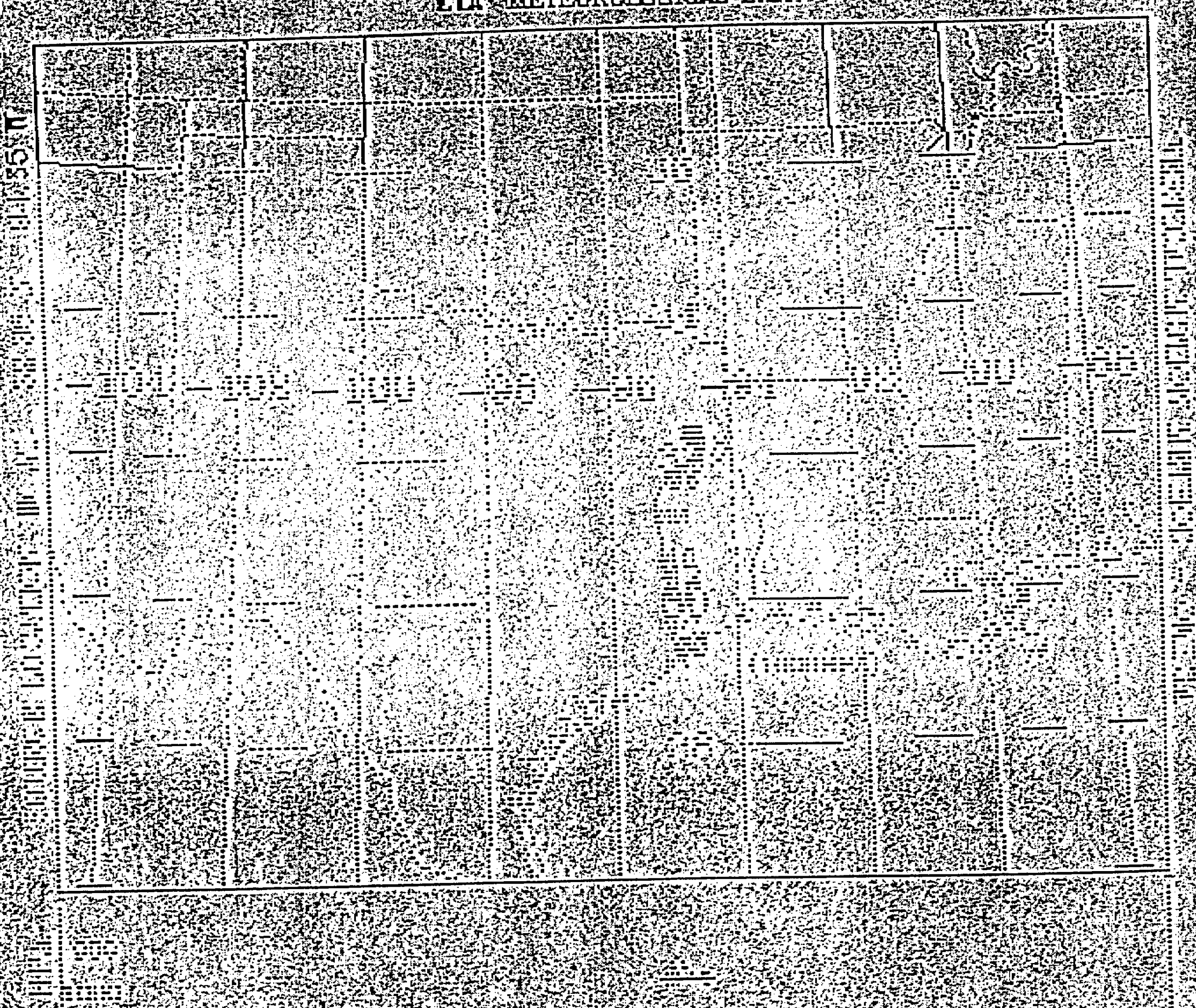

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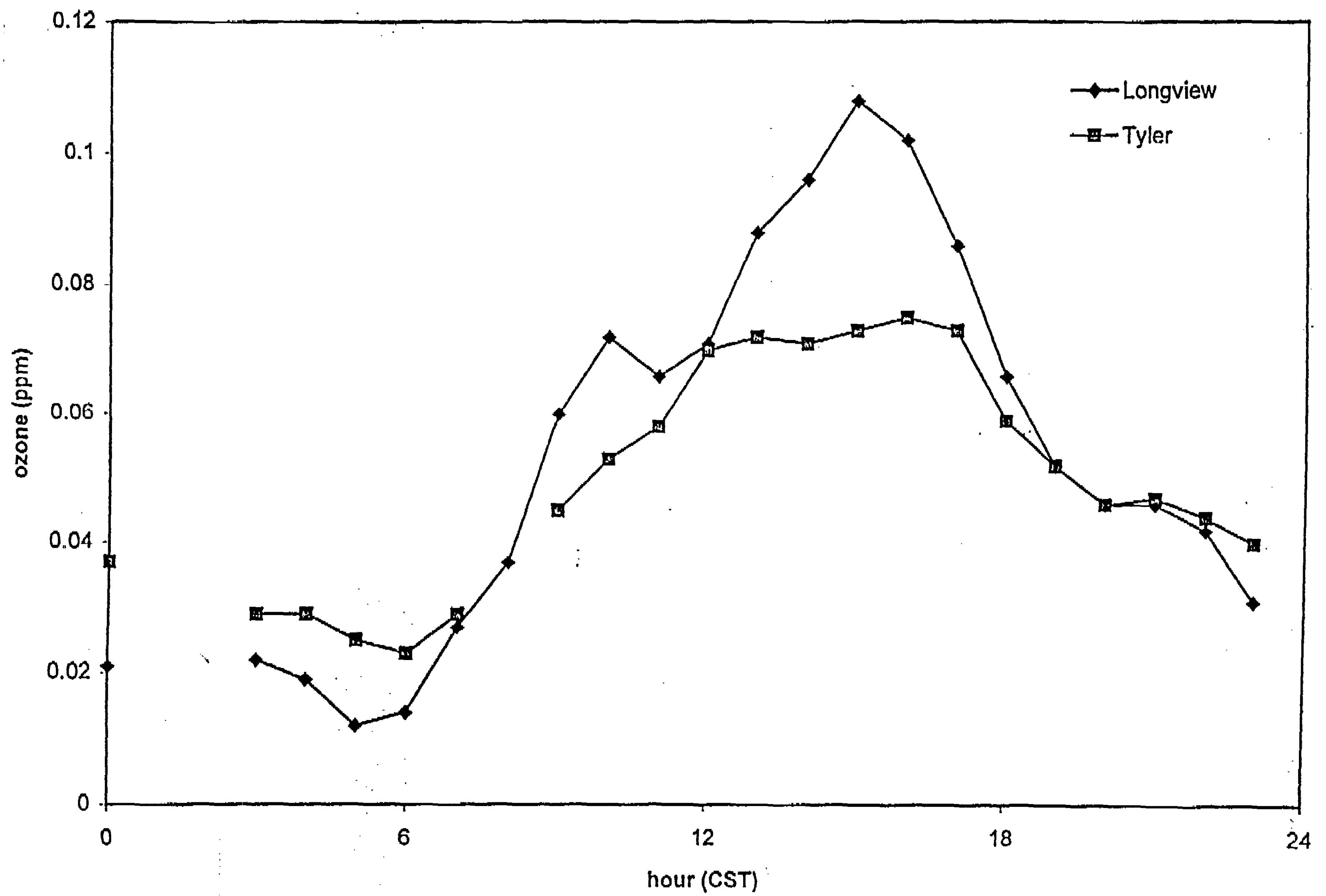

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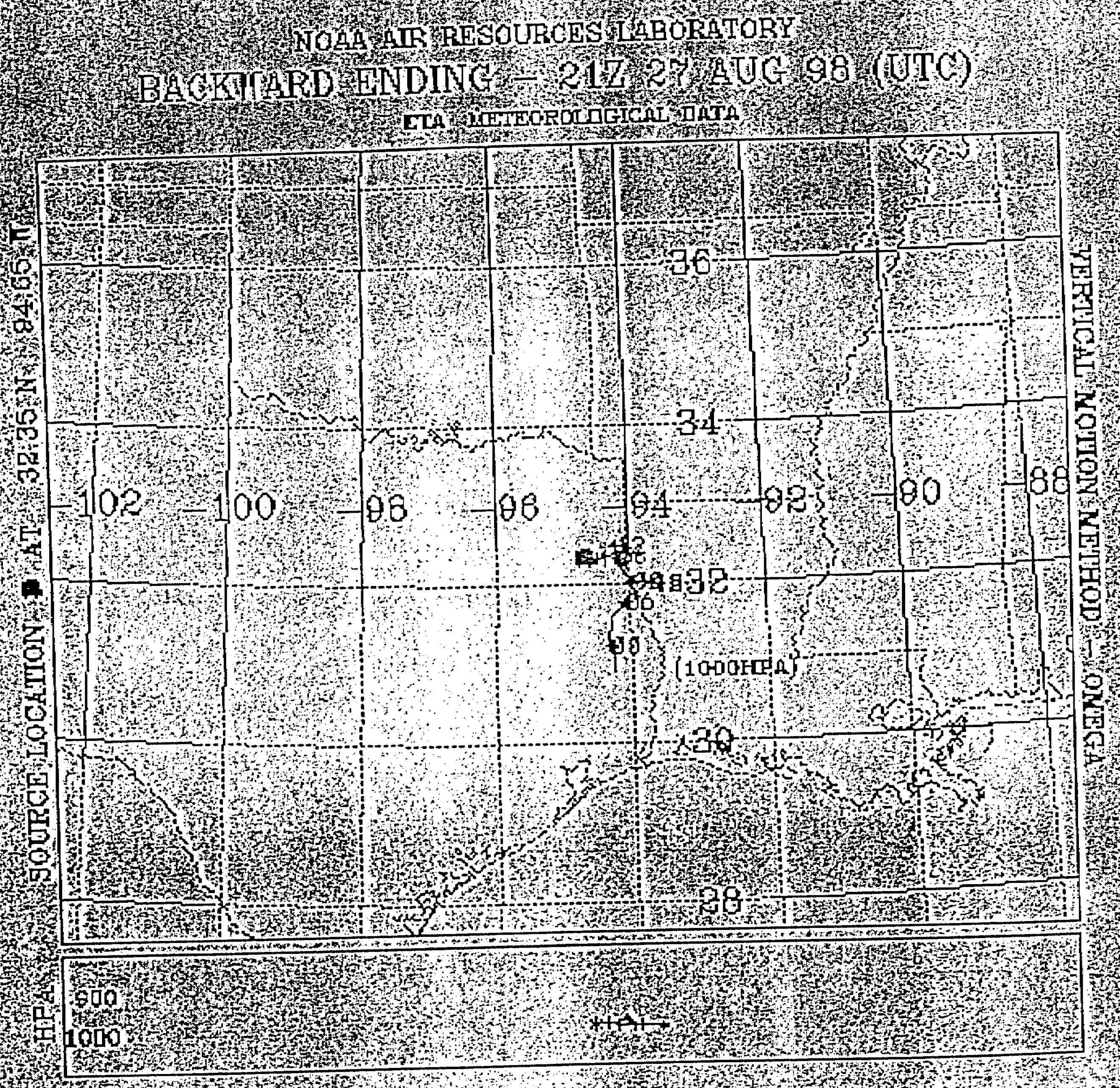
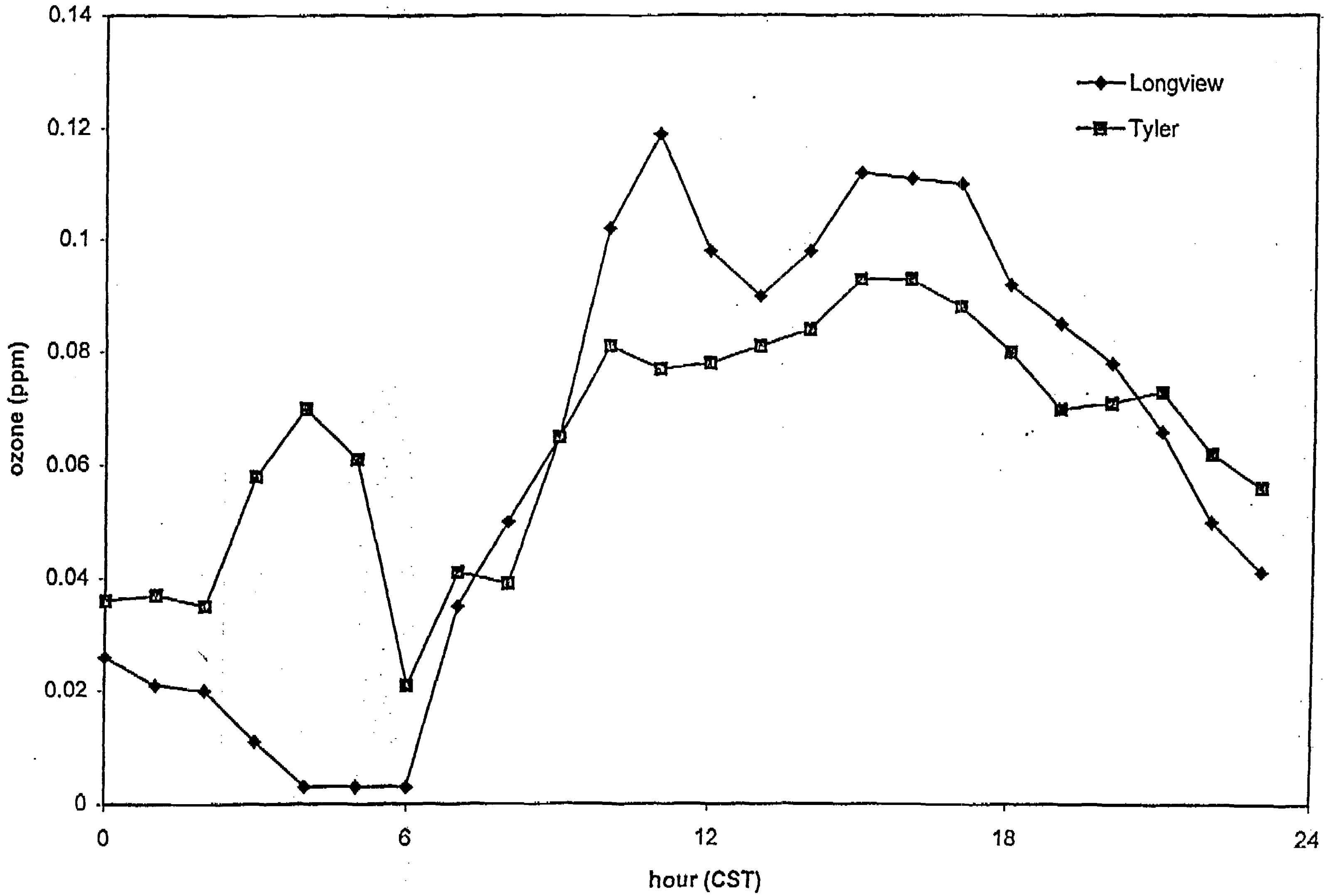
0.02
0
ozone (ppm)
Longview
Tyler
0
6
12
18
24
hour (CST)


NOAA AIR RESOURCES LABORATORY
BACKWARD ENDING - 21Z 27 AUG 98 (UTC)
ETA METEOROLOGICAL DATA
SOURCE LOCATION ■ AT 32.35 N 94.65 W
VERTICAL MOTION METHOD - OMEGA
36
34
32
30
28
102
100
98
96
94
92
90
88
(1000HPA)
HPA
900
1000

8/27/98



Longview
Tyler
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
ozone (ppm)
0
6
12
18
24
hour (CST)

NOAA Air Resources Laboratory

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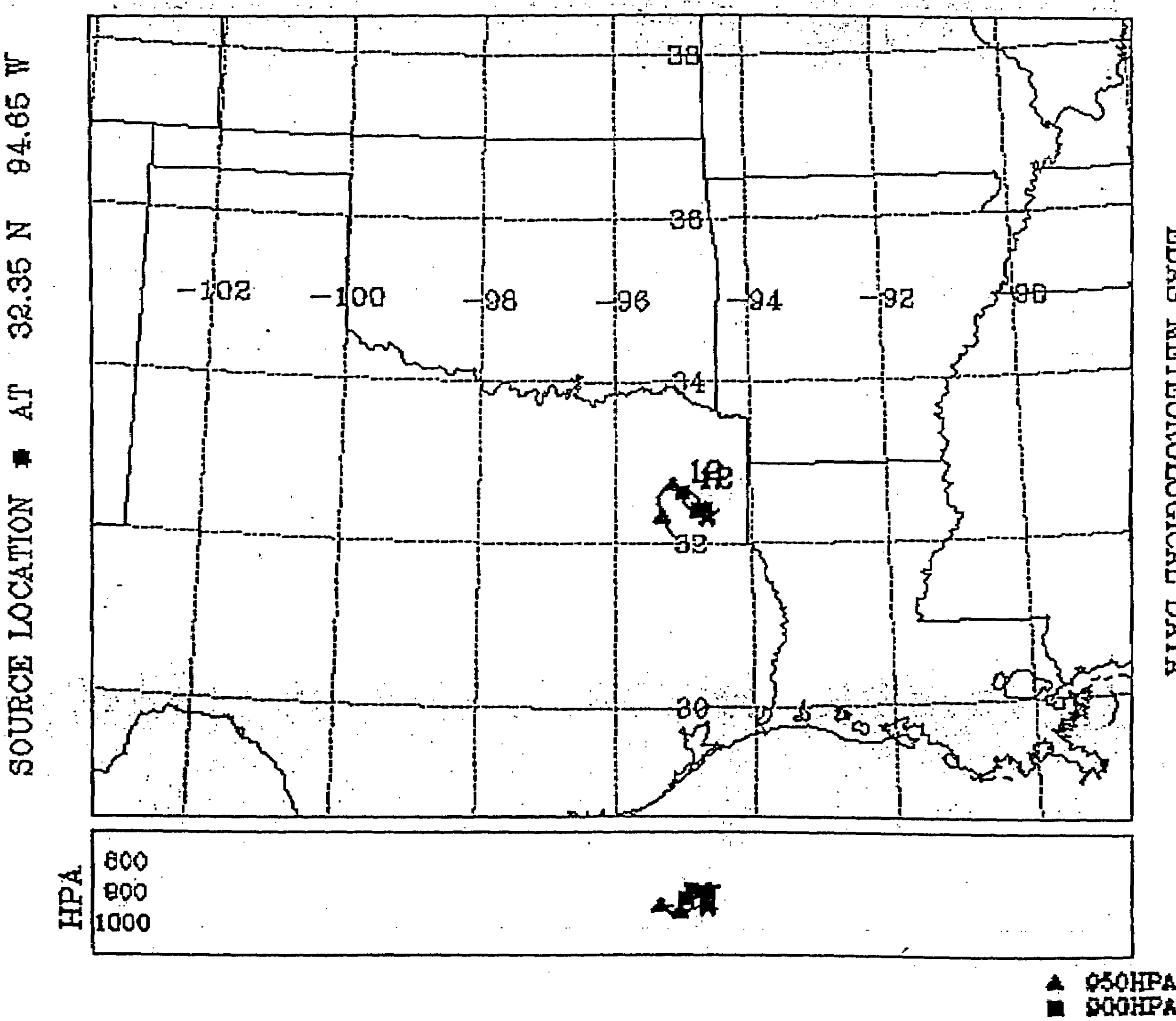
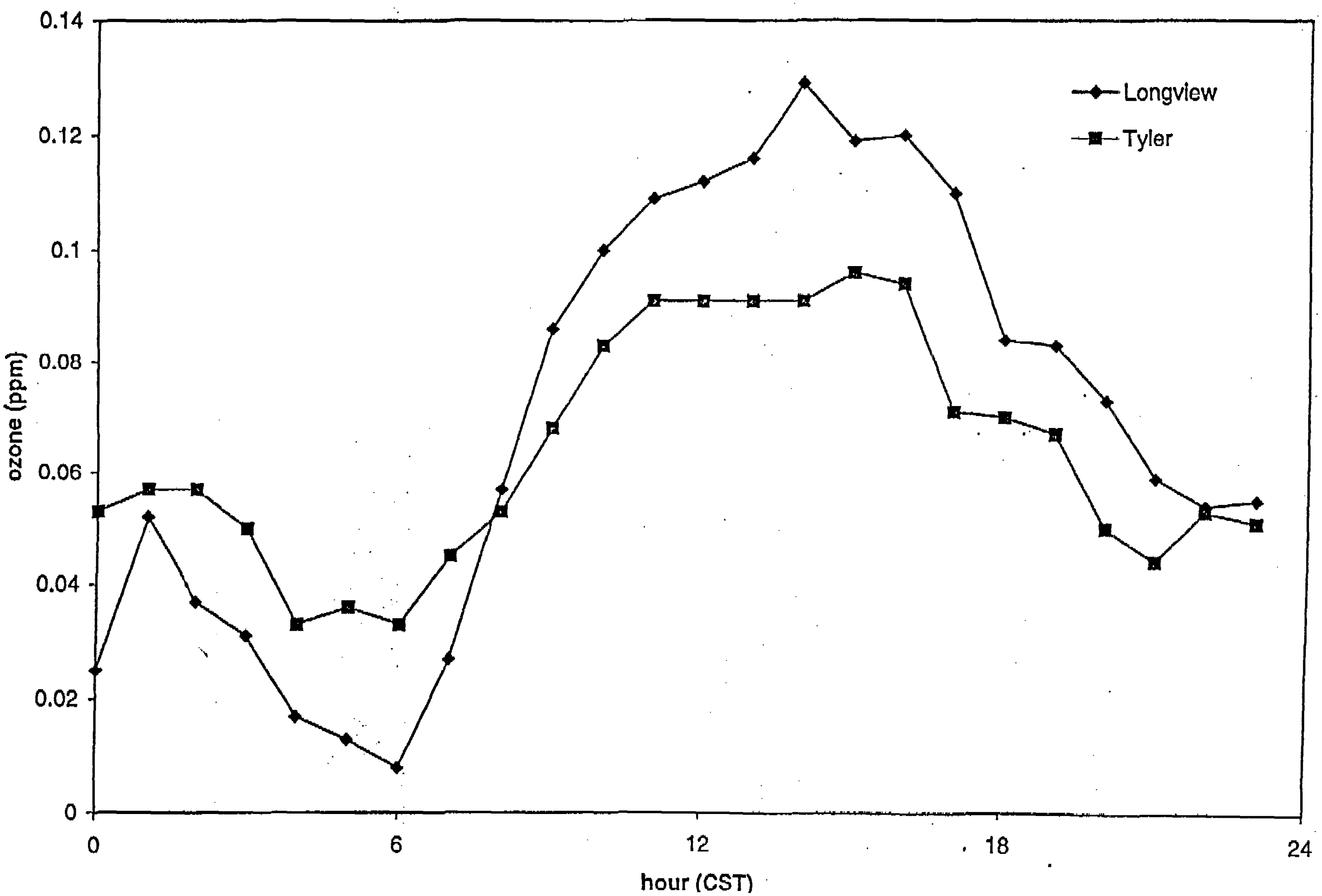
U.S. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
ARL / NCEP

BACKWARD TRAJECTORIES ENDING— 21UTC 26 AUG 98



8/28/98



0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
ozone (ppm)
Longview
Tyler
0
6
12
18
24
hour (CST)

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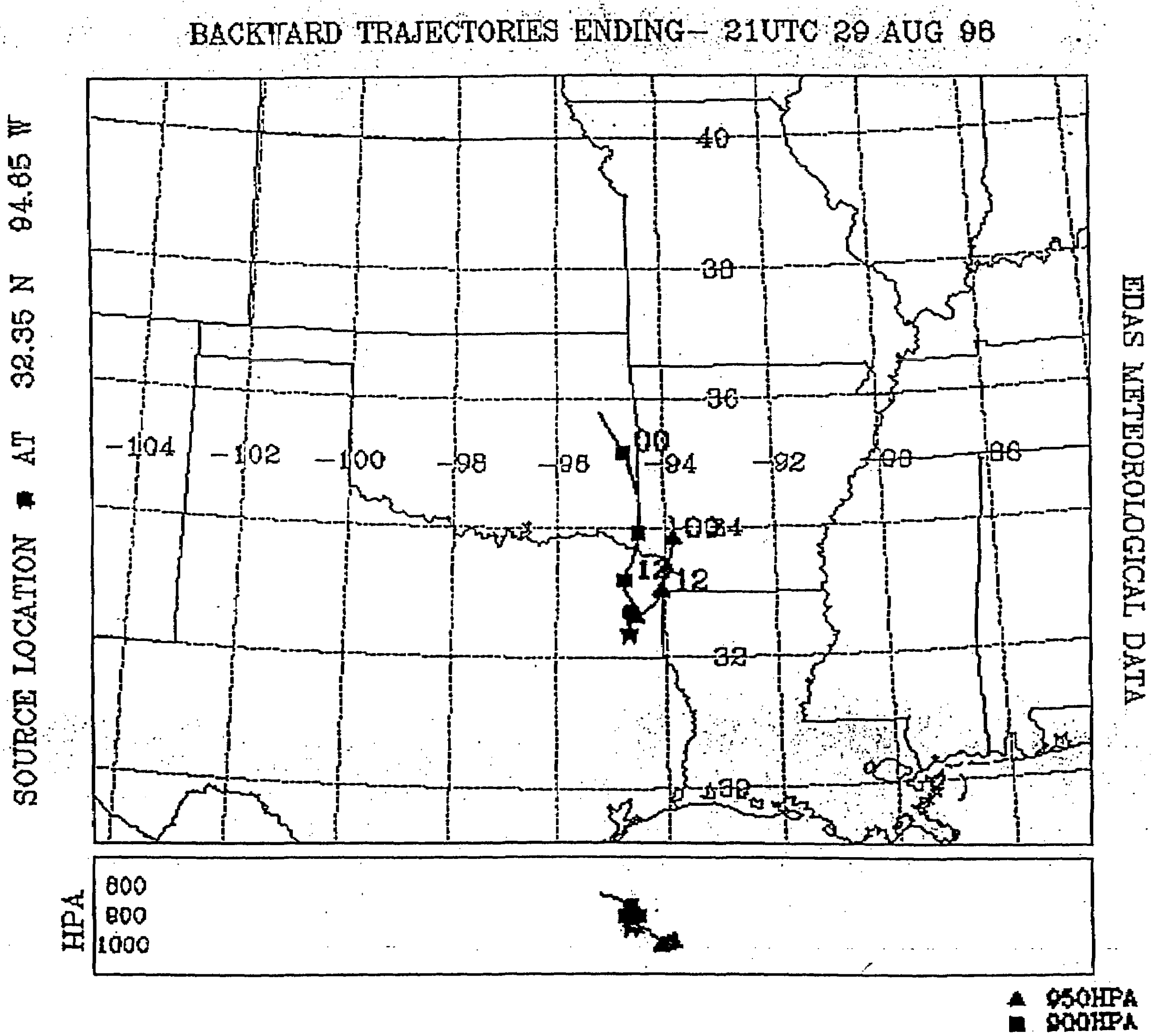
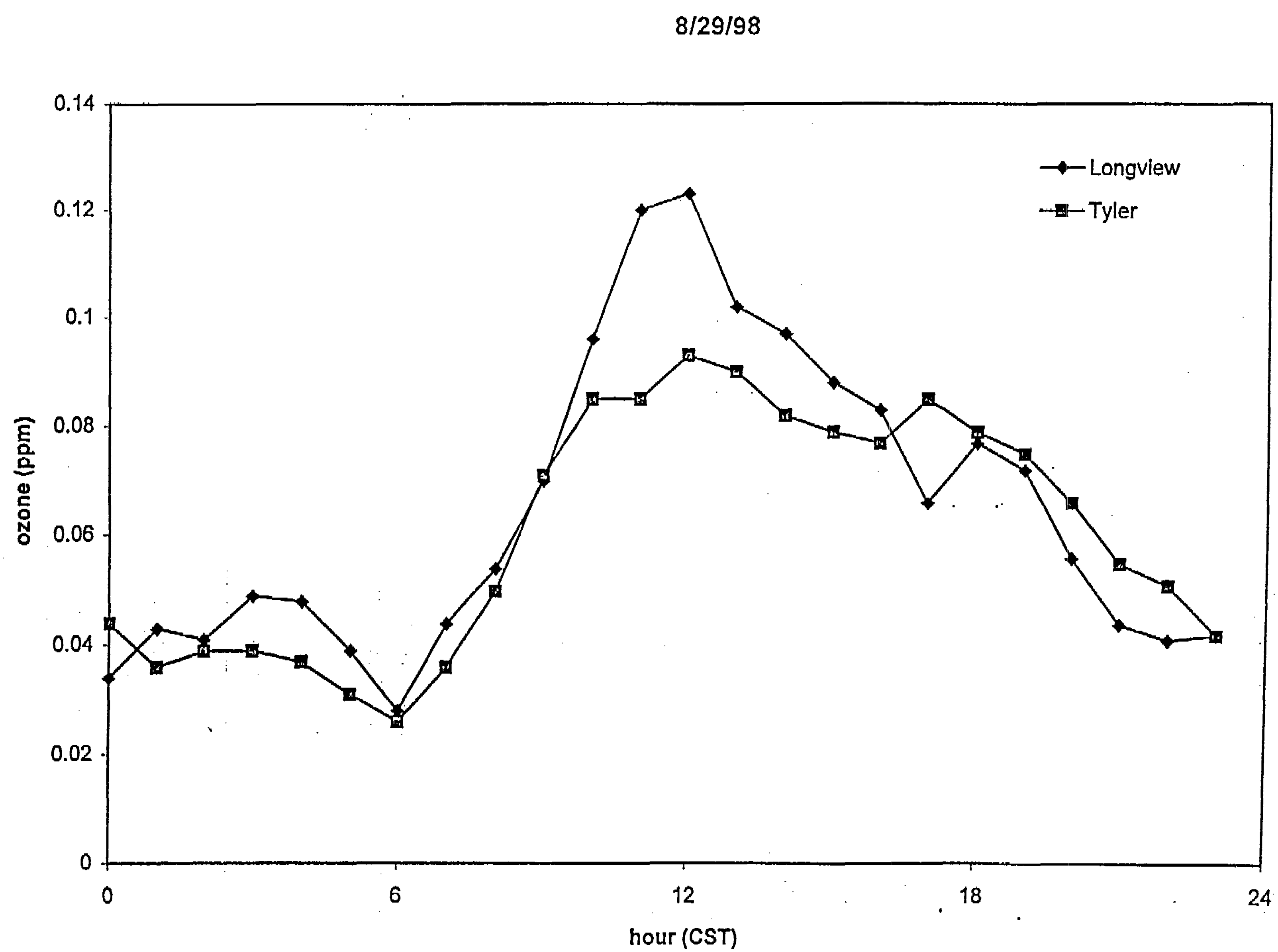
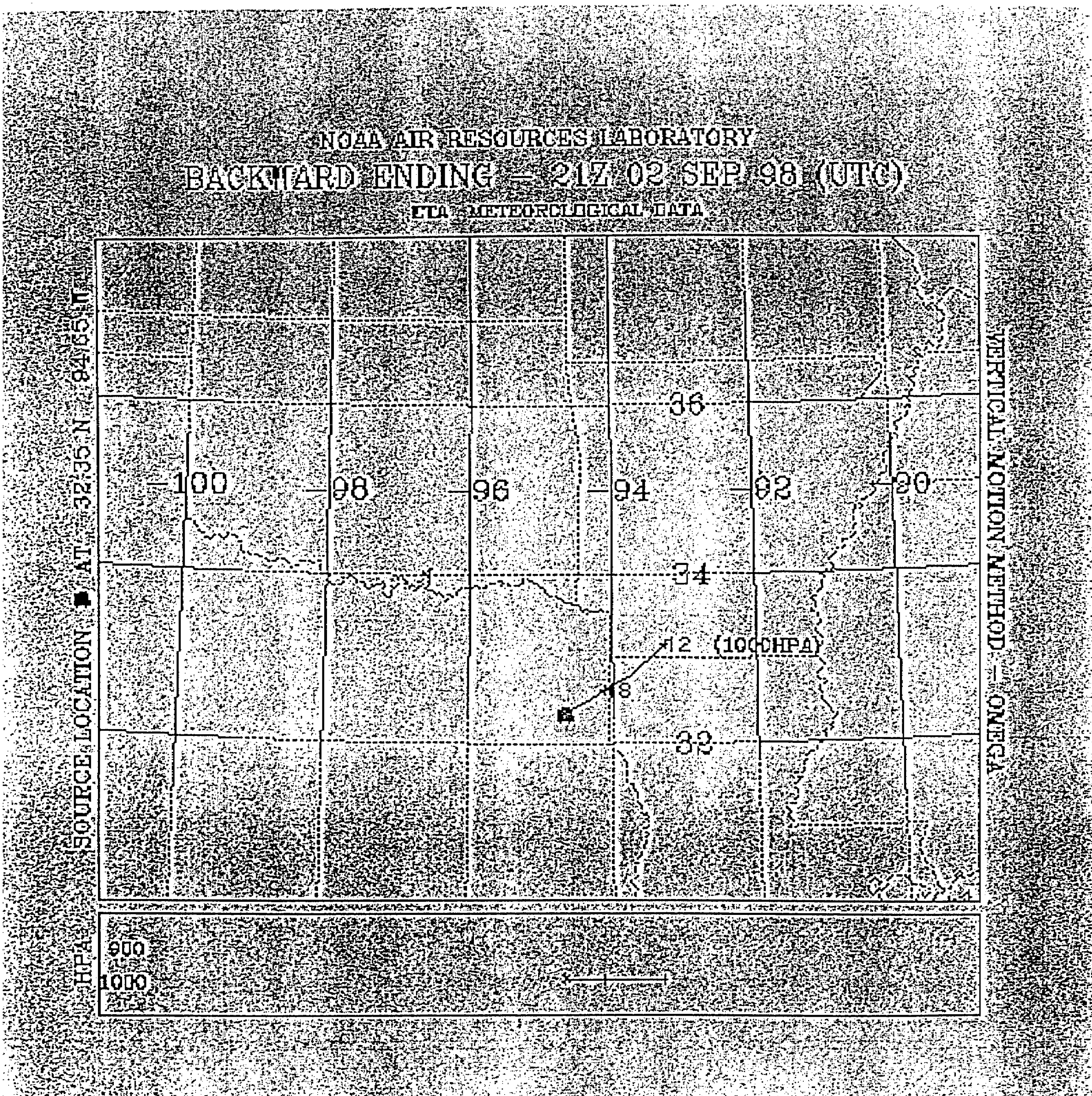
ARL / NCEP

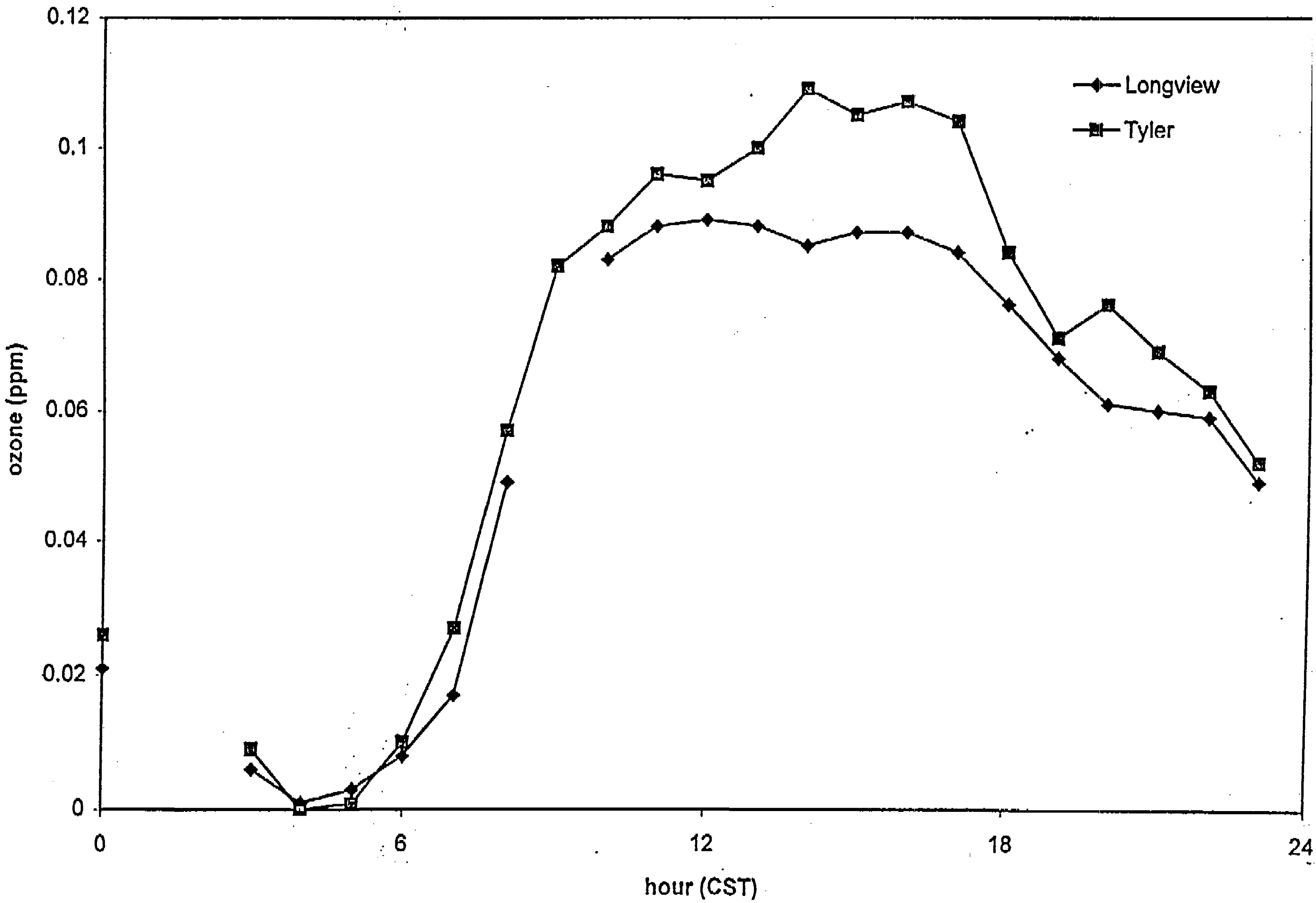



8/29/98
ozone (ppm)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
6
12
18
24
hour (CST)
Longview
Tyler

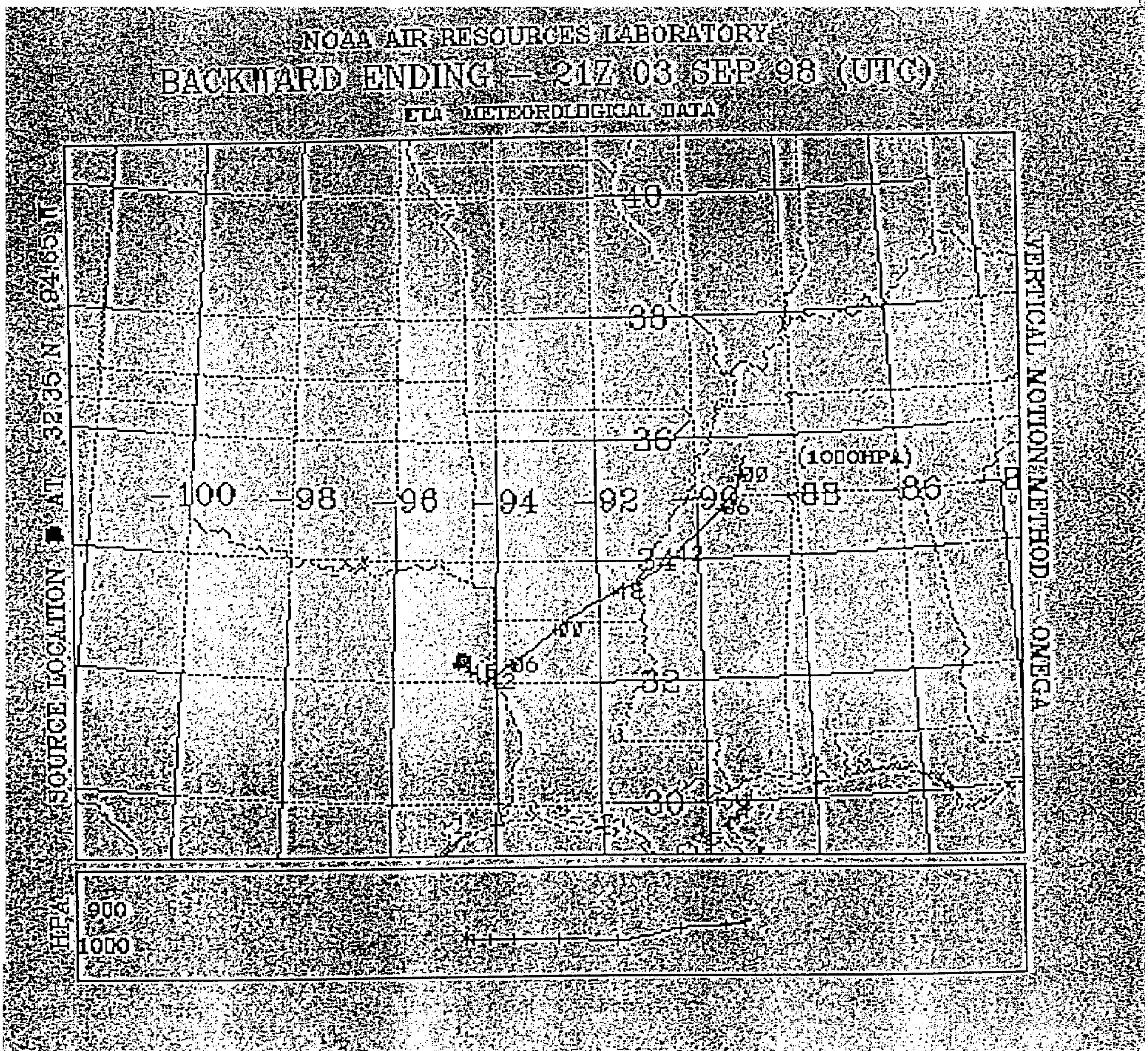


NOAA AIR RESOURCES LABORATORY
BACKWARD ENDING - 21Z 02 SEP 98 (UTC)
ETA METEOROLOGICAL DATA
SOURCE LOCATION ■ AT 32.35 N 94.65 W
VERTICAL MOTION METHOD - OMEGA
36
100
98
96
94
92
90
34
12 (1000HPA)
8
32
HPA
900
1000

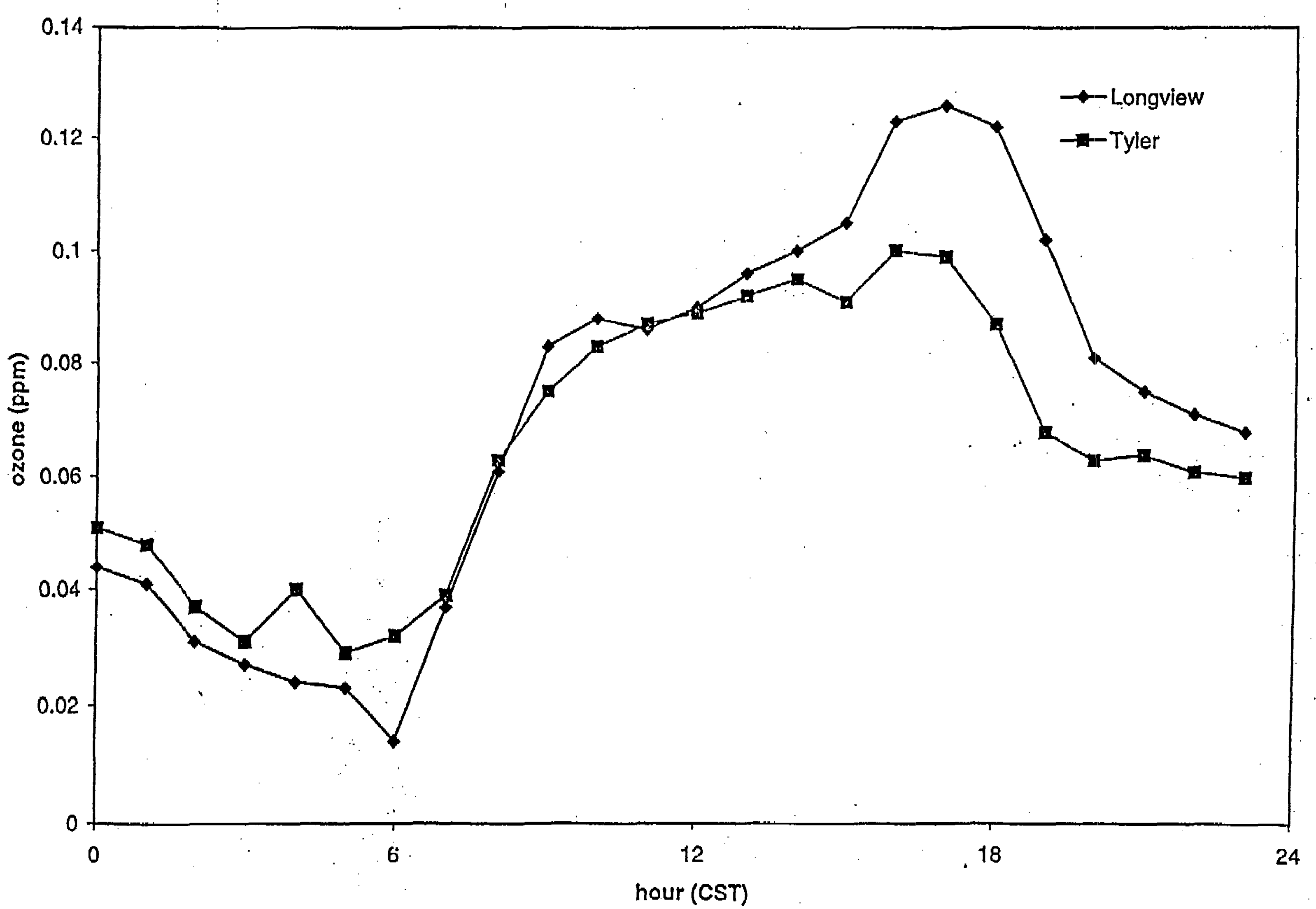
9/2/98



0.12
0.1
0.08
0.06
0.04
0.02
0
ozone (ppm)
0
6
12
18
24
hour (CST)
Longview
Tyler


NOAA AIR RESOURCES LABORATORY
BACKWARD ENDING - 21Z 03 SEP 98 (UTC)
ETA METEOROLOGICAL DATA
SOURCE LOCATION ■ AT 32.35 N 94.65 W
VERTICAL MOTION METHOD - OMEGA
(1000HPA)
40
38
36
32
30
-100
-98
-96
-94
-92
-90
-88
-86
HPA
900
1000

9/3/98



0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
ozone (ppm)
0
6
12
18
24
hour (CST)
Longview
Tyler