AMBIENT SOUND MONITORING PROGRAM FOR COLORADO PLATEAU PARKS

National Park Service Contract No. CX-1200-8-P063

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National Park Service
Mining and Minerals Branch
12795 W. Alameda Parkway
Denver, CO 80225

Performed by

Collaboration in Science and Technology Inc.
15835 Park Ten Place, Suite 105
Houston, TX 77084-5131

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1.0 INTRODUCTION

Under NPS Contract No. CX-1200-8-P063, Collaboration in Science and Technology Inc. (CSTI) has assisted the Mining and Minerals Branch of the National Park Service in measuring the ambient sound levels at four locations in two NPS Units: Glen Canyon National Recreation Area (GLCA) and Dinosaur National Monument (DINO). This report documents the work that has been performed on this project. The purpose of the measurement program is presented in Section 2 and the design of the program is presented in Section 3. The equipment used is presented in Section 4. Summaries and analyses of the data for the four sites are presented in Sections 5 through 8. Section 9 presents the conclusions of this final report. The appendices include equipment installation instructions, equipment operating instructions, data entry and processing instructions, and equipment and material supplier information.

2.0 PURPOSE OF AMBIENT SOUND MONITORING PROGRAM

One aspect of the solitude of National Parks is the absence of most man-made sounds. Indeed, the lack of these sounds results in extremely low levels of ambient sound. This is the case along undeveloped areas of the Colorado Plateau. In order to quantify these low sound levels, extensive sound monitoring is necessary. The establishment of "baseline" data is essential in order to determine the acoustical impact of any sounds which could violate the solitude, e.g., any proposed developments either within or adjacent to NPS units.

In order to predict the impact of an intruding sound at a particular location, it is necessary to have detailed information on both the intruding sound and the ambient sound at the location. Since most potentially intrusive sound sources produce predictable sound levels based on a few known variables, their expected sound level at a particular location can be accurately determined. Ambient sound levels, however, vary significantly depending on season, weather conditions, nearby activities, local flora and fauna, etc. Therefore, it is much more difficult to determine the ambient sound at a particular location.

The fundamental objective of this program is to document the ambient sound levels along the Colorado Plateau beginning in these two park units. Since the ambient sound at a particular location changes both in amplitude (level) and in frequency content as a function of time, it is necessary to consider both aspects of the sound variation.

2.1 Frequency Content

One way to characterize the frequency content is to perform an A-weighting analysis of the sound level. This technique gives a single number for a sound by weighting the frequency composition of the sound in a manner similar to the way the human ear hears the sound. For example, the human ear is much more sensitive to middle and high frequencies than to low frequencies. The A-weighting network emphasizes middle and high frequency sounds and de-emphasizes low frequency sounds. The A-weighted level is an indicator of how loud humans perceive a sound.

When specific information regarding the frequency content of ambient sound is required then it can be documented as a narrow-band spectrum, in one-third octave bands, or in octave bands.

An octave band sound pressure level is the sound pressure level of sound falling in the range of a single octave of frequencies (corresponding to an octave on a musical instrument). There are eight different octave bands normally used to represent the range of hearing and they are named after the center frequency. These octave bands are: 31.5, 63, 125, 250, 500, 1000, 2000, 4000 and 8000 Hz. The 1000 Hz octave band extends from 707 Hz to 1414 Hz.

One-third octave bands are similar to octave bands but cover one-third the range and there are three times as many of them. Narrow-band spectra give even more detailed frequency information, with each separate band of frequencies often less than 5 Hz in width.

Although an A-weighted level can be calculated from octave band, one-third octave band or narrow-band data, spectral data cannot be calculated from A-weighted data.

In general, an intruding sound that has a higher A-weighted level than the ambient sound will be audible above the ambient and an intruding sound with a much higher A-weighted level than the ambient will be clearly audible (assuming that the intruding sound is above the threshold of hearing). More detailed spectral information is needed to reveal when an intruding sound is audible when its A-weighted level is equal to or lower than the ambient sound level. This can happen when the intruding sound is louder than the ambient in only a part of the frequency spectrum (either narrow band, one-third octave band, or octave band).

2.2 Variation in Sound Level

If the frequency content of the sound is documented through the use of A-weighting, then the following statistical analyses can be used to document the variation of sound amplitude (level) during a period of time:

- Leq--the equivalent (energy averaged) sound level for a period of time,
- Lmin-the minimum sound level measured during a period of time,
- Lmax-the maximum sound level measured during a period of time, and
- Ln---the sound level exceeded "n"% of the time during a period of time.

The Leq is an energy, or logarithmic, average of the A-weighted sound level during a period of time. The decibel is a logarithmic unit and is given by the equation:

$$SPL,\ dB = 10 * \log(p^2 / p_{ref}^2)$$

where: p is the sound pressure (p^2 is the sound energy) and p_{ref} is the reference pressure (20 uPa)

This equation implies that when the sound energy is doubled, the level increases by 3 dB. For example, 40 dB + 40 dB = 43 dB, not 80 dB. 77 dB + 77 dB = 80 dB. Ten people (or machines) making a sound level of 60 dB each results in a sound level of 70 dB. Since 80 dB has 100 times as much sound energy as 60 dB, the Leq energy average of 60 dB and 80 dB is 77 dB, not 70 dB. The practical significance of this logarithmic scale can be shown by computing the Leq average of the 20 samples of A-weighted sound levels listed below.

12, 12, 13, 14, 14, 14, 15, 15, 15, 15, 15,
16, 16, 16, 17, 20, 25, 32, 33 and 33 dBA

The Leq average of these samples is 25 dBA. If these individual samples comprised a time period and the instrumentation system only recorded the Leq of 25 dBA then anyone analyzing the data would not learn that the sound level was below 18 dBA for 75% of the time. The Lmin of 12 dBA and the Lmax of 33 dBA for the time period would not fill the information void. A similar distribution of sound levels might be common in a park if the wind gusted occasionally. To illustrate the significance of such a misleading representation of the actual sound levels, someone planning a development near the park could admit to creating a noise level of 20 dBA at the park but claim that it would be inaudible compared to the ambient Leq of 25 dBA. Actually, the level of the intruding sound would be above the level of the ambient sound for 75% of the time.

The concept of Ln has been developed in order to avoid this potential problem. The L90, which is the sound level exceeded 90% of the time, is often used to represent the baseline or ambient sound level. In the report, "Methodology for the Measurement and Analysis of Aircraft Sound Levels within National Parks", prepared by Mestre Greve Associates (March 1989), the L90 was recommended for use in defining the background sound. Dr. James D. Foch, Jr. also used the L90 to define the ambient sound level in his "Technical Report on Sound Levels in Bryce Canyon National Park and the Noise Impact of the Proposed Alton Coal Mine" (October 1980).

In the example above, the L90 is 12 dBA. The L50 (the sound level exceeded 50% of the time) is 15 dBA. The L10 is 32 dBA. These can be illustrated as follows:

12	12	13	14	14	14	15	15	15	15	15	16	16	16	17	20	25	32	33	33
¦	¦								¦							¦	¦		¦
Lmin	L90								L50							Leq	L10		Lmax

This statistical information presents a clearer picture of the variation in sound levels over a period of time.

2.3 Monitoring Period and Locations

As mentioned earlier, ambient sound levels vary significantly depending on season, weather conditions, nearby activities, local flora and fauna, etc. For example, a significant natural source of sound is wind blowing through leaves; this obviously depends on the wind speed, wind direction (the area may be shielded from wind from certain directions), types of trees in the area, and season (whether leaves are in the trees, loose on the ground, or neither). Insect and animal noise can also vary tremendously based upon the time of year, time of day, and temperature.

Sound measurements made during short visits to a site will be highly dependent on the conditions during the visit. Even if short visits are made during each season, they can be affected by the particular set of conditions occurring during the visits. In order to understand the full range of sound levels that will occur at a site, it is useful to monitor the variation throughout a full year.

It is also useful to correlate the variation in sound levels with the variation in weather conditions. Such a correlation can then be used to estimate sound levels based on the generally available database of years of meteorological data. In order for the correlation to be valid, the meteorological station must be located close to the sound monitor or in a location with very similar weather conditions. Since meteorological data is normally measured with hourly intervals, the sound data should also be in hourly intervals. This is also a standard period for summarizing acoustic data.

Since sound levels vary depending on human activities, sound levels in park areas with high visitor use would be expected to be higher than those at backcountry locations. If visitor use was the predominant existing sound source, then the variation in sound level would follow the amount of visitor use.

In summary, the purpose of this project has been to quantify ambient sound levels and to report the sound level data (and weather data when available) in a consistent format. This information will assist the NPS in evaluating the potential impact of development in or near NPS units.

3.0 DESIGN OF AMBIENT SOUND MONITORING PROGRAM

Clearly, it is most desirable for the NPS to have measurements of the ambient sound quantified in one-third octave bands of frequency. Values for Lmin, Lmax, Leq, L10, L50, and L90 are of interest. At the beginning of this program, battery-powered instrumentation that could measure one-third octave band statistics while operating unattended for extended lengths of time had not been developed by instrumentation manufacturers. In order to obtain this level of detail, it would have been necessary to tape-record the sounds for later analysis in the laboratory. Clearly, obtaining such measurements covering a full year would have been a very labor intensive effort.

Alternatively, instrumentation designed for remote, unattended measurement of A-weighted sound levels was available. This instrumentation could be modified to operate unattended for 15 to 30 days. Since the NPS already owned three of these noise monitors, it was decided to utilize this equipment for the monitoring program. These are Digital Acoustics Model DA 607P noise monitors. In addition, a fourth noise monitor with the additional capability of monitoring meteorological conditions was purchased for this project. The fourth unit is a Larson-Davis Environmental Noise Monitor, Model LD 870, equipped with meteorological sensors.

In order to obtain information about the variation of sound levels with different visitor and weather conditions and during different seasons, it was decided to monitor continuously for 12-month periods at each site. The equipment was equipped with solar panels and designed and installed for a year at each site.

It was decided to concentrate on two park units within the Colorado Plateau with two monitoring sites within each unit. For each unit, a backcountry pristine area and a more heavily used visitor area were chosen. Glen Canyon NRA and Dinosaur NM were selected for the first year monitoring program both because of specific planning needs and/or projects proposed adjacent to the parks, and because of the managers' and staffs' willingness to provide the necessary assistance in maintaining the monitors.

A site near Rainbow Bridge was selected as the high visitor use area to be monitored at Glen Canyon NRA. Since there was no nearby met station and since the canyons have their own localized weather conditions that preclude use of met data even from nearby sites, NPS decided to install a Campbell Scientific met station beside the DA 607P sound monitor.

A site south of Escalante, Utah was selected as the backcountry area to be monitored at Glen Canyon NRA. Again, because of the lack of a nearby met station, met equipment was installed at this site. Because this site would be difficult to regularly access, the Larson-Davis monitor, which can store data for 5 months before needing to be downloaded, was installed (DA 607P monitors need servicing on a biweekly basis).

A site near Harpers Corner was selected as the high visitor use area to be monitored at Dinosaur NM. No separate met station was installed at this site since it was assumed that the weather would be similar to that at the met station at the ranger station. A DA 607P sound monitor was not installed until January 1990 at this site due to equipment problems.

A site on West Cactus Flat was selected as the backcountry area to be monitored at Dinosaur NM. No separate met station was installed at this site since it was assumed that the weather would be similar to that at the met station at the ranger station. A DA 607P sound monitor was installed at this site and a fence was constructed around the site to keep animals (mostly elk) away from the equipment and pole.

The Larson-Davis 870 monitor and DA 607P monitors record A-weighted sound levels. All monitors were set to measure hourly data including the Leq, Lmin, Lmax, L1, L10, L50, L90 and L99. In addition, the DA 607P measured the Lnp (noise pollution level equal to the Leq plus 2.56 times the standard deviation), Mean, Standard Deviation, L.1, L5 and L33.

In order to supplement the A-weighted sound levels, octave band sound pressure levels were measured during periodic visits to the sites. A sound monitoring system was set up to run continuously for 24 hours and to measure hourly octave band sound pressure levels and to calculate octave band and A-weighted sound level statistics. The octave band statistics sound monitor was installed once at each long-term monitoring site.

CSTI, with the assistance and advice of NPS staff from the park units, the Mining and Minerals Branch, and a meteorologist from the Air Quality Division, selected specific monitoring sites and installed the monitors during April 1989. The DA 607P monitors measured and printed out acoustical data continuously. The paper tapes were collected by NPS staff on a biweekly basis. The LD 870 monitor also measured continuously and was downloaded by NPS Mining and Minerals Branch staff on a less regular basis. Due to equipment problems encountered after installation, the LD 870 monitor was replaced with another LD 870 in January of 1990. Approximately once per quarter, CSTI personnel visited the monitoring sites, collected data, checked out the equipment, and calibrated the monitors. During these trips, octave band sound pressure level statistics were also measured.

Paper tape printouts of DA 607P data were entered into a Lotus spreadsheet program by NPS Mining and Minerals Branch staff. Larson-Davis software was used to download data directly from the LD 870 to a portable computer and to analyze the data. Sound and weather data was then analyzed and plotted by CSTI using Lotus macros developed by CSTI. The following analyses were performed and plotted:

> <u>Hourly variation in sound levels</u>: The average Leq, average L90 and minimum Lmin sound levels for each hourly period in a month were calculated. For example, the 31 L90 sound levels for 1 PM to 2 PM for the 31 days of the month were averaged arithmetically to determine the average 1 PM to 2 PM L90 sound level for the month. A figure plotting all 24 hours depicted the variation in hourly sound levels during an average day for a specific month at a specific site. In the analysis sections, such numbers are referred to as L90 hourly sound levels for an average day for a specific month. A similar figure was made which plotted the L1, L10, L50, L90, L99 and Lmin and a third figure was made which plotted the maximum, arithmetic average, and minimum L90's.
>
> <u>Hourly variation in wind speed and temperature</u>: The average hourly wind speeds were also averaged for each month in a manner similar to the method described for acoustic data above. The resulting figure, depicting the variation in wind speed during an average day for a specific month at a

specific site, can be compared with the corresponding acoustic data to determine the impact of wind on ambient sound levels. A similar figure was also made using temperature data.

Daily variation in sound levels: The maximum, minimum and average hourly L90 sound levels for each day were also calculated and plotted. The maximum and minimum hourly L90 sound levels were the highest and lowest of the 24 hourly L90 sound levels for each day. The average was the arithmetic average of the 24 hourly L90 sound levels. The figure plotted these three numbers for each day of each month. These monthly figures can be connected end to end to show the variation in daily sound levels for several months, assuming that there were no major data lapses. In the analysis sections, such numbers are referred to as maximum, minimum and average daily L90 sound levels.

Quarterly summaries of hourly variation in sound levels: For each month, the L90 hourly sound levels for an average day were calculated as described in the section on "hourly variation of sound levels". For each quarter, a single figure was then produced plotting the three curves for average days for each of the three months in the quarter. This graph provides a summary of the seasonal variation in sound levels.

Monthly analysis was conducted by CSTI and the NPS was provided with printouts of data as well as the graphs discussed above. Quarterly summary graphs were also provided whenever a full or nearly full quarter of data was measured. Complete sets of data and figures are on file at Glen Canyon NRA, Dinosaur NM, the Rocky Mountain Regional Office, and the office of the Mining and Minerals Branch. All conclusions and interpretations of the data are presented in this report.

4.0 SOUND AND METEOROLOGICAL MONITORING EQUIPMENT

As mentioned earlier, the NPS owned 3 Digital Acoustics monitors and purchased a Larson-Davis monitor for this program. During the course of this project, CSTI assisted the NPS in obtaining five additional DA monitors from the United States Air Force (USAF).

4.1 Digital Acoustics Environmental Noise Analyzer

Digital Acoustics DA 607P monitors were installed at Rainbow Bridge in Glen Canyon NRA and at West Cactus Flat in Dinosaur NM. A third monitor was to have been installed at Harpers Corner in Dinosaur NM but it was not functioning properly and was determined to be irreparable. A different

DA 607P was installed at Harpers Corner in late January 1990. At the conclusion of the project, the DA 607P monitor at Harpers Corner was still monitoring sound levels and three additional DA 607P units were installed at Colorado National Monument to continue monitoring along the Colorado Plateau. The continued monitoring at Harpers Corner and the monitoring at Colorado National Monument are beyond the scope of this contract and will not be further discussed in this report.

The DA 607P is a Type 1 (Precision) Sound Level Meter and Statistical Noise Analyzer. It has a dynamic range of over 120 dB, due to a special autoranging technique. The DA 607P has a built-in thermal printer (2 1/2" wide) on which all data are printed. The unit does not store data in memory, so data must be read from the printout and then entered into a Lotus spreadsheet for analysis. The paper take-up spool can only hold about two weeks of data with the unit printing out the daily Leq and the hourly Leq, Max, Min, Mean, Std. Dev., Lnp, and Ln's.

The DA 607P can operate off of its batteries for about one week. In order to allow for continuous unattended operation at remote sites, the DA 607P was connected to an Arco solar panel which recharged the batteries during daylight hours. For each DA 607P monitor, a kit was assembled including a ten-foot pole stabilized with guy wires and built to allow access for periodic calibration of the microphone. The microphone was located at the top of the pole and was protected by a wind screen and a rain hat. The solar panel was located about half-way up the pole. Cables connected the microphone and solar panel to the DA 607P monitor which was housed in a large weather-proof box. All equipment was grounded. The system was designed to have a minimal impact on the installation site with no permanent installation components such as footings or anchors.

All DA 607P Monitors were inspected, tested and certified prior to installation at the monitoring sites.

4.2 Larson-Davis Environmental Noise Monitor

A Larson-Davis LD 870 Environmental Noise Monitor was installed at the Escalante site in Glen Canyon NRA and is currently operating at that site.

The Larson-Davis Model 870 is a Type 1 (Precision) Sound Level Meter with the capacity to measure and store large amounts of data on noise along with data from four other inputs. The NPS monitor used these four additional channels for storing data on wind speed, wind direction, humidity and temperature. The Model 870 stores acoustic and meteorological data in its internal memory and the data can be retrieved by a computer with an RS-232 interface.

The LD 870 installation system consisted of a 10 foot tall pole supported by guy wires attached to stakes driven into the ground. The meteorological monitors were located at the end of an arm extending off of the main pole. The solar panel was connected about half-way up the pole. The LD 870 monitor and rechargeable batteries were housed in a box connected to the pole. All equipment was grounded. Like the DA 607P systems, the LD 870 system was designed to have a minimal impact on the installation site with no permanent installation components such as footings or anchors.

Although the LD 870 functioned well during September 1989, there were many problems before and after that month. After servicing, the monitor was normally left running but upon returning to the site, the unit was usually found stopped and with all data lost. There were also difficulties in getting the monitor to interface with the portable computer. Several trips were made to the site by a representative of the monitor manufacturer but the "solutions" always turned out to be inadequate.

In January of 1990, the manufacturer discovered that a bad batch of solder had been used in the manufacturing of the monitor and that this was resulting in the monitor shut-downs and loss of data. A new LD 870 was installed and it has run properly ever since.

4.3 Meteorological Equipment

A meteorological station was installed and maintained by NPS personnel at Rainbow Bridge. The station used a Campbell Scientific datalogger to monitor wind speed, wind direction, temperature, humidity, and solar radiation. NPS personnel downloaded the data to a portable computer and a copy of the data file was sent to CSTI for comparison with the sound data.

As noted in Section 4.2, meteorological equipment was also located at the Escalante site in Glen Canyon NRA as part of the LD 870 Monitor.

4.4 Octave Band Statistical Analysis System

The octave band statistical analysis system consisted of a Larson-Davis Model 800B Sound Level Meter connected to a Hewlett-Packard HP-75C Laptop Computer and an HP 9114B Disk Drive. The system was battery powered and housed in a portable weather-proof container. It included a high sensitivity microphone that could measure octave band sound pressure levels down to 5 dB (in some octave bands) and A-weighted sound levels down to 16 dB. The HP-75C computer ran the sound level meter, calculated hourly statistics on the acoustic data, and then stored the statistics on the disk drive. The computer was used later to recall the data from the disk drive and to print out the data.

4.5 Calibrators

The DA 607P Sound Monitors were calibrated on a quarterly basis with a GenRad Model 1562-A Sound-Level Calibrator. The calibration level was corrected for altitude. There were no problems with the monitors drifting significantly.

The LD 870 Monitor was calibrated on a quarterly basis with a Larson-Davis CA250 calibrator. The LD 870 also has a built-in calibrator to check its internal calibration on a daily basis.

The octave band statistical analysis system was calibrated before every use with a Larson-Davis CA250 calibrator.

5.0 MONITORING RESULTS AT RAINBOW BRIDGE SITE, GLEN CANYON NRA

5.1 Monitoring Site

Rainbow Bridge was selected as the monitoring location in Glen Canyon NRA with periods of high visitor use. The primary considerations in selecting an exact site for the installation were to have sound levels that were representative of the general area, to get adequate sunlight for the solar panel, and to avoid the high visibility that might result in vandalism (previous equipment in the area had been vandalized). The site also had to be readily accessible for biweekly servicing by park personnel and had to be near the dock area so that boat noise would be measured as part of the ambient.

Two locations were considered--one just south of the docks and one on a hill just east of the docks. The site just south of the docks was on the north slope of an incline that might have completely shielded the site from the low winter sun. The primary concern, however, was that this site was clearly visible from the dock area and the equipment would have been obvious to anyone visiting the area. Although the east site was significantly shielded from early morning sun and was later found to be shielded from late afternoon sun in the winter, it was selected since the monitors would be less conspicuous, reducing the potential for vandalism.

Although Rainbow Bridge itself was not visible from the monitoring site, boats approaching the docks were clearly visible (and audible) along with most of the docks and the walkway to Rainbow Bridge. Because of the steep canyon walls that reflected noise, boats were also audible even when they were not visible around the bend of the canyon north of the monitor.

The monitoring site was on a hill overlooking the canyon and was located about 30 feet west of a large cliff. There were no trees nearby but there was some sparse low vegetation. Because the wind speeds and direction were strongly affected by the canyon and the nearby cliffs, a meteorological station was located about 15 feet from the sound monitoring system to allow for correlation of the sound and meteorological data.

Figure 1 shows the monitoring site. All figures for the Rainbow Bridge site are contained in Section 5.6.

5.2 Monitoring Equipment

A DA 607P noise monitor was installed at Rainbow Bridge on April 19, 1990. From late spring until early fall, the monitor ran continuously except for June 4-7 and August 9-11. These short periods without data occurred when the paper take-up roll was full and stopped operating before the monitor was serviced by NPS staff.

From October 12 - January 16, there were a number of problems with the monitor. The DA 607P was accidentally turned off once resulting in a need for the acoustic calibrator before restarting. During this period, the daily sunshine on the monitor was insufficient to keep the batteries charged and the batteries were not sufficiently holding their charge even when manually recharged. The monitor was run from January 17-21, 1990 on a charged set of batteries but some of this data looks unreliable. The batteries died because of insufficient charging on January 21 and the monitor was left off until April 6 when the sun was again sufficiently high to adequately recharge the batteries. The monitor then ran until April 14 and was removed shortly afterwards.

5.3 Analysis of Monitored Data

Acoustic data for the Rainbow Bridge site is primarily available for the late spring until early fall. There is a good consistency of the data for these seven months as shown in Figures 2 - 4. This type of diurnal pattern (low steady levels at night and a curve with the highest levels around noon) is normally associated with the wind since wind speed follows a similar pattern and is the major source of noise in undeveloped areas.

Figure 5 shows average wind speeds for the month of August (the first month with complete wind data). By comparing this curve with the curve showing sound levels for August (Figure 3), the correlation between wind speed and sound is shown to be less obvious. Sound levels begin increasing at 7 AM and have increased significantly by 9 AM while wind speeds do not begin to increase until 10 AM. Sound levels also peak by 11 AM whereas the wind speeds do not peak until 1 PM.

Although the wind will have some effect on sound levels, there are many other factors. Although there is not a great deal of fauna in the area, birds and some other animals often start making noise at sunrise. The primary cause of noise, however, is probably visitors to Rainbow Bridge. A plot of daily visitors to the site might look very similar to the plot of daily sound levels. A few visitors arrive early in the morning but the highest attendance (including the large tour boats) is in the middle of the day. This source of the noise also explains the gradual increase in maximum hourly L90 sound levels for an average day in April (34 dBA) to May (37 dBA) to June (40 dBA); the number of visitors to Rainbow Bridge is also increasing during this period. The maximum hourly L90 sound level is the same for average days in the months of June, July and August (40 dBA) and decreases slightly in September and October (39 dBA).

For April, May, June, July, September and October, nighttime sound levels range from 18 to 25 dBA. The lack of visitors and low wind speeds result in these low sound levels. For the month of August, however, there is an increase in sound levels between 8 PM and 4 AM. A more detailed investigation of the data shows that this increase occurs primarily during the last half of the month and the hourly L90 sound levels typically range from 30 dBA all the way to 50 dBA. This is probably the result of insect noise and is described in more detail in the following section (5.4).

Plots of the maximum, minimum and average daily L90 sound levels are presented in Figures 6 - 12. As is shown, the minimum hourly L90 sound level for most days is 18 to 20 dBA which is the noise floor of the noise monitor. Since the primary sound source, visitors to the site, is steady throughout weekdays and weekends, the average daily L90 sound levels are very consistent from day to day. There is a gradual increase in this average from late April (25 dBA) until the middle of June (30 dBA). This level stays steady throughout most of the summer but is increased to about 32 dBA by the insect noise in the second half of August. In September, the average daily L90 sound level decreases to 28 dBA and in October it decreases further to 22 dBA.

Data from April 1990 as shown in Figure 13 are similar to the data from April 1989 with an average day having L90 hourly sound levels of 21 dBA at night increasing to a maximum of 34 dBA during the day.

5.4 Analysis of Octave Band Data

Octave band sound pressure level statistics were measured next to the long-term sound monitor from 3 PM on August 22, 1989 to 3 PM on August 23. Figure 14 is an example of the statistical data that was calculated for each hour. Figure 15 presents three hourly L90 spectra measured during the monitoring period. These spectra are from the hours with the lowest L90 A-weighted sound level (20 dBA from 6-7 PM), the highest L90 A-weighted sound level (54 dBA from

8-9 PM), and the highest daytime L90 A-weighted sound level (42 dBA from 11 AM - 12 Noon).

The data for 6-7 PM are just above the noise floor for the equipment for most octave band sound pressure levels. The 8000 Hz octave band sound pressure level is at the noise floor so the actual sound pressure level in that octave band may have been even lower. The highest spectrum (8-9 PM) is dominated by high sound levels in the 2000 - 8000 Hz octave bands and especially the 4000 Hz octave band. This was probably the result of insect noise. The octave band sound pressure levels for the middle and low frequencies, however, are even lower than the 6-7 PM spectrum due to the lower winds and no boat traffic. The spectrum from 11 AM to 12 Noon includes some boat and visitor noise (the boat engines create the high levels of low frequency noise). Although the A-weighted sound level is 12 dB lower than the A-weighted sound level for the sample with the insect noise, most of the octave band sound pressure levels are substantially higher than those from that hour.

5.5 Conclusions

The major sources of noise at the Rainbow Bridge monitoring site were boats and visitors. L90 hourly sound levels for average days ranged from 22 to 34 dBA in April and from 22 to 40 dBA throughout the main visitor season in the summer. Average daily L90 sound levels ranged from 22 dBA in October to 34 dBA in August. During the winter, when there are less visitors, daily sound levels would be expected to be even lower.

During the nighttime when there were no visitors, hourly L90 sound levels were normally 20 to 25 dBA. Actual sound levels may have been lower since the measurements were at the noise floor of the equipment. For the purpose of comparison, 20 dBA is about the sound level of a very quiet concert hall and is also about the sound level of a whisper. In the last half of August just after sundown, however, nighttime hourly L90 sound levels increased to 30 to 50 dBA, probably as a result of insect noise.

5.6 Figures for Rainbow Bridge Site

The figures for the Rainbow Bridge Site listed below are presented on the following pages.

Rainbow Bridge

Figure 1. Rainbow Bridge Monitoring Site.

Average L90's for 2Q 1989

Rainbow Bridge, GLCA

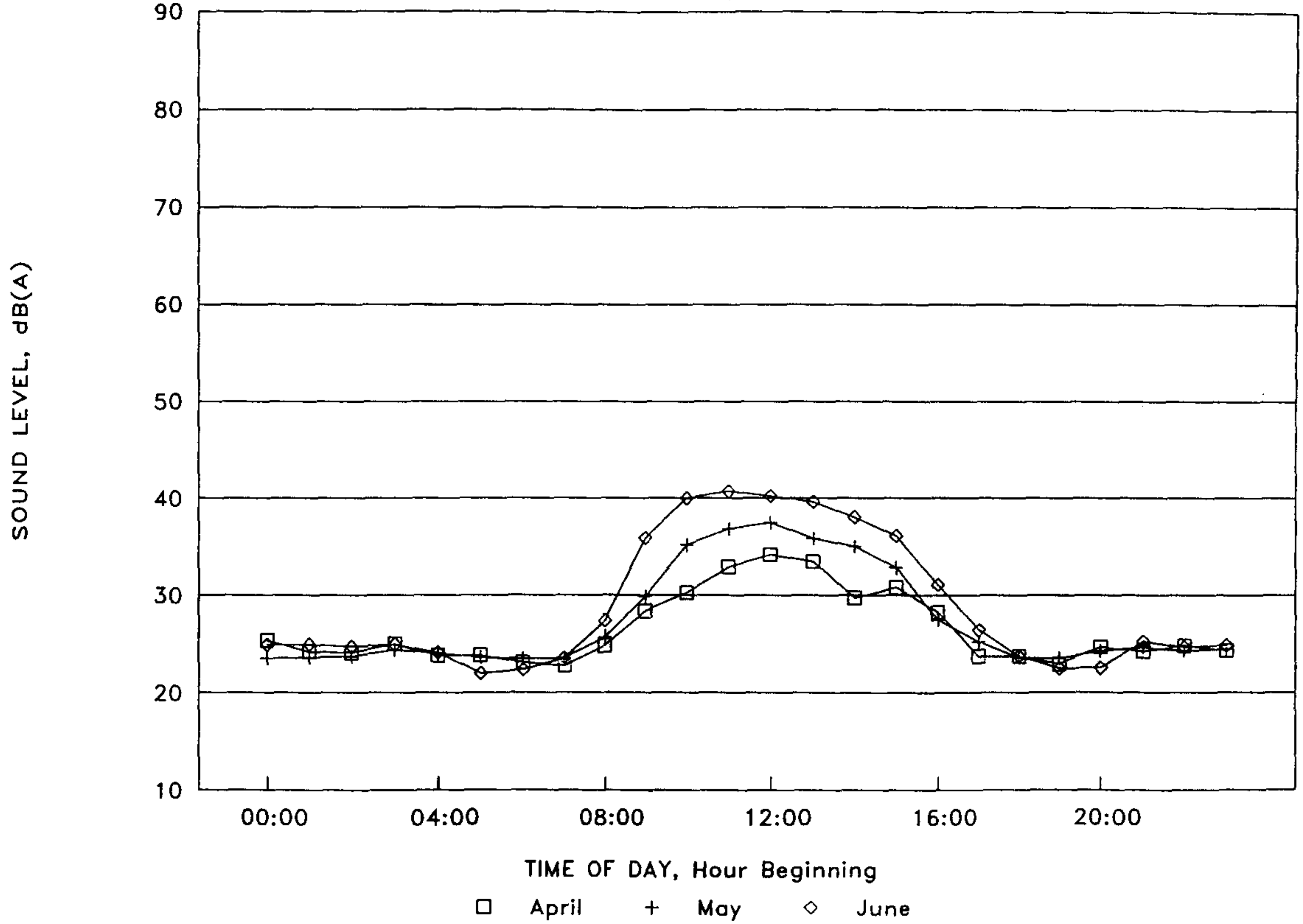


Figure 2

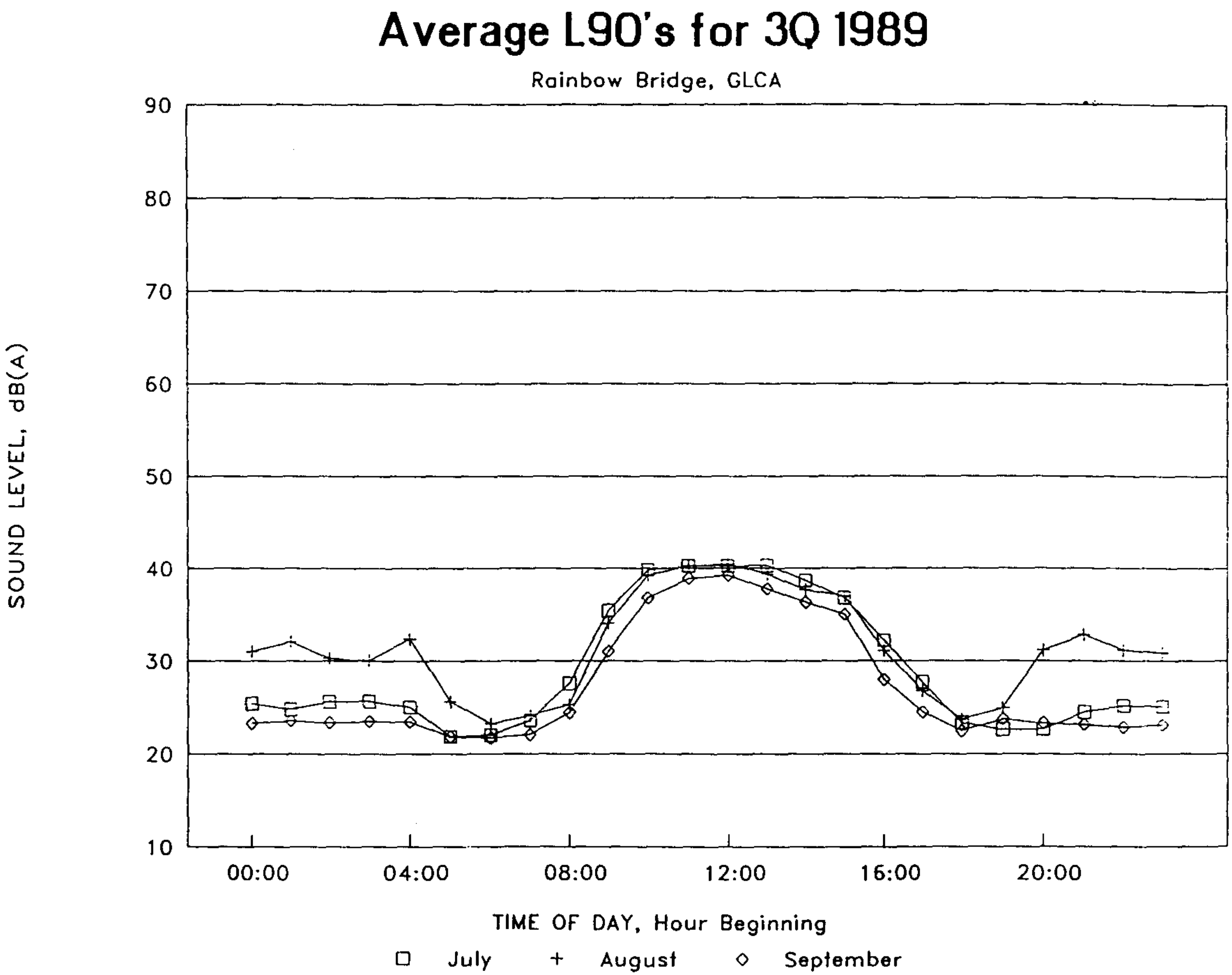
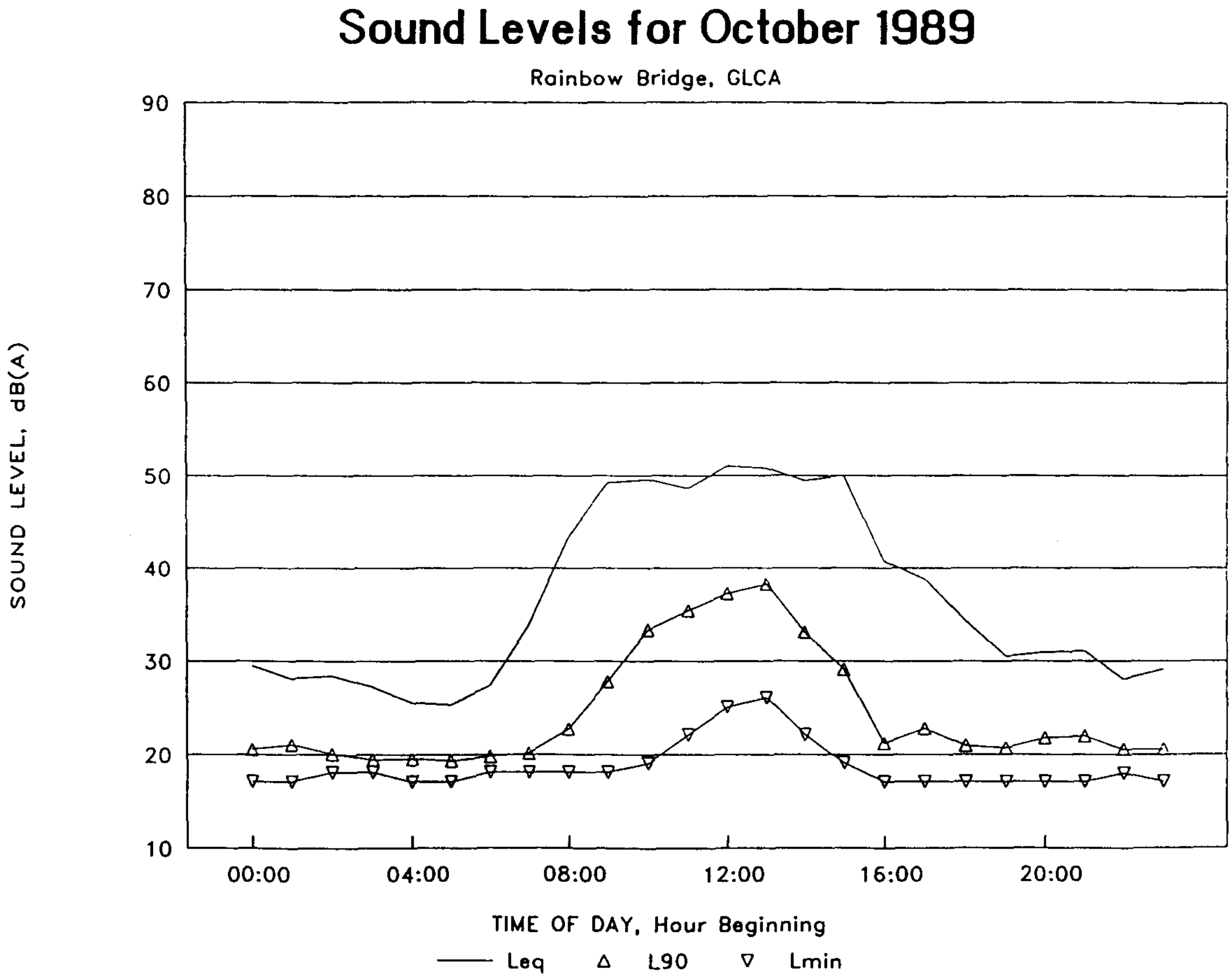

Average L90's for 3Q 1989
Rainbow Bridge, GLCA
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
00:00
04:00
08:00
12:00
16:00
20:00
TIME OF DAY, Hour Beginning
July
August
September

Figure 3



Sound Levels for October 1989
Rainbow Bridge, GLCA
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
00:00
04:00
08:00
12:00
16:00
20:00
TIME OF DAY, Hour Beginning
Leq
L90
Lmin

Fig. 4

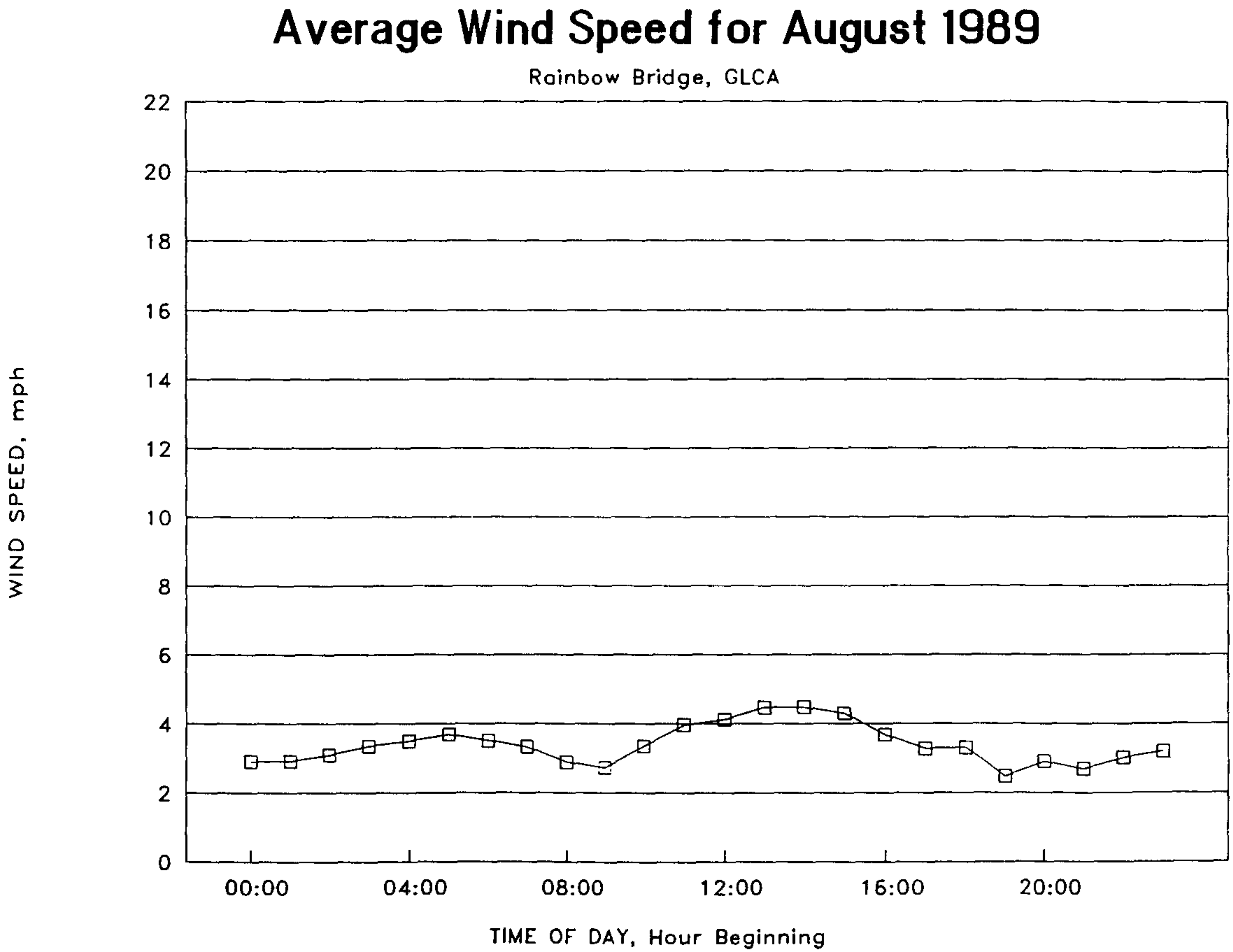
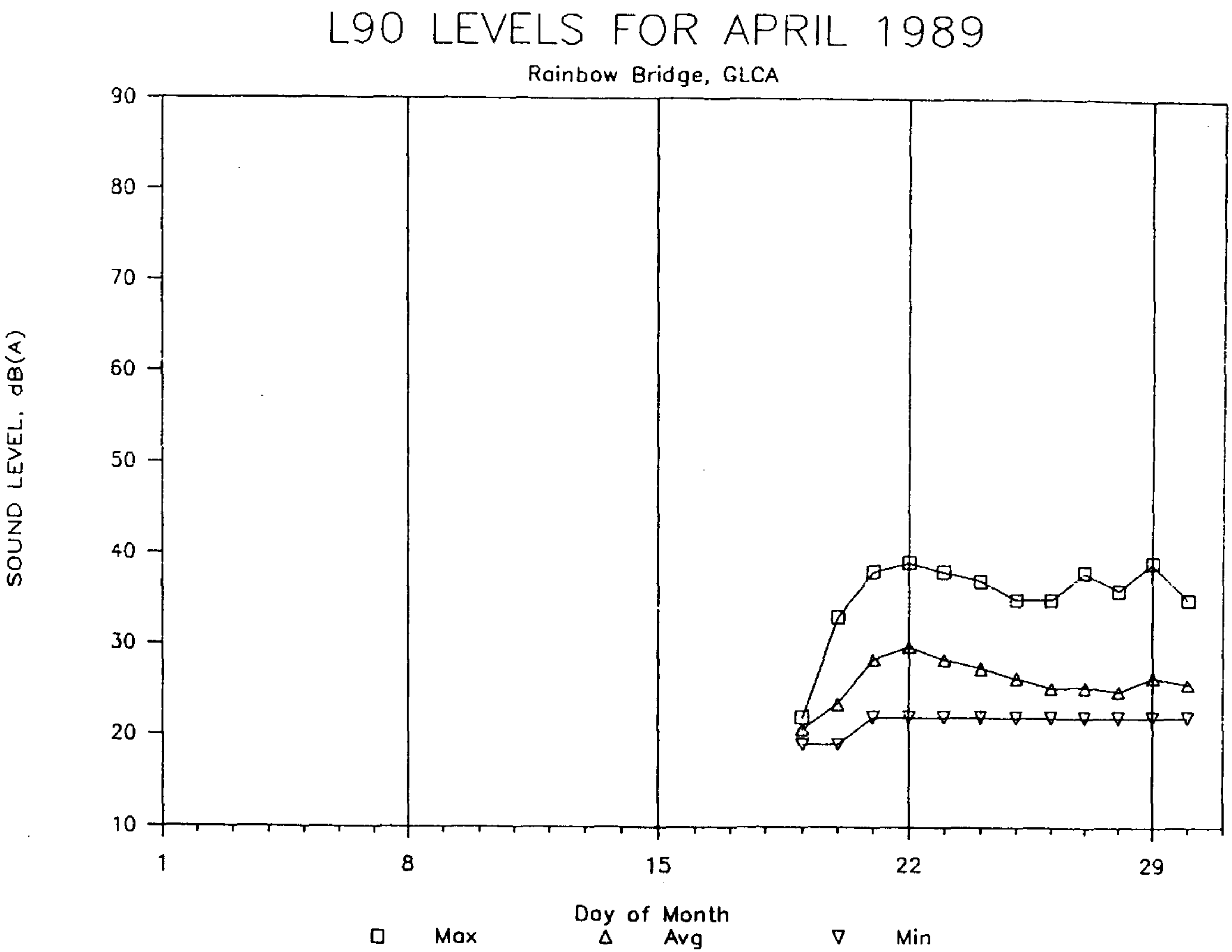

Average Wind Speed for August 1989
Rainbow Bridge, GLCA
WIND SPEED, mph
0
2
4
6
8
10
12
14
16
18
20
22
00:00
04:00
08:00
12:00
16:00
20:00
TIME OF DAY, Hour Beginning

Figure 5



L90 LEVELS FOR APRIL 1989
Rainbow Bridge, GLCA
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
1
8
15
22
29
Day of Month
Max
Avg
Min

Figure 6

L90 LEVELS FOR MAY 1989

Rainbow Bridge, GLCA

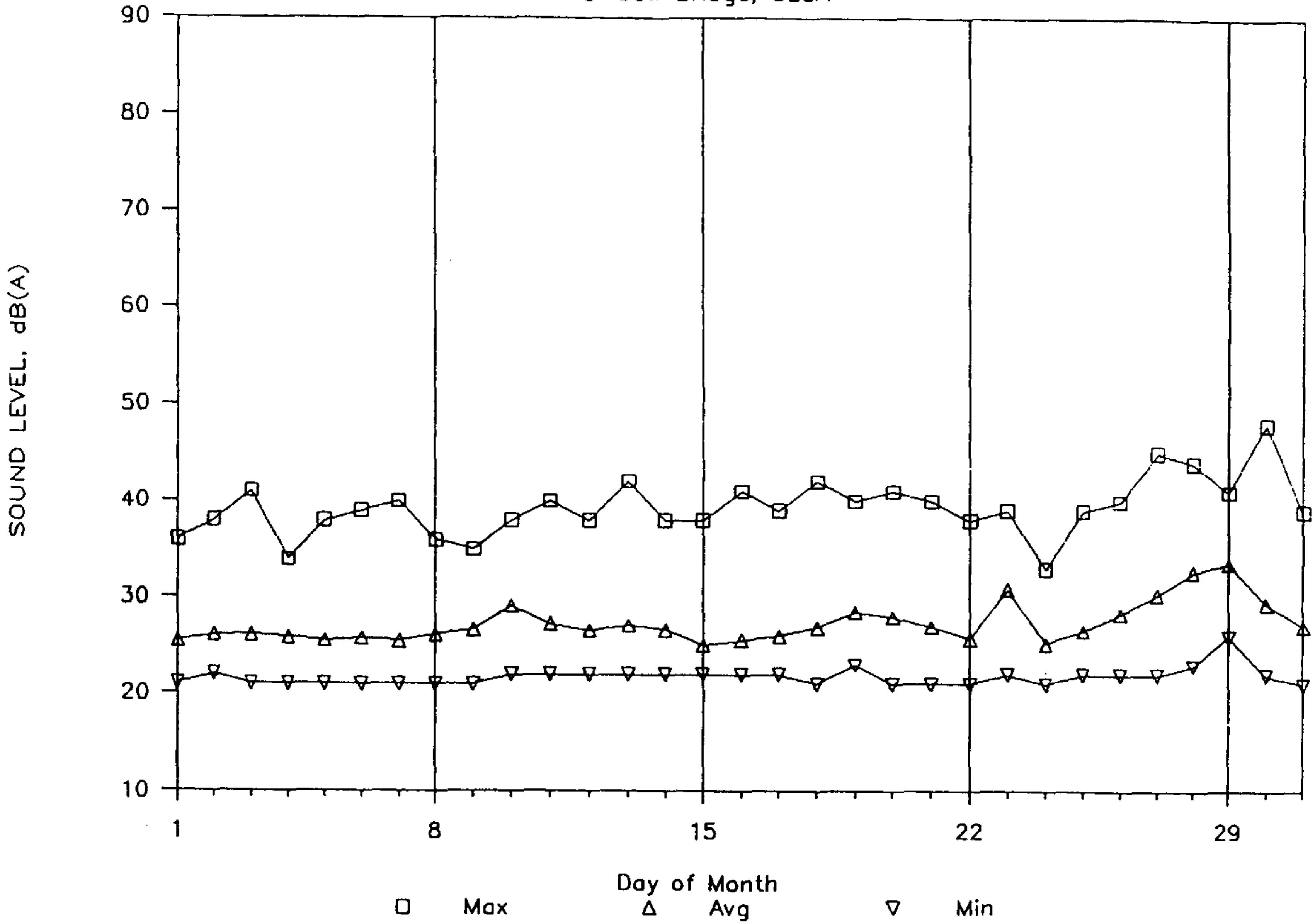
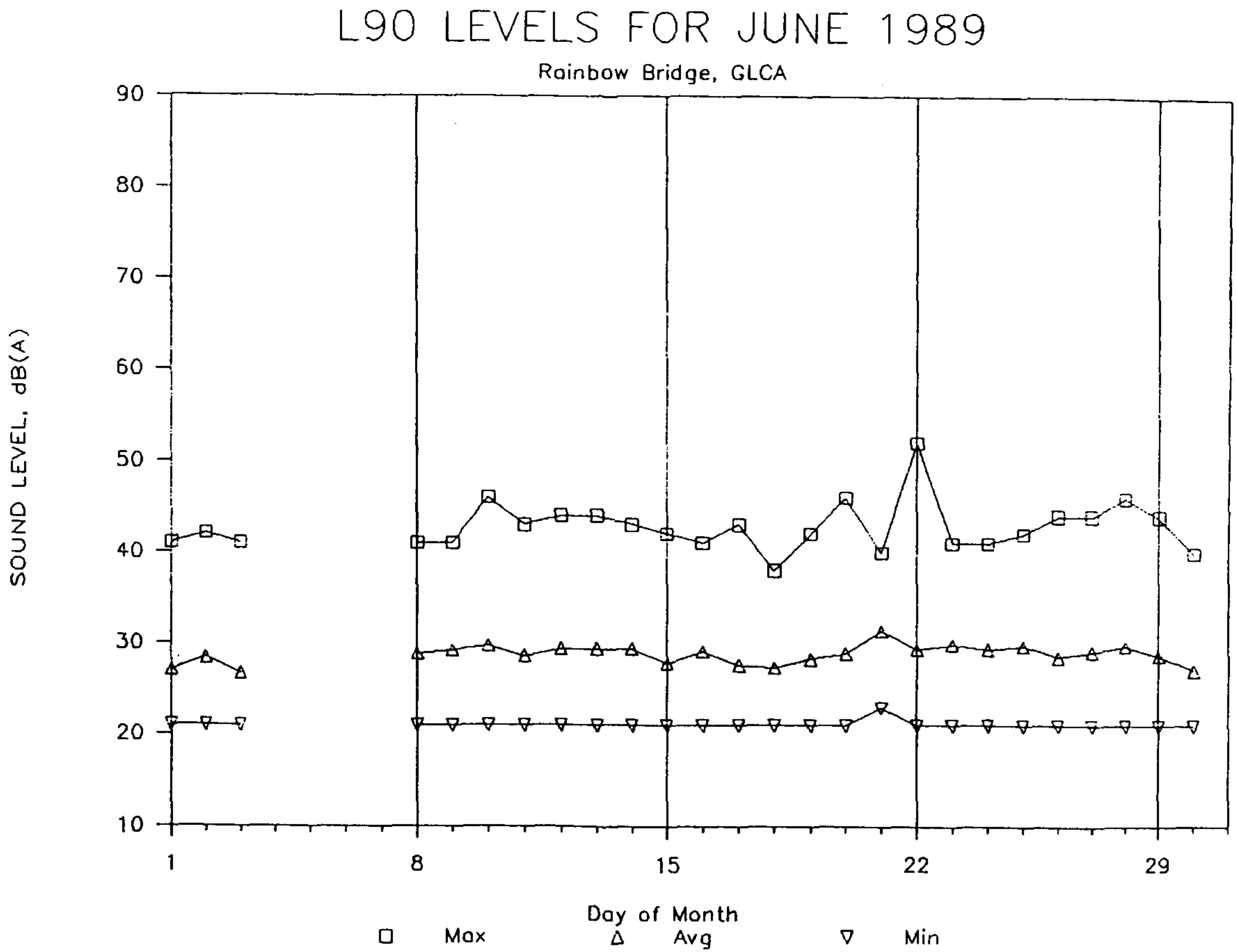


Figure 7



L90 LEVELS FOR JUNE 1989
Rainbow Bridge, GLCA
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
1
8
15
22
29
Day of Month
Max
Avg
Min

Figure 8

L90 LEVELS FOR JULY 1989

Rainbow Bridge, GLCA

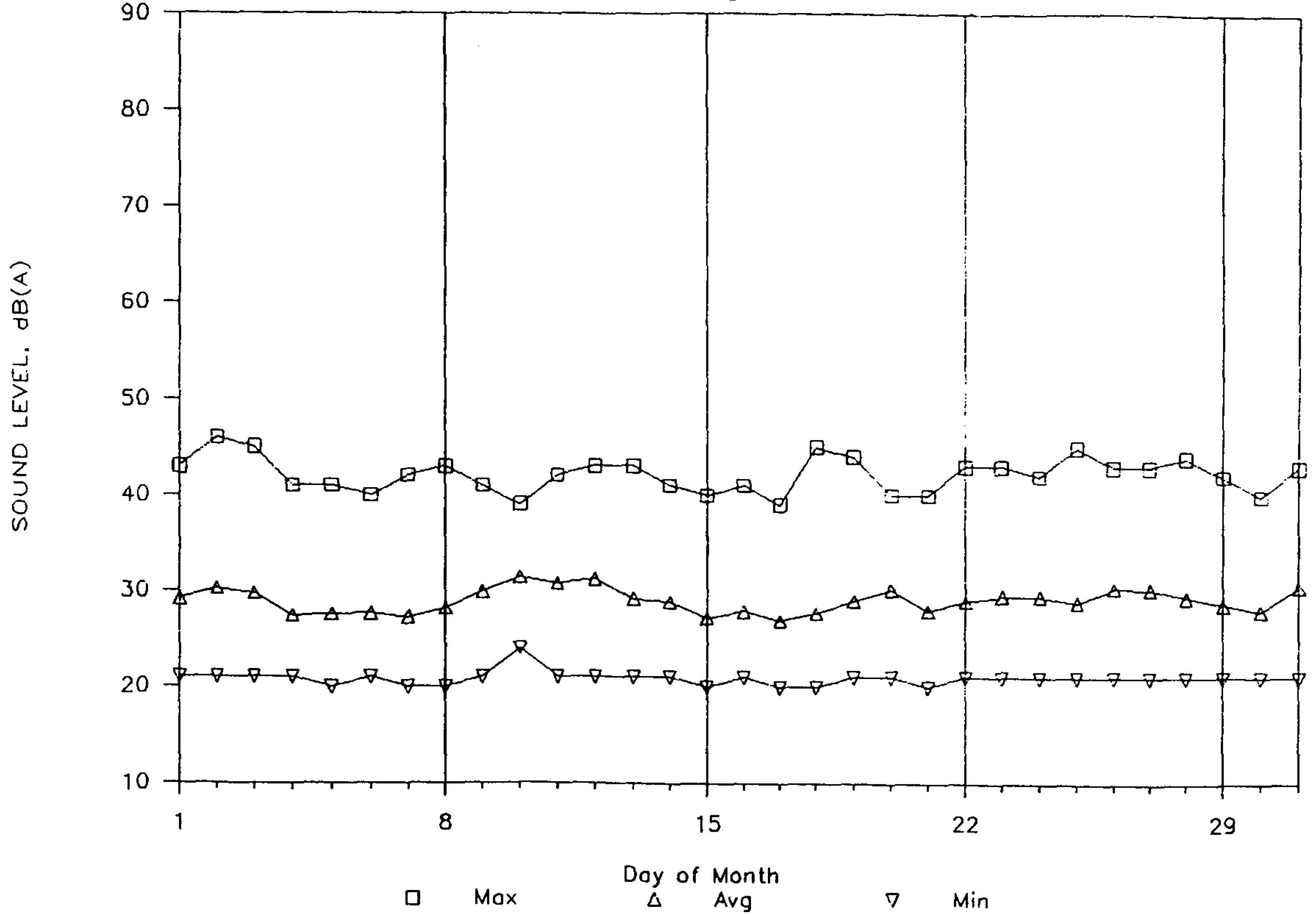


Figure 9

L90 LEVELS FOR AUGUST 1989

Rainbow Bridge, GLCA

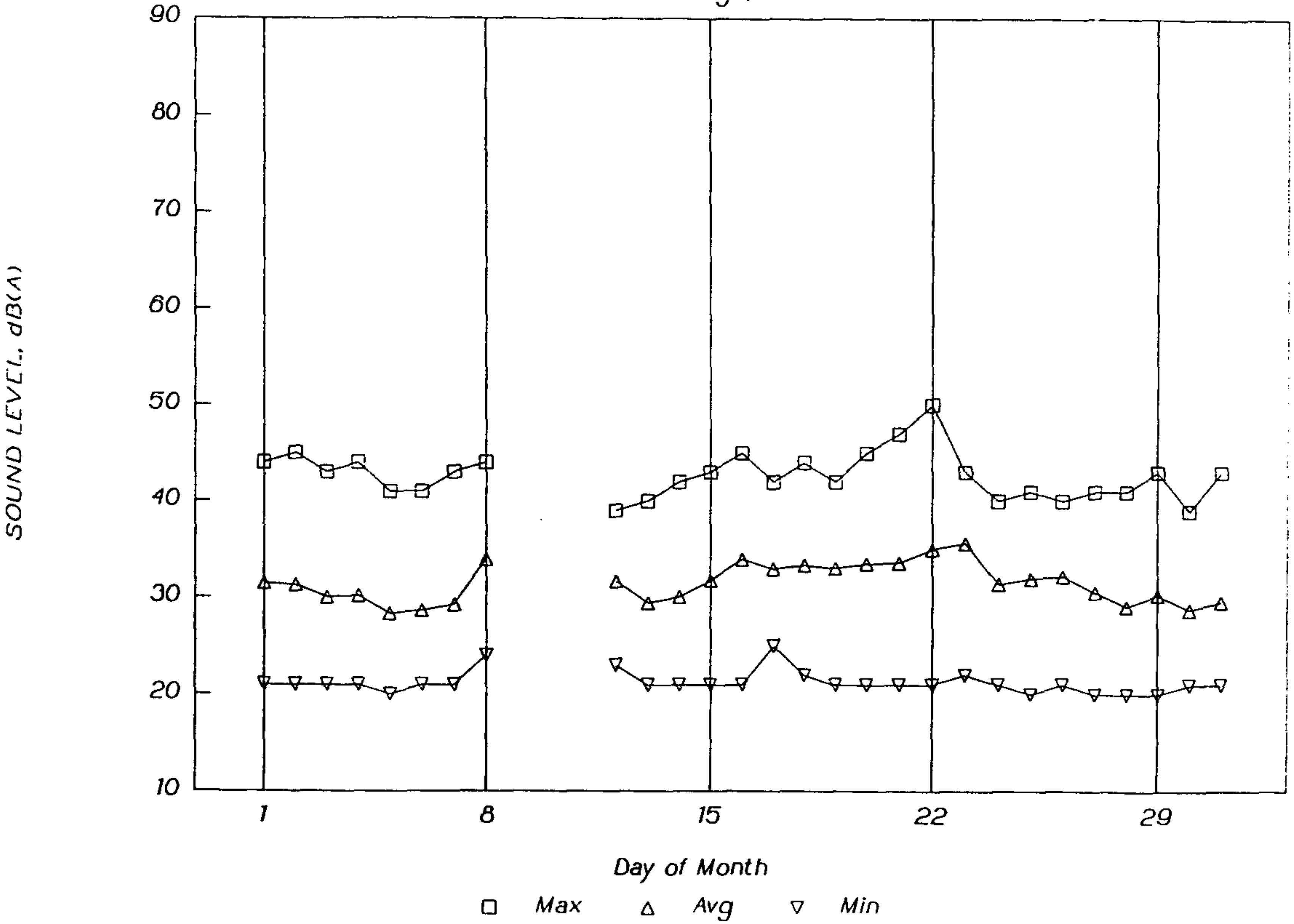


Figure 10

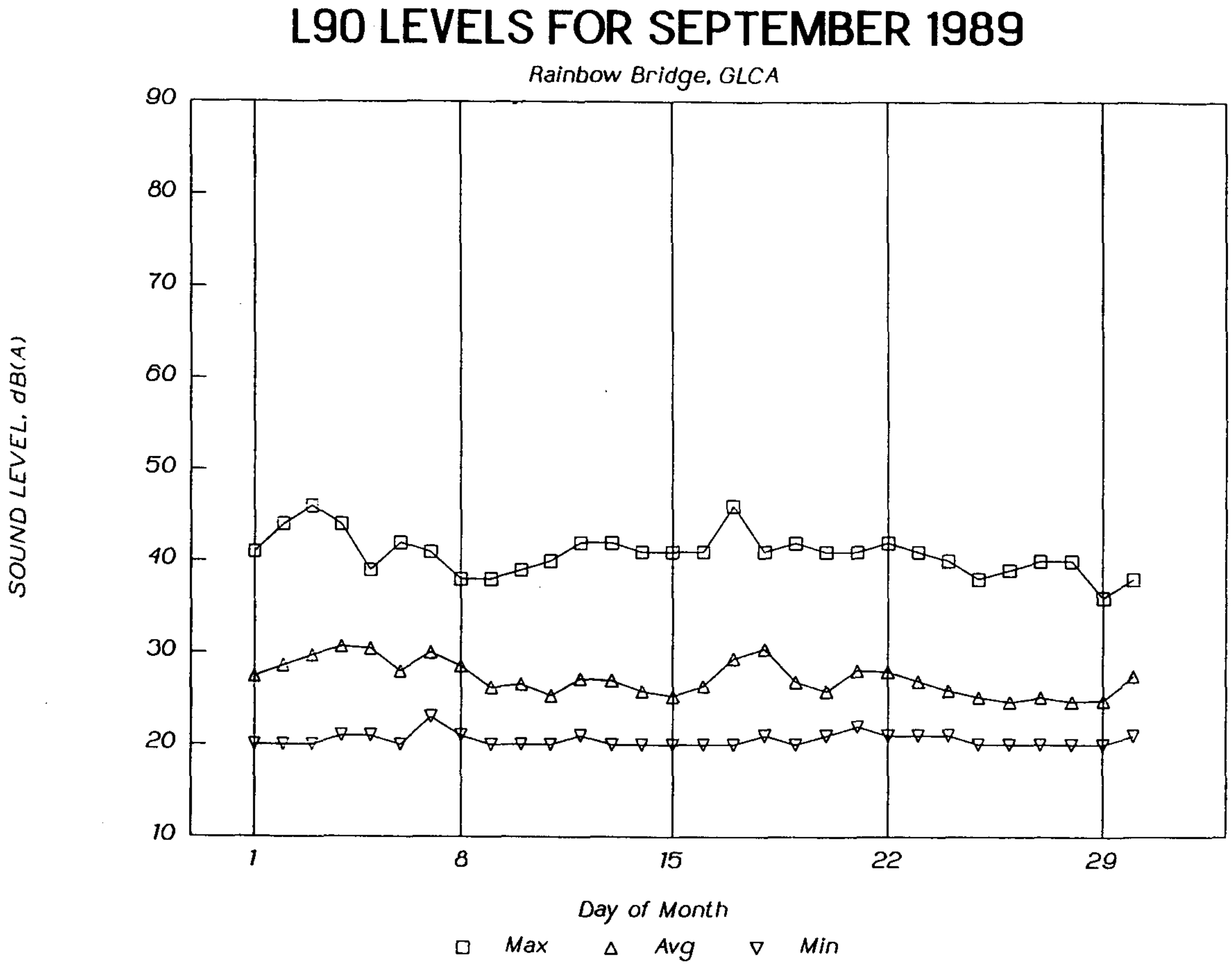

L90 LEVELS FOR SEPTEMBER 1989
Rainbow Bridge, GLCA
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
1
8
15
22
29
Day of Month
Max
Avg
Min

Figure 11

L90 Levels for October 1989

Rainbow Bridge, GLCA

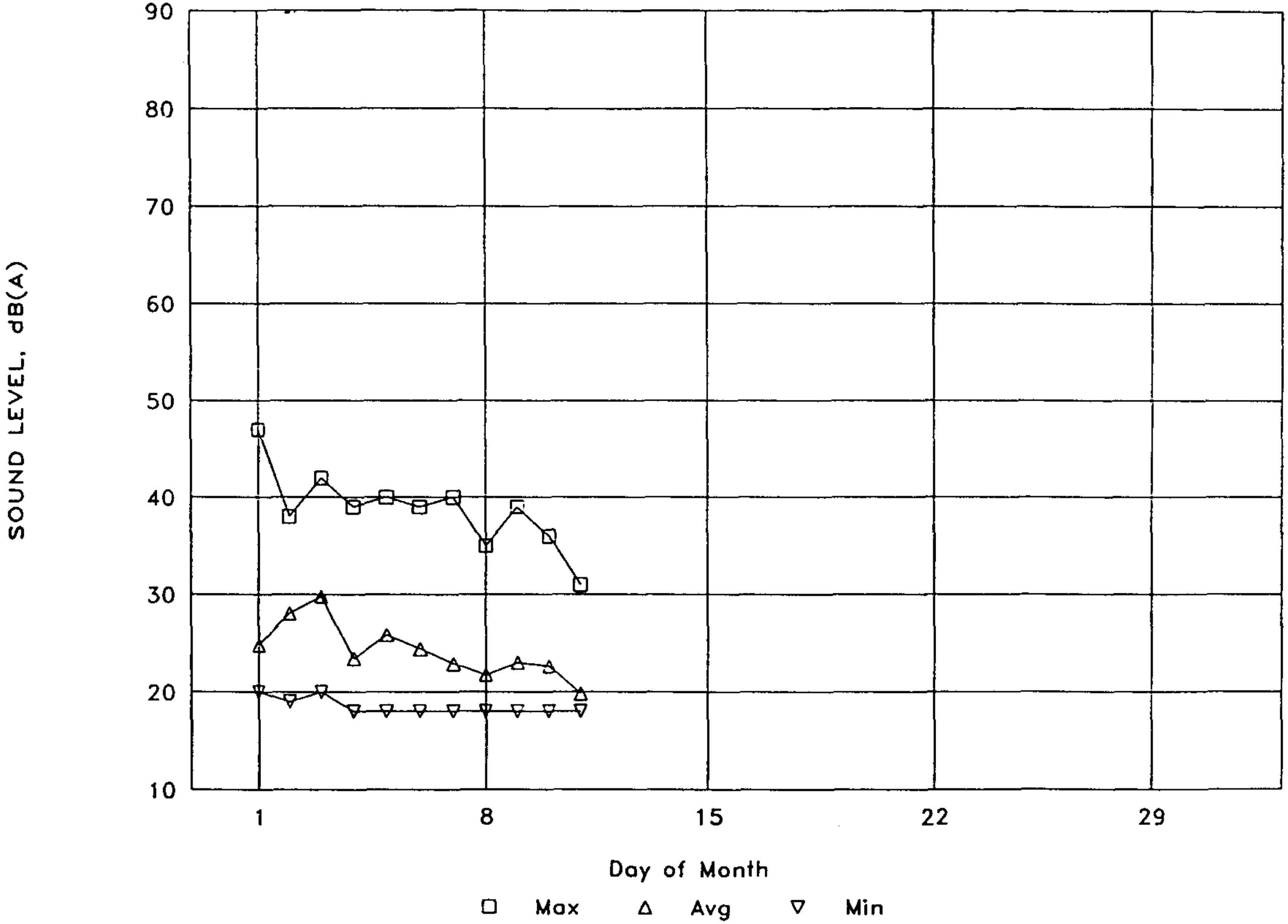


Figure 12

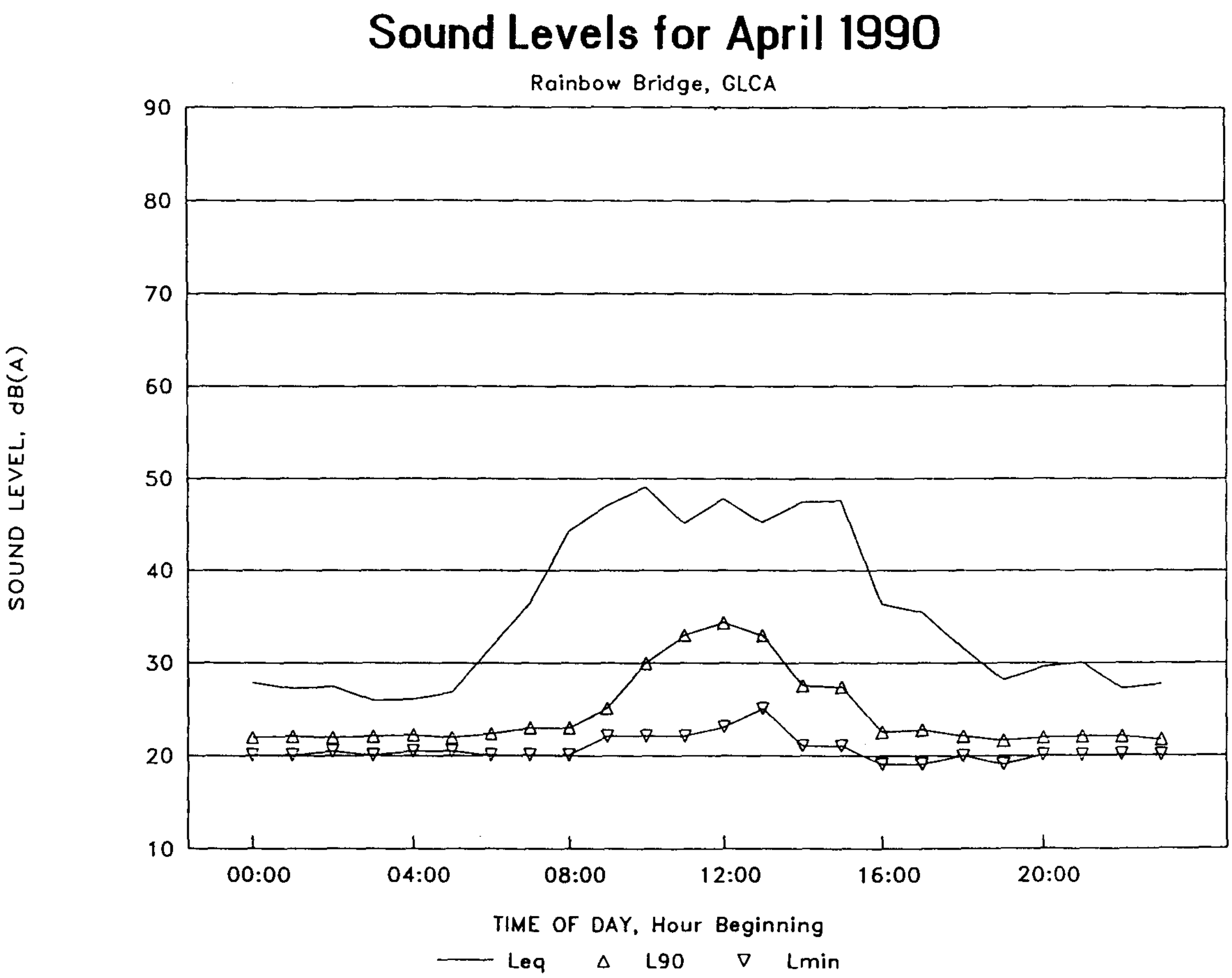

Sound Levels for April 1990
Rainbow Bridge, GLCA
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
00:00
04:00
08:00
12:00
16:00
20:00
TIME OF DAY, Hour Beginning
Leq
L90
Lmin

Figure 13

COLLABORATION IN SCIENCE AND TECHNOLOGY INC.

Consultants in Acoustics
Houston, Texas

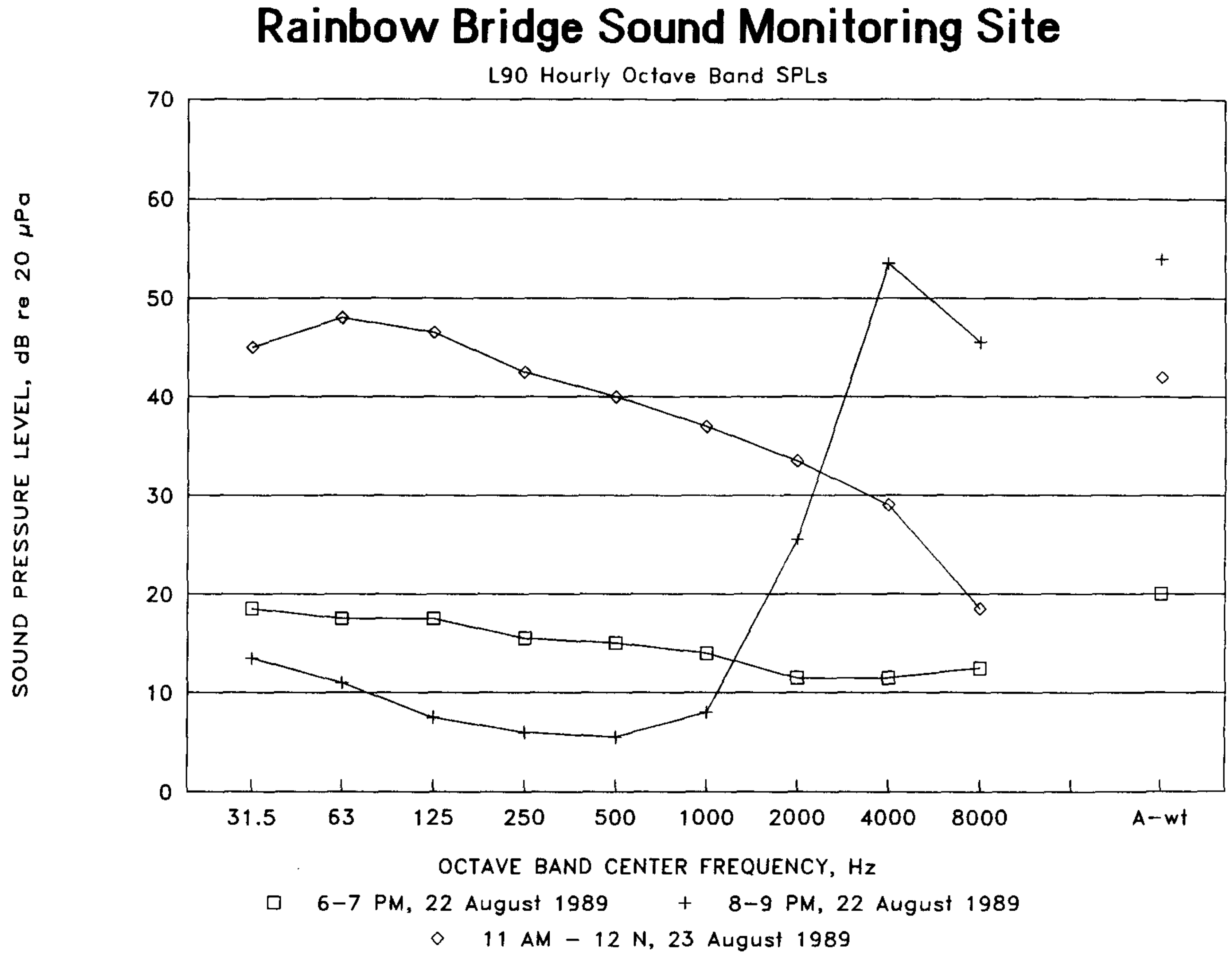
08/23/89

Job #: 5026
Location: Rainbow Bridge
Date: 08/22/89
Range: -10 to 90 dB (autorange)
Integration: 2 sec.
Start Time: 20:00:00
Stop Time: 20:58:35

OCTAVE BAND STATISTICS

	31.5	63	125	250	500	1000	2000	4000	8000	A WT
Leq, dB	33.0	33.5	29.0	21.9	12.9	10.3	27.5	55.6	47.5	56.2
L10, dB	37.0	37.0	31.5	21.5	13.0	10.5	29.5	57.5	49.5	58.0
L33, dB	19.5	16.5	11.5	10.0	7.0	9.5	27.5	55.5	47.5	56.5
L50, dB	16.5	12.0	9.0	7.0	6.5	9.0	27.0	55.0	47.0	55.5
L90, dB	13.5	11.0	7.5	6.0	5.5	8.0	25.5	53.5	45.5	54.0
Lmin,dB	13.0	9.5	6.3	5.0	5.0	7.8	24.5	48.5	43.3	51.9
Std Dev	9.69	10.77	9.85	7.35	4.42	1.84	1.40	1.66	1.54	1.65
# SAMPLES	71	71	71	71	71	71	71	71	71	71
# OVLDS	0	0	0	0	0	0	0	0	0	0

Figure 14. Example of Hourly Octave Band Sound Pressure Level Statistics Printout.



Rainbow Bridge Sound Monitoring Site
L90 Hourly Octave Band SPLs
SOUND PRESSURE LEVEL, dB re 20 μPa
0
10
20
30
40
50
60
70
31.5
63
125
250
500
1000
2000
4000
8000
A-wt
OCTAVE BAND CENTER FREQUENCY, Hz
□ 6-7 PM, 22 August 1989
+ 8-9 PM, 22 August 1989
◇ 11 AM - 12 N, 23 August 1989

Figure 15

6.0 MONITORING RESULTS AT ESCALANTE SITE, GLEN CANYON NRA

6.1 Monitoring Site

The Escalante monitoring site was selected to represent backcountry areas of Glen Canyon NRA. The monitor was located near the Red Well trailhead just off of Hole-In-The-Rock Road. At the trailhead, there is a small parking area where hikers leave their cars while they hike down Coyote Gulch.

The monitor was located about 200 yards from the parking area just over a small hill to hide it from view. This location was just inside the Glen Canyon NRA boundary. Hole-In-The-Rock Road was about a mile away but the very small amount of traffic on it had little or no effect on measured sound levels. The vegetation around the site consisted primarily of sparse low scrub.

Figure 16 shows the monitoring site. All figures for the Escalante site are contained in Section 6.6.

6.2 Monitoring Equipment

As mentioned in the equipment section, there were major equipment problems until a new monitor was installed at the monitoring site around February 1, 1990. Before this time, the only useful data obtained was for the period of August 24, 1989 until September 30. The monitor has run well since February 1, 1990.

6.3 Analysis of Monitored Data

At this backcountry location, the predominant sound source was the wind. The wind at the site showed a consistent diurnal pattern for September in 1989 and February, March and April in 1990. During each of these months, the average wind speed was about 3 mph during the evening and then increased to about 7 mph during the day when the temperature increased. Figures 18 - 20 show the variation in average wind speed for an average day in each of these months.

The sound levels for these months follow a similar pattern to the wind speed. Figures 21 - 24 show the variation in hourly sound levels for an average day in each of these months. Although the pattern is similar, the increase in daytime sound levels is greatest in the month of March. This may be due to more vegetation blowing in the wind or to some insect or bird activity that increases in the middle of the day. One difference is that the sound level decreases by 1 PM while the average wind speed stays steady until

4 PM. As shown in these figures, there are also periods during each hour of the day when the sound level is about 18 dBA which is near the noise floor of the monitor. L90 sound levels normally range from about 21 dBA during the night to a maximum monthly average of 25 to 35 dBA during the day.

Although there is a strong diurnal variation of sound levels caused by the diurnal variation in wind speed, there is also a strong effect from weather fronts passing through the area. The accompanying increased winds cause increased sound levels. Figure 25 is a plot of the variations of daily average wind speeds for September. Figure 26 is the corresponding plot of the variations of daily L90 sound levels for September. The effect of these longer term variations in sound level are shown for February through April in Figures 27 - 29.

6.4 Analysis of Octave Band Data

Octave band sound pressure level statistics were measured next to the long-term sound monitor from 7 PM on August 20, 1989 to 7 PM on August 21. Figure 30 presents two hourly L90 spectra measured during the monitoring period. These spectra are from the hours with the lowest L90 A-weighted sound level (16.5 dBA from 9-10 AM) and the highest L90 A-weighted sound level (21.5 dBA from 5-6 AM).

The wind was probably slightly higher from 5-6 AM resulting in slightly higher sound levels but both spectra are very close to the noise floor of the equipment.

6.5 Conclusions

The sound levels at the Escalante monitoring site are highly dependent on the wind. During average days, the L90 hourly sound level is about 20 dBA during the night. During late August and throughout September, 1989, the L90 hourly sound level ranged from 20 to 23 dBA for an average day. Maximum L90 hourly sound levels ranged from 20 to 30 dBA on calm days and ranged from 30 to 40 dBA for individual hours on stormy days. In February, the L90 hourly sound level ranged from 20 to 28 dBA for an average day. Individual hourly L90 sound levels exceeded 40 dBA on only four days. In March, the L90 hourly sound levels ranged from 20 to 36 dBA for an average day. Individual hourly L90 sound levels exceeded 40 dBA on 17 days and reached 60 dBA on March 18 and 24. In April, the L90 hourly sound levels ranged from 20 to 32 dBA for an average day. Individual hourly L90 sound levels exceeded 40 dBA on 9 days, reaching a maximum of 56 dBA on March 28.

Hourly L90 octave band sound pressure levels made during a period of low wind on August 21, 1989 were somewhat limited by the equipment noise floor but recorded levels below 15 dB for the 125 to 8000 Hz octave bands and levels below 30 dB for the 31.5 and 63 Hz octave bands.

6.6 Figures for Escalante Site

The figures for the Escalante Site listed below are presented on the following pages.

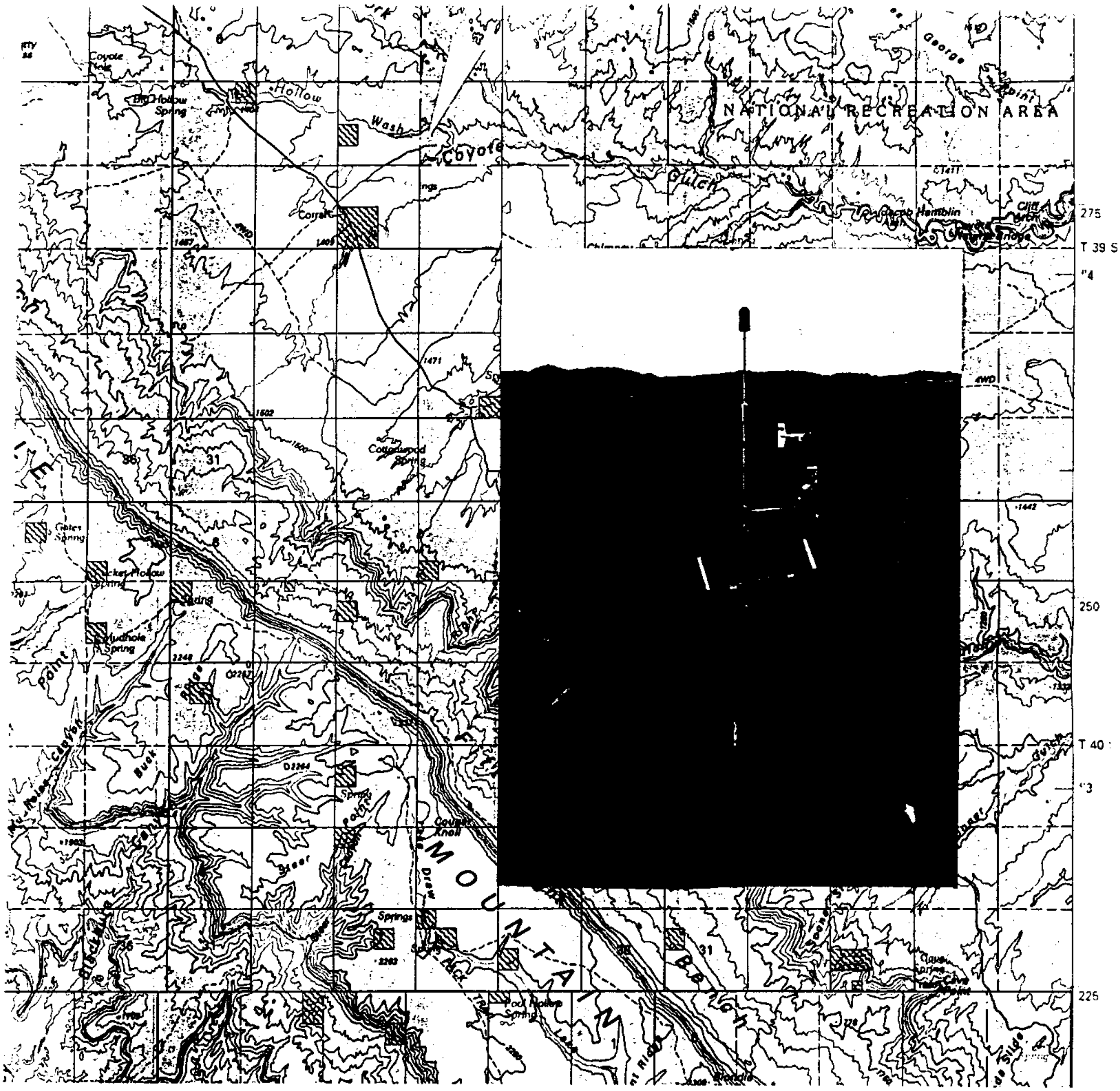


Figure 16. Escalante Monitoring Site

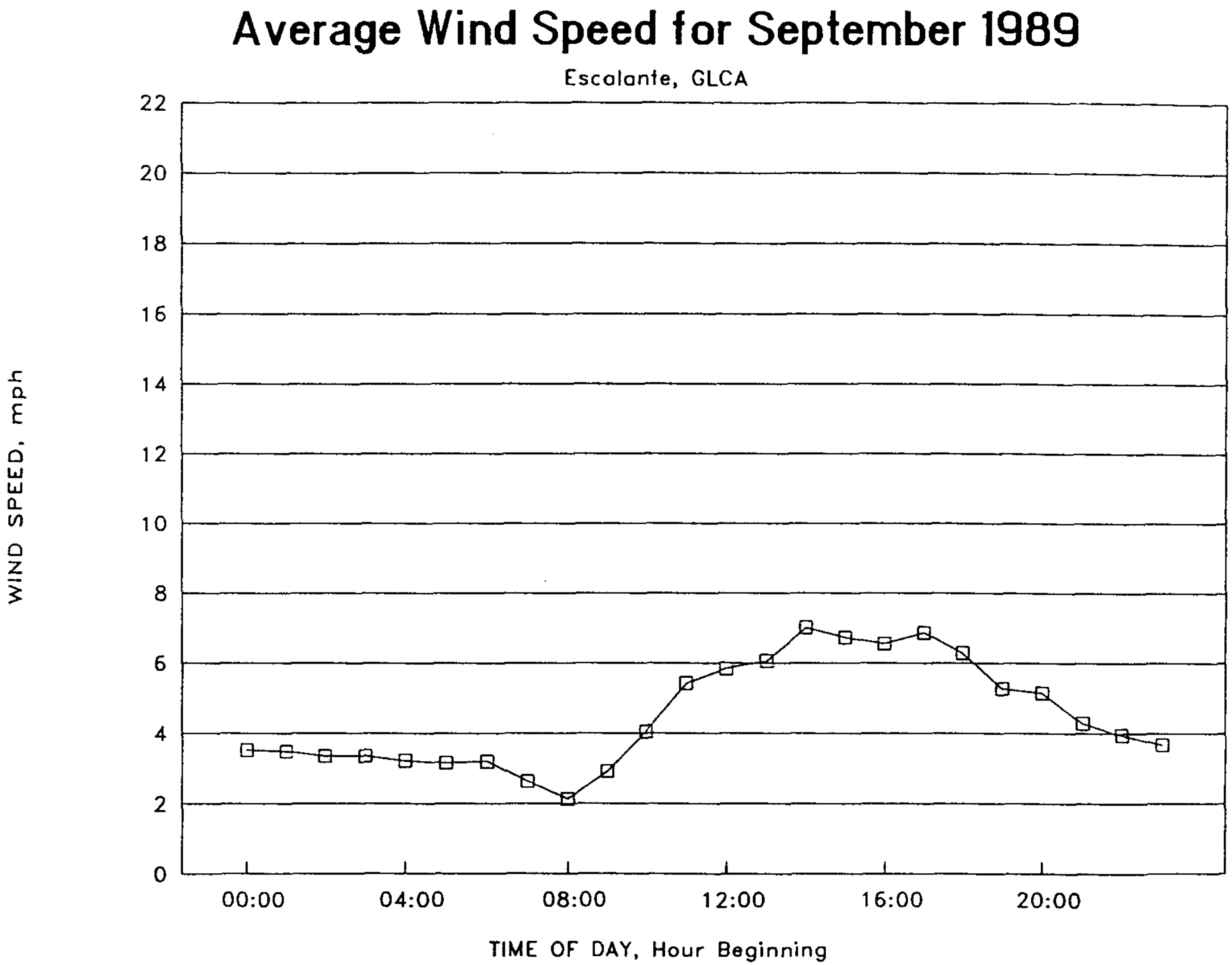

Average Wind Speed for September 1989
Escalante, GLCA
WIND SPEED, mph
22
20
18
16
14
12
10
8
6
4
2
0
00:00
04:00
08:00
12:00
16:00
20:00
TIME OF DAY, Hour Beginning

Figure 17

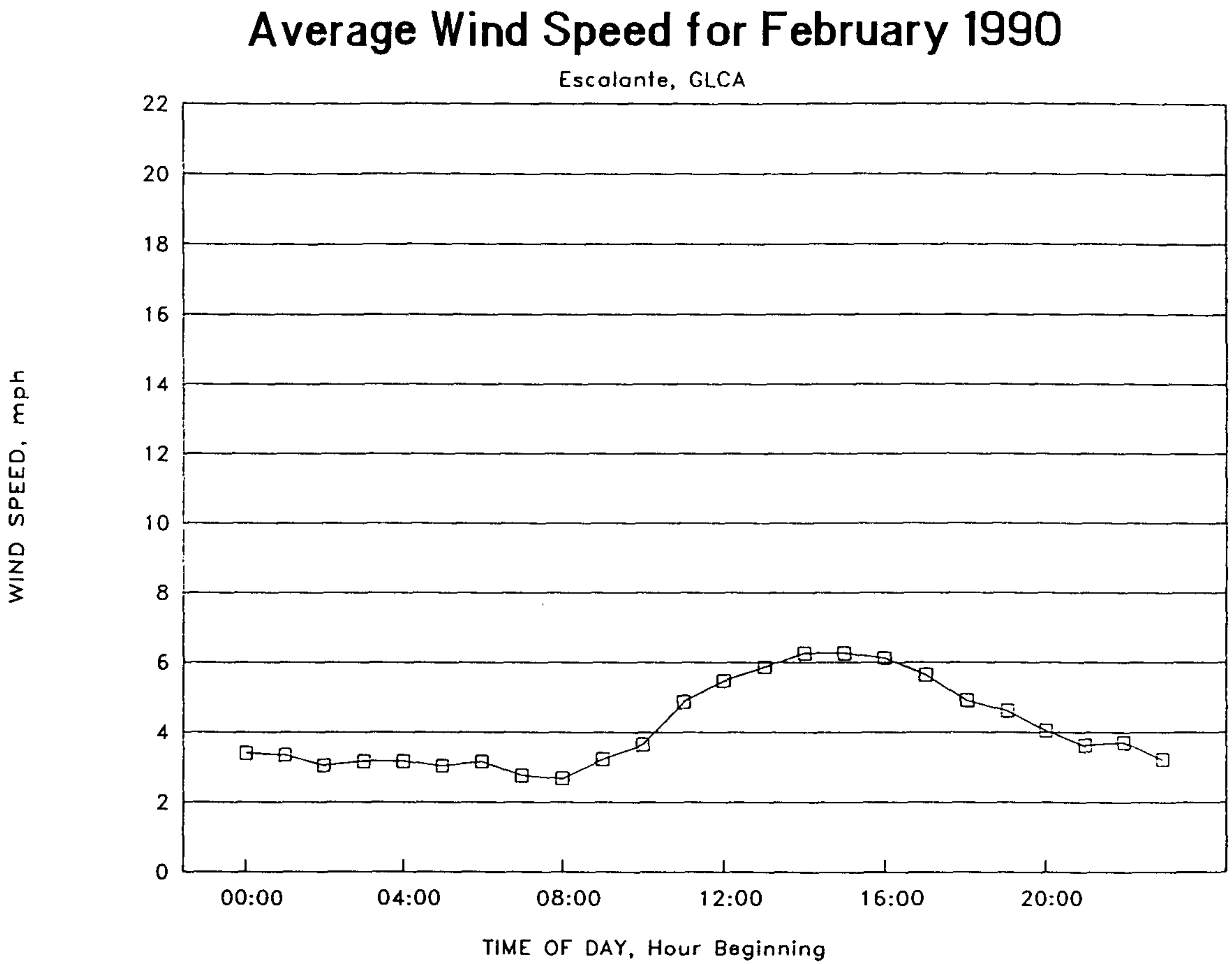

Average Wind Speed for February 1990
Escalante, GLCA
WIND SPEED, mph
0
2
4
6
8
10
12
14
16
18
20
22
00:00
04:00
08:00
12:00
16:00
20:00
TIME OF DAY, Hour Beginning

Figure 18

Average Wind Speed for March 1990

Escalante, GLCA

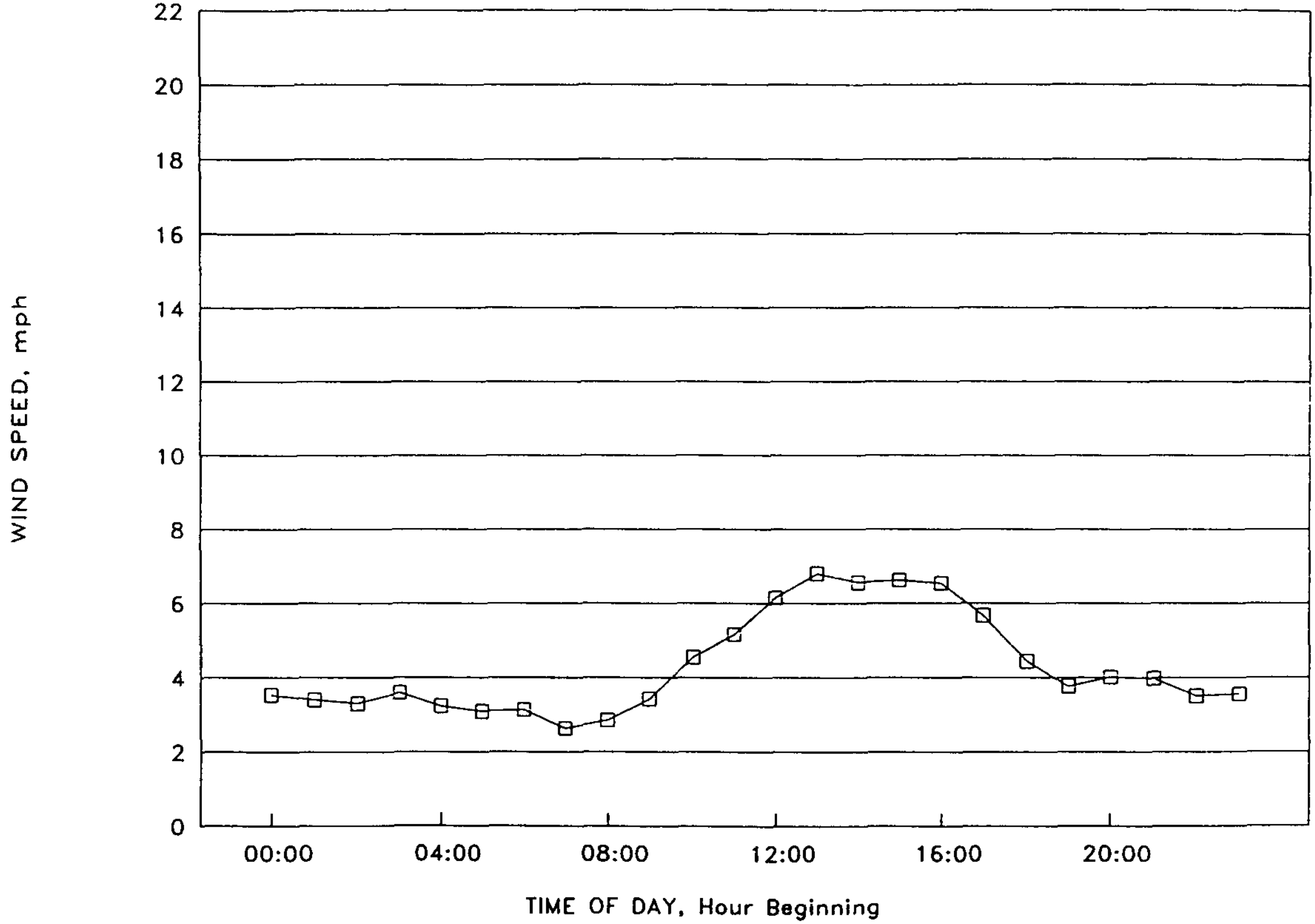


Figure 19

Average Wind Speed for April 1990

Escalante, GLCA

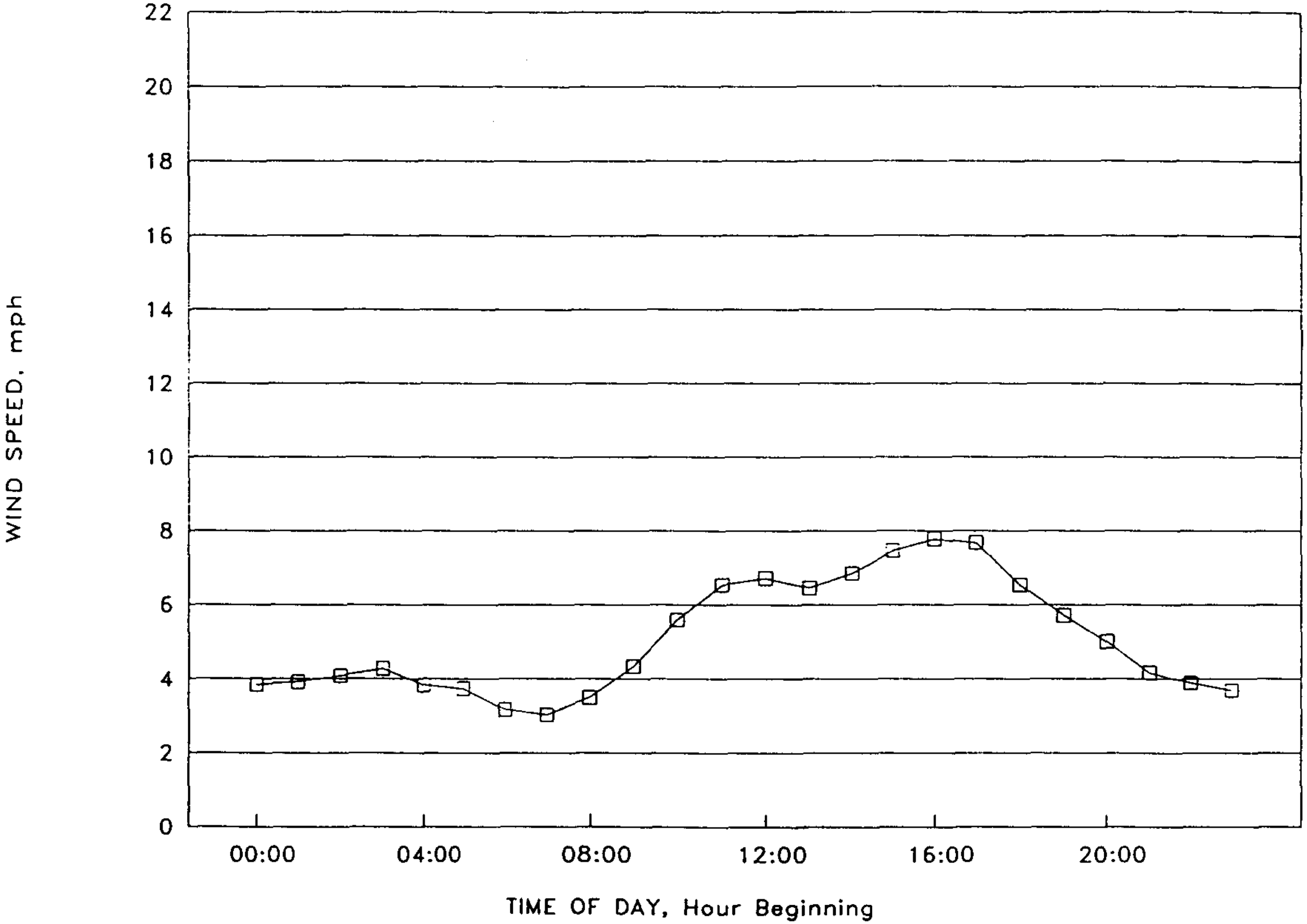


Figure 20

SOUND LEVELS FOR SEPTEMBER 1989

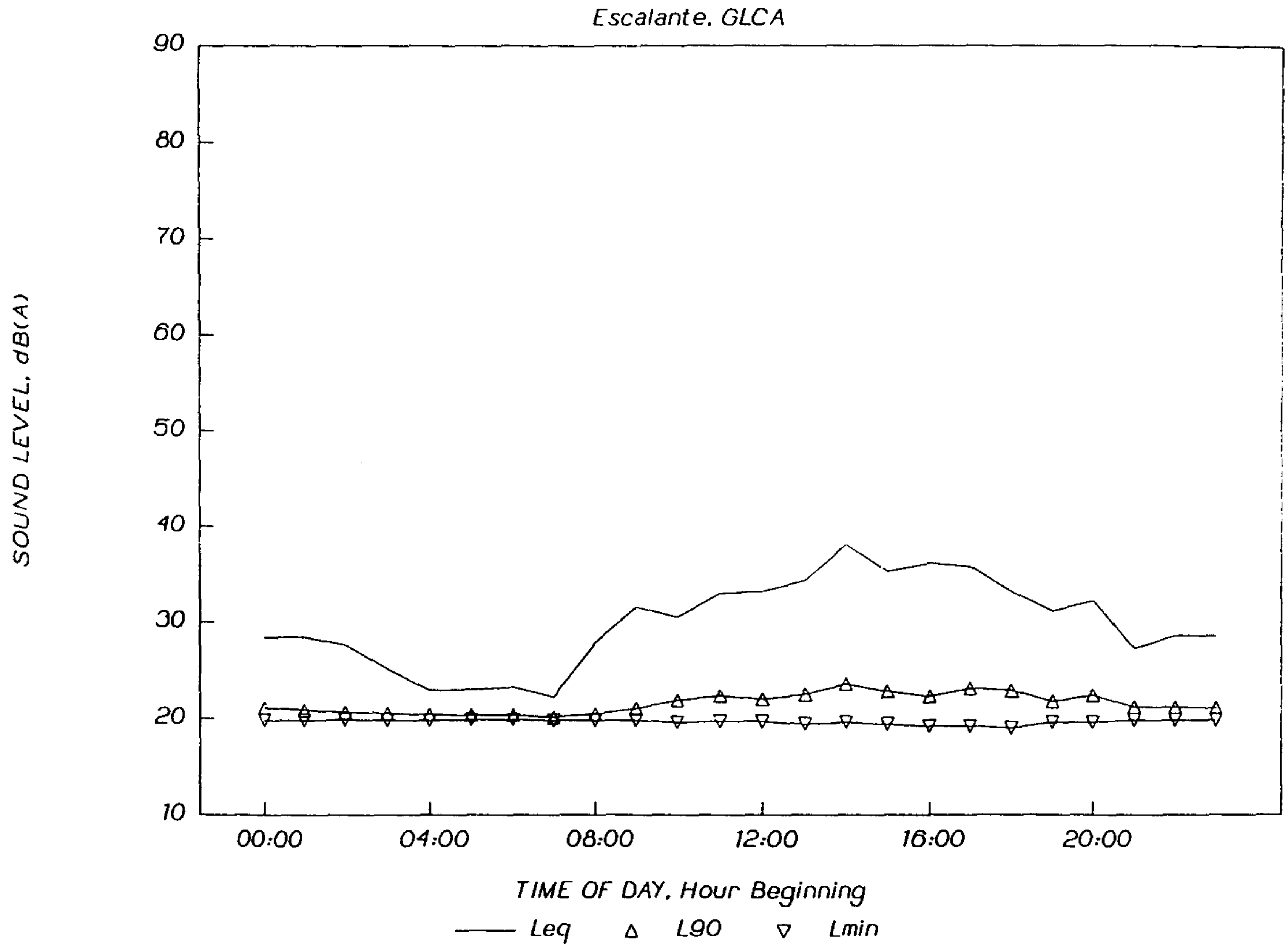
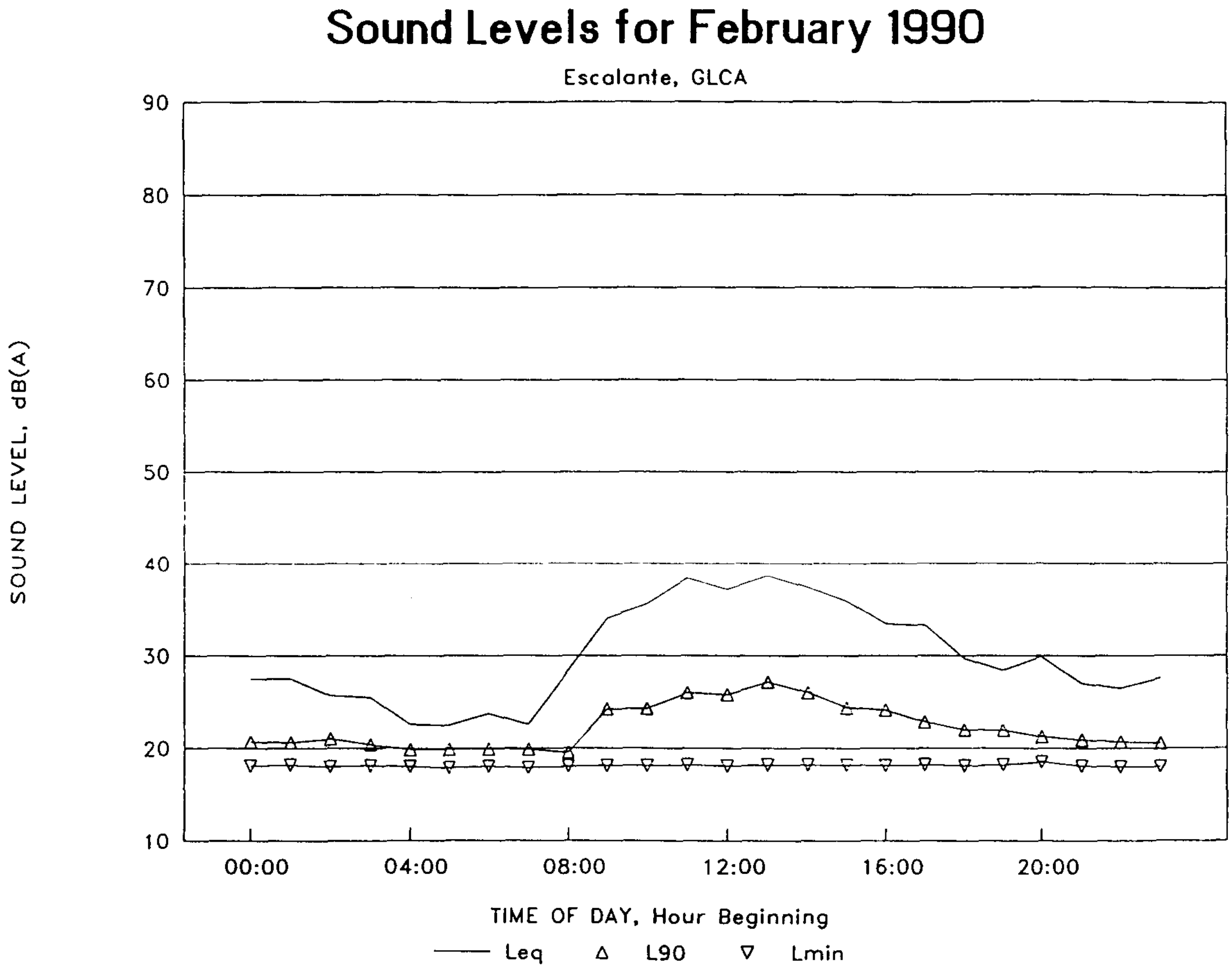


Figure 21



Sound Levels for February 1990
Escalante, GLCA
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
00:00
04:00
08:00
12:00
16:00
20:00
TIME OF DAY, Hour Beginning
Leq
L90
Lmin

Figure 22

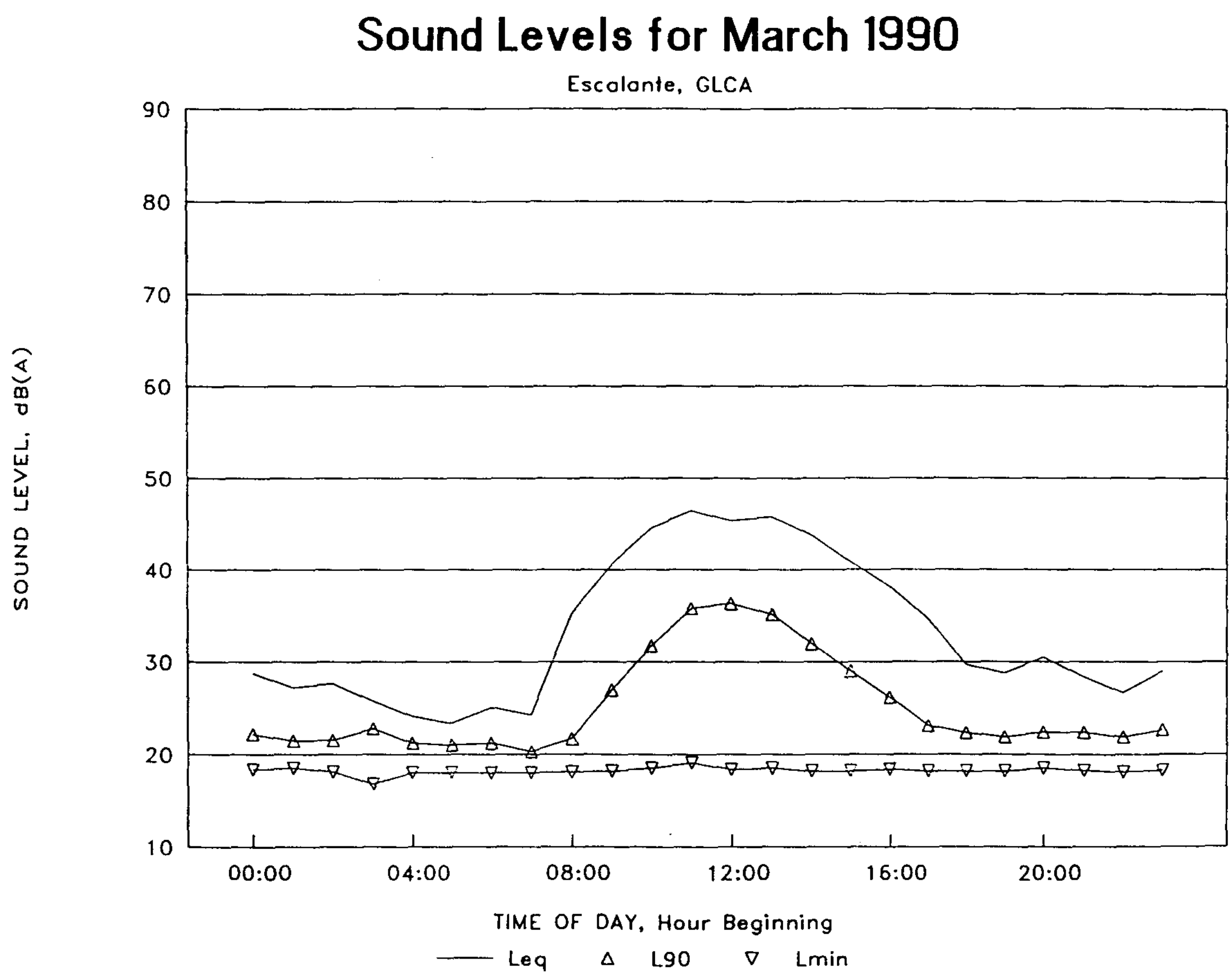

Sound Levels for March 1990
Escalante, GLCA
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
00:00
04:00
08:00
12:00
16:00
20:00
TIME OF DAY, Hour Beginning
Leq
L90
Lmin

Figure 23

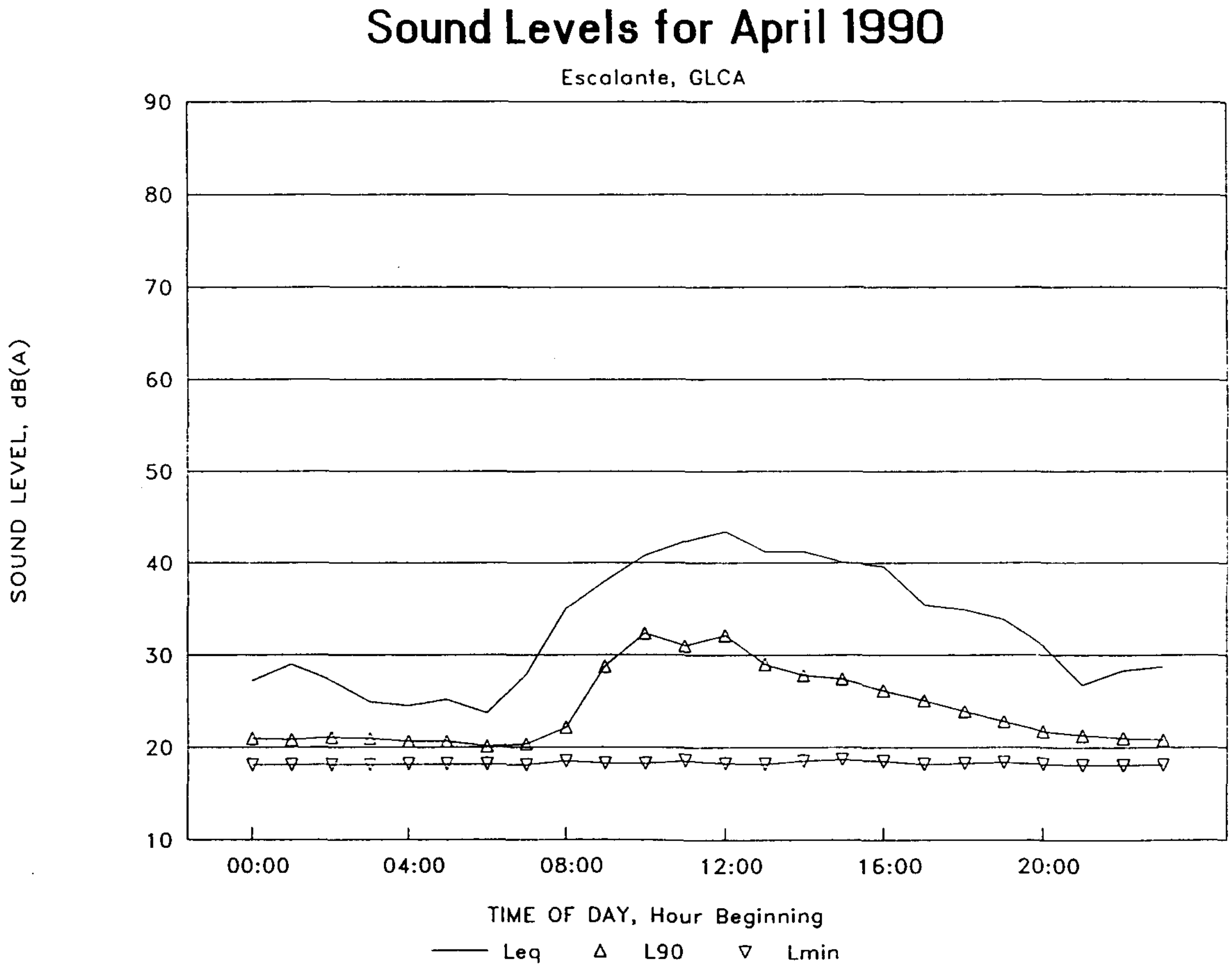
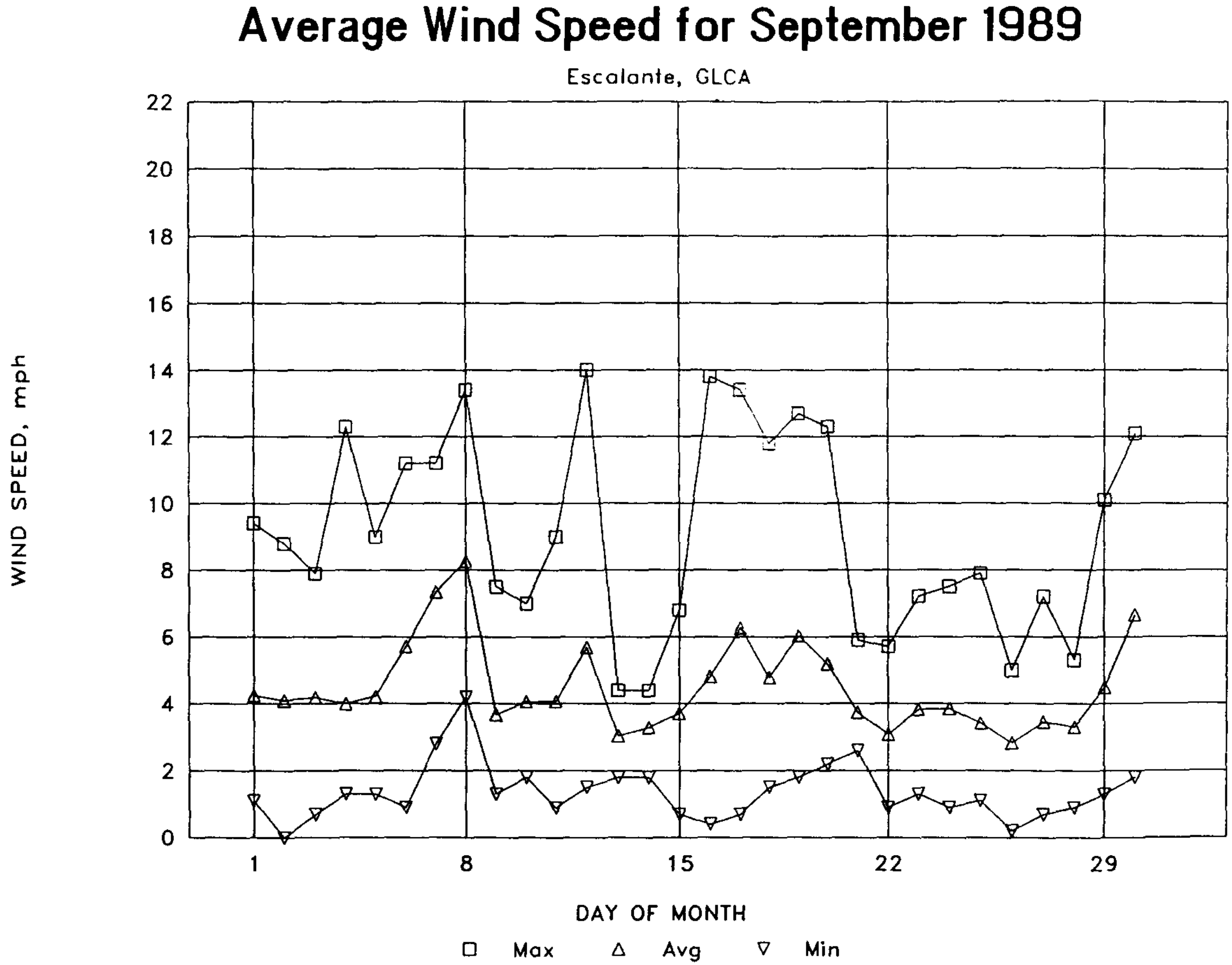
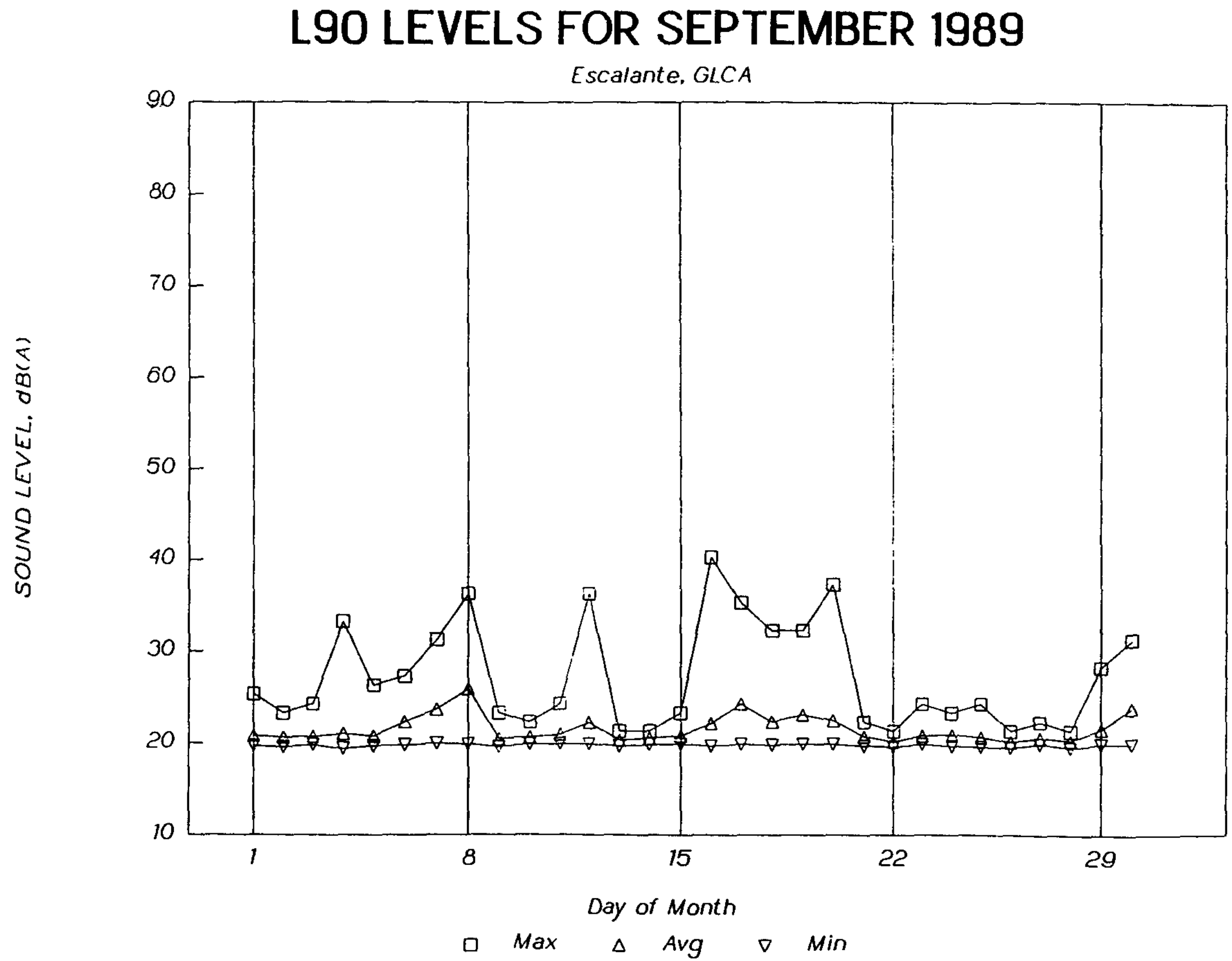

Sound Levels for April 1990
Escalante, GLCA
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
00:00
04:00
08:00
12:00
16:00
20:00
TIME OF DAY, Hour Beginning
Leq
L90
Lmin

Figure 24



Average Wind Speed for September 1989
Escalante, GLCA
WIND SPEED, mph
22
20
18
16
14
12
10
8
6
4
2
0
1
8
15
22
29
DAY OF MONTH
Max
Avg
Min

Figure 25



L90 LEVELS FOR SEPTEMBER 1989
Escalante, GLCA
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
1
8
15
22
29
Day of Month
Max
Avg
Min

Figure 26

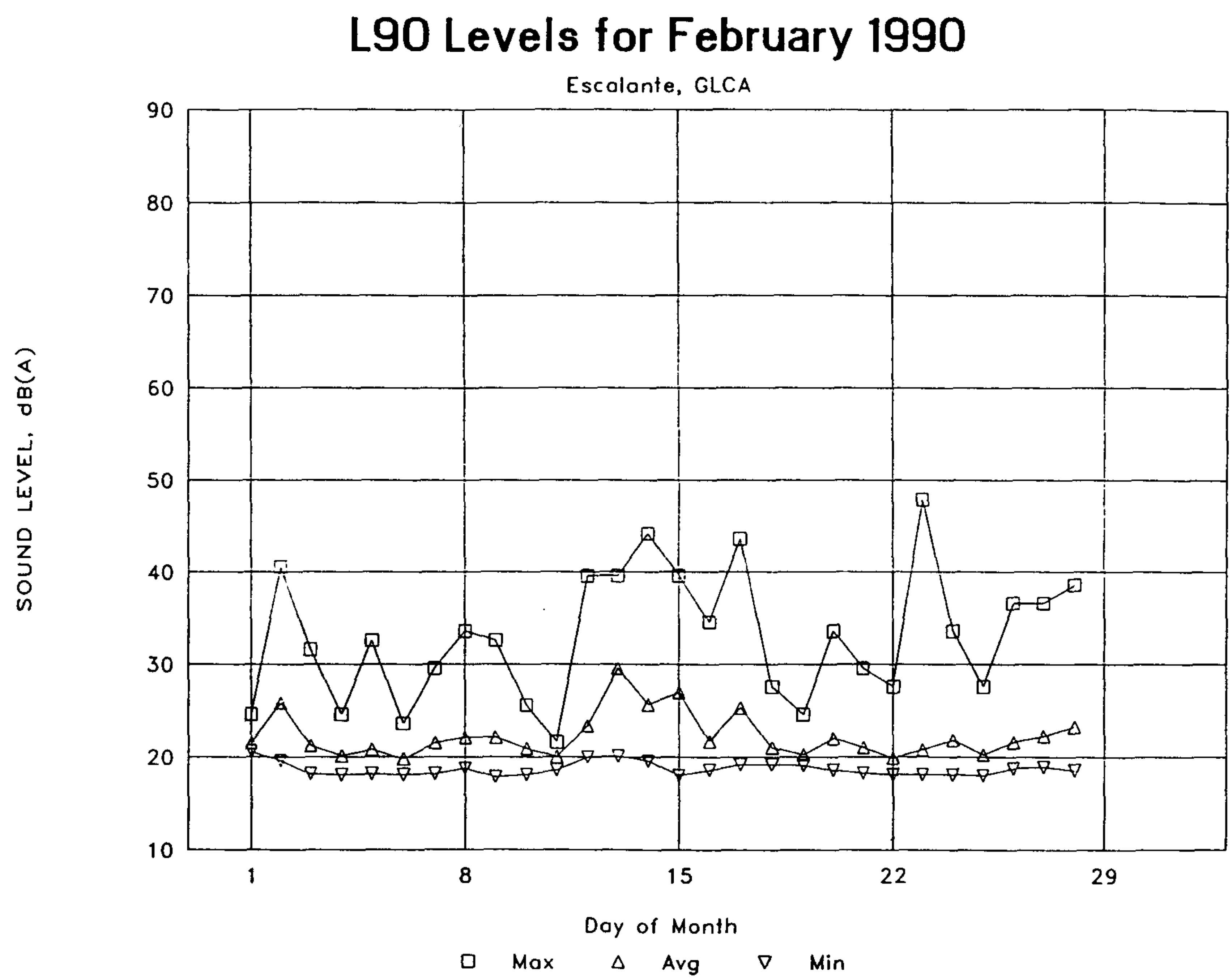

L90 Levels for February 1990
Escalante, GLCA
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
1
8
15
22
29
Day of Month
Max
Avg
Min

Figure 27

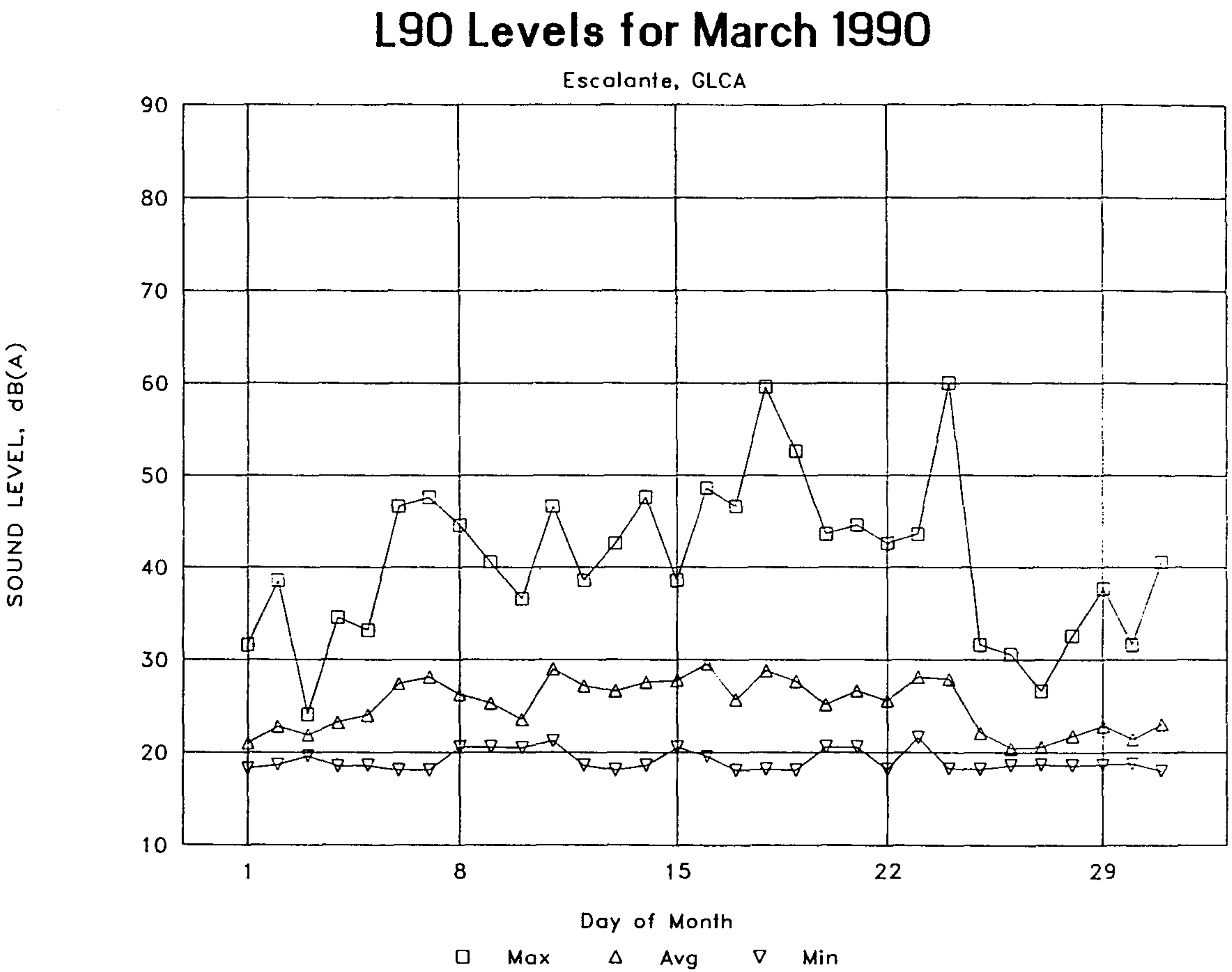

L90 Levels for March 1990
Escolante, GLCA
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
1
8
15
22
29
Day of Month
Max
Avg
Min

Figure 28

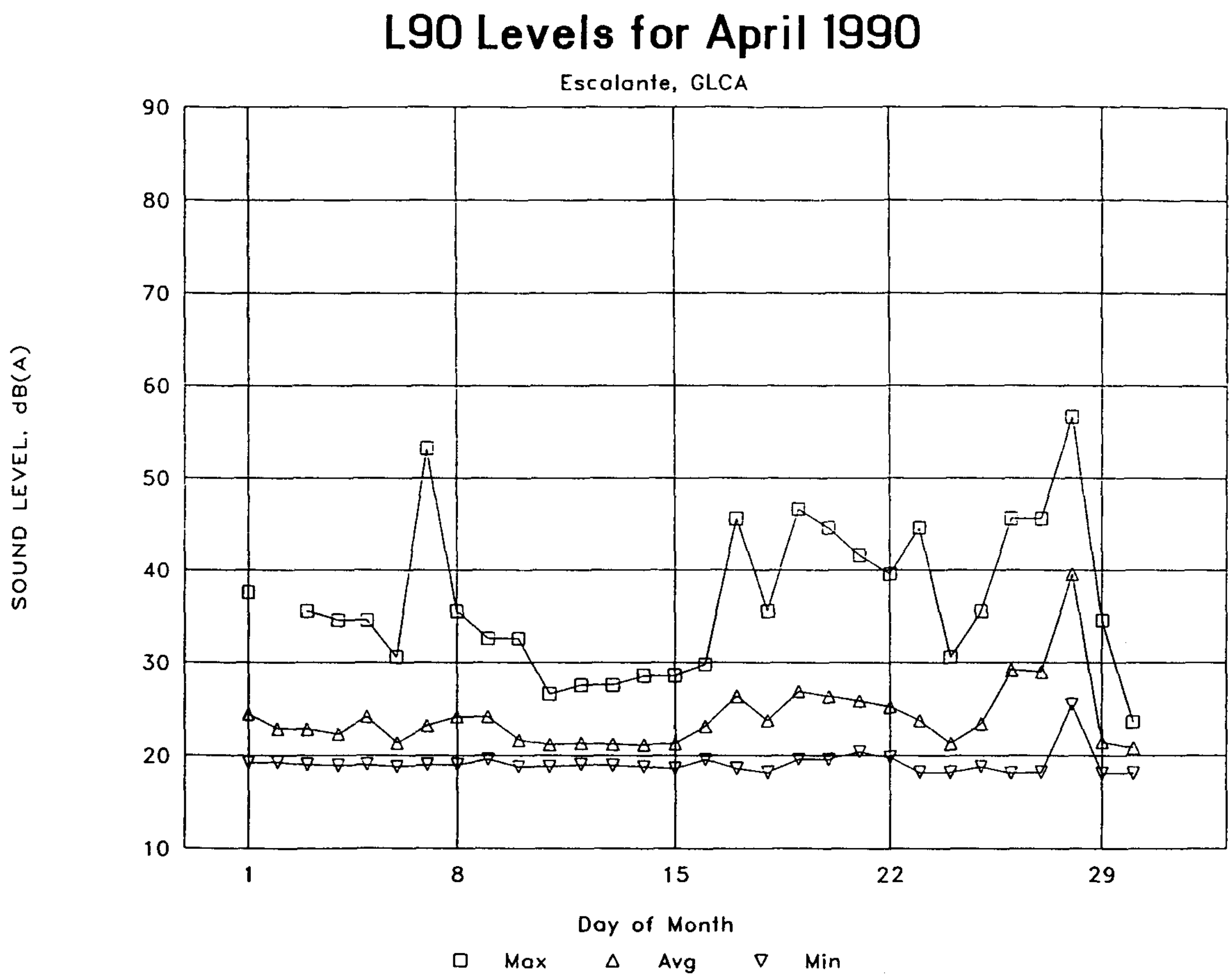

L90 Levels for April 1990
Escalante, GLCA
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
1
8
15
22
29
Day of Month
Max
Avg
Min

Figure 29

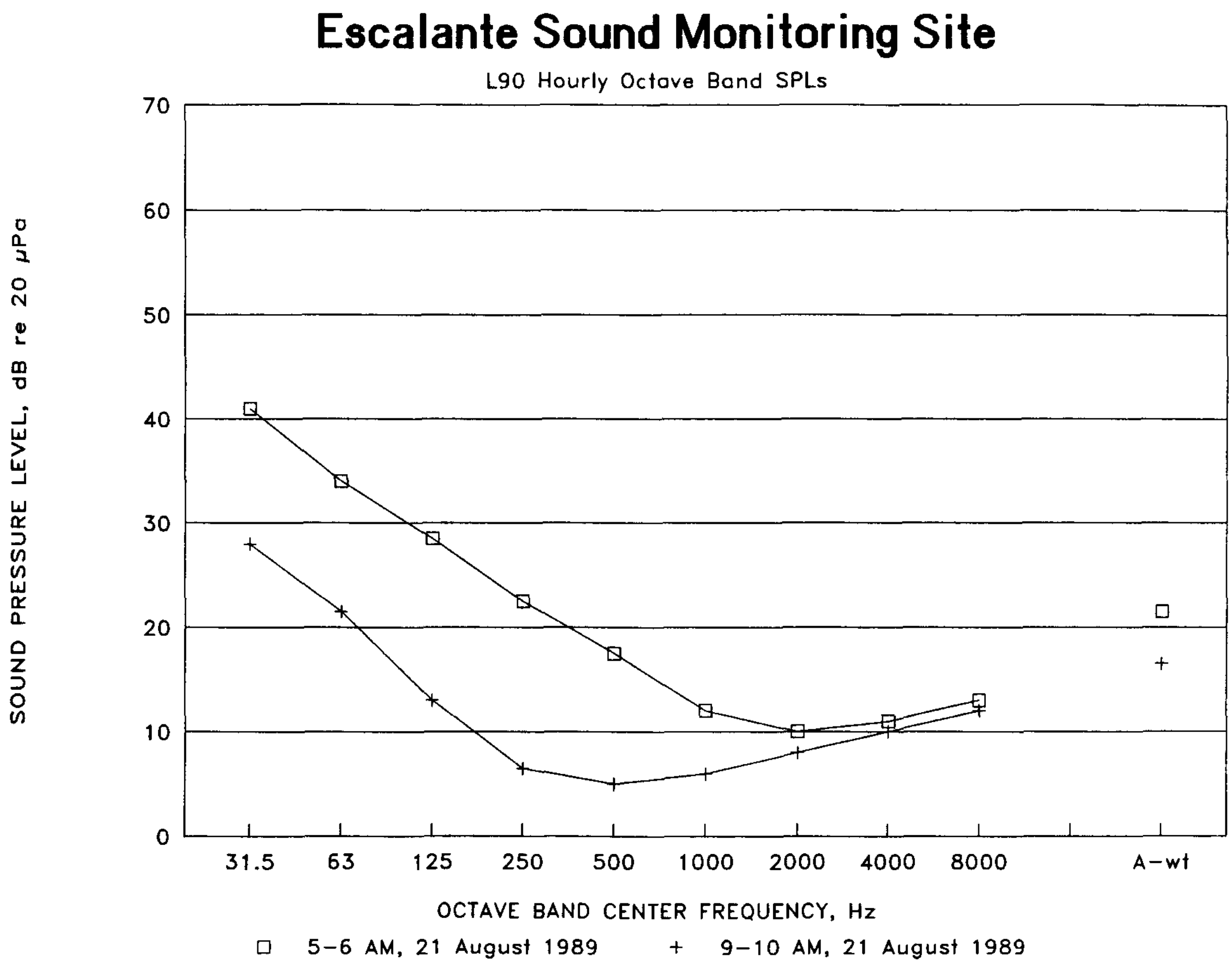

Escalante Sound Monitoring Site
L90 Hourly Octave Band SPLs
SOUND PRESSURE LEVEL, dB re 20 μPa
70
60
50
40
30
20
10
0
31.5
63
125
250
500
1000
2000
4000
8000
A-wt
OCTAVE BAND CENTER FREQUENCY, Hz
□ 5-6 AM, 21 August 1989
+ 9-10 AM, 21 August 1989

Figure 30

7.0 MONITORING RESULTS AT WEST CACTUS FLAT SITE, DINOSAUR NM

7.1 Monitoring Site

The West Cactus Flat monitoring site was selected to represent backcountry areas of Dinosaur NM. The monitor was located on West Cactus Flat about 1 mile north of Mantle Ranch Road. The very small amount of traffic on this road had little or no effect on measured sound levels. The vegetation around the site consisted primarily of low grasses and scrub but there were some small trees about 40 feet from the monitor.

A fence was built around the monitor to protect it from the many elk in the area and the fence and some of the guy wires were damaged, possibly by an elk, shortly before the end of the sound monitoring program.

Figure 31 shows the monitoring site. All figures for the West Cactus Flat site are contained in Section 7.6.

7.2 Monitoring Equipment

A DA 607P noise monitor was installed at West Cactus Flat in April 1989. The monitor ran continuously from May 9 until July 22 when it was possibly struck by lightning. The monitor was restarted on August 30, 1989 and ran continuously until March 26, 1990 except for September 10-11, September 30 - October 12, October 28-29, Jan 22, and February 22-25. These short periods without data occurred when the paper take-up roll was full and stopped operating before the monitor was serviced by NPS staff.

7.3 Analysis of Monitored Data

Acoustic data for the West Cactus Flat site is available for May 1989 until March 1990 with the primary exception of most of the month of August. Summaries of the data for these months is presented in Figures 32 - 35. As shown, L90 hourly sound levels for average days are all very quiet, ranging from 16 to 30 dBA. All of the curves are fairly flat with very little variation from nighttime sound levels to daytime sound levels. The primary difference between the curves for the different months is based upon the variation in the equipment noise floor.

The noise floor of the DA 607P monitor significantly varied during the year from 23 dBA in May to 22 dBA in June and July to 21 dBA in September to 13-22 dBA in October and November to 18-22 dBA in December to 20-26 dBA in January to 26 dBA in February to 24-26 dBA in March. This amount of variation is unusual but may have resulted from variations in temperature, humidity or some other factors. The monitor was regularly calibrated and found to be holding its calibration and the distribution of the sound level statistics look normal so the monitor was judged to be operating properly.

Although there is not a large difference between daytime and nighttime sound levels, there is some effect. Figure 36 shows an average day for the month of September. The minimum sound levels for each hour remain constant but the L90 and Leq average hourly sound levels do increase during the daylight hours. This is normally the result of increases in wind speed. Since no analysis of meteorological data was included in the monitoring program at Dinosaur NM, no definite conclusions have been drawn relating sound levels to wind speed or temperature.

Figures 37 - 46 show the minimum, average and maximum daily L90 sound levels. The high maximum sound levels on some days may have been due to weather fronts passing through the area but, again, no analysis of weather data has been made to confirm this. The minimum daily L90 sound levels are fairly constant and are near the noise floor of the equipment. Peaks in the maximum daily L90 sound levels sometimes represent a loud period that lasted for just an hour such as elk sounding or possibly a short rain. If the source of the noise lasts for a longer period of time, then the average daily L90 sound level will also increase significantly. Since the average daily L90 sound level is the arithmetic average of all 24 hourly L90 sound levels in a day, the equipment noise floor greatly affects the average. Take, for example, a day where the L90 sound level is between 15 and 18 dBA for 12 hours and equal to 34 dBA for the other 12 hours. If the noise floor is 26 dBA then the average daily L90 sound level will be 30 dBA. If the noise floor is 18 dBA then the average daily L90 sound level will be 26 dBA. Average daily L90 sound levels for the days of the monitoring period were almost all between 20 and 30 dBA and much of the variation was based on the variation of the equipment noise floor.

7.4 Analysis of Octave Band Data

Octave band sound pressure level statistics were measured next to the long-term sound monitor from 4-5 PM on November 27, 1989. An equipment problem prevented the octave band monitor from running beyond the single hour. Figure 47 presents the hourly L90 spectrum measured during the monitoring period. During the hour, there was a slight wind and the temperature was about 25° F. The sound pressure levels in the 2000 Hz and 8000 Hz octave bands are at the noise floor of the equipment so actual sound pressure levels may have been lower. The L90 A-weighted sound level for this hour was 17.5 dBA.

7.5 Conclusions

Sound levels at the West Cactus Flat site are consistently very low. There are few sound sources in the area and there is little diurnal variation in sound levels. The L90 hourly sound levels for average days in the ten months of monitoring range from 16 dBA during the evening for a month when the equipment noise floor was 13 dBA (October) to 30 dBA during the day for a month when the noise floor was 23 dBA (May). The variation in the level of the noise floor was unexpected but may have been due to varying weather conditions. The monitor was periodically calibrated and found to be holding its calibration and operating normally.

Average and maximum daily L90 sound levels did increase substantially on some days and this may have been the result of weather fronts passing through the area. On these days, average daily L90 sound levels increased to 30 dBA and several individual hourly L90 sound levels to 45 dBA. The highest hourly L90 sound level was 53 dBA from 10-11 AM on March 6, 1990.

Hourly L90 octave band sound pressure levels made during a period of low wind on November 27, 1989 were somewhat limited by the equipment noise floor but recorded levels below 15 dB for the 125 to 8000 Hz octave bands and at 31 dB for the 31.5 Hz octave band and 20 dB for the 63 Hz octave band.

7.6 Figures for West Cactus Flat Site

The figures for the West Cactus Flat Site listed below are presented on the following pages.

Figure 31. West Cactus Flat
Monitoring Site.

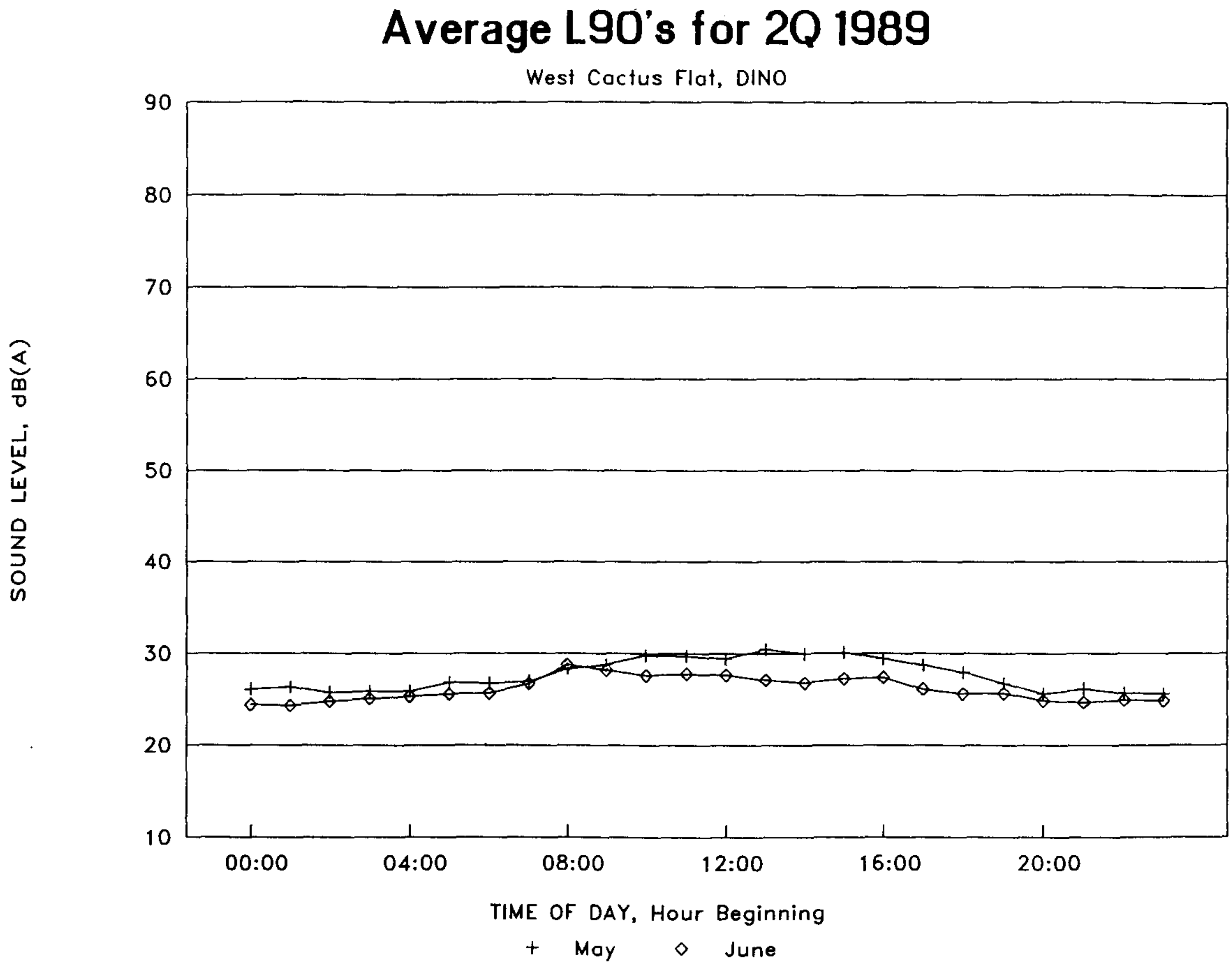

Average L90's for 2Q 1989
West Cactus Flat, DINO
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
00:00
04:00
08:00
12:00
16:00
20:00
TIME OF DAY, Hour Beginning
+ May
◇ June

Figure 32

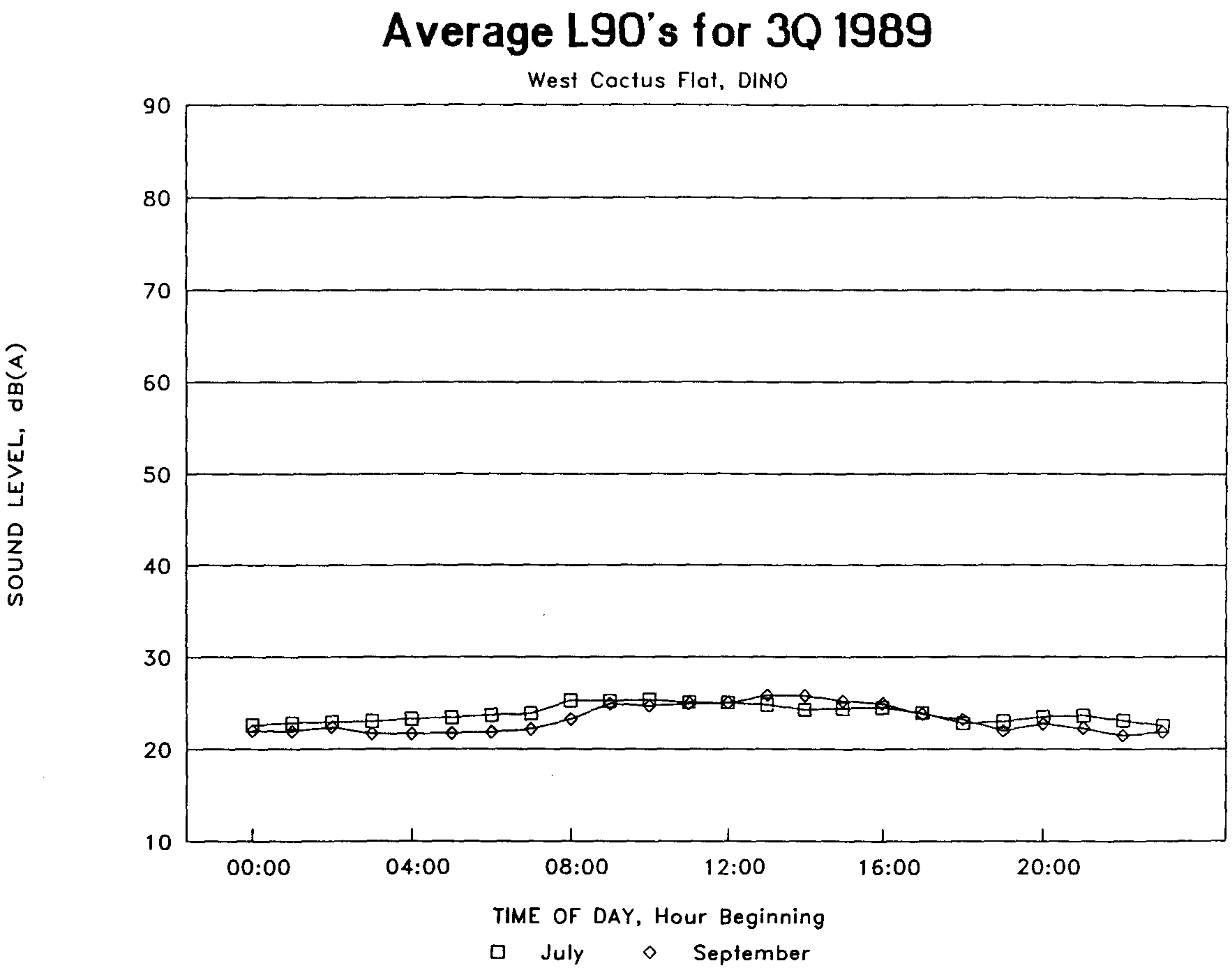

Average L90's for 3Q 1989
West Cactus Flat, DINO
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
00:00
04:00
08:00
12:00
16:00
20:00
TIME OF DAY, Hour Beginning
July
September

Figure 33

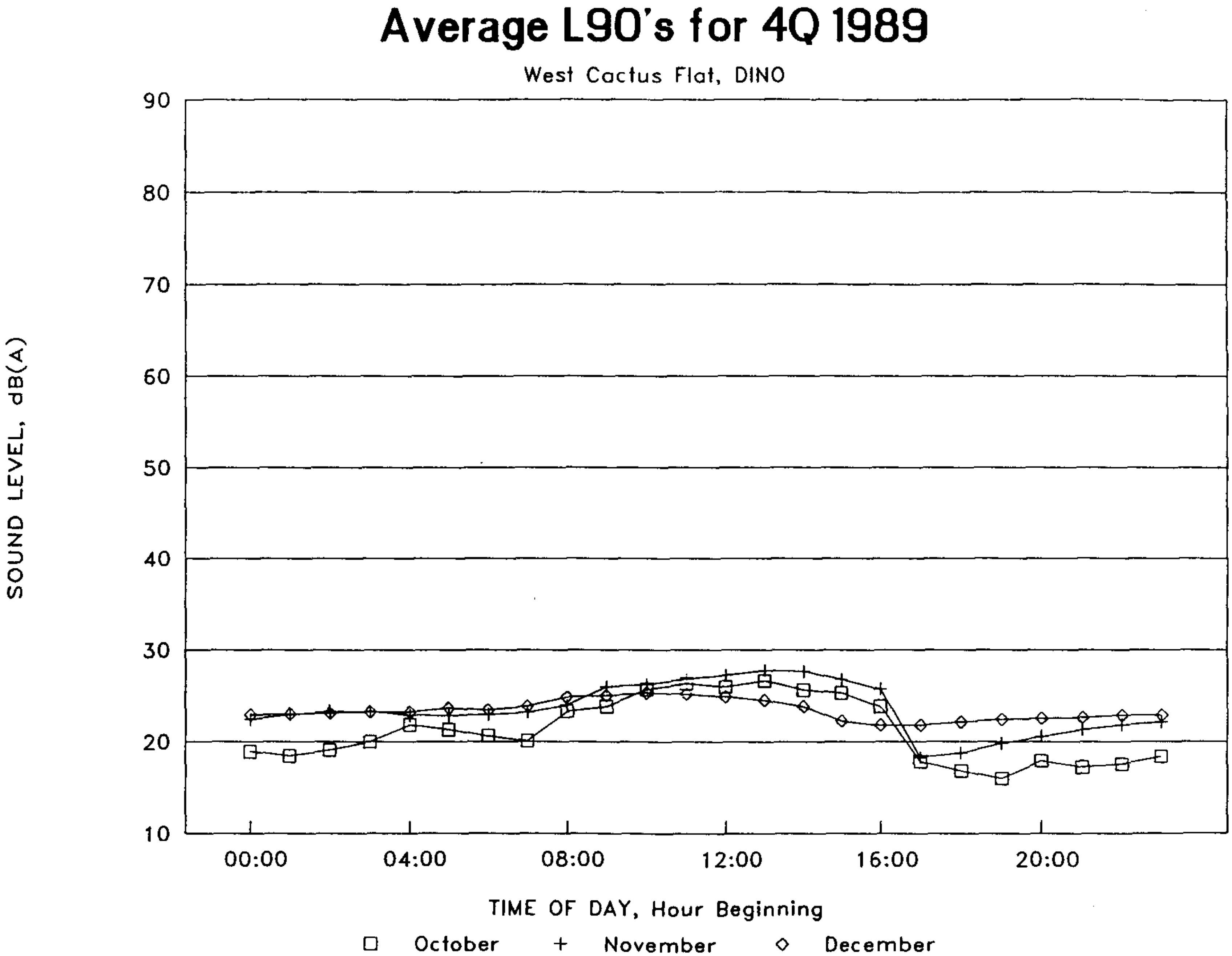

Average L90's for 4Q 1989
West Cactus Flat, DINO
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
00:00
04:00
08:00
12:00
16:00
20:00
TIME OF DAY, Hour Beginning
October
November
December

Figure 34

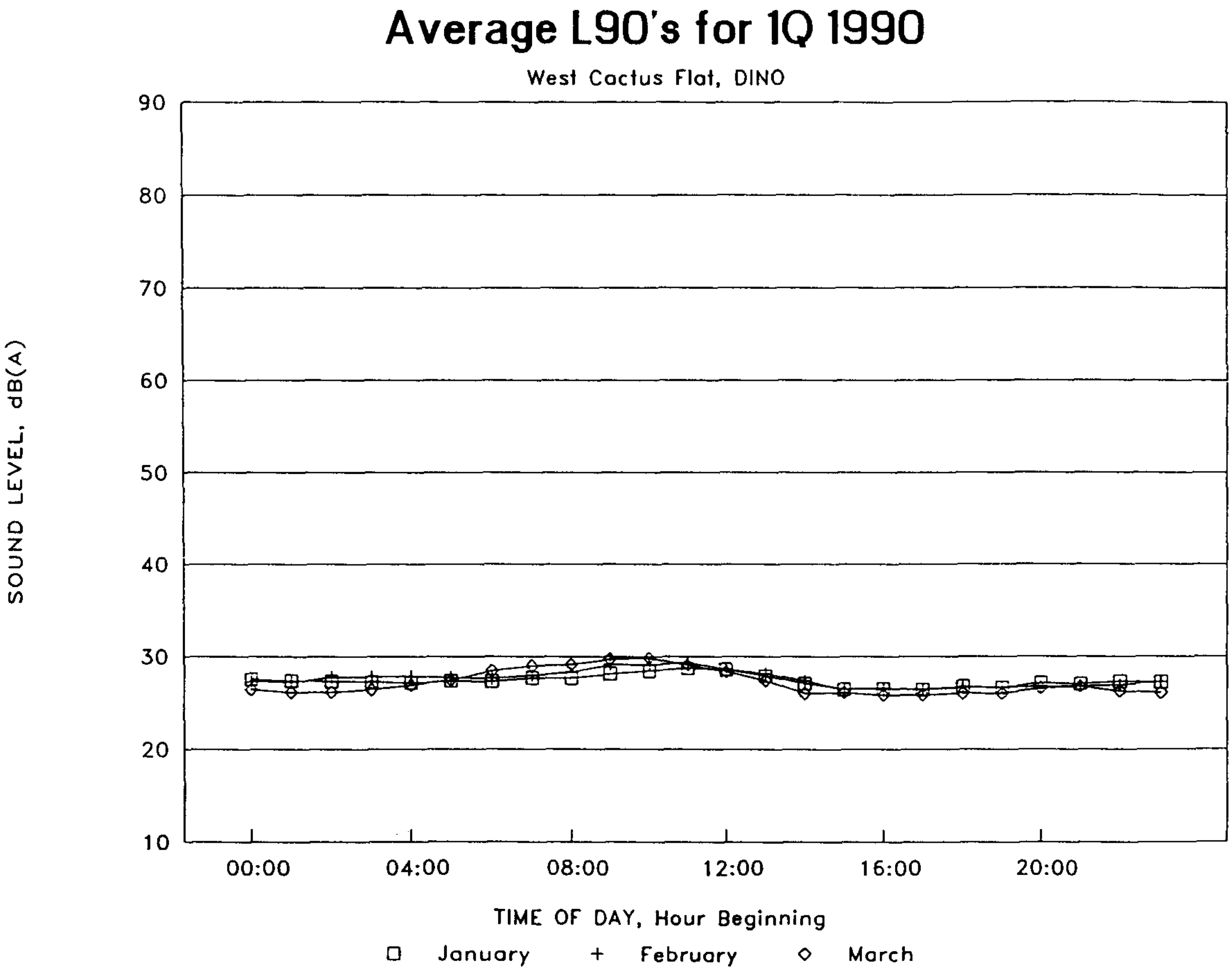

Average L90's for 1Q 1990
West Cactus Flat, DINO
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
00:00
04:00
08:00
12:00
16:00
20:00
TIME OF DAY, Hour Beginning
January
February
March

Figure 35

SOUND LEVELS FOR SEPTEMBER 1989

West Cactus Flat, DINO

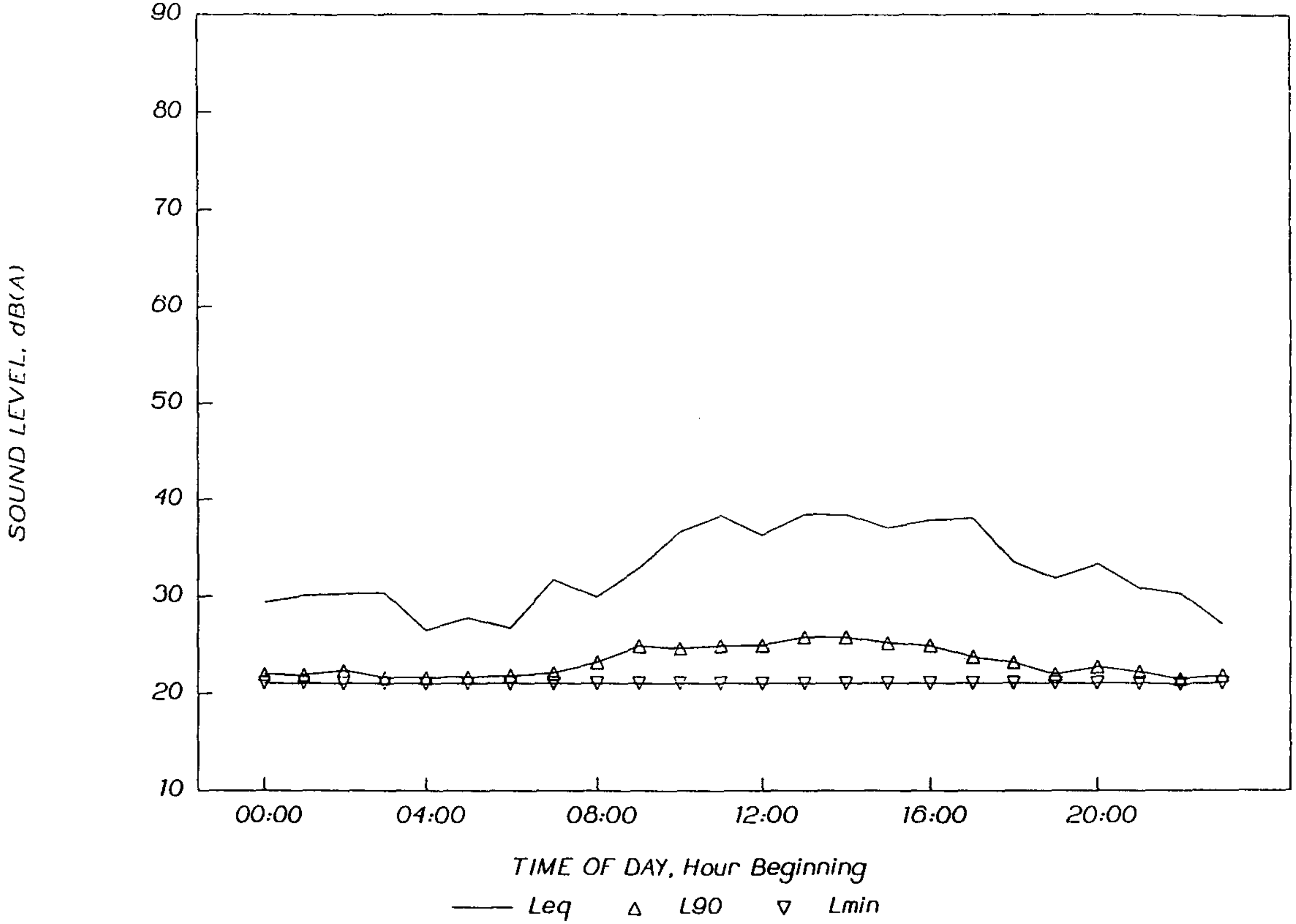


Figure 36

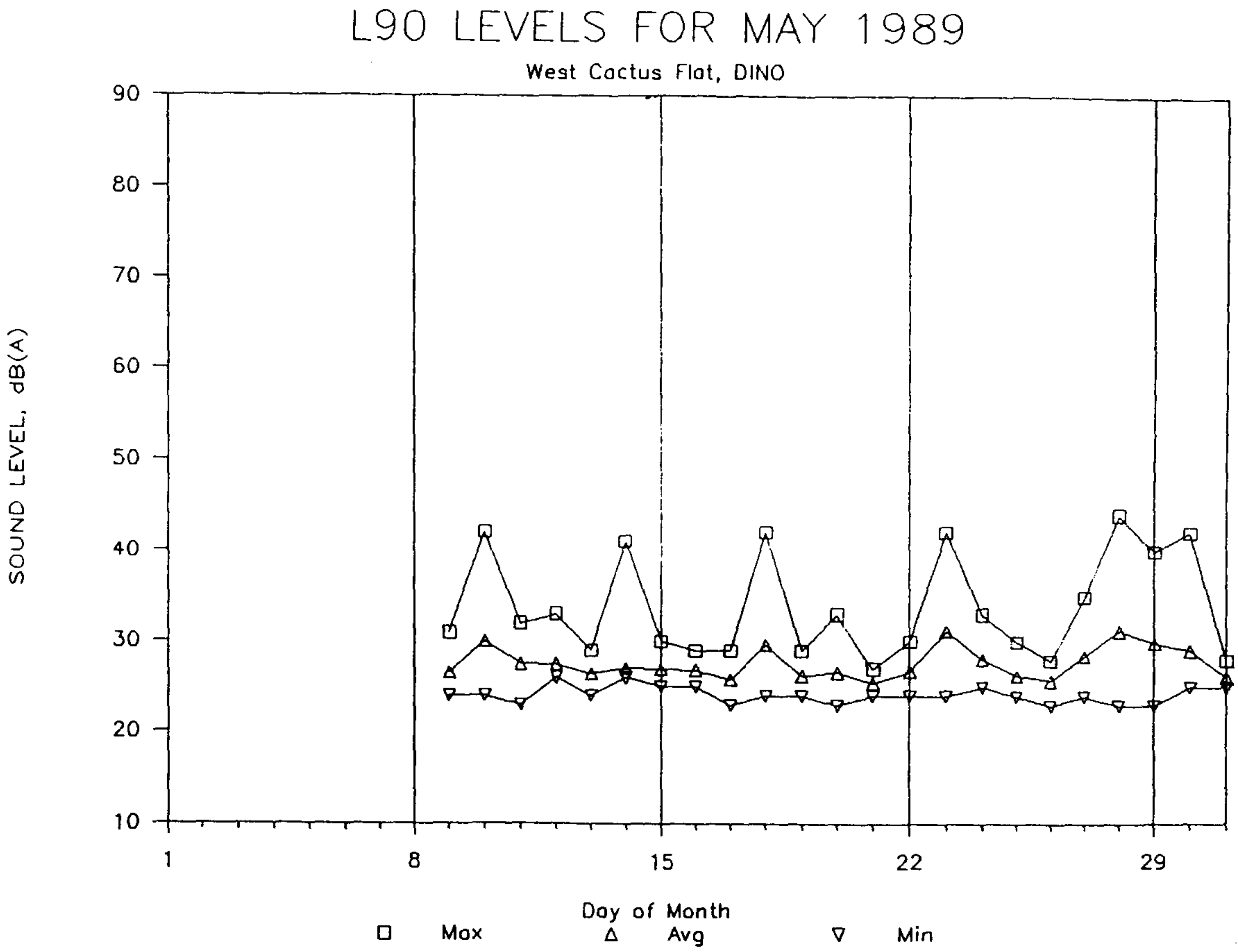

L90 LEVELS FOR MAY 1989
West Cactus Flat, DINO
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
1
8
15
22
29
Day of Month
Max
Avg
Min

Figure 37

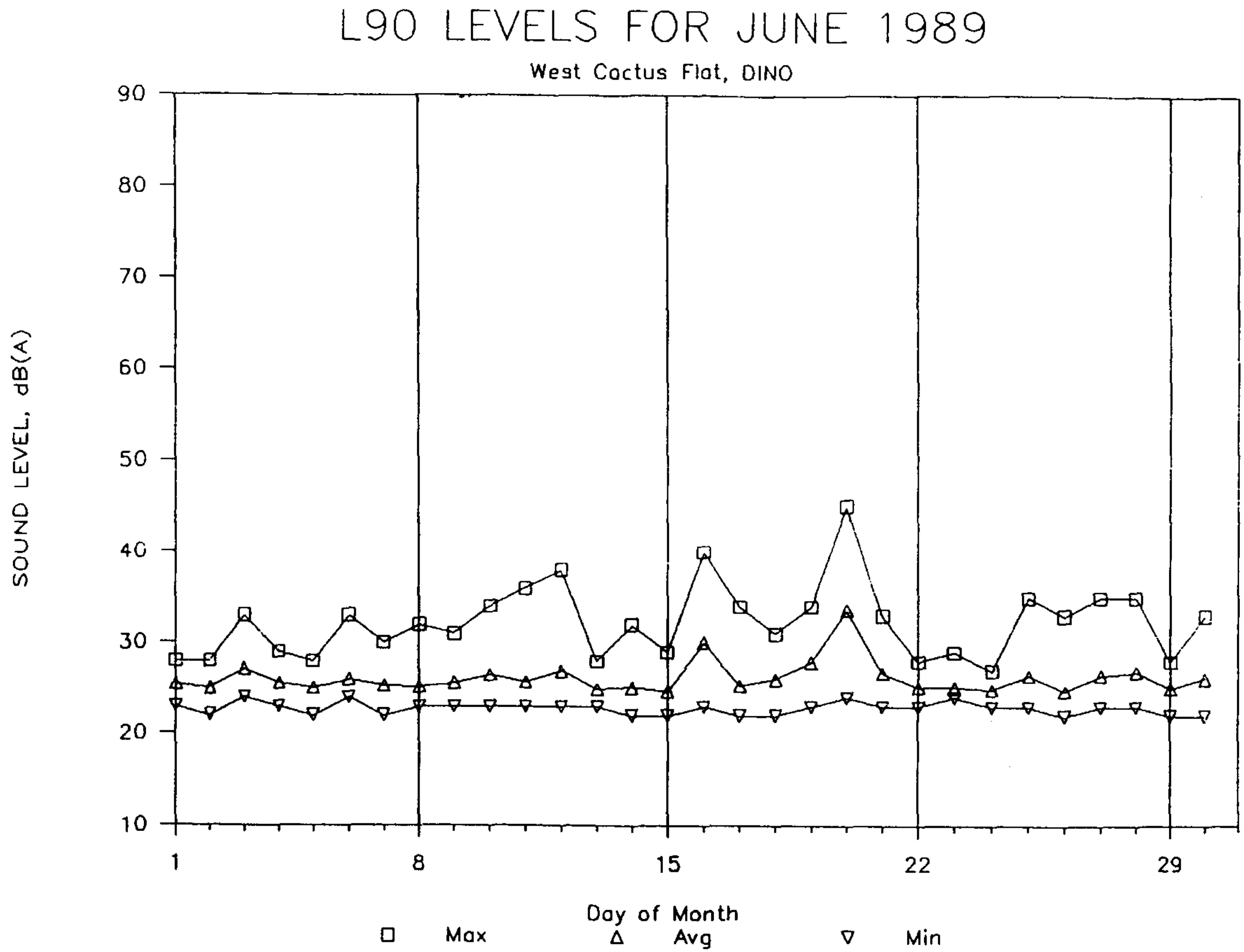
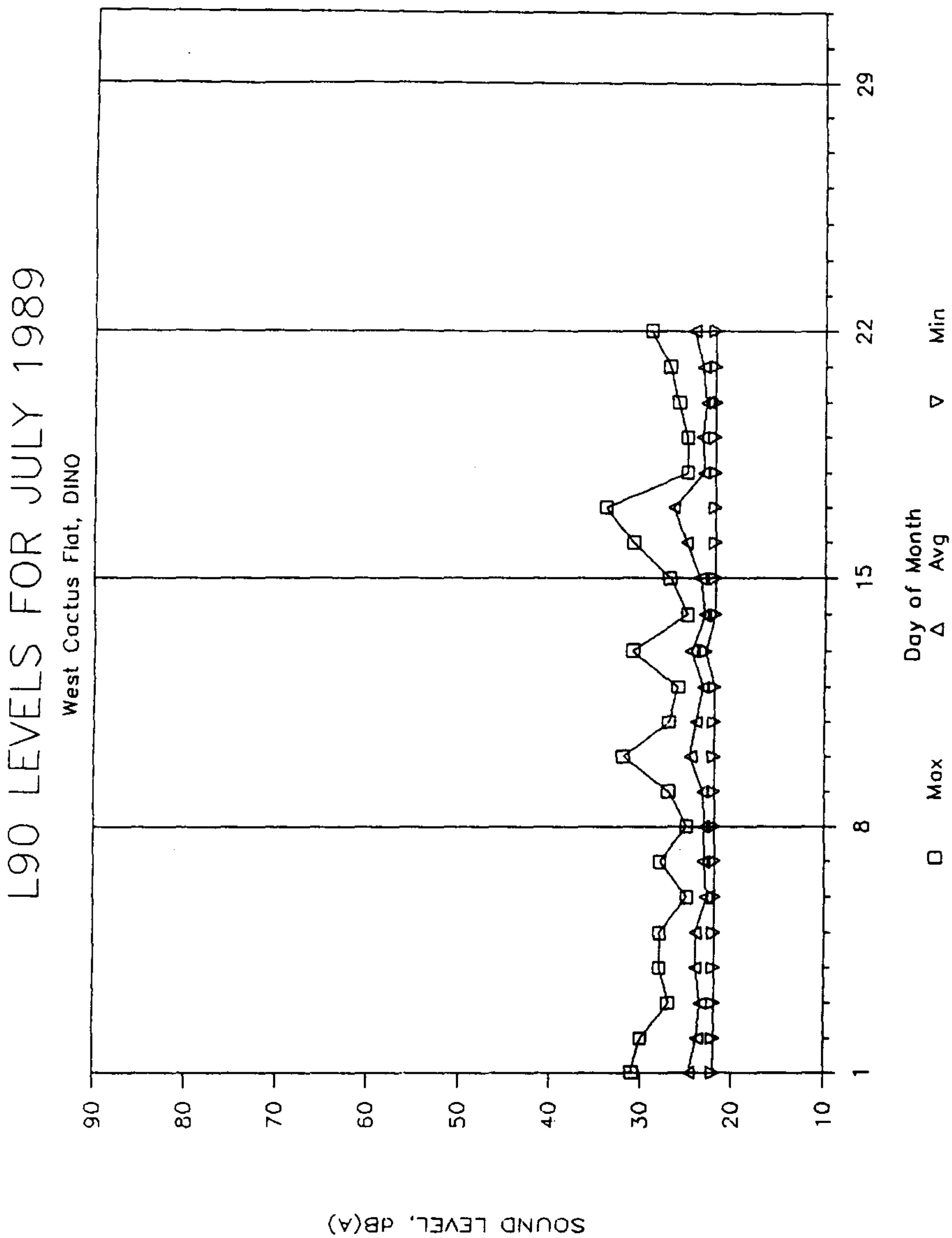

L90 LEVELS FOR JUNE 1989
West Cactus Flat, DINO
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
1
8
15
22
29
Day of Month
Max
Avg
Min

Figure 38


L90 LEVELS FOR JULY 1989
West Cactus Flat, DINO
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
1
8
15
22
29
Day of Month
Max
Avg
Min

Fic e 39

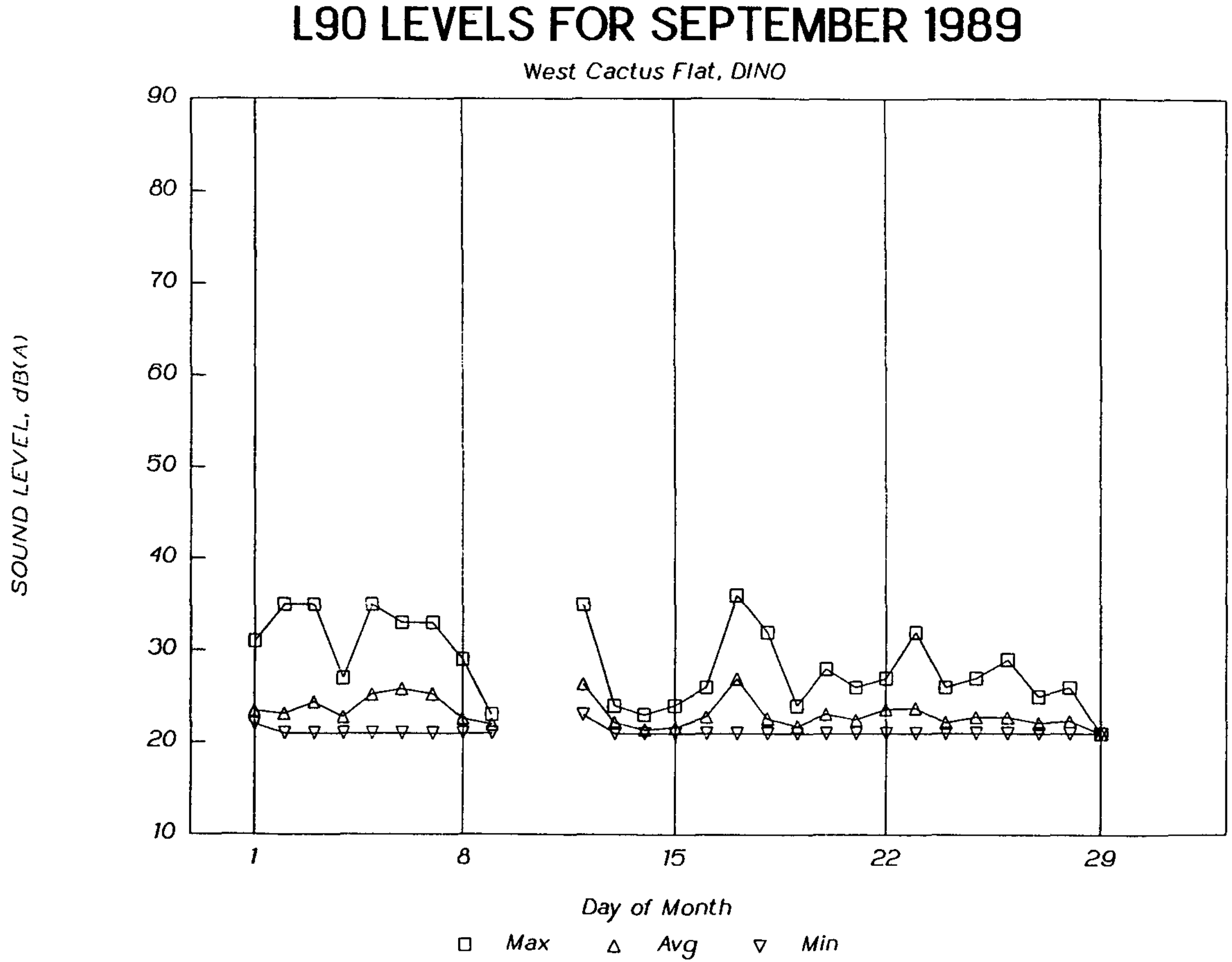

L90 LEVELS FOR SEPTEMBER 1989
West Cactus Flat, DINO
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
1
8
15
22
29
Day of Month
Max
Avg
Min

Figure 40

L90 LEVELS FOR OCTOBER 1989

West Cactus Flat, DINO

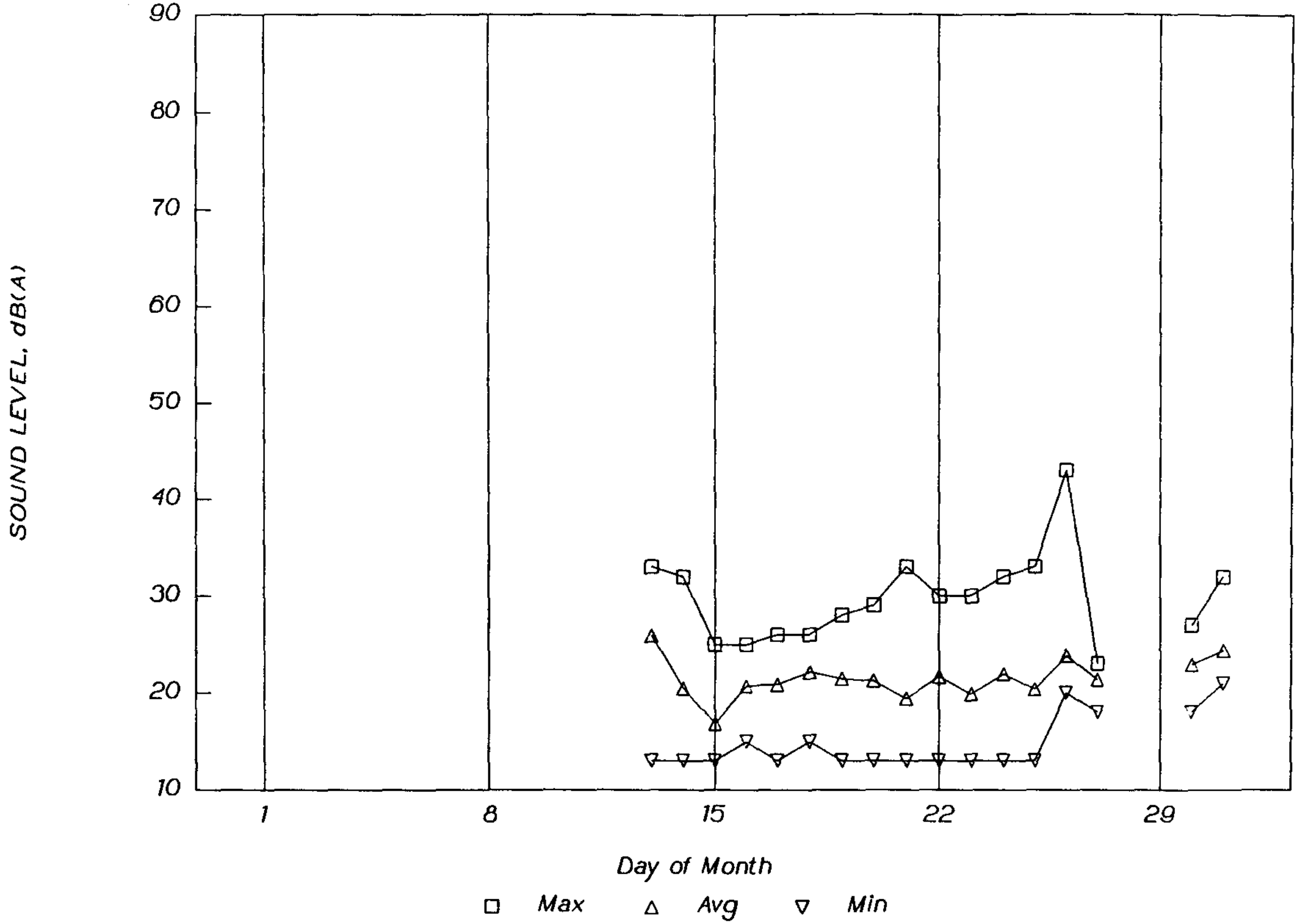
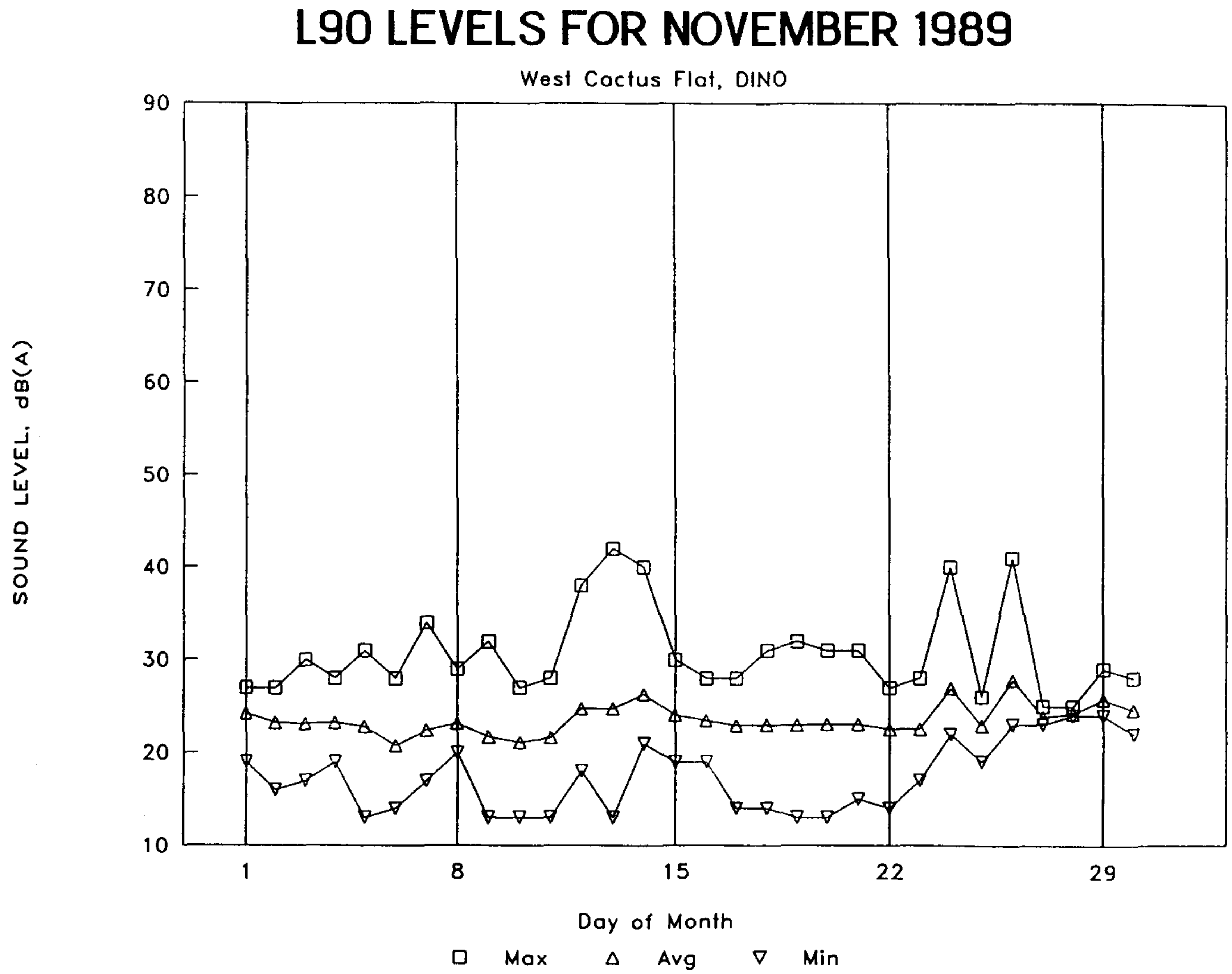


Figure 41



L90 LEVELS FOR NOVEMBER 1989
West Cactus Flat, DINO
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
1
8
15
22
29
Day of Month
Max
Avg
Min

Figure 42

L90 Levels for December 1989

West Cactus Flat, DINO

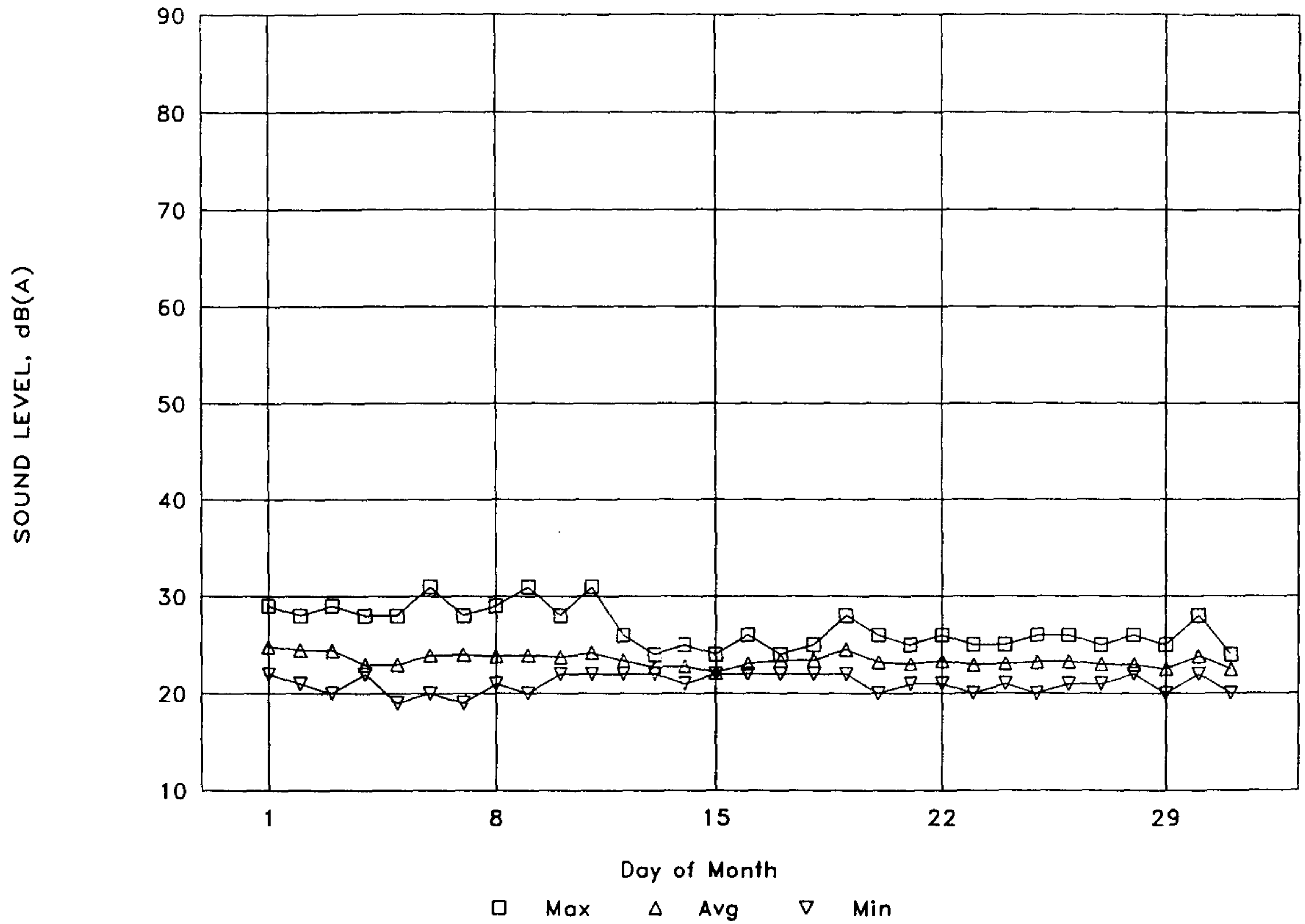
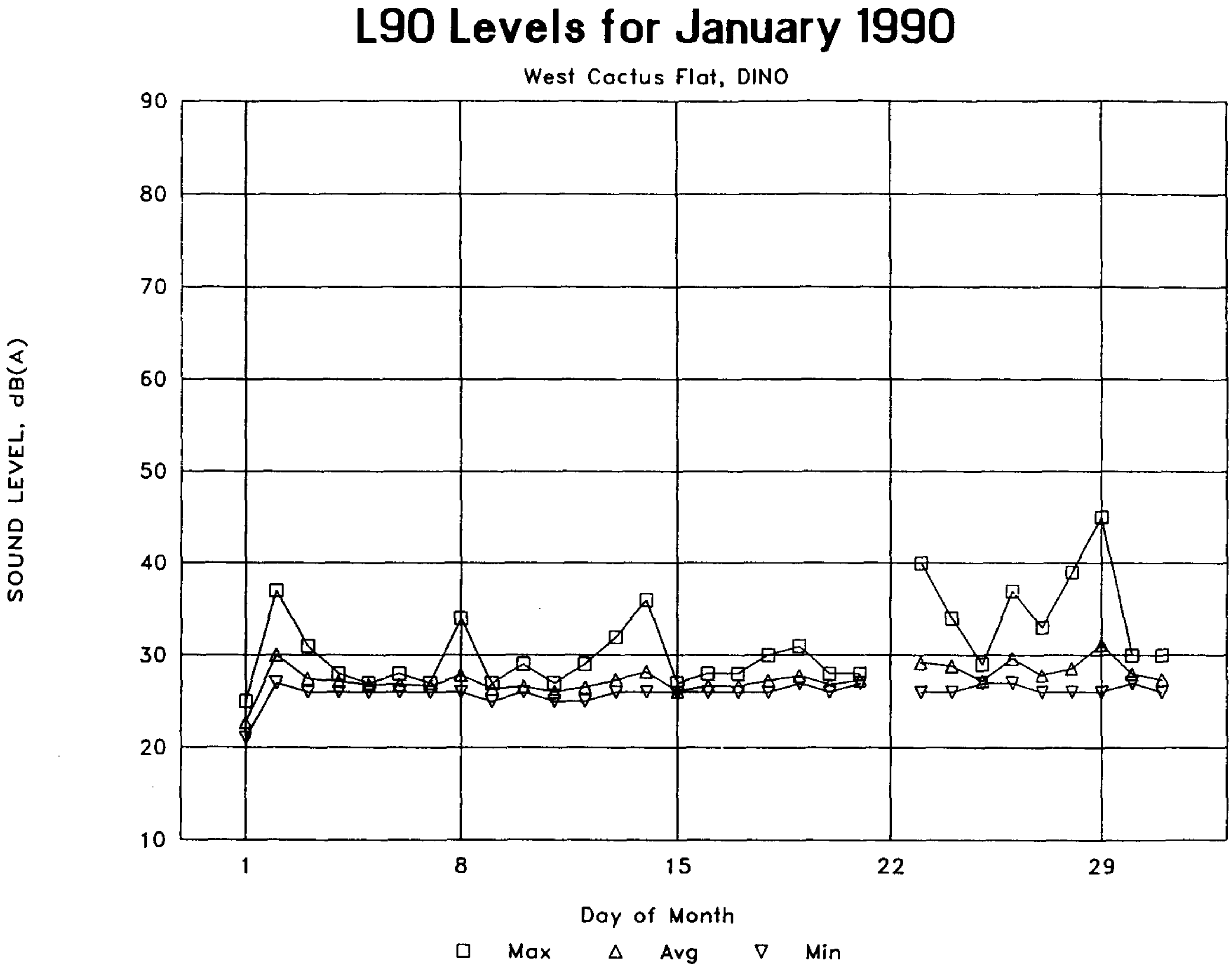
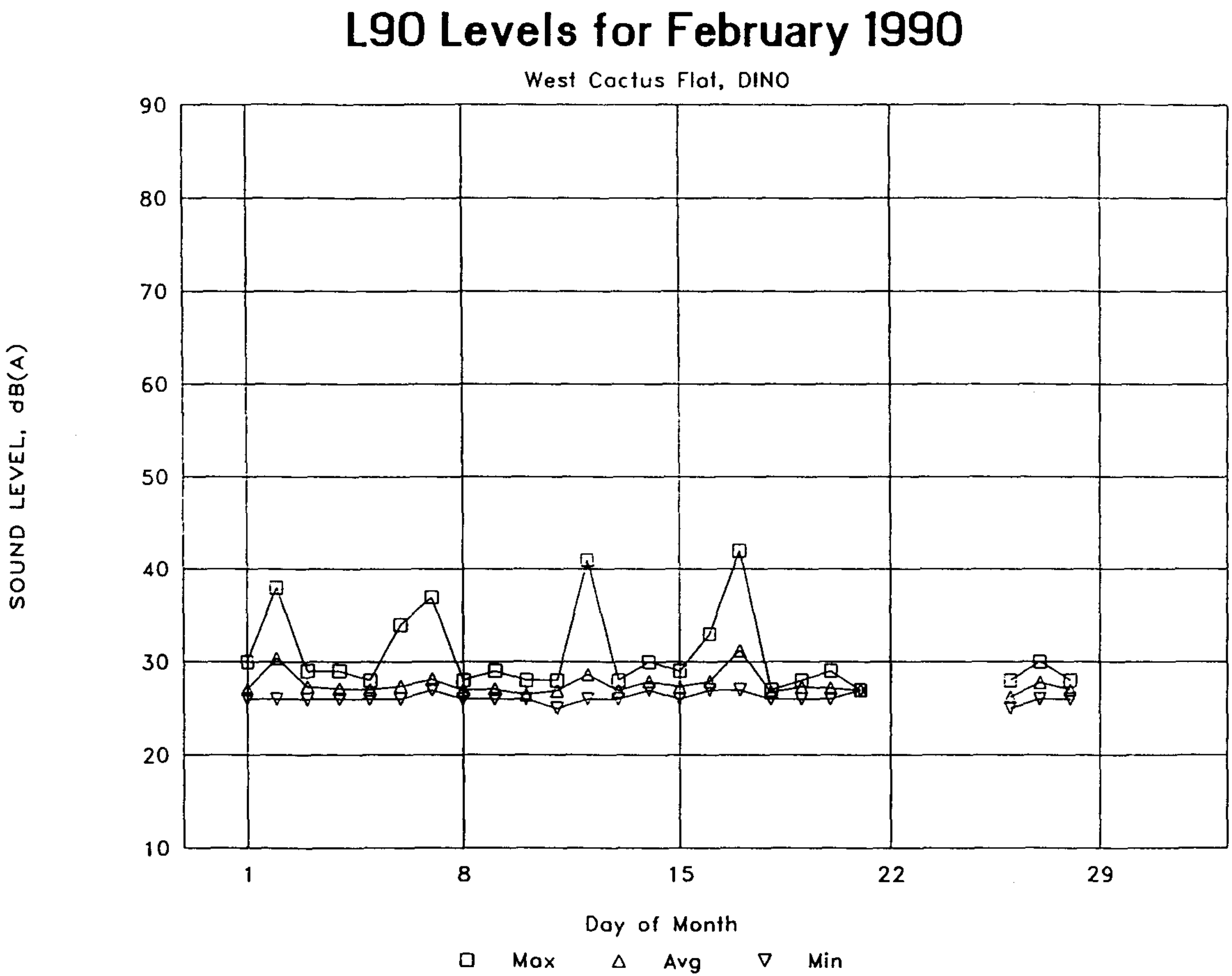


Fig---e 43



L90 Levels for January 1990
West Cactus Flat, DINO
90
80
70
60
50
40
30
20
10
SOUND LEVEL, dB(A)
1
8
15
22
29
Day of Month
Max
Avg
Min

Figure 44


L90 Levels for February 1990
West Cactus Flat, DINO
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
1
8
15
22
29
Day of Month
Max
Avg
Min

Fic e 45

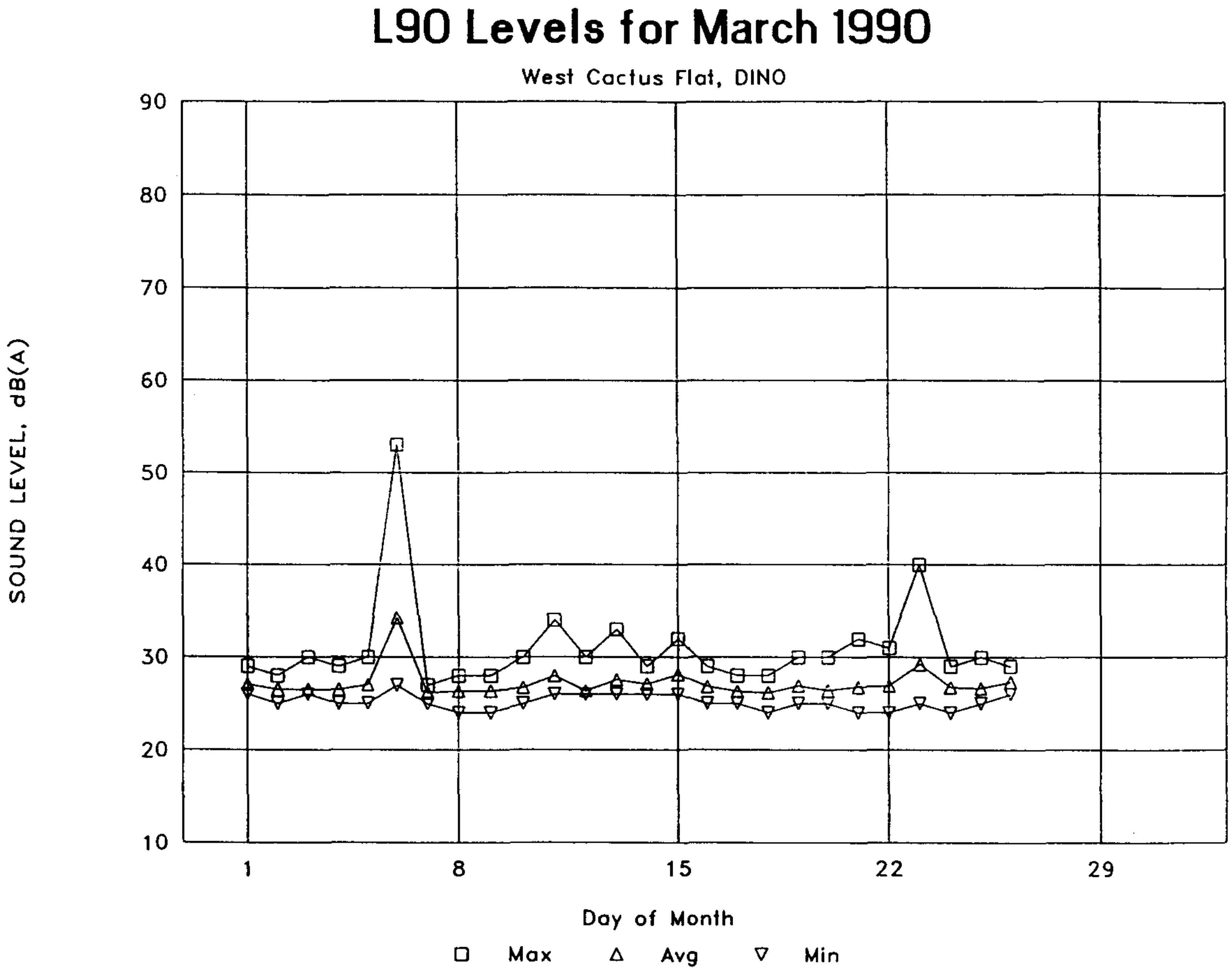
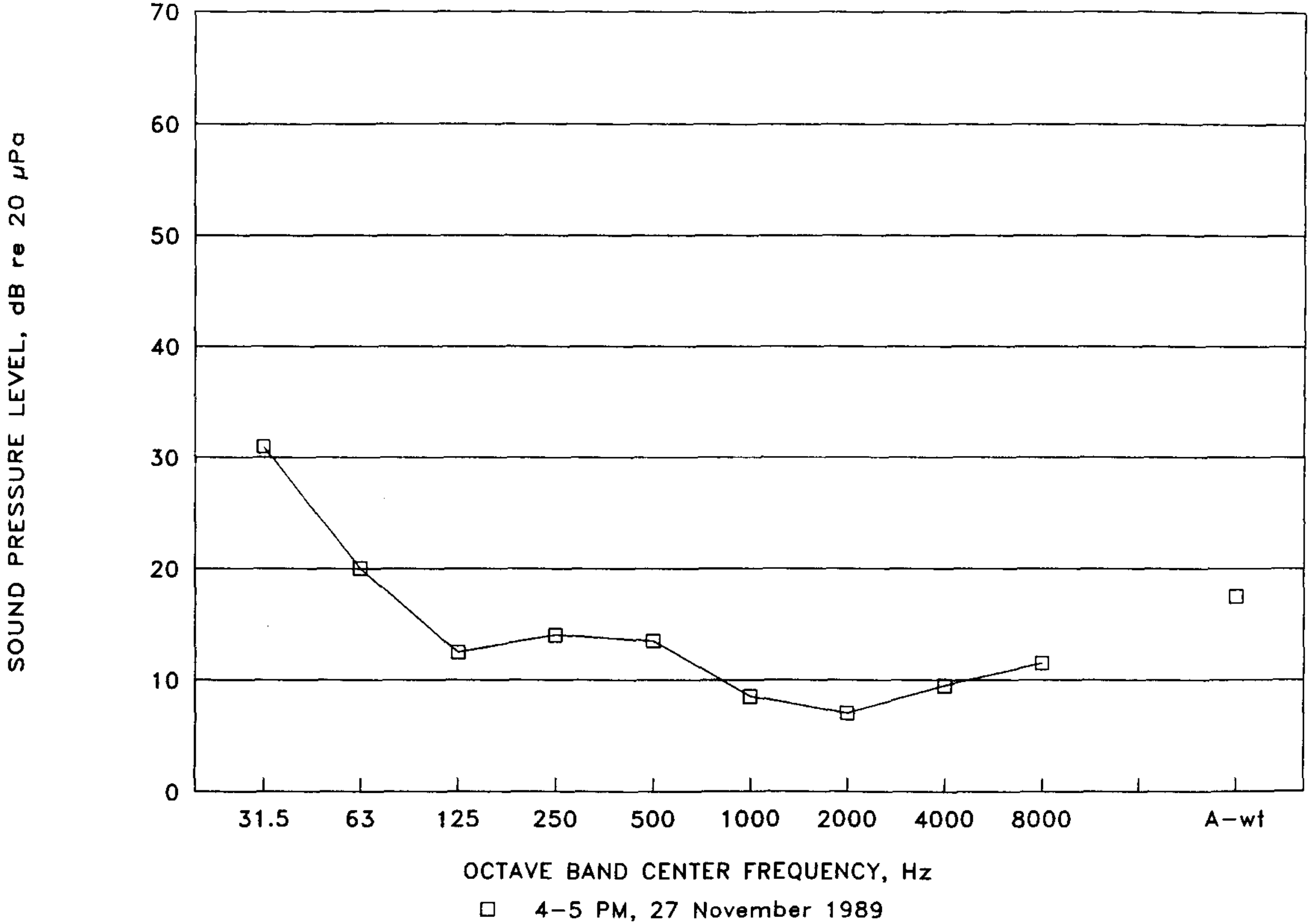

L90 Levels for March 1990
West Cactus Flat, DINO
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
1
8
15
22
29
Day of Month
Max
Avg
Min

Figure 46

West Cactus Flat Sound Monitoring Site

L90 Hourly Octave Band SPLs



Fic e 47

8.0 MONITORING RESULTS AT HARPERS CORNER SITE, DINOSAUR NM

8.1 Monitoring Site

Sound monitoring equipment was set up in an enclosure near Harpers Corner. This site was about 200 yards west of the park road about one mile west of the Echo Park overlook and traffic was visible and audible from the site.

The enclosure area had thick brush ranging from one to three feet high. The general area is a hilly plateau overlooking the Green River.

Figure 48 shows the monitoring site. All figures for the Harpers Corner site are contained in Section 8.6.

8.2 Monitoring Equipment

The original plan was to install a DA 607P monitor at this site but the unit planned for the installation was not operating properly and could not be repaired. Therefore, no monitor was installed until January 30, 1990 after the NPS had received additional DA 607P monitors from the Air Force.

The monitor collected data until March 5, 1990. Because of deep snow, NPS staff at Dinosaur NM were unable to service the monitor until March 30, 1990. Although the monitor was still running, the paper tape take-up spool was full and no paper tape record was made from March 5-30. After servicing, the monitor again collected data. As of the writing of the report, the monitor is still at the site collecting data but any data collected after April 13, 1990 is beyond the scope of this report.

8.3 Analysis of Monitored Data

Because of the equipment difficulties at this site, no data is available for the summer or fall of 1989. There is, however, good data for the month of February which can be used to represent the winter conditions at the site.

During February, there was snow on the ground and no visitor use on the nearby road. Figure 49 is a graph of the hourly sound levels for an average day in February. Note that there is little variation in the sound level throughout the day. This may have been the result of little diurnal variation in the wind speed though no meteorological data has been analyzed to confirm this.

Sound levels may have been increased by weather fronts passing through the park but, again, no meteorological data has been analyzed to confirm this. The higher sound levels were apparent in the early morning of February 7 and from February 16-21. The increase in L90 sound levels during these days is shown in Figure 50.

For this particular sound monitor, the equipment noise floor ranged from 21 to 22 dBA and most of the Lmin sound levels are measurements of the equipment noise floor rather than measurements of the sound level. Actual minimum sound levels and many L90 sound levels were probably below 21 dBA.

Measurements made from April 1-13 represent some of the spring-time conditions at this site. Figure 51 is a graph of the hourly sound levels for an average day in the first half of April. Like in February, there is no strong diurnal pattern but there is somewhat of an increase in daytime sound levels. Again, there are significant periodic increases in sound levels which may have been the result of weather fronts passing through the area but this has not been confirmed. These increases are shown in Figure 52. The average and maximum L90 sound levels on the 5th, 9th and 12th-13th increased significantly but there were still some periods during each of these days when the hourly L90 was at the equipment noise floor.

8.4 Analysis of Octave Band Data

Octave band sound pressure level statistics were measured at the long-term sound monitoring site from 10 AM on November 29, 1989 to 3 AM on November 30 (although the long-term monitor was not yet running, the measurement pole had been installed). At 3 AM, the monitor stopped running because of the cold temperature (about 0° F). Figure 53 presents two hourly L90 spectra measured during the monitoring period. These spectra are from the hours with the lowest L90 A-weighted sound level (16 dBA from 11 PM - 12 M) and the highest L90 A-weighted sound level (18 dBA from 5-6 PM).

There was no significant wind and the daily high temperature was about 30° F. Both spectra are very close to the noise floor of the equipment for the 1000 to 8000 Hz octave bands.

8.5 Conclusions

During the winter and spring seasons, sound levels at Harpers Corner were consistently low. L90 sound levels were often below the 21-22 dBA noise floor of the equipment. Individual hourly L90 sound levels averaged for each day of February and April ranged from 22 to 28 dBA. Average daily L90 sound levels ranged from 21 dBA (the equipment noise floor) on most days to 34 dBA on other days. The increased sound levels may have been due to weather fronts passing through the area but meteorological data has not been analyzed to confirm this.

Hourly L90 octave band sound pressure levels made during a period of low wind on November 29, 1989 were also limited by the equipment noise floor but recorded levels below 12 dB for the 63 to 8000 Hz octave bands.

8.6 Figures for Harpers Corner Site

The figures for the Harpers Corner Site listed below are presented on the following pages.

Figure 48. Harpers Corner Monitoring Site.

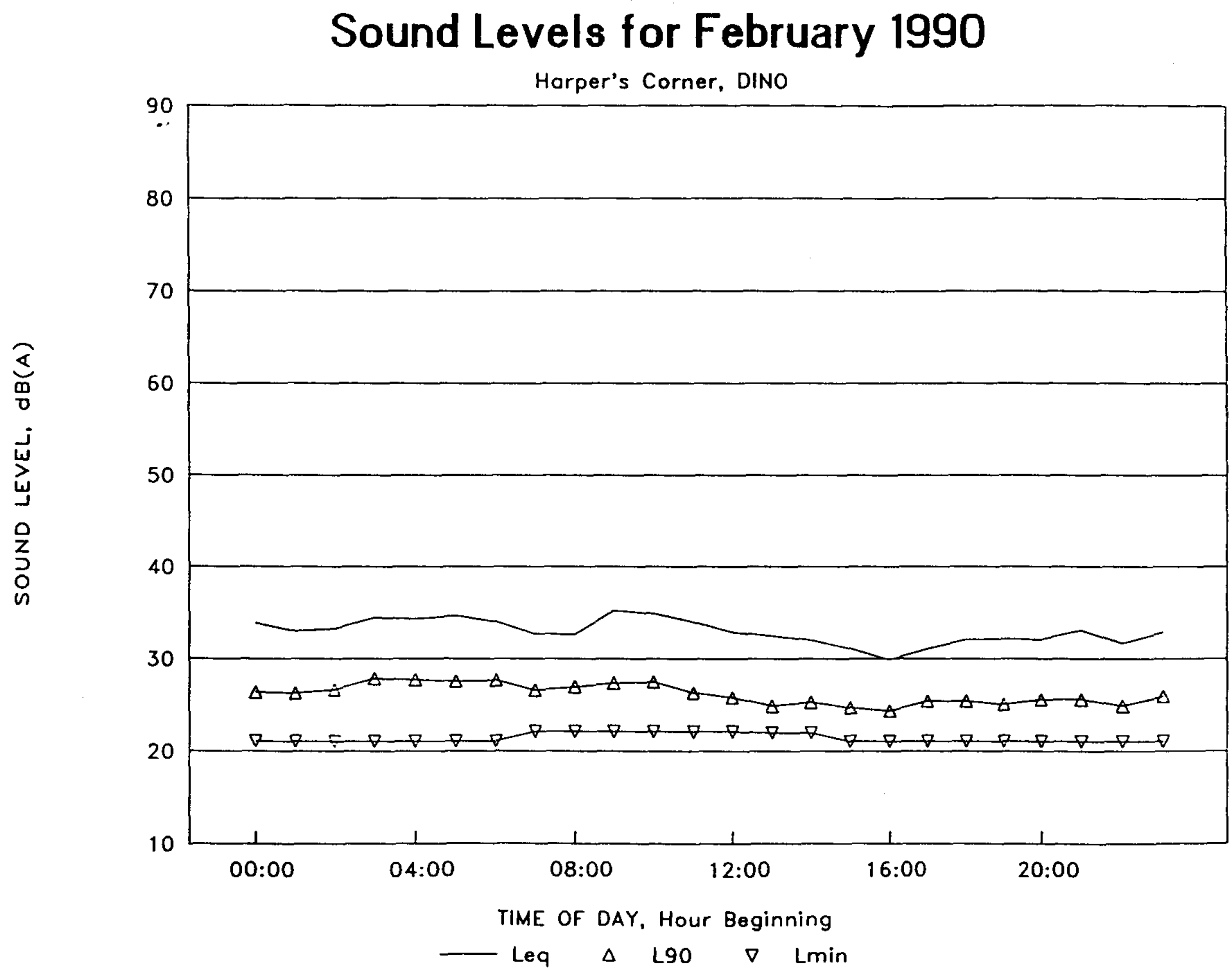

Sound Levels for February 1990
Harper's Corner, DINO
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
00:00
04:00
08:00
12:00
16:00
20:00
TIME OF DAY, Hour Beginning
Leq
L90
Lmin

Figure 49

L90 Levels for February 1990

Harper's Corner, DINO

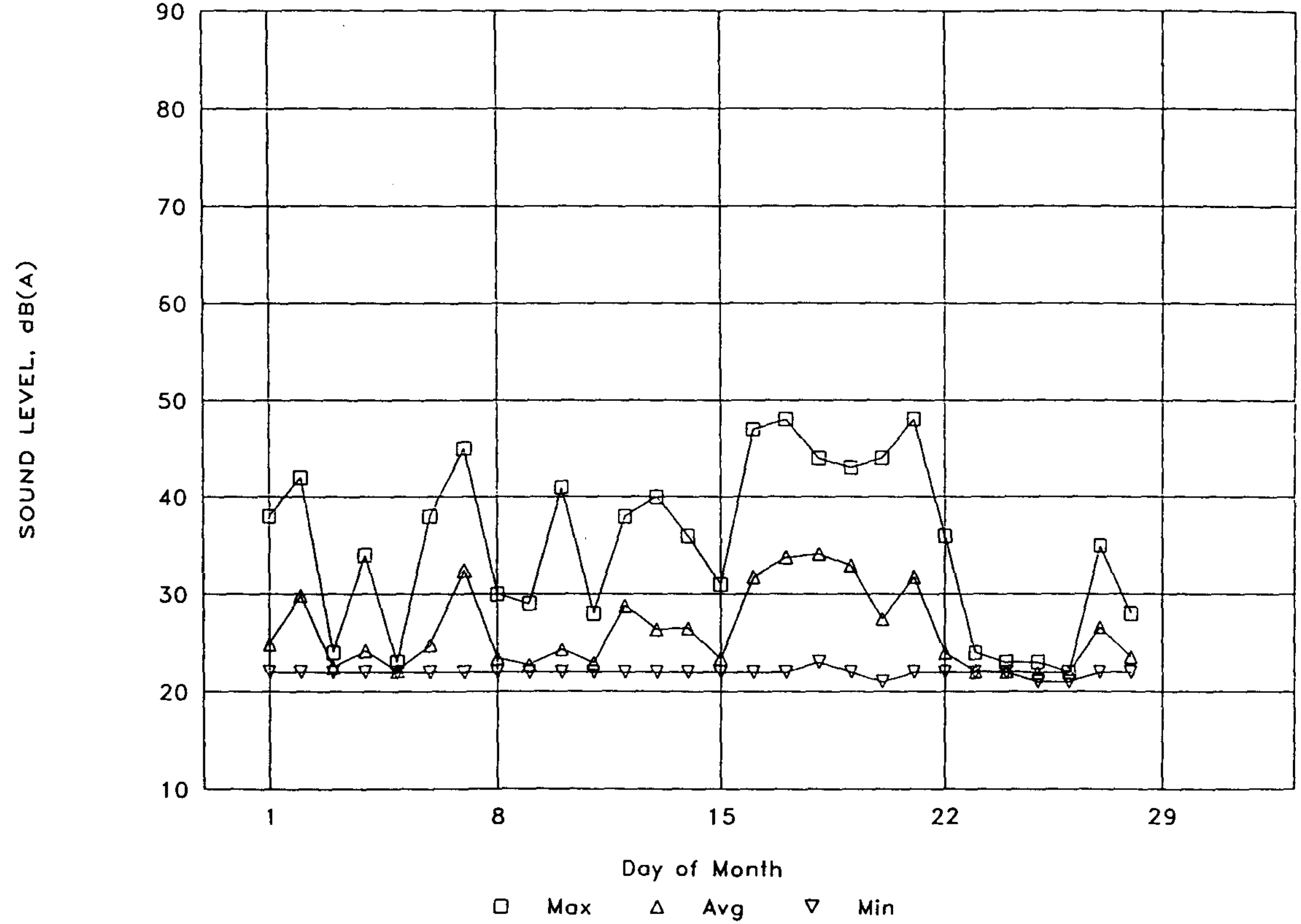


Figure 50

Sound Levels for April 1990

Harper's Corner, DINO

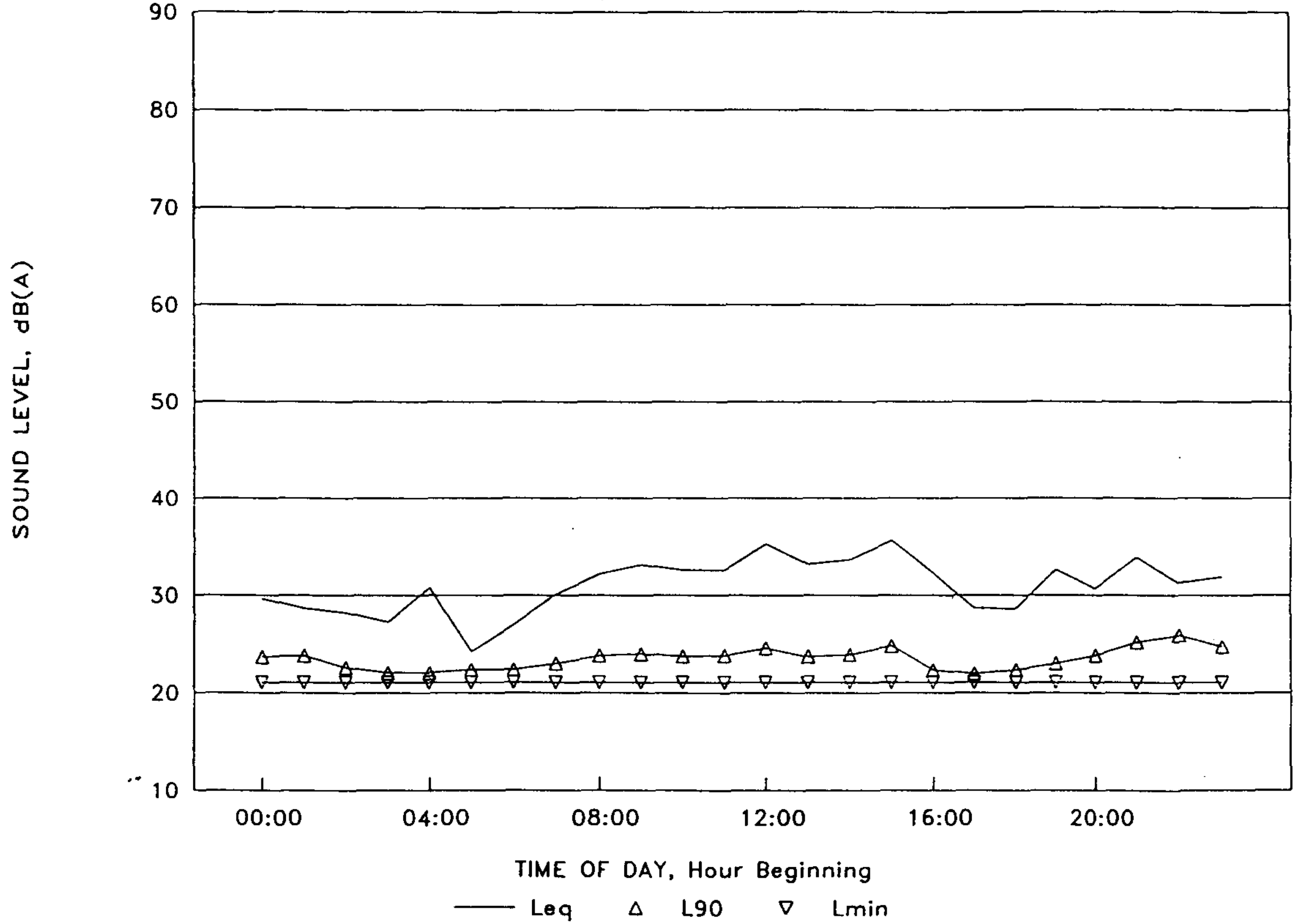


Figure 51

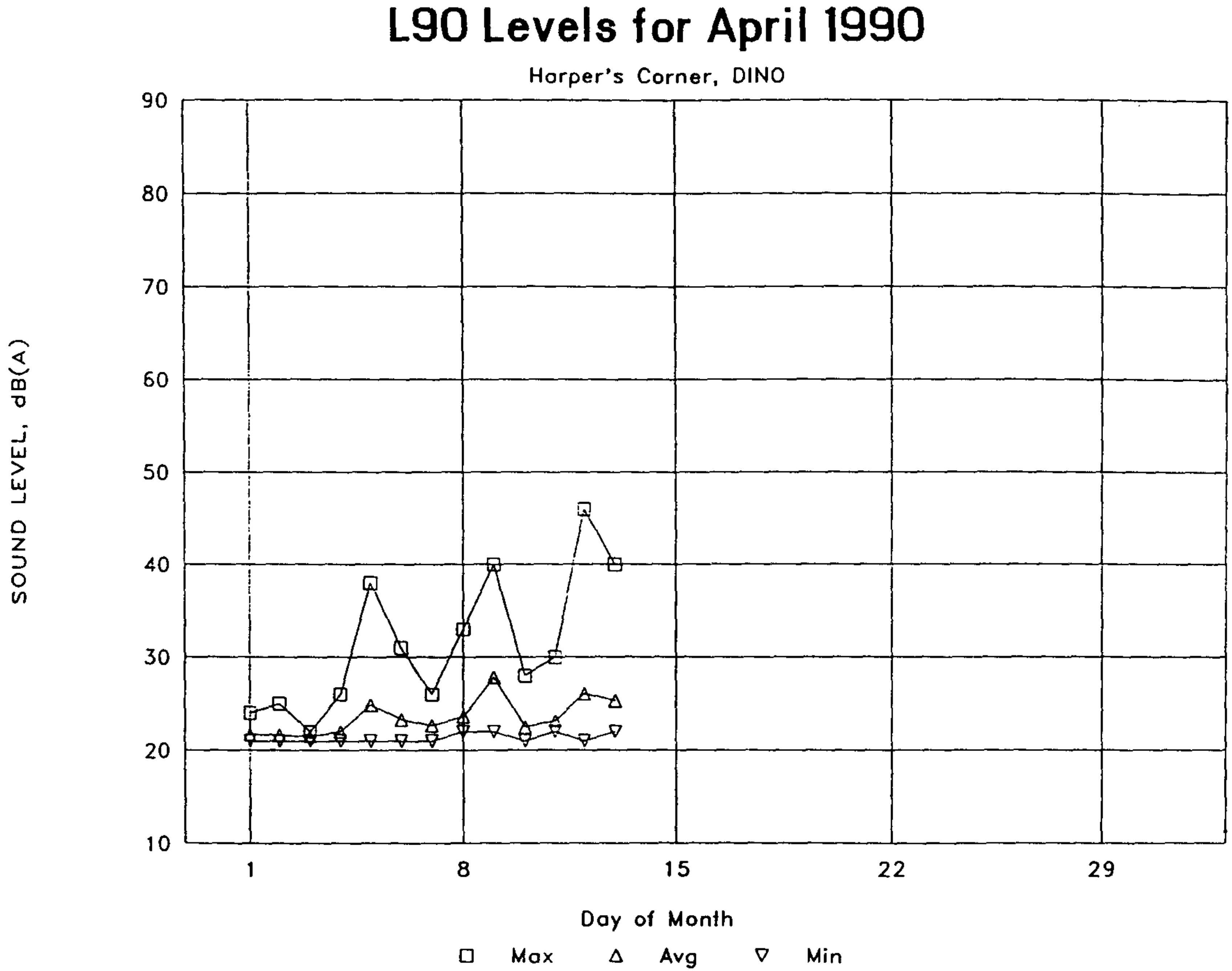

L90 Levels for April 1990
Harper's Corner, DINO
SOUND LEVEL, dB(A)
90
80
70
60
50
40
30
20
10
1
8
15
22
29
Day of Month
Max
Avg
Min

Figure 52

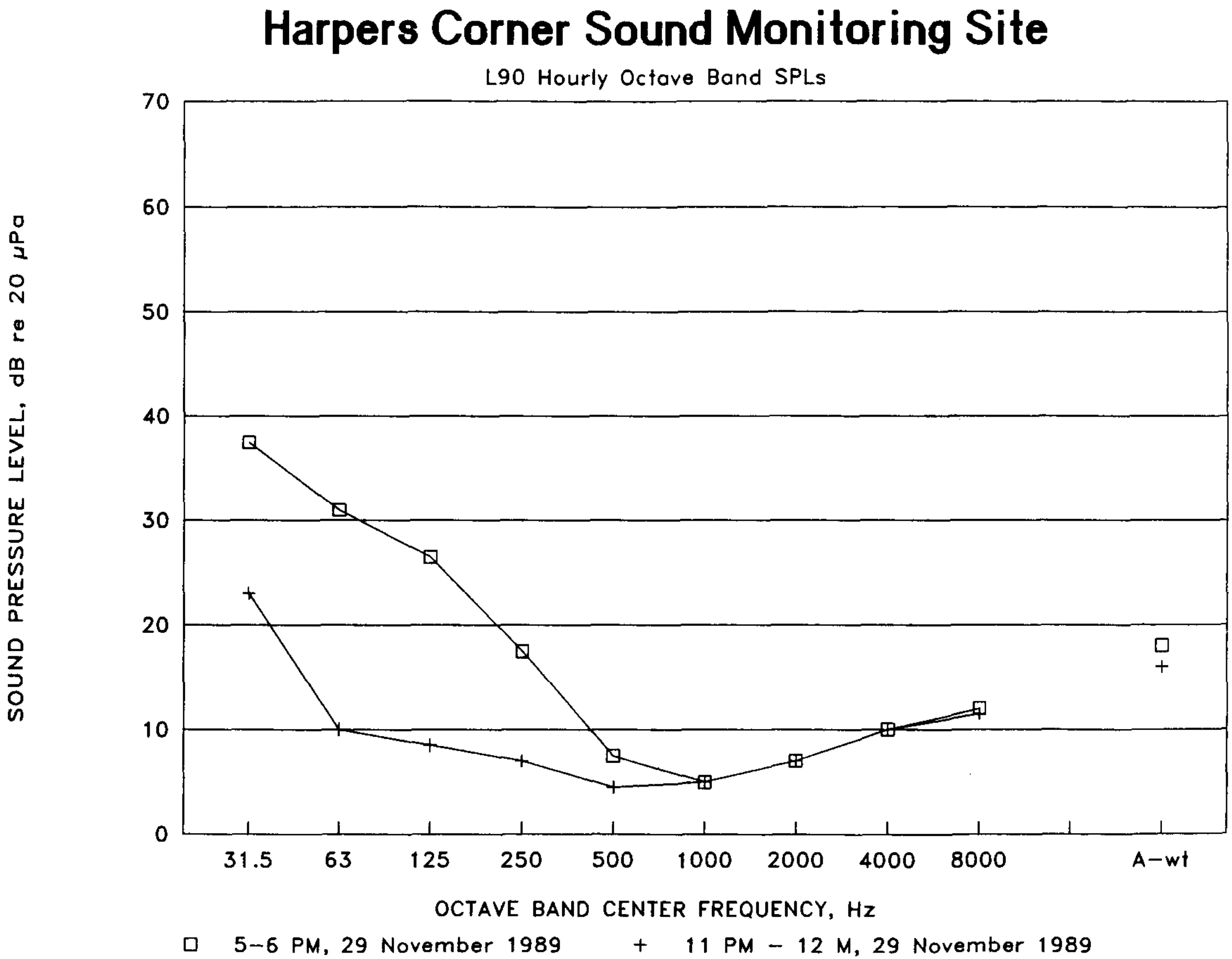

Harpers Corner Sound Monitoring Site
L90 Hourly Octave Band SPLs
SOUND PRESSURE LEVEL, dB re 20 μPa
70
60
50
40
30
20
10
0
31.5
63
125
250
500
1000
2000
4000
8000
A-wt
OCTAVE BAND CENTER FREQUENCY, Hz
□ 5-6 PM, 29 November 1989
+ 11 PM - 12 M, 29 November 1989

Figure 53

9.0 CONCLUSIONS

Under contract to the National Park Service, CSTI has assisted the Mining and Minerals Branch in quantifying the sound levels at 4 locations in the Colorado Plateau. Two of the locations were in Glen Canyon National Recreation Area and two were in Dinosaur National Monument. The locations in Glen Canyon NRA were Rainbow Bridge and Escalante. The locations in Dinosaur NM were West Cactus Flat and Harpers Corner.

Sound levels at Dinosaur NM and sound levels and weather conditions at Glen Canyon NRA have been monitored for some portion of the time from April 1989 to April 1990. In general, the nighttime ambient sound levels have been very near and even below the electrical noise floor of the Digital Acoustics noise monitors (normally about 21 dBA) and the Larson-Davis noise monitor (normally about 18 dBA). In other words, the minimum values that have been reported have often been higher than the actual acoustic ambient sound level.

Octave band sound pressure level measurements were made with a more sophisticated instrumentation system with a lower noise floor. The electrical noise floor of this system has octave band values ranging from about 22 dB in the 31.5 Hz band down to 4 dB in the 500 Hz band and back up to about 12 dB in the 8000 Hz band. The A-weighted electrical noise floor is about 16 dB. Sometimes the acoustic ambient noise floor was less than these values.

Based on the measurements performed during this study we have concluded:

- o daytime acoustic ambient sound levels (L90) are controlled by diurnal wind variation and passing weather fronts at the Escalante site in Glen Canyon NRA,
- o daytime acoustic ambient sound levels (L90) at the two sites at Dinosaur NM are normally low but may be affected by variation in wind speeds,
- o daytime acoustic ambient sound levels (L90) are controlled by boats and visitors at the Rainbow Bridge site in Glen Canyon NRA,
- o nighttime acoustic ambient sound levels (L90) are commonly less than 21 dBA at all four sites and were measured below 16 dBA,
- o octave band values for ambient L90's were measured in the low 20's in the low frequency bands and in the single

numbers in the mid and high frequency bands at all four sites,

- the L90's are controlled primarily by wind noise, which is composed of several components: the acoustic signal due to the turbulence in the air, the acoustic signal due to any leaves rustling together, and the microphone wind noise due to the wind blowing past the microphone, and

- insect sounds, bird calls and other animal sounds can contribute to the L90 but only for limited hours during parts of the year at some locations.

Currently, one monitor is installed at Harpers Corner in Dinosaur National Monument and three monitors are installed at the Colorado National Monument.

APPENDIX A

TECHNICAL PROCEDURES

Digital Acoustics DA 607P Monitors

A-1. INSTALLATION PROCEDURE

A-1-1. TELESCOPING POLE

* Pick location for pole and drive 1/2" copper rod into the ground as far as possible, leaving about 6" exposed.

* Drive stake at a location about 10' due north of the rod, and another at 10' south of the rod.

* Drive the other four stakes at locations 10' from the rod and 10' from the north or south stake.

* Place 3" PVC cap over copper rod. Attach ground wire clamp to rod as close to the ground as possible.

* Assemble the pole on the ground. Start by inserting microphone wire down the 2" pole and screw the microphone assembly onto the top of the pole.

* Attach solar panel to the 3" pole.

* Insert the microphone cable from the 2" pole into the 3" pole.

* With the 2" pole inserted about 12" into the 3" pole, align the black arrows on the two poles. Insert two 3/8" bolts into both poles and secure with lockwashers and wing nuts.

* Unroll the guy wires attached to the 2" pole.

* Place the bottom of the 3" pole in close proximity to the 3" cap. Wrap the two ground wires (from the windscreen and from the solar panel) around the pole a time or two and insert them into the hole at the bottom of the 3" pipe. Secure with ty-raps (two linked together) near the bottom and top of the 3" pole.

* Attach the two ground wires to the clamp on the copper rod. If possible, drive the rod in another inch or two.

* Insert the microphone cable into the slot at the bottom of the 3" pole. Erect the pole assembly and place the pole into the cap, being careful not to pinch the cable.

* The solar panel should be facing due south. Attach the cable from the 3" pole which points north to the north stake. Attach the other two cables from the 3" pole to the appropriate stakes.

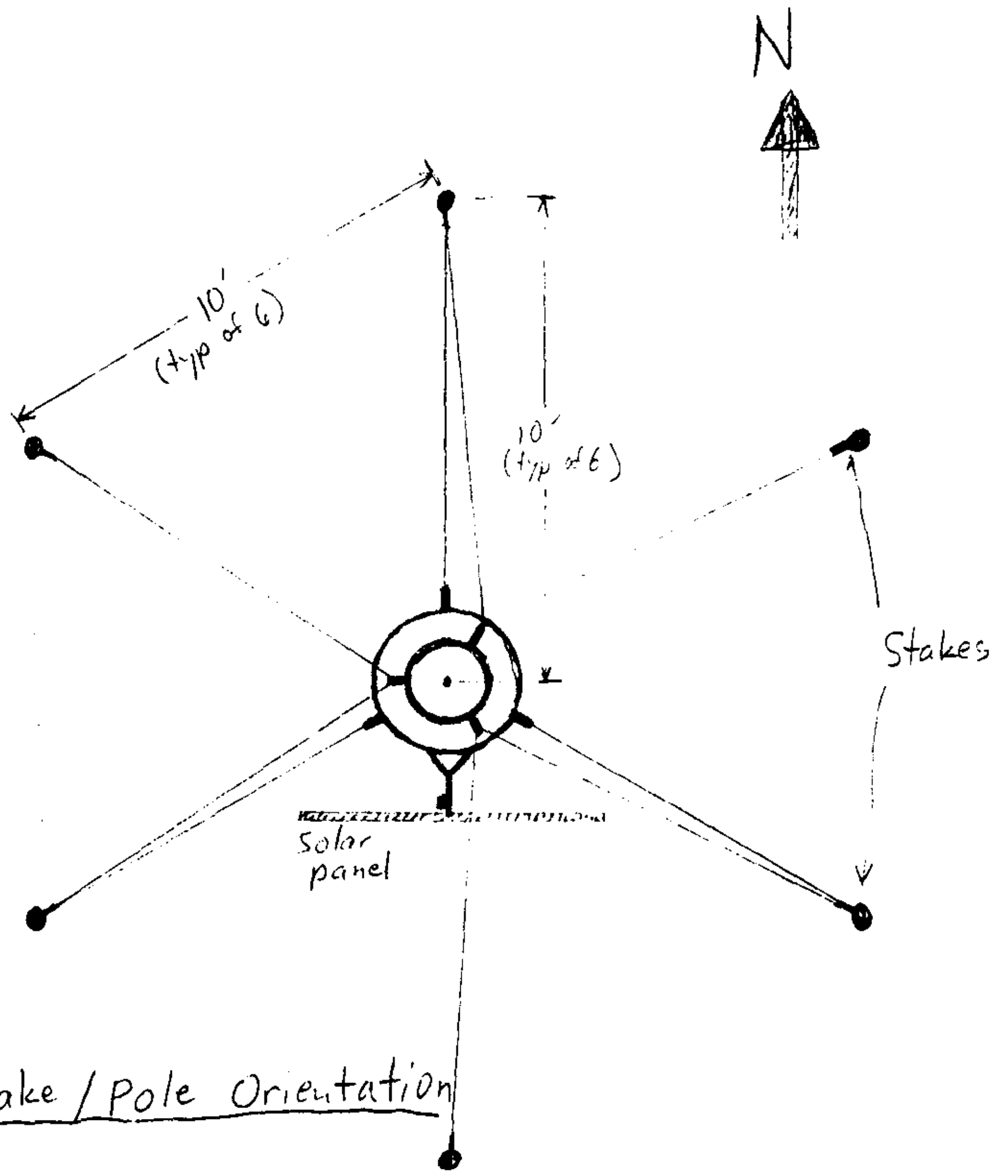
* Using a level, adjust the length of the cables until the pole points straight up.

* Attach the six cables from the 2" pole to the turnbuckles on the six stakes (refer to the drawing on page A2a). Use the turnbuckles to provide even tension on each cable.

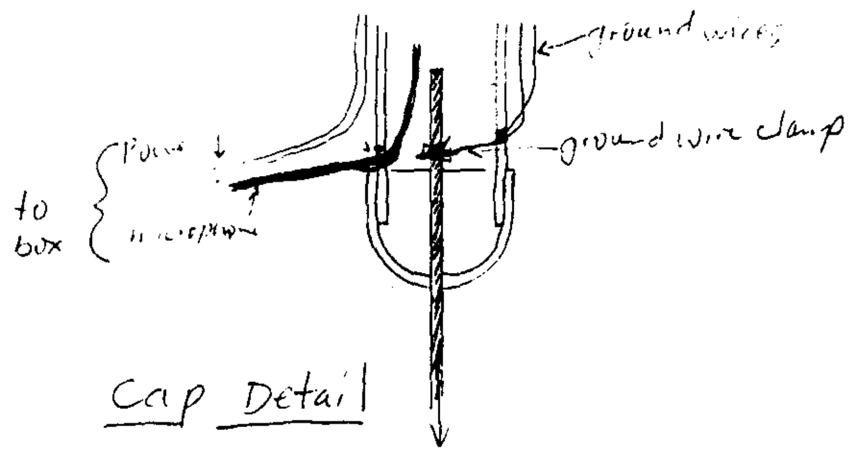
* Insert the power and microphone connectors through the hole in the side of the black box and connect to the monitor. Place the cables into the piece of foam and seal the hole with the foam.

* Calibrate using the recalibration/cold start instructions.

* Apply spray paint of the appropriate colors to obfuscate the black box.



Stake / Pole Orientation



Cap Detail

A-1-2. NON-TELESCOPING POLE

* Pick location for pole and drive 1/2" copper rod into the ground as far as possible, leaving about 6" exposed.
* Drive stake at a location about 10' due north of the rod, and another at 10' south of the rod.
* Drive the other four stakes at locations 10' from the rod and 10' from the north or south stake.
* Place 3" PVC cap over copper rod. Attach ground wire clamp to rod as close to the ground as possible.
* Insert green ground wire through the hole in the 3" pole and attach it to the ground wire clamp. Insert pole into cap.
* Attach one of the guy wires to the north stake. Attach the other two wires to alternate stakes. Make sure the pole is pointing straight up before securing guy wires.
* Insert the 2" pole into the adapter in the 3" pole.
* Attach the six guy wires to the six stakes. The three turnbuckles should be attached to <u>adjacent</u> stakes. Use the turnbuckles to point the pole straight up.
* Attach solar panel to the mounting bracket. The panel should be facing due south, angled toward the noon sun.
* Attach the green ground wire to the solar panel.
* Insert the power and microphone connectors through the hole in the side of the black box and connect to the monitor. Place the cables into the piece of foam and seal the hole with the foam.
* Calibrate using the recalibration/cold start instructions.
* Secure the wires to the pose with duct tape.
* Apply spray paint of the appropriate colors to obfuscate the black box.

A-2. SUPPLIES TO BE CARRIED TO THE FIELD EACH TIME

The following supplies and materials should be carried to the field each time:

* Key for "black box" containing monitor
* Sound level calibrator, when available
* Data dump and recalibration/cold start instructions
* Copy of DA 607P manual
* Transparent tape
* Cotton swabs with crushed ends
* Rubbing alcohol
* Supply of paper for printer
* Spare desiccant bags, sealed in plastic (The desiccant should be blue in color.)
* Empty paper spool (if available)
* Flat head screwdriver
* 5/16" and 3/8" nut drivers
* Crescent wrench or vise-grip pliers
* Compass

A-3. SUPPLIES TO BE KEPT AT MONITOR LOCATION

The spare (charged) batteries should be kept in the "black box" at the monitor location. We recommend that all other supplies be carried to the site each time.

A-4. DATA RETRIEVAL INSTRUCTIONS

* Open "black box" and monitor case.

* Place desiccant bags in zip-lock bag and seal, so they will not be exposed to air.

* Remove data as follows:

  Press **PRINT**, 1, 0, **ENTER** and wait while printer dispenses blank paper.
  (If the system is dead, go to "Cold Start Procedure.")
  Tear off paper from printer.
  Disconnect battery on left side ONLY and remove.

CAUTION: DO NOT TURN POWER SWITCH OFF OR DISCONNECT BOTH BATTERIES AT ANY TIME!

  Remove spool containing data roll of paper by sliding off to the left. Unroll the paper or replace with the empty spool you brought.

* Remove used paper roll.
  Lift tab on brown paper cover.
  Pull white lever back toward you until it locks.
  Remove roll by lifting it out and pulling paper back through roller.

* Clean print head.
  Moisten a cotton swab with alcohol. Insert the swab between the roller and the top of the white print head and rub it back and forth. The residue will come off on the swab as a dark gray material. Continue until no more residue from the print head comes off on the swab.

* Install new roll of paper.
  Remove the black plastic spindle from the used roll and insert it into a fresh roll.
  Insert the new roll, making sure that the spindle is centered between the guides. The paper should be feeding from the bottom of the roll.
  Fold the end of the paper back on itself, for a length of about one inch.
  Insert the paper under the black roller and manually turn the roller until the paper exits from the print head.
  Push the white lever down, away from you.
  Insert the end of the paper through the slot in the paper cover and close the cover.

* Attach paper to take-up spool.
  Pull the paper through until it reaches the spool.
  Attach a small piece of tape to the end of the paper.
  Pulling the paper straight back with the tape, carefully center the paper on the spool and attach the tape to the spool.

* Check the batteries as follows:
  Press **READ, 1, 0, ENTER.**
  Note voltage of right battery.
  Install and reconnect left battery.
  Disconnect right battery.
  Press **READ, 1, 0, ENTER.**
  Note voltage of left battery.
  Reconnect the right battery.

* If either battery is less than 5.8 volts, replace with one of the spare batteries. However, **BE SURE THAT AT LEAST ONE OF THE BATTERIES IS PLUGGED IN AT ALL TIMES** - otherwise you will have to recalibrate.

* Recalibrate.

  If the calibrator is available, follow the RECALIBRATION / COLD START procedure. Otherwise, proceed to CONTINUATION OF PROCEDURE.

CONTINUATION OF PROCEDURE

* Press **PRINT, 0, ENTER** to print initialization data.
  The information on the printout should be exactly the same as follows:

  MODE= A WTD SLOW
  THRESHOLDS: SEL= 65.0 DB
  PRINT MODES: 3456

  This is extremely important.

* Check color of desiccant.
  If the material inside the cloth bags has turned pink, replace bags with the spares which are sealed in a plastic bag.

* Remove blue desiccant bags from plastic bag and place them under the battery pack handles.

* Snap latches shut on noise monitor case.

* Lock "black box" with key, but do not fasten latches.

* Remember to take with you:
  - paper roll with data
  - discharged batteries if applicable
  - desiccant bags if desiccant is pink

* Unwind paper from spool and mail paper roll to the appropriate person in Denver.

A-5. RECALIBRATION / COLD START PROCEDURE

A-5-1. TELESCOPING POLE

* Ignore the CAUTION and turn the power switch OFF.
* Set WEIGHTING switch to A.
* Set RESPONSE switch to SLOW.
* Remove wing nuts from 3/8" bolts.
* Remove the hose clamp and rubber piece from 2" pipe.
* Exerting upward force on the 2" pipe, remove the two bolts and let the 2" pipe slowly slide down inside the 3" pipe until it stops.
* With a screwdriver, detach the ground wire from the windscreen and unscrew the windscreen.
* Turn on the calibrator to 1000 Hz, turn on the DA607P monitor, and let them warm up a few seconds.
* Press **SET**, 0, **ENTER**.
* Press **SET**, 1, **ENTER**, 0, **ENTER**.
* Press **READ**, 1, **ENTER** and note reading.
* Look at the table below and see what it should read. Subtract the reading from what it should read to find the difference.

Elevation	SPL
Sea level	114.0
5000'	112.8
5800'	112.7
6500'	112.6
7700'	112.4

* Press **SET**, 1, **ENTER**, then enter the difference and press **ENTER**.

For example, after pressing **SET**, 1, **ENTER**, 0, **ENTER**, **READ**, 1, **ENTER**, the display reads 104.5. You are at 6000 feet and the table says that the display should read 112.7 dB. The difference is 112.7 - 104.5 = 8.2. So, press **SET, 1, ENTER, 8, #, 2, ENTER.**

* Press **READ, 1, ENTER.** The value in the table should be displayed. If not, repeat the above procedure.

* Turn off the calibrator.

* Replace the windscreen and reattach the ground wire.

* Make sure the cable clamps at the 2" and 3" poles are tight.

* Raise the 2" pipe until the cables are taut, and align the two black arrows.

* Insert the 3/8" bolts and secure with lockwashers and wingnuts.

* Wrap the piece of rubber around the 2" pipe where it enters the 3" pipe. The bead should be touching the 3" pipe. Secure it with the hose clamp, leaving as little gap as possible.

* Adjust the turnbuckles if necessary.

* Press **PRINT, 12, ENTER** on the monitor to defeat HNL printing.

* Press **PRINT, 3, ENTER** to set print mode 3.

* Press **PRINT, 4, ENTER** to set print mode 4.

* Press **PRINT, 5, ENTER** to set print mode 5.

* Press **PRINT, 6, ENTER** to set print mode 6.

* Press **SET, 8, ENTER, 65, ENTER** to set SEL threshold.

* Set Interval start time: Note the time of day and set the interval to start on the next hour, using 24-hour (military time) format. For example, if it is 1:15 pm, the start time should be set to 2:00 pm (14:00) as follows:

  Press **SET, 6, ENTER.**
  Press 1, 4, #, 0, 0, **ENTER.**

* Go to "CONTINUATION OF PROCEDURE" in the data dump instructions.

A-5-2. NON-TELESCOPING POLE

* Ignore the CAUTION and turn the power switch OFF.
* Set WEIGHTING switch to A.
* Set RESPONSE switch to SLOW.
* Loosen the three turnbuckles. Remove the 2" section of the pole and place it on the ground.
* Remove the rain hat by loosening the hose clamp with a screwdriver. Remove the windscreen.
* Turn on the calibrator to 1000 Hz, turn on the DA607 monitor, and let them warm up a few seconds.
* Press **SET, 0, ENTER.**
* Press **SET, 1, ENTER, 0, ENTER.**
* Press **READ, 1, ENTER** and note reading.
* Look at the table below and see what it should read. Subtract the reading from what it should read to find the difference.

Elevation	SPL
Sea level	114.0
5000'	112.8
5800'	112.7
6500'	112.6
7700'	112.4

* Press **SET, 1, ENTER,** then enter the difference and press **ENTER.**

  For example, after pressing **SET, 1, ENTER, 0, ENTER, READ, 1, ENTER,** the display reads 104.5. You are at 6000 feet and the table says that the display should read 112.7 dB. The difference is 112.7 - 104.5 = 8.2. So, press **SET, 1, ENTER, 8, #, 2, ENTER.**

* Press **READ, 1, ENTER.** The value in the table should be displayed. If not, repeat the above procedure.
* Turn off the calibrator.
* Replace the windscreen and rain hat.

* Make sure the cable clamps at the 2" and 3" poles are tight.
* Raise the 2" pipe and insert it into the 3" pipe. Align the two black arrows.
* Tighten the turnbuckles.
* Press **PRINT**, 12, **ENTER** on the monitor to defeat HNL printing.
* Press **PRINT**, 3, **ENTER** to set print mode 3.
* Press **PRINT**, 4, **ENTER** to set print mode 4.
* Press **PRINT**, 5, **ENTER** to set print mode 5.
* Press **PRINT**, 6, **ENTER** to set print mode 6.
* Press **SET**, 8, **ENTER**, 65, **ENTER** to set SEL threshold.
* Set Interval start time: Note the time of day and set the interval to start on the next hour, using 24-hour (military time) format. For example, if it is 1:15 pm, the start time should be set to 2:00 pm (14:00) as follows:

  Press **SET**, 6, **ENTER**.
  Press 1, 4, #, 0, 0, **ENTER**.

* Go to "CONTINUATION OF PROCEDURE" in the data dump instructions.

A-6. INITIAL SOFTWARE SETUP

The following describes an initial setup required to analyze sound and meteorological data from the Digital Acoustics 607P and Campbell Scientific monitors. If you have any questions about the setup or use of the software, contact Mr. Gris Steele at CSTI, (713) 492-2784 (phone) or (713) 492-1434 (fax).

* Make four subdirectories in the root directory of your hard disk with the following names:

  \MACROS
  \ORIGINAL
  \PROCESSD
  \PICS

LOTUS 123

Several macro programs are needed to process the data:

- NPS1HR.WKS - enter hourly DA 607P data
- NPS2HR.WKS - enter bi-hourly DA 607P data
- DA-SOUND.WK1 - process monthly sound data from Digital Acoustics monitors
- DA-PRINT.WK1 - print monthly sound data from DA monitors
- CSXFMMET.WK1 - format meteorological data from Campbell Scientific system to be read by CS-MET
- CS-MET.WK1 - process monthly met data from Campbell Scientific system
- QUARTER.WK1 - summarize three months of L90 sound levels from DA and LD monitors

* Copy the above macro files into the \MACROS subdirectory.

* Start Lotus 123. Set the default drive to the root directory which contains the \MACROS, \ORIGINAL, \PROCESSD, and \PICS subdirectories.

* Retrieve DA-PRINT.WK1 from the \MACROS subdirectory.

* Set the print options as follows:

  Margins: Left 0 Right 94 Top 4 Bottom 0

  Borders: Rows A5..A7

  These should already be set, but you do need to enter the setup string for printing 12 characters per inch. If you are using an Epson compatible printer, the setup string should be "\027M" (the typing sequence would be **/ppos\027M ENTER qq**.

* Save the file (**/fs ENTER r**).

<u>PRINTGRAPH</u>

* Load PrintGraph from the 1-2-3 Access System and set the following parameters:

  Image size: full
  Top margin: 0.5
  Left margin: 0.8
  Font 1: BOLD
  Font 2: BLOCK2
  Graphs directory: d:\PICS

  Also make sure the correct printer is selected, then save the setup. The following series of keystrokes will accomplish all but the printer selection:

  sisfmt.5 ENTER 1.8 ENTER qq
  f1, select "BOLD" with the space bar, then press ENTER
  f2, select "BLOCK2" then ENTER
  qhg\pics ENTER qse

A-7. DATA ENTRY PROCEDURE

This section gives instructions for entering the data from the paper tape into a Lotus data file.

INITIALIZATION

First, load LOTUS 1-2-3 into your computer.

Retrieve the appropriate template file on the supplied disk:

NPS1HR for data with one-hour intervals
NPS2HR for two-hour intervals

When loaded, the template will use an auto-executing macro to duplicate itself so that up to 17 days of one-hour data can be entered (35 days of two-hour intervals). This will take several seconds, then the duplicating macro will self-destruct.

Then the program will prompt you with

Enter serial number:

Enter the serial number of the noise monitor (e.g., 303) as found on the initialization printout at the beginning of the data.

You will also be prompted to

Enter location:

Type the location of the monitor (e.g. West Cactus Flat, DINO). Then it will ask you to

Enter threshold:

This is the SEL threshold found on the initialization printout. If the instructions for each site were followed, it should be 65 dB.

At the prompt,

Enter beginning date '@DATE(YY,MM,DD)'

enter the first date for which you are entering data. For example, if the data begins May 16, 1990, type **@date(90,5,16)** and press Return.

The program will then fill in the date column with successive dates, so you will only have to type a date once.

If you make a mistake in the above entries, you can invoke the "A" macro by holding down the **ALT** key and pressing **A**. (We'll call it **ALT-a** in succeeding paragraphs.) The program will ask you the questions again.

At this point you should change the name of the file and save it. First of all, remove the template disk and insert a blank, formatted, 5 1/4" disk. Save by typing **/fs** and then entering a new filename. Filenames should contain the serial number, the underline character, and the date of the first data, in the following format:

ser_mmdd

For example, for data from unit #303 starting on May 16, the filename would be

303_0516

DATA ENTRY

Now you are ready to enter the interval data. Start with the "Leq" column that corresponds to the proper start time for the interval. Enter numbers across the spreadsheet as you go down the data printout. Figure 1 illustrates the location of each of the quantities on both the printout and the spreadsheet.

A note about the "OvrThr" columns. This is the amount of time that the sound level exceeded the threshold during the interval. If the data printout says "OVER THR. 0H 0M 0S" then skip over the three columns. However, if the threshold was exceeded, replace the 0's with the appropriate number of hours, minutes, and seconds, respectively.

Numbers in the "Time" column should not be changed. The data should be entered on the line corresponding to the proper start time of the interval.

After entering a line of data, an easy way to go to the next line is to invoke the Z macro (**ALT-z**). Most of the time it will take you to the next entry slot. When all the interval data for a particular day has been entered, enter the daily data (Ldn, CNEL, and 24-hour Leq) under the appropriate headings.

ERROR DETECTION

There are a few error-checking features in the spreadsheet which can detect obvious entry errors. Invoke the "E" macro (press **ALT-e**) and the spreadsheet will make some calculations, then shift the screen so that any error flags will appear. Figure 2 illustrates the error flags. The following explains the error types:

Ln - The Ln values, that is, the L.1 through L99 values, should be in descending order. If not, "ERR" will appear in the "Ln" column on the appropriate row.

Lmax - The Lmax value should be higher than the L.1 level. If "ERR" appears in the "Lmax" column, then either the Lmax or the L.1 value is incorrectly entered.

Lmin - The Lmin value should be lower than the L99 value. Either the Lmin or the L99 could be incorrectly entered.

Lnp - The noise pollution level is equal to the Leq plus 2.56 times the standard deviation. If there is an "Lnp" error, either the interval Leq, the Lnp, or the standard deviation may be entered incorrectly.

Leq - An Leq value is calculated for the entire day by computing the power average of the 24 (or 12) interval Leq's (shown as "CalcLeq24"). This value is compared to the "24 hour Leq" that the monitor computes. If "ERR" appears next to "Leq", check all the interval Leq entries as well as the 24-hour Leq.

NOTE: If only a partial day of data is entered (such as the first and last days of the monitoring period), the Leq error may appear even if the values are correct.

After any errors have been corrected, invoke macro "E" again (**ALT-e**) and check that the error flags are gone. The error macro is not foolproof on Release 1A, and it may occasionally send you into far right field. If so, just get back to the "ERRORS" columns and you will see the errors. A "0" means the entries pass the error checks; "ERR" means they do not.

SAVING DATA TO DISK

It is a good idea to save the spreadsheet after entering each day's data. AFTER THE FILENAME HAS BEEN CHANGED from "NPS1HR" (or "NPS2HR"), the file can easily be saved by pressing **ALT-s**. This will take SEVERAL seconds, but is worth the insurance against lost data.

A-8. PROCEDURE FOR PROCESSING MONTHLY SOUND DATA

EXTRACT DATA

* From DOS, copy the data file into the d:\ORIGINAL subdirectory, where "d:" is the name of the hard drive (e.g., **copy A:\303_0708.WKS C:\ORIGINAL\303_0708.WKS**).

* Start Lotus 123. Set the default directory to the drive which contains the \MACROS, \ORIGINAL, \PROCESSD, and \PICS subdirectories (e.g., **/fdC:**).

* Retrieve the data file from the \ORIGINAL subdirectory into Lotus (**/fr**, select \ORIGINAL, select filename).

* Search for any blank labels (') and erase them. Otherwise, they will be interpreted as zeroes and will skew the data.

  - type **/rs**. The search range should be B8..Fxxx, where xxx is the last row of data.
  - String to search for: type a "'" and press the space bar once (i.e., the string will be "' ").
  - Select "Labels"
  - Select "Find"
  - If you get an error, "String not found", then press **CTRL-BREAK** and go to the next step.
  - If a blank label is found (a cell with a ' in it but no other label), select **Quit** and erase the cell (**/re Enter**. Repeat the search until all blank labels are eliminated (you will get a "String not found" error).

* Repeat the search for the other section of the data. Type **/rs**. The search range should be H8..Sxxx, where xxx is the last row of data. Handle blank and non-blank labels as described above.

* Clear the titles (**/wtc**).

* Press **HOME**. Extract the data values into another file (**/fxv**). Select the \PROCESSD subdirectory and name the file as follows:

  llllmmdd

  where llll = the location (e.g., "HARP" for Harper's Corner), and
  mmdd = the month and day from the original filename.

The range should include all data, excluding the error columns (A1..Sxxx).

* Retrieve the next data file from the \ORIGINAL directory which contains relevant data and extract the data as above. Repeat this process until the entire month has been processed.

PRINT DATA

* Retrieve DA-PRINT.WK1 from the \MACROS subdirectory. You will be prompted to select a file from the \PROCESSD subdirectory. Select the file which you previously extracted.

* You will then be prompted to edit the header. There are three fields in the header, separated by the "¦" character. Edit the header to read as follows:

  Sound Data¦location, park¦month, year

  For example, for May data at Harpers Corner, the header should be

  Sound Data¦Harper's Corner, DINO¦May, 1990

* When the header is entered, you will be prompted to select the print range. Select the data within the month desired and include columns A through S. The data will be printed to the printer.

* If there is data in the same file from another month, press **ALT-n** to edit the header, etc.

* Press **ALT-g** to retrieve another file. Print the data from each file which contains data from the given month.

SUMMARIZE DATA

* Retrieve DA-SOUND.WK1 from the \MACROS subdirectory.

* Select "New" for a new month or site and select "Yes".

* Enter the name of the site. Be sure to include the park designation (e.g., GLCA, DINO, etc.).

* Choose the month for which you wish to summarize data from the menu.

* When asked to select the file to combine, choose the first file with data in the appropriate month. For example, xxx_0226 would be the first file with data in March.

* Press **ALT-d** to move appropriate data into the summary table. Sometimes the program will ask you to "Enter number of first row of data:". If data first appears on, say, row 17 of the spreadsheet, type "17" and press **ENTER**.

* If there is more data to be added from other files, press **ALT-m** to bring up the menu and select "Add". Choose the next file (chronologically) with data in that month, then press **ALT-d** as above.

When all data for the month has been retrieved and summarized ...

* Press **ALT-t** to calculate and transfer averages and max/mins to a table so they can be graphed.

* Select "Graph" from the menu, then select "1) Leq" and a graph will appear. Press **ENTER** and an updated graph will appear. Press **ENTER** again and name the graph as follows:

  d:\PICS\llttttmm

  where ll = location (WC, HC, etc.),
  tttt = type of graph (LEQ, LN, L90D, or L90M), and
  mm = number of month.

* After the graph is saved, the menu will reappear. Select "Graph" again and choose the next type of graph. Repeat until all four types have been saved.

* Select "Save" from the menu to save the summary of the entire month's data. Name the file as follows:

  d:\PROCESSD\lll-mmmS

  where lll = location,
  mmm = abbreviation for the month, and
  "S" = sound.

* Select "Quit" from the menu.

* Press **ALT-m** to process the next month's data.

QUARTERLY SUMMARY OF SOUND DATA

* Start Lotus 123.

* Retrieve QUARTER.WK1 from the \MACROS subdirectory.

* You will be prompted to "Enter name of site". Enter the site name and include the park designation.

* The program will ask if data is available for the first month of the quarter that you are summarizing. If you are not sure, you can select the "List" option from the menu and see a list of the \PROCESSD files. The appropriate files are the ones which contain the summary of an entire month's data. They will be named something like CACT-APR.WK1 (data for April at West Cactus Flat). For locations which have both sound and met data (such as Escalante, GLCA), the file name will end in "S" (e.g., ESC-APRS). After viewing the list, press **Enter** to return to the menu.

* If for some reason the data is not available, select "No". Otherwise, choose "Yes".

* You will be asked for a range name. Type in the <u>first three letters</u> of the name of the month. For example, if you are summarizing data for the second quarter, the first range name will be **apr**.

* Select the data file to combine. If you choose the wrong month's data, or you did not type the range name correctly, you will get an error. In that case, press **CTRL-BREAK** to stop the macro, then **ALT-g** to start over.

* The above process will repeat for the second and third months of the quarter.

* Then the program will prompt you to "Enter first line of graph title:". Correct the quarter number and the year in the existing title, and press **ENTER**.

* A graph will appear. Press **ENTER** and you will be asked to enter a file name for the graph. Use the following naming convention:

  lllnQyy

  where lll = abbreviation for location,

n = number of the quarter (1-4),
"Q" = designates quarterly data, and
yy = the year.

* To process another quarter, retrieve QUARTER.WK1 again from the \MACROS subdirectory.

A-9. PROCEDURE FOR PROCESSING MONTHLY METEOROLOGICAL DATA

If a Campbell Scientific met station was set up near a DA 607P sound monitor (as it was at Rainbow Bridge, GLCA), there will be meteorological data to process along with the sound data.

* From DOS, copy the *.prn data file from the Campbell Scientific system to the \ORIGINAL subdirectory.

* View the file with a text editor. The number in the third column indicates the Julian date (the number of days since December 31. Figure out the month and day and rename the file something like

  CSmmdd.PRN

  where "CS" = Campbell Scientific data, and
  mmdd = the first date in the file.

* Start Lotus 123 and set the default directory to the directory that contains the \MACROS, \ORIGINAL, \PROCESSD, and \PICS subdirectories.

* Retrieve CSXFMMET.WK1 from the \MACROS subdirectory.

* When asked to "Enter name of file to import:", select the file you just renamed. Take a break. The file will be imported and the unnecessary data erased.

* Press **ALT-1** and the data will be reformatted.

* Press **ALT-d**. You will be asked for a "file to extract to:". Name the file as follows:

  lllmmddM

  where lll = a three-letter mnemonic for the location,
  mmdd = the month and day of the first data, and
  "M" = met data.

* If there is another file to prepare, press **Alt-g** to restart the process.

* Retrieve CS-MET.WK1 from the \MACROS subdirectory. Select "New" and then "Yes".

* Enter the name of the site. Be sure to include the park designation (e.g., GLCA, DINO, etc.).

* Choose the month for which you wish to summarize data from the menu.

* When asked to enter the file to combine, choose the first file with data in appropriate month.

* Press **ALT-d** to move appropriate data into the summary table. Sometimes the program will ask you to "Enter number of first row of data:". If data first appears on, say, row 17 of the spreadsheet, type 17 and press **ENTER**.

* If there is more data to be added from other files, press **ALT-m** to bring up the menu and select "Add". Choose the next file (chronologically) with data in that month, then press **ALT-d** as above.

When all data for the month has been retrieved and summarized ...

* Press **ALT-t** to calculate and transfer the averages to a table so they can be graphed.

* Select "Graph" from the menu, then select "1) Wind" and a graph will appear. Press **ENTER** and an updated graph will appear. Press **ENTER** again and name the graph as follows:

  d:\PICS\llttttmm

  where ll = location (WC, HC, etc.),
  tttt = type of graph (WIND or TEMP), and
  mm = number of month.

* After the graph is saved, the menu will reappear. Select "Graph" again and choose "2) Temp". Name the graph as above.

* Select "Save" from the menu to save the summary of the entire month's data. Name the file as follows:

  d:\PROCESSD\lll-mmmM

  where lll = location,
  mmm = abbreviation for the month, and
  "M" = met data.

* Select "Quit" from the menu.

* Press **ALT-m** to process the next month's data.

A-10. PRINTING GRAPHS

* Exit 123 and start the PrintGraph program from the 1-2-3 Access System.

* Select "Image-Select". If the default graphs directory is set correctly, you will see a list of the graphs you have created with the macros.

* Select each graph that you want to print with the space bar, then press **ENTER**.

* Select "Align" and "Go". Take a break for several hours while the graphs are printed.

A-11. SUPPLIERS OF EQUIPMENT AND ACCESSORIES

Prices are approximate.

Batteries
Power Sonic PS-6120
6 volt, 12 AH
Dimensions: 4.25" X 2.75" X 5.51"
Alternative: PS-6105 (10 AH)
Supplier: Allied Electronics (800) 433-5700
Price: $28 ea.

Black Box
Tuff-Bin Model 3722
Supplier: Home Depot or similar
Price: $60

Calibration for DA 607P's and Calibrators
Engineering Dynamics Inc. (EDI)
3925 South Kalamath Street
Englewood, CO 80110
(303) 761-4367

Connector - solar panel to DA 607P
Amphenol 3106A-18-01P
Supplier: Newark Electronics (303) 373-4540
Price: $14

Desiccant
Drierite
Indicating, 8 mesh, 5 lb.
Supplier: Fisher Scientific (303) 371-0888
Price: $60

PVC Poles, Guy Wire, Hardware
Supplier: Home Depot or similar

Rain Hat
Foam Speaker Grille
Supplier: Radio Shack
Price: $8

Solar Panel
ARCO Solar Inc. M25
Mounting bracket: FRPS-01
Supplier: Thermal Supply (713) 224-1060
Price: $175 for panel, $60 for bracket

Thermal Paper
Labelon CR-025
Supplier: office supply

DA 607P Monitor

There may be additional DA 607P monitors not currently being used for sound monitoring. If needed, contact:

L. Lorraine Mintzmyer
Regional Director, Rocky Mountain Region
National Park Service
P.O. Box 25287
Denver, CO 80225

ref: DA equipment being used for Colorado Plateau ambient monitoring program

APPENDIX B

TECHNICAL PROCEDURES

Larson-Davis LD 870 Monitor

B-1. INSTALLATION PROCEDURE

For the most part, the installation of the Larson-Davis 870 monitor is covered in the documentation which came with the monitor. However, since steel pipe is used instead of the Larson-Davis pole, there are a few exceptions.

* Pick location for pole and drive the lower portion of the pipe into the ground. Be careful not to damage the threads on the pipe.

* Adjacent to the pipe, drive the 1/2" copper rod into the ground as far as possible, leaving at least 6" exposed.

* Drive a stake at a location about 10' due north of the pipe, and another at 10' south of the pipe.

* Drive the other four stakes at locations 10' from the pipe and 10' from the north or south stake.

* Attach ground wire clamp to rod.

* Assemble the rest of the pole assembly to the pipe. The arm of the pole which holds the wind sensor should point due east.

* Attach six guy wires between the top of the pole and the stakes. Level the pole and tighten the wires. Use the turnbuckles to provide even tension on each cable.

* Connect the microphone cables and attach the microphone assembly to the top of the pole.

* Attach solar panel to the pole. The panel should be facing due south and be angled toward the noon sun.

* Calibrate using the recalibration instructions.

B-2. SUPPLIES TO BE CARRIED TO THE FIELD EACH TIME

The following supplies and materials should be carried to the field each time:

* Portable computer to download data
* Serial interface cable
* Key for box containing monitor
* CA-250 Sound level calibrator
* Data dump and recalibration/cold start instructions
* Copy of LD 870 manual and software manual
* Flat head screwdriver
* 5/16" and 3/8" nut drivers
* Crescent wrench or vise-grip pliers
* Compass

B-3. SUPPLIES TO BE KEPT AT MONITOR LOCATION

* Metal microphone screen for use in calibrating.

B-4. DATA RETRIEVAL INSTRUCTIONS

* Open enclosure and attach serial cable from LD 870 to laptop computer.

* Refer to instructions in software manual to download data and store on disk.

* If the calibrator is available, follow the RECALIBRATION procedure.

* Adjust the turnbuckles if necessary.

* Make sure the little man in the display is "running" when you leave the site.

* Label the data disk and send it to the appropriate person in Denver.

B-5. RECALIBRATION PROCEDURE

* Climb the pole and remove the outer windscreen from the microphone.
* Remove the smaller windscreen.
* Carefully unscrew the white rain protector from the microphone.
* Using extreme caution, screw the metal screen (found in the battery enclosure) onto the microphone.
* Using the Larson-Davis calibrator and the instructions in the LD 870 manual, calibrate the unit. The calibrator operates at 114 dB.
* Unscrew the metal screen and replace the white rain protector.
* Replace the two windscreens.
* Climb down the pole.

B-6. INITIAL SOFTWARE SETUP

The following describes an initial setup required to analyze sound and meteorological data from the Larson-Davis 870 monitor. If you have any questions about the setup or use of the software, contact Mr. Gris Steele at CSTI, (713) 492-2784 (phone) or (713) 492-1434 (fax).

* Make five subdirectories in the root directory of your hard disk with the following names:

  \MACROS
  \ORIGINAL
  \PROCESSD
  \PICS
  \870

  The first four will contain Lotus 123 macro and data files. The fifth is for the Larson-Davis 870 program and data.

LOTUS 123

Several macro programs are needed to process the data:

LDXFMMET.WK1 - format meteorological data from Larson-Davis 870 system to be read by LD-MET

LDXFMSND.WK1 - format sound data from Larson-Davis 870 system to be read by LD-SOUND

LD-SOUND.WK1 - process monthly sound data from Larson-Davis monitor

LD-MET.WK1 - process monthly met data from Larson-Davis monitor

LD-PRINT.WK1 - print monthly sound data from Larson-Davis monitor

QUARTER.WK1 - summarize three months of L90 sound levels

* Copy the above macro files into the \MACROS subdirectory.

* Start Lotus 123. Set the default drive to the root directory which contains the \MACROS, \ORIGINAL, \PROCESSD, and \PICS subdirectories.

* Retrieve LD-PRINT.WK1 from the \MACROS subdirectory.

* The print options should read as follows:

  Margins: Left 14 Right 93 Top 4 Bottom 0

  Borders: Rows A6..A8

  These should already be set, but you do need to enter the setup string for printing 12 characters per inch. If you are using an Epson compatible printer, the setup string should be "\027M" (the typing sequence would be **/ppos\027M ENTER qq**.

* Save the file (**/fs ENTER r**).

PRINTGRAPH

* Load PrintGraph from the 1-2-3 Access System and set the following parameters:

  Image size: full
  Top margin: 0.5
  Left margin: 0.8
  Font 1: BOLD
  Font 2: BLOCK2
  Graphs directory: d:\PICS

  Also make sure the correct printer is selected, then save the setup. The following series of keystrokes will accomplish all but the printer selection:

  sisfmt.5 ENTER 1.8 ENTER qq
  f1, select "BOLD" with the space bar, then press **ENTER**
  f2, select "BLOCK2" then **ENTER**
  qhg\pics ENTER qse

870 PROGRAM

* Install the 870 program into the \870 subdirectory according to the 870 software manual.

B-7. DATA PREPARATION PROCEDURES

Data entry is not necessary for the LD 870 monitor because the data is downloaded directly from the monitor to the computer. The following instructions explain how to prepare the data files retrieved from the LD 870 to be processed and graphed.

<u>870 PROGRAM</u>

* From DOS, copy any 870 data files into the \870 directory.

* Start the 870 program by typing "870" and pressing **ENTER**.

* Select "Intervals".

* Select the **Data Setup** menu.

* Select "Intv Data".

* Place "X"s by the following (and ONLY the following!):

  Date
  Time
  Lint
  Lmin
  Lmax
  L1
  L2
  L4
  L5
  L6

  then select "Ok".

* From the **Data Setup** menu, select "Read Data From File".

* Select the data file which you want to process.

* From the **Setup** menu, select "Print to Screen".

* From the **Output** menu, select "Print Data".

* Make sure the headings displayed on the screen are as follows:

		Leq	Lmin	Lmax	L1	L10	L50	L90	L99
Date	Time	dBA	dBA	dBA	dBA	dBA	dBA	dBA	dBA

If, for example, the header says L33 instead of L50,

- press **ESC** twice,
- from the **Data Setup** menu, select "Select Intv Data" and make any needed changes.

* When you are satisfied that the format is correct, go to the **Setup** menu and select "Print to Disk".

* From the **Output** menu, select "Print Data".

* Set the path name to d:\ORIGINAL (where "d:" is the letter of the hard drive).

* Enter a file name as follows:

  LDmmddSI

  where "LD" = Larson-Davis monitor,
  mmdd = the month and day of the data,
  "S" = sound data, and
  "I" = interval data.

  For example, if the 870 file is dated 5/2/90, the file name will be LD0502SI.

Now do the same for the met data...

* From the **Data Setup** menu,

  choose "Select Intv Data",
  select "Clr All",
  select the following: Date
  Time
  AD1 Avg (or Wind Avg)
  AD1 Max (or Wind Max
  AD2 Avg
  AD3 Avg
  and select "OK".

* From the **Setup** menu, select "Print to Screen".

* From the **Output** menu, select "Print Data".

The header should read as follows:

		Wind Avg mph	Wind Max mph	Air Te Avg Dg C	Humidi Avg Pcnt
Date	Time				

* Press **ESC** twice.

* Choose the **Setup** menu and select "Print to Disk".

* Choose the **Output** menu and select "Print Data".

* Set the path name to d:\ORIGINAL.

* Enter a file name as follows:

  LDmmddMI

  where mmdd = the month and day of the data,
  "M" = met data, and
  "I" = interval data.

* Exit the 870 program by selecting "Stop Program" from the Setup menu.

LOTUS 123

* Start Lotus 123. Set the default directory to the drive which contains the \MACROS, \ORIGINAL, and \PROCESSD subdirectories (e.g., /fdC:\).

* Retrieve the macro which transforms the ASCII data (the *.PRN files created by the 870 program) into the worksheet format. Press /fr, select the \MACROS subdirectory, and select LDXFMSND.WK1.

* Select the sound file, LDmmddSI.PRN to import. Take a coffee break while Lotus imports the file.

* Lotus will prompt you to "Enter name of file to extract to:". Name the file

  lllmmddS

  where lll = location (e.g., ESC for Escalante),
  mmdd = the date of the data file, and
  "S" = sound data.

* The extract range should begin at Q53 and end in column Z on the last row of data.

* After the file is created, retrieve LDXFMMET.WK1 from the macros directory.

* When it asks for the file to import, select the met file, LDmmddMI.

* The "file to extract to" should be named as above, except instead of an "S", use an "M" to indicate meteorological data. The extract range should be from Q53 to column V, on the last row of data.

B-8. PROCEDURES FOR PROCESSING MONTHLY SOUND DATA

PRINT DATA

* Retrieve LD-PRINT.WK1 from the \MACROS subdirectory. You will be prompted to select a file. Select the file which you previously extracted (such as ESC0502S.WK1).

* You will then be prompted to edit the header. There are three fields in the header, separated by the "¦" character. Edit the header to read as follows:

  Sound Data¦location, park¦month, year

  For example, for May data at Escalante, the header should read

  Sound Data¦Escalante, GLCA¦May, 1990

* When the header is entered, you will be prompted to select the print range. Select the data within the month desired and include columns A through J. The data will be printed to the printer.

* If the file is long and contains data in another month, press **ALT-c** to change the date in the header and print a new range of data. Or, press **ALT-g** to print from a different data file.

SUMMARIZE DATA

* Retrieve the macro file, LD-SOUND.WK1.

* Select "New", and answer "Yes" to erase data.

* Select the month of the data you want to process.

* When asked for the "file to combine", select a file with the proper location which ends in "S".

* Press **ALT-d** and the program will select the data in the file which is in the correct month.

* Watch the screen and observe the cellpointer. Every time the screen updates, the pointer should be on the first row of a new date (e.g., if the pointer is an a cell which contains "03Feb1990", there should be a column of cells which says "02Feb1990" immediately above it.)

- If the cellpointer is not on a new date, (i.e. the cell says "02Feb1990" with a string of identical cells above it) then the 870 may have glitched and stored extra intervals. If so, press **CTRL-BREAK** to stop the macro. To see an example of extra intervals, the 0502 data file has two extra intervals at 08:58 and 08:59 on February 2.
- **Do not delete these extra intervals from the spreadsheet!** To remedy the situation, move the valid data on top of the invalid data. For example, put the pointer on the 9:00 row and move the entire data range to the 08:58 row. Then the rows will read 07:00, 08:00, 09:00, 10:00, and so on.
- EXCEPTION: There should always be an extra interval at 23:58. Do not remove these, as the macro accounts for them.
- Again, do not delete any rows, as you may also delete part of the macro.

* If the file does not include data for the entire month,

  - press **ALT-m** and select "Add" to add data from another file
  - press **ALT-d** to process the additional data.

* Press **ALT-t** to calculate averages and create tables for graphing.

* Select "Graph" from the menu. The names of four types of graphs will appear. All four should be selected in sequence. The instructions that follow are for the first.

  - Select "1) Leq". A graph will appear.
  - Press **ENTER** and the graph will be updated with the correct title.
  - Observe graph to see if any anomalous values appear.

    * If so, note time, go to column AY, find the proper data table, then find the proper time column and erase any anomalous data (/re **ENTER** Do not insert a blank, as it will be interpreted as a zero). Press **ALT-t** and observe the graph again.

  - Press **ENTER** again.
  - You will be asked to "Enter graph file name:". Name it as follows:

llnnnnmm

where ll = location (only <u>two</u> characters this time, e.g., "ES" for Escalante),
nnnn = type of graph (**LEQ**, **LN**, **L90D**, or **L90M**), and
mm = the number of the month.

* Repeat this procedure for the other 3 types of graphs.

* Select "Save" from the menu.

* Save the worksheet containing all data and graphs in the \PROCESSD subdirectory as

  lll-mmmS

  where lll = the location,
  mmm = the name of the month, and
  "S" = sound.

* If the file contains data for the next month, select "New Month" from the menu. Press **ALT-d**, then **ALT-t**, as above and store the graphs.

<u>QUARTERLY SUMMARY OF SOUND DATA</u>

* Start Lotus 123.

* Retrieve QUARTER.WK1 from the \MACROS subdirectory.

* You will be prompted to "Enter name of site". Enter the site name and include the park designation.

* The program will ask if data is available for the first month of the quarter that you are summarizing. If you are not sure, you can select the "List" option from the menu and see a list of the \PROCESSD files. The appropriate files are the ones which contain the summary of an entire month's data. They will be named something like CACT-APR.WK1 (data for April at West Cactus Flat). For locations which have both sound and met data (such as Escalante, GLCA), the file name will end in "S" (e.g., ESC-APRS). After viewing the list, press **Enter** to return to the menu.

* If for some reason the data is not available, select "No". Otherwise, choose "Yes".

* You will be asked for a range name. Type in the first three letters of the name of the month. For example, if you are summarizing data for the second quarter, the first range name will be **apr**.

* Select the data file to combine. If you choose the wrong month's data, or you did not type the range name correctly, you will get an error. In that case, press **CTRL-BREAK** to stop the macro, then **ALT-g** to start over.

* The above process will repeat for the second and third months of the quarter.

* Then the program will prompt you to "Enter first line of graph title:". Correct the quarter number and the year in the existing title, and press **ENTER**.

* A graph will appear. Press **ENTER** and you will be asked to enter a file name for the graph. Use the following naming convention:

  lllnQyy

  where lll = abbreviation for location,
  n = number of the quarter (1-4),
  "Q" = designates quarterly data, and
  yy = the year.

* To process another quarter, retrieve QUARTER.WK1 again from the \MACROS subdirectory.

B-9. PROCEDURES FOR PROCESSING MONTHLY METEOROLOGICAL DATA

* Retrieve LD-MET.WK1 from the \MACROS subdirectory.

* Select "New", and answer "Yes" to erase data.

* Select the month of the data you want to process.

* When asked for the "file to combine", select a file with the proper location which ends in "M".

* Press **ALT-d** and the program will select the data in the file which is in the correct month. Again, watch the screen and observe the cellpointer. Every time the screen updates, the pointer should be on the first row of a new date.

* After all data for a particular month has been read, press **ALT-t**.

* Select "Graph" from the menu.

  - First select "1) Wind". A graph will appear.
  - Press **ENTER** and the graph will be updated with the correct title.
  - Press **ENTER** again.
  - You will be asked to "Enter graph file name:". Name it as follows:

```
llnnnnmm

where ll = location,
    nnnn = type of graph (WIND or TEMP), and
      mm = the number of the month.
```

* Repeat this procedure for the "Temp" graph.

* Select "Save" from the menu.

* Save the worksheet containing all data and graphs in the \PROCESSD subdirectory as

```
lll-mmmM

where lll = location,
      mmm = name of the month, and
      "M" = met data.
```

* If the file contains data for the next month, select "New Month" from the menu. Press **ALT-d**, then **ALT-t**, as above and store the graphs.

B-10. PRINTING GRAPHS

* Exit 123 and start the PrintGraph program from the 1-2-3 Access System.

* Select "Image-Select". If the default graphs directory is set correctly, you will see a list of the graphs you have created with the macros.

* Select each graph that you want to print with the space bar, then press **ENTER**.

* Select "Align" and "Go". Then press p for "Page". This may take a few hours if you are printing several graphs.

B-11. EQUIPMENT SUPPLIERS

All equipment, other than a few hardware items, was purchased from:

Larson-Davis Laboratories
1681 West 820 North
Provo, UT 84601
(801) 375-0177

Guillaume Bock or John Cary