

# Exploratory Data Analysis for the Filling Ozone Gaps in Regions 6/7 (FOGIR6/7) 2003 Study

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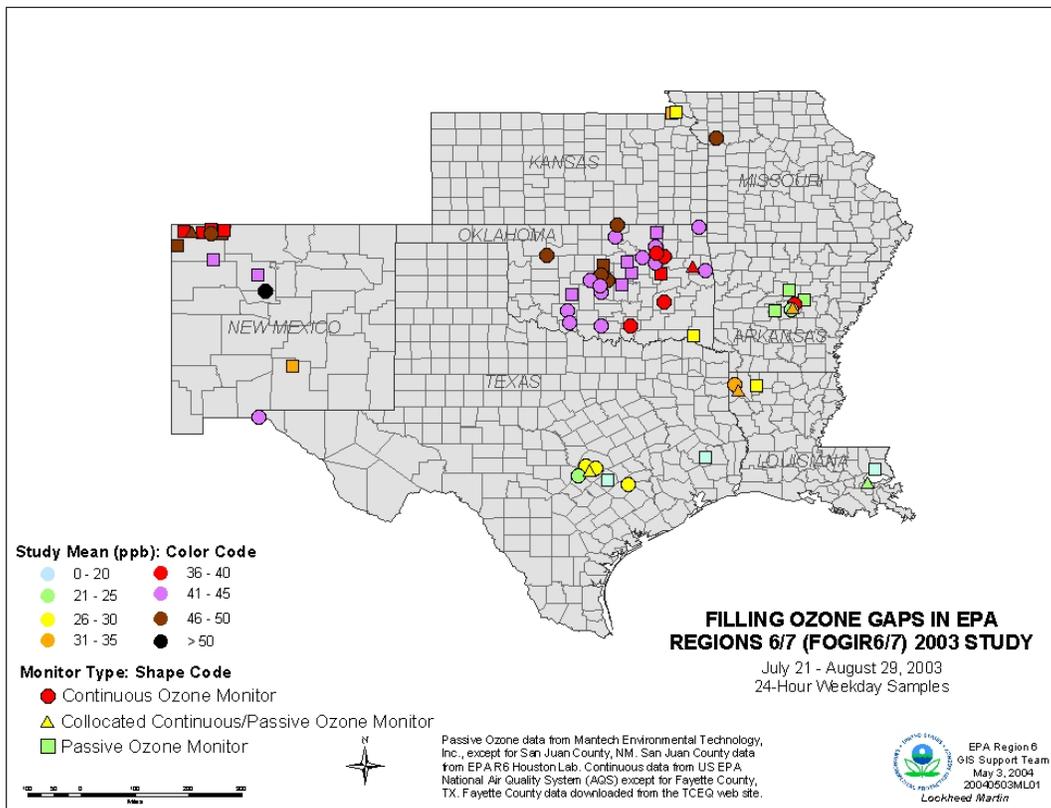
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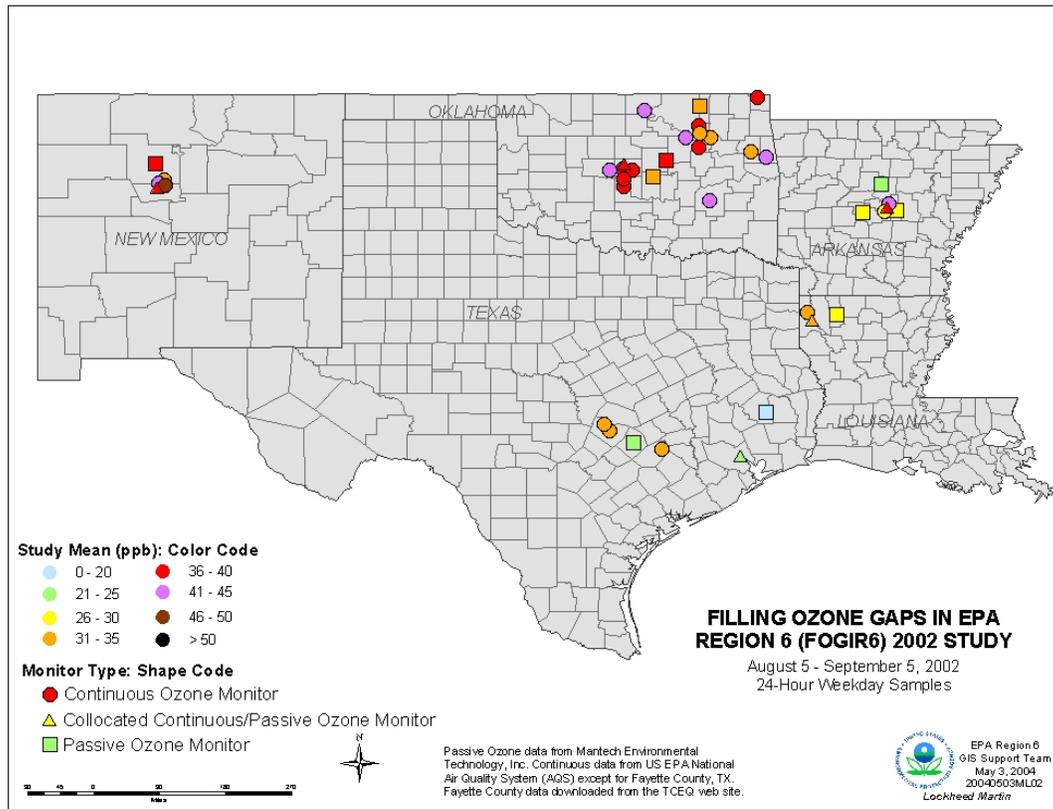
## Executive Summary

In 2003 the U.S. EPA Region 6 expanded its first time regional daily passive ozone monitoring project from 2002, doubling the number of passive ozone sites in Region 6 from 15 to 30, and adding two passive ozone sites from another EPA Region (Region 7). This study, named FOGIR6/7 2003, again produced excellent correlations with conventional continuous ozone samplers. Like the previous Passive Ozone Network of Dallas (POND) and the FOGIR6 2002 project, the FOGIR6/7 2003 study provided an opportunity for direct community involvement, and provided a considerably less expensive method for collecting credible ozone screening data to supplement the existing regional ozone monitoring network. Twenty-four hour sampling was conducted on weekdays from July 21, 2003 – August 29, 2003 at 32 sites (6 collocated with continuous monitors) throughout Texas, Louisiana, Arkansas, Oklahoma, New Mexico, and Kansas. The 2003 and 2002 ozone study mean maps are shown below in Figures 1 and 2.

**Figure 1.** FOGIR6/7 2003 Site Locations and Study Arithmetic Means.



**Figure 2.** FOGIR6 2002 Site Locations and Study Arithmetic Means.



*Highlights of the FOGIR6/7 2003 Study*

1. The FOGIR6/7 2003 study expanded the previous POND and FOGIR6 2002 studies to a first time multi-regional daily passive ozone monitoring project.
2. Excellent correlations between passive ozone sampling devices and continuous federal reference method ozone monitors for 24-hour samples seen in the POND and FOGIR6 2002 studies were also seen in the FOGIR6/7 2003 study.
3. The Bastrop County passive ozone site in the Austin, Texas area was again on average about 10 ppb below the ozone concentrations recorded by the continuous ozone monitors in Travis, Hays, and Fayette Counties.
4. Despite being more downwind of the Shreveport core area during the 2003 study the Webster Parish, Louisiana passive ozone site continued to record lower ozone concentrations compared to the Bossier and Caddo Parishes continuous ozone sites.
5. For the New Orleans area, the St. Tammany Parish passive ozone site recorded a 2003 study mean 7 ppb below the Jefferson Parish continuous ozone site, traditionally one of the highest ozone concentration site in the New Orleans area.

6. For 2003 in the Little Rock, Arkansas Metropolitan Statistical Area (MSA), as observed in 2002, the ozone concentrations were highest in north Pulaski County and considerably lower in the surrounding three counties (Saline, Faulkner, and Lonoke).
7. Monitoring results from the San Juan County, New Mexico (Four Corners area) passive ozone saturation study showed significantly high ozone concentrations in the western and northeastern portions of San Juan County in addition to the high ozone concentrations already found in the north central area of the county.
8. The Jemez site (central Sandoval County, New Mexico) is in a good location between the Albuquerque area and the Four Corners area of New Mexico to record transported ozone concentrations from those two areas.
9. The far northeastern Kansas passive ozone sites on Sac & Fox Missouri Nation Tribal land usually recorded ozone concentrations considerably lower than one of the high ozone concentration Kansas City sites. However, there was one day, July 24, 2003, when the NE Kansas passive ozone sites recorded a higher 24-hour ozone concentration (56 ppb) than the Clay County, MO site (48 ppb).
10. In Oklahoma passive ozone sensors were placed in eight locations to help fill in ozone data gaps around Oklahoma City, Tulsa, and the southeast corner of the State. The passive ozone data was very valuable in screening potential new areas for future continuous ozone monitoring. The Logan County (north of Oklahoma City), Washington County (north of Tulsa), Okmulgee County (south of Tulsa), Lincoln County (between Tulsa and Oklahoma City), and Caddo County (southwest of Oklahoma City) sites are all good candidates for future continuous ozone monitoring.

#### Austin, Texas Area

As in 2002 for the Austin area, a passive ozone monitoring sensor was deployed at Bastrop State Park in central Bastrop County for six weeks of the ozone season in 2003. This county represents a portion of the Austin MSA which has no current or historical ozone air monitoring data. The other four counties in the Austin MSA (Travis, Williamson, Caldwell, and Hays) all have either current or historical continuous ozone air monitoring data recorded in, or close to, the county boundaries. The Bastrop County passive ozone monitoring site was located approximately 33 miles southeast from continuous ozone site #48-453-0014, and approximately 41 miles southeast from continuous ozone site #48-453-0020, both in neighboring Travis County. For the 24 sampling days during the study period (weekdays from July 21, 2003 to August 29, 2003), the Bastrop passive ozone monitoring site was primarily impacted by southwesterly and southeasterly wind flow. As seen in Table 1, southerly wind directions dominated at 84% from site #48-453-0014 and 83% from site #48-453-0020.

**Table 1.** Breakdown by Sector of Resultant Wind Directions at the Two Travis County Ozone Monitoring Sites; Weekdays July 21, 2003 – August 29, 2003; 7 AM Local Standard Time (LST) - 7 AM LST.

Site	sector	% of time rwd from sector	mean rwd from sector
#48-453-0014	NE	10%	37 deg.
	SE	36%	157 deg.
	SW	48%	203 deg.
	NW	6%	318 deg.
#48-453-0020	NE	11%	38 deg.
	SE	34%	152 deg.
	SW	49%	209 deg.
	NW	5%	315 deg.

Concerning ozone concentrations in 2003, the Bastrop site recorded a study mean of only 19 ppb, again about 10 ppb below the continuous ozone sites in Travis and Fayette Counties as seen previously in 2002. Instead of primarily easterly wind flow found during the 2002 study period, southwesterly wind flow dominated in 2003, meaning the Bastrop site was more downwind of the southern Austin and northern San Antonio areas in 2003 than 2002. Despite the change in wind flow the overall study mean of 19 ppb was relatively unchanged from the 2002 study mean of 21 ppb. No 8-hour ozone concentrations close to, or over, the standard were recorded by the continuous ozone monitors in Hays, Travis, and Fayette Counties during the study, with the highest 8-hour ozone concentration at 74 ppb on August 7, 2003, from AQS site #48-453-0014. This same site was collocated with the passive and continuous ozone sensors, and an excellent correlation between the two data methods was acquired during the 2003 study ( $r = 0.97$ ).

#### Northeast of Houston, Texas Area

There are presently no continuous federal reference method ozone monitoring sites northeast of the Houston MSA. Thus, to help fill in an ozone data gap in the FOGIR6 2002 and FOGIR6/7 2003 summer studies, a passive ozone monitoring site was located on Alabama-Coushatta Tribal land in Polk County. This passive site recorded a very low 2003 study mean of 20 ppb, similar to 2002. A CASTNET ozone sampler has been installed in 2004 close to the passive ozone monitoring site in order to record rural background ozone concentrations in southeast Texas.

#### Shreveport, Louisiana Area

For the Shreveport area, a passive ozone monitoring sensor was deployed in Webster Parish in 2003 for a second year of passive ozone data collection. This parish is the only one of three in the Shreveport MSA (Caddo and Bossier comprising the other two) without any current or historical ozone air monitoring data. The Webster Parish passive ozone monitoring site was located approximately 25 miles northeast of the Bossier Parish continuous ozone monitoring site (AQS #22-015-0008) and approximately 25 miles east

of the Caddo Parish continuous ozone monitoring site (AQS #22-017-0001). The two continuous sites in Bossier and Caddo Parish did not have meteorological equipment, so meteorological data were analyzed from the nearby Harrison County, Texas continuous ozone site (AQS #48-203-0002), approximately 10 miles to the west of the Caddo Parish continuous ozone monitoring site. For the 24 days during the study period (weekdays from July 21, 2003 to August 29, 2003), the Webster Parish passive ozone monitoring sensor was downwind about half of the time from the continuous ozone sensors in Bossier and Caddo Parishes. As shown in Table 2, westerly wind directions averaged 48% according to the nearby Harrison County, Texas site.

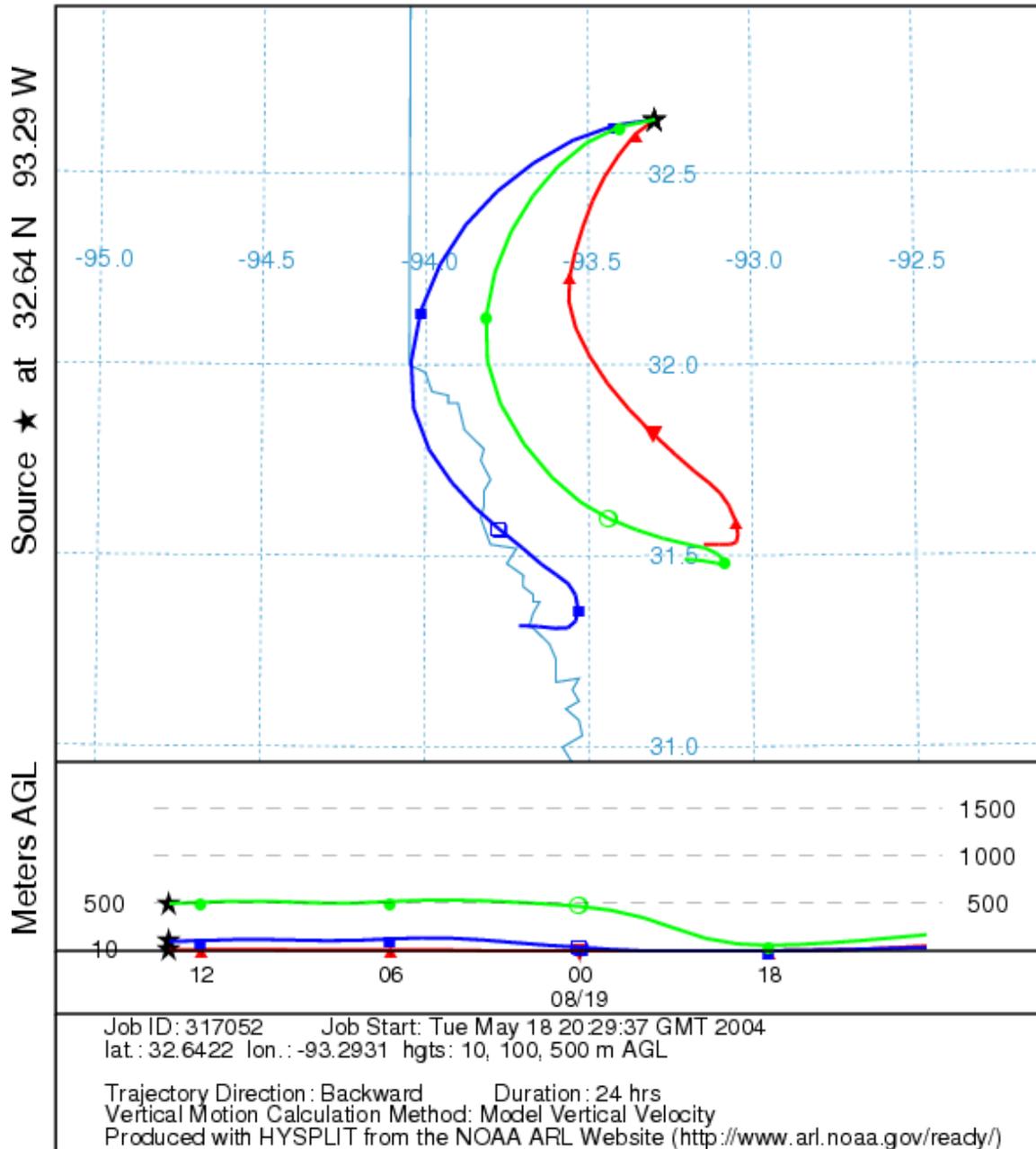
**Table 2.** Breakdown by Sector of Resultant Wind Directions at the Harrison County, Texas Ozone Monitoring Site; Weekdays July 21, 2003 – August 29, 2003; 7 AM LST-7 AM LST.

Site	Sector	% of time rwd from sector	mean rwd from sector
#48-203-0002	NE	30%	48 deg.
	SE	22%	144 deg.
	SW	33%	226 deg.
	NW	15%	308 deg.

Regarding ozone concentrations, the Webster Parish passive ozone sensor recorded a 2003 study mean of 26 ppb, below the study means recorded at the Bossier continuous site (33 ppb) and the Caddo continuous site (31 ppb). These concentrations were similar to those recorded during the 2002 passive ozone study. An excellent correlation was obtained at the Bossier collocated passive/continuous site ( $r = 0.98$ ). There were no 8-hour ozone concentrations in the Shreveport MSA that exceeded the new standard during the study period, with the highest 8-hour ozone concentrations recorded at the Bossier site on August 19, 2003 at 77 ppb (45 ppb accompanying 24-hour average), and at the Caddo site on August 18, 2003 at 75 ppb (37 ppb accompanying 24-hour average). The Hysplit back trajectories on August 18 and 19, 2003, both show southwesterly wind flow, putting the Webster passive ozone site downwind of the Shreveport area on those two days (reference Figure 3 for the back trajectory for August 18). However, the Webster passive ozone sensor recorded lower 24-hour ozone concentrations than the Bossier and Caddo sites at 29 ppb and 32 ppb, respectively, on those two days.

Figure 3. Webster Parish 24-hour Back Trajectory Ending 0700 LST 8/19/03.

NOAA HYSPLIT MODEL  
Backward trajectories ending at 13 UTC 19 Aug 03  
EDAS Meteorological Data



### New Orleans, Louisiana Area

A passive ozone monitoring sensor was deployed in St. Tammany Parish in 2003 to gather ozone monitoring information in a previously unmonitored section of the New Orleans MSA. Currently six of the eight New Orleans MSA parishes contain a continuous ozone sensor operated by the Louisiana Department of Environmental Quality. Only Plaquemines and St. Tammany Parishes do not have historical ozone monitoring information. Ozone concentrations were very low during the FOGIR6/7 2003 study period at the Jefferson Parish collocated passive/continuous ozone monitoring site (25 ppb), and even lower at the St. Tammany Parish passive ozone site (18 ppb study mean). The collocated site in Jefferson Parish (AQS #22-051-1001) produced an excellent Pearson correlation coefficient ( $r = 0.99$ ). As mentioned above ozone concentrations were low with the highest 8-hour concentration recorded at the Jefferson Parish monitor being only 67 ppb on August 11, 2003. The 24-hour ozone values recorded on this day at the sensors were only 34 ppb in Jefferson Parish and only 21 ppb in St. Tammany Parish.

### Little Rock, Arkansas Area

Previous to the FOGIR6 2002 summer study, ambient ozone monitoring had occurred in only one county of the four county Little Rock MSA (Pulaski, which currently has three operating continuous ozone monitors). For FOGIR6 2002, and for FOGIR6/7 2003, passive ozone monitoring devices were placed at one site apiece in Lonoke, Saline, and Faulkner Counties surrounding Pulaski County. For 2002, the Lonoke site was closest to Pulaski County at around 10 miles to the east of the closest Pulaski County continuous ozone monitoring site. In 2003 the Lonoke site was moved northeast near the town of Cabot. The Saline and Faulkner sites were located about 25 miles to the west and the north, respectively, of the nearest Pulaski County continuous ozone air monitoring site. As in 2002, ozone concentrations were highest at the North Little Rock Airport site, the northernmost monitor of the three in Pulaski County. The 2003 study mean at this site was 36 ppb. Ozone concentrations decreased in Pulaski County from north to south as the central collocated site recorded a study mean of 31 ppb and the south lab site recorded a study mean of 25 ppb. Similar to 2002 the central Pulaski County collocated site produced an excellent correlation coefficient  $r$  of 0.95. The three surrounding county passive ozone sites were again lower in ozone concentrations compared to the Pulaski County sites, with the Saline site reporting a 24 ppb study mean, and the Lonoke and Faulkner sites recording the lowest study means in the area at 23 ppb. Ozone concentrations across the whole State of Arkansas were lower during the summer of 2003 compared to the summer of 2002 with all passive ozone sites also recording lower 2003 study means compared to 2002. On 43% of the 2003 study days the North Little Rock Airport meteorological station recorded at least a trace of precipitation. Wind direction and wind speed data for the 2003 study period from the collocated passive/continuous ozone site in central Pulaski County were similar to that collected in 2002 as seen in Table 3. The highest 8-hour ozone concentration recorded by the continuous monitors during the FOGIR6/7 2003 study was 73 ppb at the North Little Rock Airport site on August 21, 2003.

**Table 3.** Breakdown by Sector of Resultant Wind Directions at the Central Pulaski County, Arkansas Ozone Monitoring Site; July 21, 2003 – August 29, 2003.

Site	Sector	% of time rwd from sector (2002)	% of time from sector (2003)
#05-119-0007	NE	25%	23%
2002 avg. ws=3mph	SE	22%	17%
2003 avg. ws=2mph	SW	34%	38%
	NW	19%	22%

New Mexico

In New Mexico passive ozone sensors were deployed in the northwest, northcentral and southcentral portions of the State. The northwest section of the State was the location of the San Juan County passive ozone monitoring saturation study. Seven passive ozone sites supplemented the two continuous ozone sites in the County. For the details and results of this study please reference the powerpoint file titled “farmingtondec16.ppt”.

In the northcentral part of the State near the Albuquerque MSA a passive ozone monitoring sensor was operated by the Jemez Tribe in Central Sandoval County for a second year, about 25 miles north of the northernmost continuous ozone monitors in Albuquerque. A collocated passive/continuous ozone site in San Juan County (AQS #35-045-1005) produced a good correlation with  $r = 0.86$ . As seen in 2002 some high 24-hour passive ozone concentrations recorded at the Jemez site were recorded with southerly wind flow downwind of the Albuquerque area. In addition, a high 24-hour passive ozone concentration (56 ppb on August 4, 2003) was recorded under a northwesterly wind flow. The Jemez site study mean in 2003 was also significantly high at 45 ppb. Thus, the Jemez site is in a good location between the Albuquerque area and the Four Corners area of New Mexico to record transported ozone concentrations from those two areas. Continuous ozone monitoring has now commenced at the Jemez site for 2004.

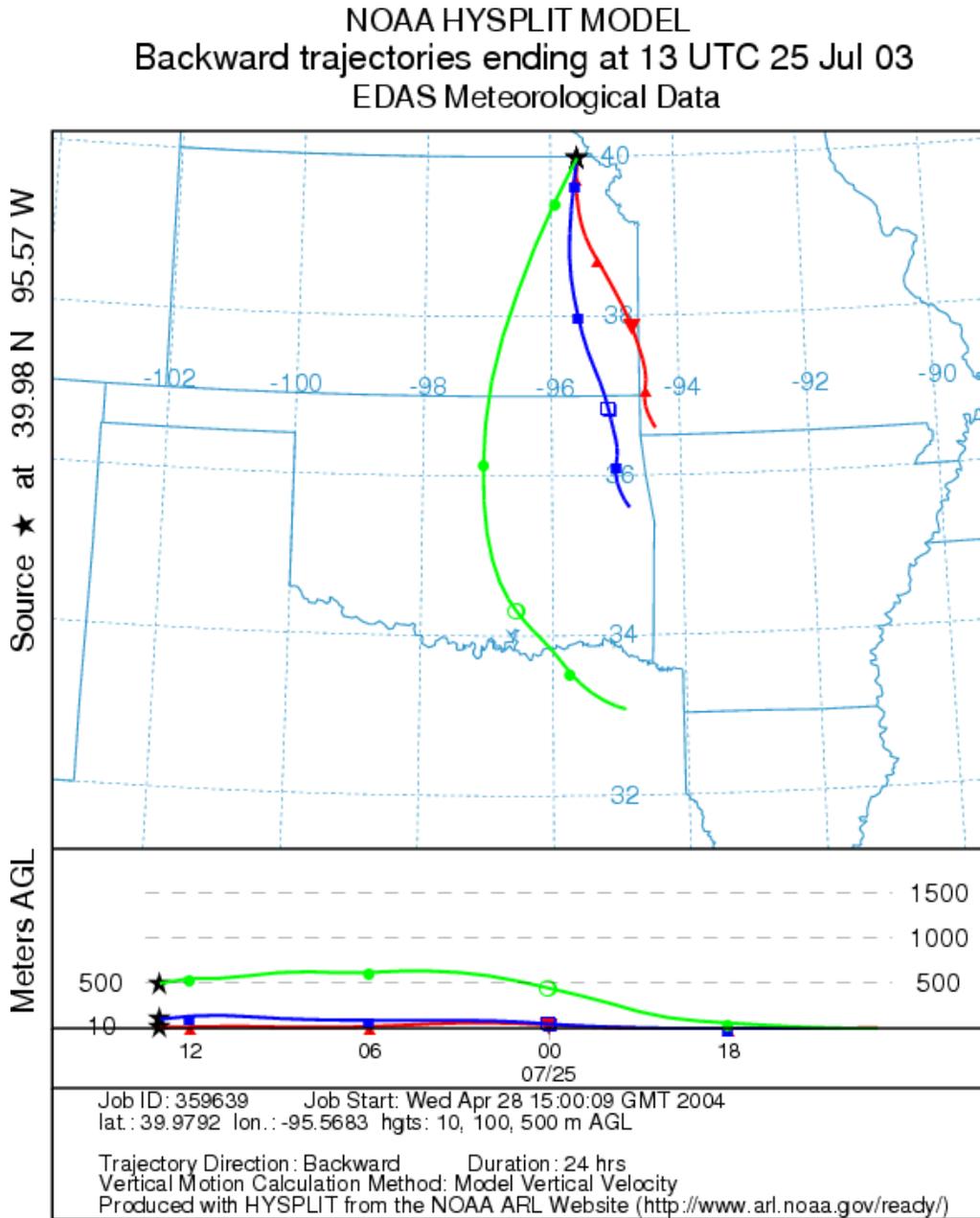
In the southcentral part of the State a passive ozone sampler was operated for the first time in Otero County on Mescalero-Apache Tribal land. Although the overall study mean (35 ppb) was about 10 ppb below a site in the El Paso area, a high maximum 24-hour reading of 50 ppb was recorded. A second year of passive ozone data will be taken on Mescalero-Apache Tribal land in 2004 to compare to the data gathered in 2003.

NE Kansas (Sac & Fox Missouri Nation Tribal Land)

Two passive ozone sites were operated for the first time in Region 7 on Sac & Fox Missouri Nation Tribal Land in the northeast corner of Kansas. The two sites were about 5 miles apart and tracked very well together with a high correlation coefficient ( $r = 0.97$ ). In comparison with a high concentration Kansas City site (the Clay County AQS site #29-047-0005) the two passive ozone sites were usually significantly lower in 24-hour

ozone concentration (32 ppb and 29 ppb study means vs. a 46 ppb study mean at the Clay County site). There was one day, though, on July 24, 2003, when the NE Kansas passive ozone sites recorded a higher 24-hour ozone concentration (56 ppb) than the Clay County, MO site (48 ppb). The Hysplit back trajectory pictured in Figure 4 shows southerly wind flow toward the NE Kansas passive ozone sites. That day (July 24, 2003) was also the highest ozone concentration day recorded at the NE Kansas passive ozone sites for the study period. A second year of passive ozone data collection is planned for the Sac & Fox Missouri Nation for 2004, and a new tribal passive ozone site is planned for deployment on Potawatomi Tribal Nation Land north of Topeka in 2004.

**Figure 4.** NE Kansas 24-hour Back Trajectory Ending 0700 LST 7/25/03.



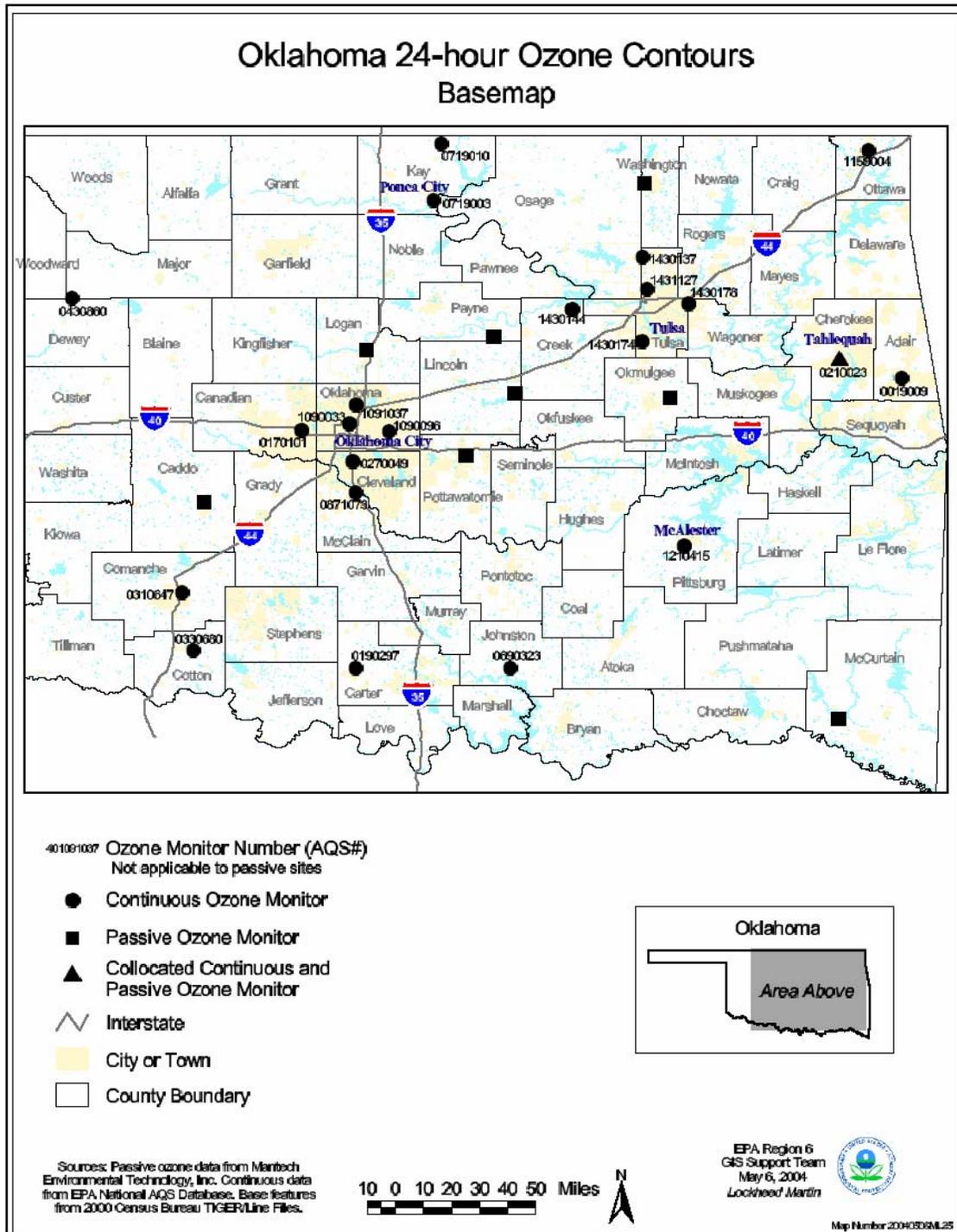
## Oklahoma

Passive ozone sensors were placed in eight locations to help fill in ozone data gaps around Oklahoma City, Tulsa, and the southeast corner of the State (Figure 5). Three of the eight passive ozone sensors recorded a second summer of data in Pottawatomie County, Lincoln County (Sac & Fox Tribal Land), and Washington County (Eastern Delaware Tribal Land). The 2003 summer study means at all three sites increased from 2002 mean levels, imitating mean increases seen at the continuous Oklahoma ozone sites. As seen on the map in Figure 1, many site study means at Oklahoma sites were above 40 ppb, with the highest site means recorded at rural sites in Dewey and Kay Counties (48 ppb). The lowest site mean was recorded at the southeastern corner of Oklahoma in McCurtain County on Choctaw Tribal Land. A second year of passive ozone data will be taken at this site in 2004 to compare to the overall low readings recorded in 2003.

The collocated passive/continuous ozone site at the Tahlequah site on Cherokee Nation Tribal Land (AQS #40-021-9002) produced an excellent correlation with  $r = 0.97$ . There were three 8-hour ozone exceedance days in the Tulsa area during the study period on July 21, July 29, and August 25, 2003. In the Oklahoma City area during the study period there were two 8-hour ozone exceedance days on July 29 and August 7, 2003. All of these days were analyzed in detail by constructing 24-hour ozone pollutant concentration contour maps and 24-hour Hysplit back trajectories (Sample graphics are pictured in Figures 6 and 7). The contour map is one valuable tool in studying the possibility of whether a passive ozone site is recording ozone concentrations over or close to the 8-hour standard on an 8-hour ozone exceedance day. On July 21, 2003, an 8-hour ozone exceedance was recorded at the Tulsa Skiatook site in north Tulsa County (AQS site #40-143-0137, 94 ppb maximum 8-hour ozone concentration and an accompanying 7 AM – 7 AM LST 24-hour ozone concentration of 63 ppb) and at the central Tulsa County site (AQS site #40-143-1127, 94 ppb maximum 8-hour ozone concentration and an accompanying 24-hour ozone concentration of 52 ppb). The closest passive ozone site to these two exceeding sites was the Washington County site with a high 24-hour passive ozone reading of 55 ppb, but this site was upwind of the Tulsa area according to the Hysplit back trajectory. During August 25, 2003, however, the Washington County site was downwind of the Tulsa area. On this day the Tulsa Skiatook site recorded an 8-hour ozone exceedance of 85 ppb with an accompanying 24-hour reading of 48 ppb. With southerly wind flow the Washington County passive ozone site also recorded a 24-hour ozone concentration of 48 ppb.

On July 29, 2003, 8-hour ozone concentrations above the standard were recorded at southern sites in Tulsa and Oklahoma City. Of note is the high 24-hour passive ozone reading of 52 ppb at the Okmulgee County site (Creek Nation Tribal Land). Taking into account the wind back trajectory and the 8-hour ozone exceedance at the Glenpool site in southern Tulsa County (AQS site #40-143-0174, 88 ppb maximum 8-hour ozone concentration and accompanying 24-hour ozone concentration of 53 ppb), it is possible that the Okmulgee County passive ozone site on July 29, 2003, could have recorded a maximum 8-hour ozone concentration close to or over the standard.

**Figure 5.** Oklahoma Continuous/Passive Ozone Site Locations for the FOGIR6/7 2003 study.



**Figure 6.** July 21, 2003, 24-hour O<sub>3</sub> Contour Analysis for Oklahoma; Eight Hour O<sub>3</sub> Exceedances at Tulsa County Sites #1430137 and #1431127 (94 ppb).

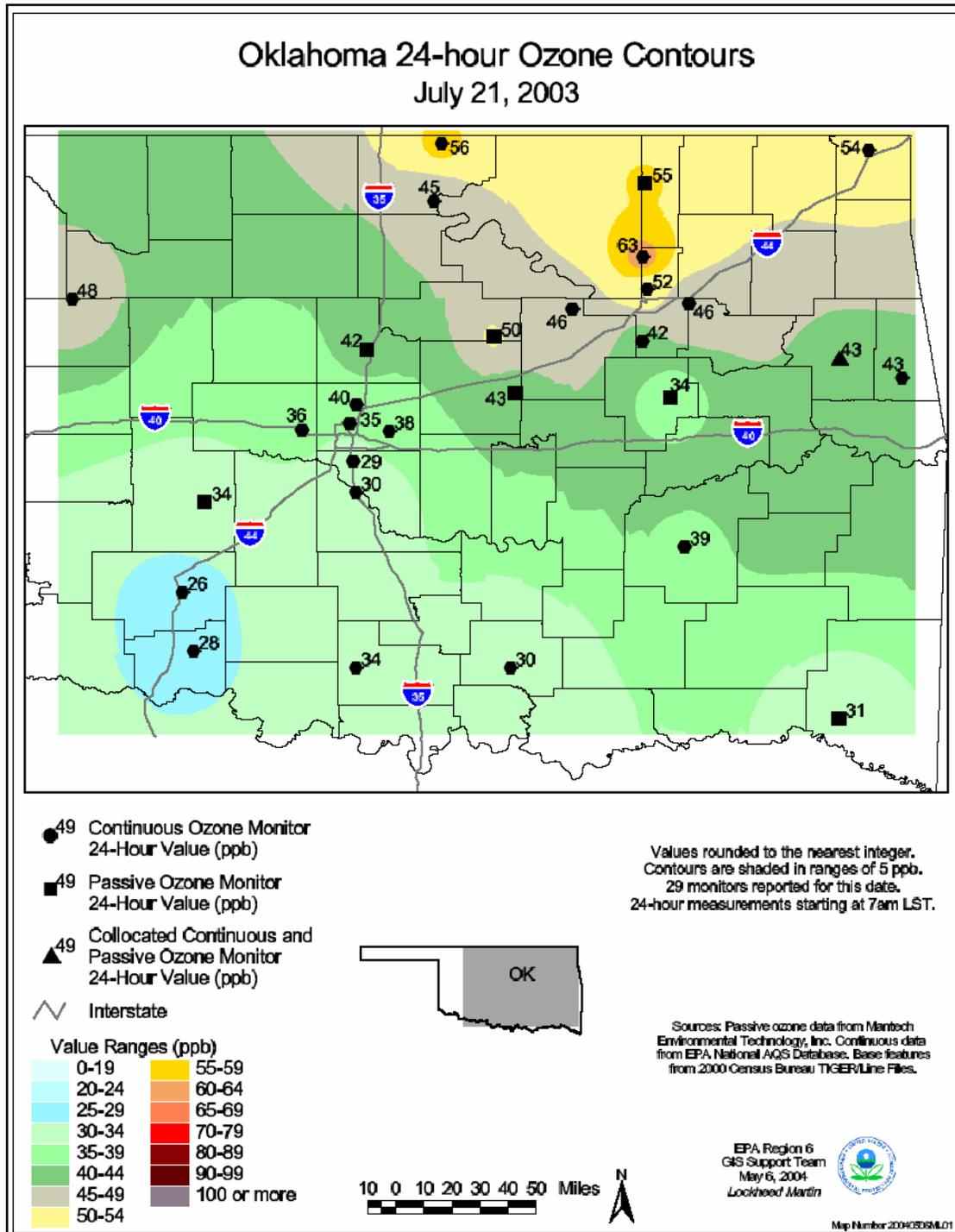
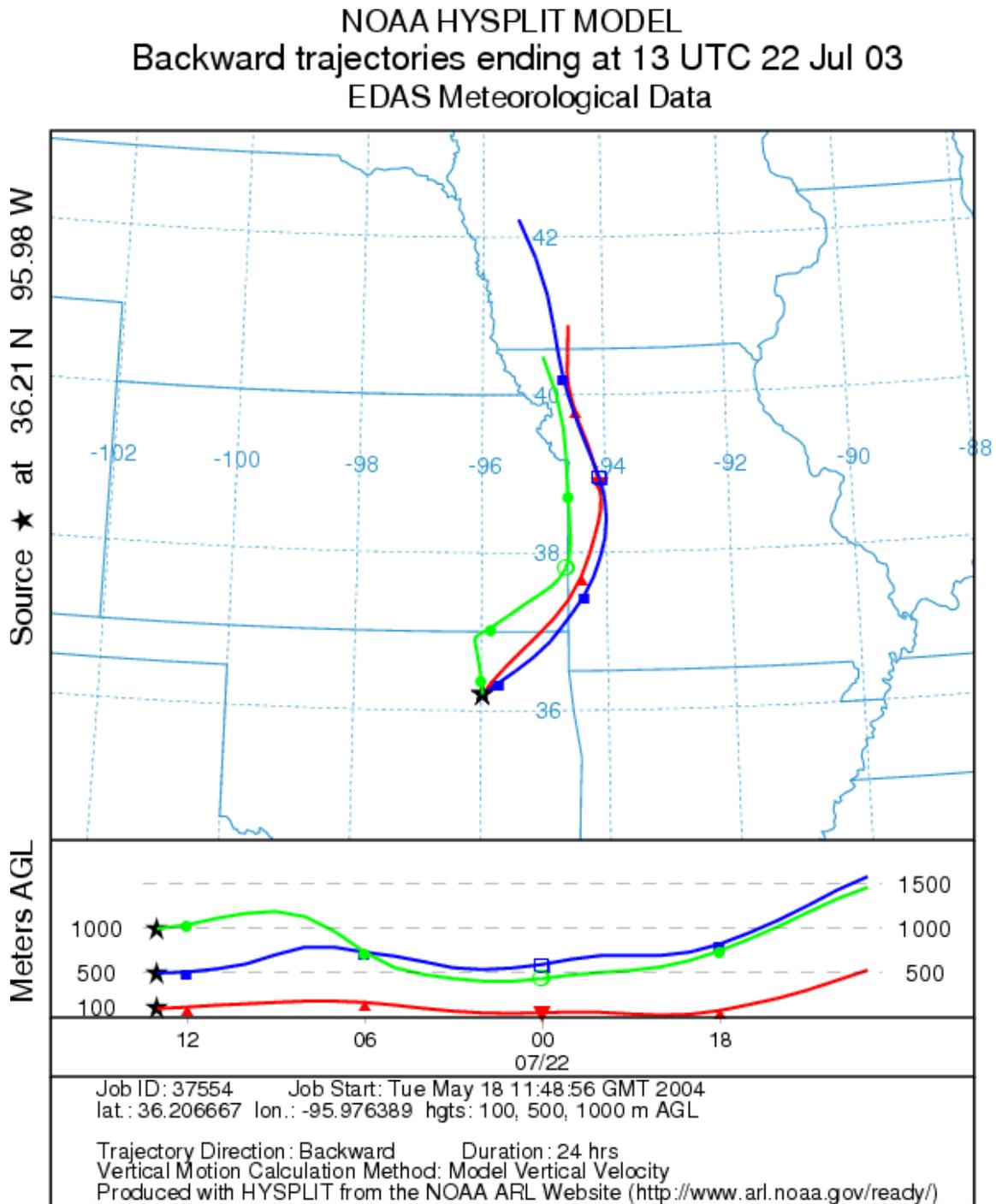


Figure 7. Tulsa Site #1431127 24-hour Back Trajectory Ending 0700 LST 7/22/03.



The last 8-hour ozone exceedance day occurred on August 7, 2003, in the Oklahoma City area. On this day all three Oklahoma County continuous ozone monitors recorded 8-hour ozone exceedances. The eastern Oklahoma County site recorded a maximum 8-hour ozone concentration of 85 ppb (63 ppb accompanying 24-hour level), the central Oklahoma County site recorded a maximum 8-hour ozone concentration of 93 ppb (69 ppb accompanying 24-hour level), and the north Oklahoma County site recorded a maximum 8-hour ozone concentration of 88 ppb (65 ppb accompanying 24-hour level). No additional continuous ozone sites in the State recorded 8-hour levels over the standard despite 24-hour levels as high as 64 ppb so it is unlikely that any passive ozone sites in the State exceeded the 8-hour ozone standard on August 7, 2003.

Additional interesting information gleaned from review of the contour maps are: (1) the high 24-hour levels of 65 ppb and 67 ppb recorded at the Logan County site downwind of the Oklahoma City area on July 24, 2003, and August 19, 2003, were the highest 24-hour values recorded in the State on those two days; (2) a potential close to the standard 8-hour reading at the Logan County site on July 31, 2003; Logan County recorded the highest 24-hour level in the Oklahoma City area on that day with a 59 ppb, and the north Oklahoma County site recorded a 24-hour level of 55 ppb (82 ppb max. 8-hour average); (3) the Caddo County passive ozone site (Delaware Nation Land) recorded high 24-hour levels on August 5 and 6, 2003, higher than the southernmost Oklahoma City continuous monitor 24-hour averages; the southern Oklahoma City monitor recorded maximum 8-hour ozone concentrations of 82 ppb and 80 ppb, respectively, on those two days.

The passive ozone data is very valuable in screening potential new areas for future continuous ozone monitoring. Each passive ozone site in Oklahoma was evaluated for the potential of future continuous ozone monitoring as summarized below:

#### Caddo County, Oklahoma (Delaware Nation Tribal Land)

This site is a good candidate for future continuous ozone monitoring. The site is situated between the cities of Lawton and Oklahoma City and recorded a FOGIR6/7 2003 study mean (44 ppb) higher than Lawton and similar to the southern and eastern Oklahoma City sites. According to Hysplit back trajectories the Caddo site was downwind of pollution sources in Lawton or Oklahoma City on many days during the FOGIR6/7 2003 study (please reference the ozone contour maps and back trajectories from July 22, July 24, August 5, August 6, August 7, and August 18).

#### Washington County, Oklahoma (Eastern Delaware Nation Tribal Land)

This site is a good candidate for future continuous ozone monitoring. The site is downwind of the Tulsa core under southerly wind flow and its FOGIR6/7 2003 study mean (41 ppb) was similar or higher than the Tulsa County sites. According to Hysplit back trajectories the Washington site was downwind of pollution sources in Tulsa on the 8-hour ozone exceedance day of August 25, 2003, and on the close call 8-hour ozone days of July 24 and 31, 2003.

Okmulgee County, Oklahoma (Creek Nation Tribal Land)

This site is also a good candidate for future continuous ozone monitoring. The site provides a far downwind site of the Tulsa core under northerly wind flow. On the 8-hour ozone exceedance day of July 29, 2003 in Tulsa at site #1430174 (88 ppb), wind flow was from the NNE, placing the Okmulgee site downwind of the Tulsa area on that exceedance day.

Lincoln County, Oklahoma (Sac and Fox Nation Tribal Land)

Over the last two years (2002 and 2003) passive ozone monitors have operated in the area between Oklahoma City and Tulsa in Pottawatomie, Lincoln, and Payne Counties. The monitor that has recorded the highest study means and is the most centrally located between the two cities is located in Lincoln County. The FOGIR6/7 2003 study mean at this site (44 ppb) was similar or higher than the study means recorded at fringe sites in Oklahoma City and Tulsa. The Lincoln County site would be a good candidate for future continuous ozone monitoring because of its centralized location between Oklahoma's largest cities, measuring transported ozone between the cities. During both years of passive ozone sampling, especially in 2003, the Lincoln County site recorded many passive 24-hour ozone concentrations in the high 40's and 50's ppb, with a peak 24-hour value of 61 ppb on July 24, 2003.

McCurtain County, Oklahoma (Choctaw Nation Tribal Land)

Average 24-hour ozone passive readings were low at this site for much of the FOGIR6/7 2003 study period. The study mean at this site was 30 ppb with a maximum 24-hour passive ozone concentration of 44 ppb. This site is planned for participation in the FOGIR6/7 2004 summer study and the 24-hour ozone concentrations will be compared to the overall low readings of 2003.

Logan County, Oklahoma (Guthrie)

This site is a good candidate for future continuous ozone monitoring. The site is downwind of the Oklahoma City core under southerly wind flow and its FOGIR6/7 2003 study mean (46 ppb) was similar or higher than the existing Oklahoma City area continuous ozone sites. According to Hysplit back trajectories the Logan site was downwind of pollution sources in Oklahoma City on many days during the FOGIR6/7 2003 study (please reference the ozone contour maps and back trajectories from July 24, July 31, August 19, and August 25, 2003).